UNIT 3: GENERAL ELECTRICAL SYSTEM DIAGNOSIS

LESSON 3: TEST ELECTRICAL CIRCUITS

I. Types of electrical circuit tests and electrical faults

A. Different types of electrical circuit tests are used to diagnose circuits.

1. An operational test determines what parts of the electrical circuit have failed or are operating incorrectly.

2. Using a wiring schematic to trace the current path of an electrical circuit determines the relationship between components of the electrical circuit.

3. The process of elimination determines the most likely location of a fault in an electrical circuit.

4. Voltage drop tests, which measure how much voltage is used between the power source and the component, locate high-resistance problems in an electrical circuit.

a. Each component must receive the proper voltage to operate. Normally, voltage drop is less than .2 volts on the power feed side and less than .5 volts on the ground side.

b. Voltage that is not within specifications indicates a loose connection, corrosion, or faulty power source. High-current electrical circuits do not tolerate high resistance. Low-current electrical circuits do tolerate high resistance.

B. Failure of an electrical circuit or its components is caused by one of three possible electrical faults.

1. An open occurs when the current path is broken because of a gap or hole in the conductor.

2. A short occurs when current follows a low-resistance, or shortened, path within an electrical circuit. A short creates excessive current draw and interrupts the operation of electrical components.

3. A ground occurs when current bypasses the load devices of an electrical circuit and flows from one side of the power source directly back to the other.

II. Procedures for diagnosing the electrical/electronic integrity of electrical circuits using Ohm's law

A. Test an electrical circuit wired in series using a digital multimeter (DMM).

1. Measure and record one of the following: resistance and voltage, resistance and current, or voltage and current.

2. Using Ohm's law, determine the condition of the electrical circuit.

B. Test an electrical circuit wired in parallel using a DMM.

1. Measure and record one of the following: resistance and voltage, resistance and current, or voltage and current.

2. Using Ohm's law, determine the condition of the electrical circuit.

C. Test an electrical circuit wired in series-parallel using a DMM.

1. Measure and record one of the following: resistance and voltage, resistance and current, or voltage and current.

2. Using Ohm's law, determine the condition of the electrical circuit.

III. Procedures for measuring voltage in an electrical circuit

A. Measure voltage in electrical circuits using a DMM.

1. Measure voltage on a battery. Record the polarity.

2. Wire two batteries in series. Measure the combined voltage. Record the polarity.

3. Wire two batteries in parallel. Measure the combined voltage. Record the polarity.

4. Connect two automotive bulbs and sockets wired in series to two batteries wired in series. Measure voltage at the two test points. Record the polarity.

5. Wire two automotive bulbs and sockets in parallel to two batteries wired in series. Measure voltage at the two test points. Record the polarity.

B. Measure voltage in an automotive electrical circuit.

1. Set the DMM to measure voltage.

2. Energize the electrical circuit.

3. Measure and record voltage of the electrical circuit.

4. Compare source voltage to available voltage at the electrical circuit.

5. De-energize the electrical circuit.

C. Based on the tests, determine the necessary action to correct any problems. Include further diagnosis and/or repairs.

IV. Procedures for measuring current in an electrical circuit

A. Measure current in electrical circuits using a DMM.

1. Wire two automotive bulbs and sockets in series to a battery. Measure current and observe the polarity. Record the readings.

2. Wire two automotive bulbs and sockets in parallel to a battery. Measure current and observe the polarity. Record the readings.

B. Measure current in an automotive electrical circuit using a DMM.

1. Set the DMM to the ammeter function or inductive test.

2. Connect the DMM in series or connect the inductive pickup.

3. Energize the electrical circuit.

4. Measure and record current.

5. De-energize the electrical circuit. Disconnect the DMM.

C. Based on the tests, determine the necessary action to correct any problems. Include further diagnosis and/or repairs.

V. Procedures for checking continuity and measuring resistance in an electrical circuit

A. Check continuity in an electrical circuit.

1. Locate the appropriate wiring schematic for the selected electrical circuit.

2. Perform a continuity test using a test light.

a. Connect the test light to ground.

b. Energize the electrical circuit.

c. Probe a wire along the electrical circuit to check for current. Record observations.

d. De-energize the electrical circuit. Disconnect the test light.

