

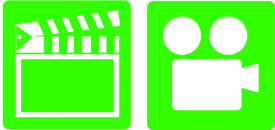
Advanced Automotive Electricity & Electronics

Chapter 7 Wiring Schematics & Circuit Testing

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This course or class covers operation and service of Advanced Automotive Electricity and Electronics Systems . It correlates material to task lists specified by ASE and NATEF.
Motivate Learners	Explain how the knowledge of how something works translates into the ability to use that knowledge to figure why the engine does not work correctly and how this saves diagnosis time, which translates into more money.
State the learning objectives for the chapter or course you are about to cover and explain this is what they should be able to do as a result of attending this session or class.	Explain the chapter learning objectives to the students. <ol style="list-style-type: none">1. Interpret wiring schematics.2. Locate shorts, grounds, opens, and resistance problems in electrical circuits, and determine necessary action.3. Inspect and test switches, connectors, relays, solid state devices, and wires of electrical circuits, and perform necessary action. <p>This chapter will help you prepare for the ASE Electrical/Electronic Systems (A6) certification test content area "A" (General Electrical/Electronic System Diagnosis).</p>
Establish the Mood or Climate	Provide a <i>WELCOME</i> , Avoid put downs and bad jokes.
Complete Essentials	Restrooms, breaks, registration, tests, etc.
Clarify and Establish Knowledge Base	Do a round robin of the class by going around the room and having each student give their backgrounds, years of experience, family, hobbies, career goals, or anything they want to share.

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1. SLIDE 1 CH7 WIRING SCHEMATICS & CIRCUIT TESTING

Check for **ADDITIONAL VIDEOS & ANIMATIONS**
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WEB SITE IS CONSTANTLY UPDATED

2. SLIDE 2 **EXPLAIN** WIRING SCHEMATICS & SYMBOLS

DISCUSSION: HAVE STUDENTS TALK ABOUT CIRCUIT INFORMATION ON A WIRING DIAGRAM. HOW IS A WIRING DIAGRAM SIMILAR TO A ROADMAP?

3. **SLIDE 3 EXPLAIN Figure 7-1** 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.
4. **SLIDE 4 EXPLAIN Figure 7-2** Typical section of a wiring diagram. Notice that 2 wire color changes at connection C210. 2 “.8” represents 2 metric wire size in square millimeters.
5. **SLIDE 5 EXPLAIN Chart 7-1** Typical abbreviations used on schematics to show wire color. Some vehicle manufacturers use 2 letters to represent a wire color. Check service information for 2 color abbreviations used.
6. **SLIDE 6 EXPLAIN TECH TIP**

DEMONSTRATION: PROCURE A WIRING HARNESS TO SHOW STUDENTS VARIOUS COLORS OF WIRES IN HARNESS

DISCUSSION: HAVE THE STUDENTS TALK ABOUT THE VARIOUS COLORS OF THE WIRES IN A WIRING HARNESS. WHAT IS THE SIGNIFICANCE OF DIFFERENT COLORS?

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7. **SLIDE 7 EXPLAIN** Figure 7-3 Electrical/electronic symbols used in automotive wiring & circuit diagrams.



DISCUSSION: HAVE STUDENTS DISCUSS THE SYMBOLS USED TO INDICATE MALE AND FEMALE CONNECTORS. WHY IS BATTERY SIDE OF CONNECTOR FEMALE & NOT MALE? HAVE STUDENTS STUDY CHART 7-3 TO BECOME FAMILIAR WITH SYMBOLS USED IN WIRING DIAGRAMS. WHAT DO SHORTER AND LONGER LINES ON BATTERY SYMBOL MEAN? HOW IS WIRING SHOWN?



8. **SLIDES 8-9 EXPLAIN** SCHEMATIC SYMBOLS
10. **SLIDE 10 EXPLAIN** FIGURE 7-4 In this typical connector, note that the positive terminal is usually a female connector.
11. **SLIDE 11 EXPLAIN** Figure 7-5 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.
12. **SLIDE 12 EXPLAIN** Figure 7-6 ground symbol on the left represents earth ground. The ground symbol on the right represents a chassis ground.



VIDEO: SHOW READING WIRING DIAGRAM VIDEO

WWW.MYAUTOMOTIVELAB.COM WIRING DIAGRAM

[HTTP://MEDIA.PEARSONCMG.COM/PH/CHET/CHET_MYLABS/AKAMAI/TEMPLATE/VIDEO640X480.PHP?TITLE=READING%20A%20WIRING%20DIAGRAM&CLIP=PANDC/CHET/2012/AUTOMOTIVE/STARTING_CHARGING_ELECT/A6T2.MOV&CAPTION=CHET/CHET_MYLABS/AKAMAI/2012/AUTOMOTIVE/STARTING_CHARGING_ELECT/XML/A6T2.XML](http://media.pearsoncmg.com/ph/chet/chet_myLABS/akamai/template/video640x480.php?title=reading%20a%20wiring%20diagram&clip=pandc/chet/2012/automotive/starting_charging_elect/a6t2.mov&caption=chet/chet_myLABS/akamai/2012/automotive/starting_charging_elect/xml/a6t2.xml)



13. **SLIDE 13 EXPLAIN** Figure 7-7 Starting at top, wire from ignition switch is attached to terminal B of connector C2, wire is 0.5 mm² (20 gauge AWG), and yellow. Circuit number is 5. Wire enters connector C202 at terminal B3.
14. **SLIDE 14 EXPLAIN** Figure 7-8 electrical terminals are usually labeled with a letter or number.
15. **SLIDE 15 EXPLAIN** Figure 7-9 Two wires that cross at the dot indicate that the two are electrically connected.



DEMONSTRATION: PROCURE A WIRING HARNESS WITH SPLICES. OPEN IT UP TO SHOW SPLICES IN HARNESS AND EXPLAIN THE NEED FOR SPLICES.

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16. **SLIDE 16 EXPLAIN Figure 7-10** Wires that cross, but do not electrically contact each other, are shown with one wire bridging over the other.
17. **