3. Perform a continuity (voltage) test using a DMM.

a. Set the DMM for parallel measure.

b. Energize the electrical circuit.

c. Probe the wire along the electrical circuit. Record the reading.

d. De-energize the electrical circuit.

4. Perform a continuity (resistance) test using a DMM.

a. Set the DMM for a resistance test.

b. Energize the electrical circuit.

c. Probe the wire along the electrical circuit to check for a low-resistance current path. Record observations.

d. De-energize the electrical circuit.

B. Measure resistance in an electrical circuit using a DMM.

CAUTION: Do not measure resistance on a live electrical circuit. This can damage test equipment.

1. Measure and record resistance on resistors or bulbs A and B. Using Ohm's law, calculate resistance.

2. Connect the resistors or bulbs A and B in series. Measure and record resistance. Using Ohm's law, calculate resistance.

3. Connect the resistors or bulbs A and B in parallel. Measure and record resistance.

4. Perform a resistance test across a diode.

   a. Test resistance with the DMM leads in one direction. Record observations.

   b. Reverse the DMM leads and test resistance again. Record observations.

5. Perform a resistance test across a throttle position sensor. Slowly sweep the DMM leads. Record observations.

C. Measure resistance in an automotive electrical circuit using a DMM.

CAUTION: Do not measure resistance on a live electrical circuit. This can damage test equipment.

1. Set the DMM for a resistance test.

2. Perform a resistance test across the electrical circuit. Record observations.

D. Based on the tests, determine the necessary action to correct any problems. Include further diagnosis and/or repairs.

VI. Procedures for checking electrical circuits using a test light

A. Wire two automotive bulbs and sockets in parallel to a battery. Using a test light, measure voltage at the two test points. Record the readings.

B. Wire two automotive bulbs and sockets in series. Using a test light, check continuity of the electrical circuit. Record observations.

C. Based on the tests, determine the necessary action to correct any problems. Include further diagnosis and/or repairs.

VII. Procedures for checking electrical circuits using fused jumper wires

A. Set up an electrical circuit according to the instructor's specifications. Have the instructor place a fault in the electrical circuit.

B. Perform an operational test. Record observations.

C. Trace the current path. Include a listing of the relationship between the components in the electrical circuit.

D. Using fused jumper wires to bypass switches, connectors, sections of wiring, and other nonresistive parts, isolate the fault. Record observations.

E. Set up the DMM.

F. Perform the test procedure. Record observations.

G. Based on the tests, determine the necessary action to correct any problems. Include further diagnosis and/or repairs.

VIII. Procedures for locating opens, shorts, and grounds in an electrical circuit

A. Test a fusible link.

1. Set the DMM to measure resistance.

2. Probe the fusible link. Measure and record continuity.

B. Test the circuit breaker for opens.

1. Set the DMM to measure resistance.

2. Remove the circuit breaker from the panel.

3. Perform a resistance test across the circuit breaker. Record the reading.

C. Test the fuse for opens with a test light.

1. Connect the test light.

2. Probe both sides of the fuse for voltage. Record the reading.

3. Disconnect the test light.

D. Test a load device for shorts and grounds.

1. Set the DMM to measure resistance.

2. Measure and record resistance on a load device.

3. Use Ohm's law to calculate current. Compare current to manufacturer's specifications.

E. Based on the tests, determine the necessary action to correct any problems. Include further diagnosis and/or repairs.

IX. Procedures for measuring and diagnosing the cause of key-off battery drain (parasitic draw)

A. Using a test light, check for large current drain on the battery.

1. De-energize as many electrical circuits as possible.

2. Connect the test light clamp to the negative battery cable. Connect the test light probe to the negative battery terminal.

3. Look for a bright light. The parasitic load needs to be repaired if there is a bright light.

4. Disconnect the test light. Energize the electrical circuits.

B. Using a DMM, check for battery drain.

1. Set the DMM for amperage.

2. De-energize as many electrical circuits as possible.

3. Disconnect the negative battery cable.

NOTE: With electronic memory functions, it may be necessary to wait thirty minutes or longer after disconnecting the battery cable before beginning this test.

4. Connect the negative DMM lead to the negative post of the battery. Connect the positive DMM lead to the negative battery cable.

5. Measure and record current flow. It should be less than .5 amps.

6. Disconnect the DMM leads.

7. Connect the negative battery cable and energize the electrical circuits.

C. Using a DMM with a low-amp induction pickup, check for battery drain.

1. Place the low-amp induction pickup on the positive battery cable.

2. Measure current flow. Record the reading.

D. Based on the tests, determine the necessary action to correct any problems. Include further diagnosis and/or repairs.

X. Procedures for testing and servicing fuses, fusible links, and circuit breakers

A. Test the fuses.

1. Connect one end of the test light to ground.

2. Energize the electrical circuits protected by the fuses.

3. Touch the other end of the test light to both ends of the fuses. Record observations. Compare to manufacturer's specifications.

4. De-energize the electrical circuits protected by the fuses and disconnect the test light.

B. Inspect the fusible links.

1. Locate the fusible links. Use service information to identify the electrical circuits protected by the fusible links.

2. Conduct a visual inspection of the fusible links. The insulation of a fusible link is burned/damaged if there is blistering of the wire or the wire is dark in color. Record observations.

3. Feel the fusible link for brittleness or a break in the wiring. Record observations.

C. Test the circuit breakers.

1. Locate the circuit breakers. Use service information to identify the electrical circuits protected by the circuit breakers.

2. Use service information to verify that each circuit breaker is the appropriate amperage.

3. Connect one end of the test light to ground.

4. Energize the electrical circuits protected by the circuit breakers.

5. Check the circuit breakers by touching the other end of the test light to both terminals of the circuit breaker. Record observations.

6. De-energize the electrical circuits protected by the circuit breakers and disconnect the test light.

D. Based on the tests, perform the necessary action to correct any problems. Retest as necessary.

XI. Procedures for testing and servicing switches, connectors, relays, solid-state devices, and wires of electrical/electronic circuits

A. Test switches.

1. Test voltage of the switches using a DMM.

a. Set the DMM to the correct range.

b. Connect the ground DMM lead to ground.

c. De-energize the switch.

d. Measure and record voltage at the battery terminal. No voltage indicates an open in the battery electrical circuit.

e. Measure and record voltage at the load terminal of the switch. Voltage indicates a short.

f. Energize the switch.

g. Measure and record voltage at the load terminal. No voltage indicates an open.

h. De-energize the switch and disconnect the DMM.

NOTE: To test a switch located on the ground side of the load, connect the positive DMM lead to the battery positive terminal. Perform the steps above using the ground DMM lead.

2. Test voltage drop of the switches using a DMM.

   a. Set the DMM to the correct range.

   b. Connect one DMM lead to the battery terminal of the switch and the other DMM lead to the load terminal of the switch.

   c. Energize the switch.

   d. Measure and record the voltage drop. A reading of more than .01 volts indicates high resistance.

   e. De-energize the switch. Disconnect the DMM.

3. Test resistance of the switches using a DMM.

   a. Disconnect battery power from the electrical circuit.

   b. Connect one DMM lead to the battery terminal of the switch and the other DMM lead to the load terminal.

   c. De-energize the switch.

   d. Measure and record resistance. There should be no continuity (very high resistance).

   e. Energize the switch.

   f. Measure and record resistance. There should be continuity (low resistance reading).

   g. De-energize the switch and disconnect the DMM. Reconnect the battery power to the electrical circuit.

4. Test switches using a test light.

   a. Connect the ground lead to ground.

   b. De-energize the switch.

   c. Test voltage at the battery terminal of the switch. The test light should light.

   d. Test voltage on the load side of the switch. The test light should not light.

e. Energize the switch.

f. Test voltage on the load side of the switch. The test light should light.

g. De-energize the switch and disconnect the test light.

NOTE: To test switches located on the ground side of the load, use the procedure above with the ground lead of the test light connected to the battery positive terminal.

5. Test switches using a fused jumper wire.

NOTE: The fused jumper wire must be the correct gauge for the current required for the electrical circuit.

a. Bypass the switch using a fused jumper wire.

b. Connect one lead of the fused jumper wire to the load terminal on the switch and the other end to the battery terminal.

c. The electrical circuit should function as if the switch were energized.

d. Disconnect the fused jumper wire.

B. Test connectors.

1. Test voltage of the connector using a DMM.

a. Connect the negative DMM lead to ground.

b. Energize the electrical circuit.

c. Measure and record voltage on the battery side of the connector. There should be voltage.

d. Measure and record voltage on the load side of the connector. There should be voltage.

e. De-energize the electrical circuit and disconnect the DMM.

2. Test voltage drop of the connector using a DMM.

a. Energize the electrical circuit.

b. Connect the positive DMM lead to the battery side of the connector. Connect the negative DMM lead to the load side of the connector.

c. Measure and record voltage drop. Voltage should be no more than .01 volts.

d. Disconnect the DMM and de-energize the electrical circuit.

3. Test resistance of the connectors and wiring using a DMM.

a. De-energize the electrical circuit.

b. Connect one DMM lead to the battery side of the connector and the other DMM lead to the load side of the connector.

c. Measure and record resistance. It should be very low.

d. Disconnect the DMM and energize the electrical circuit.

4. Test resistance of the wiring using a DMM.

a. De-energize the electrical circuit.

b. Connect one DMM lead to the battery end of the wire and the other DMM lead to the load end of the wire.

c. Measure and record resistance. It should be very low.

d. Disconnect the DMM and energize the electrical circuit.

5. Test connectors using a test light.

a. Connect the ground lead to ground.

b. Energize the electrical circuit.

c. Check for power on the battery side of the connector. The test light should light up.

d. Check the load side of the terminal. The test light should light up.

e. De-energize the electrical circuit and disconnect the test light.

6. Test the wires using a test light.

   a. Energize the electrical circuit.

   b. Connect the probe to the battery side on the wire where it connects to the load. The test light should light up.

   c. De-energize the electrical circuit and disconnect the test light.

C. Test relays.

1. Test resistance of relays using a DMM.

NOTE: Voltage suppression relays require special procedures. Use service information to locate the correct procedures.

   a. Using service information, identify the relay pins.

   b. Set the DMM to measure resistance.

   c. Measure and record resistance between the control circuit power pin and ground pin.

   d. Measure and record resistance on the load circuit between the battery terminal and load terminal.

   e. Compare to manufacturer's specifications. The readings should indicate open on normally open relays and low resistance on normally closed circuits.

2. Test voltage of relays using a DMM.

   a. Using service information, identify the relay pins.

   b. Set the DMM to measure voltage.

   c. Energize the relay control circuit by applying voltage to the battery pin. Ground the ground pin.

   d. Apply voltage to the battery pin of the load circuit.

   e. Measure and record voltage at the load pin. If the relay is normally open, there should be voltage at the load pin. If the relay is normally closed, there should not be voltage at the load pin.

f. Remove the power source to the control circuit but retain the voltage at the battery pin of the load circuit.

g. Measure and record voltage at the load pin on the load circuit. If the relay is normally closed, there should be voltage at the load pin. If the relay is normally open, there should not be voltage at the load pin.

h. De-energize the relay control circuit and disconnect the DMM.

3. Test relays using a fused jumper wire.

a. Using service information, identify the relay pins.

b. Place one end of the fused jumper wire in the connector to the load circuit battery pin and the other end in the connector for the load pin.

c. Check operation of the load circuit. It should operate as if the relay were energized.

d. Disconnect the fused jumper wire.

D. Test solid-state devices.

NOTE: There are many different types and arrangements of solid-state devices and various testing methods. Use service information to locate the correct procedures. The following methods are for testing the two most common solid-state devices.

1. Test a diode using a DMM.

a. Set the DMM to measure resistance.

b. Connect the DMM leads. Measure and record resistance.

c. Reverse the DMM leads. Measure and record resistance.

d. One of the resistance readings should be low and the other high or open.

e. Disconnect the DMM leads.

2. Test a transistor using a DMM.

a. Set the DMM to measure voltage.

b. Measure and record voltage at the emitter terminal of the transistor. There should be voltage.

c. Measure and record voltage at the base terminal. There should be voltage when the transistor is energized.

d. With voltage at the emitter and base, measure and record voltage at the collector. There should be voltage at the collector when there is voltage at the emitter and base.

e. Disconnect the DMM.

E. Based on the tests, perform the necessary action to correct any problems. Retest as necessary.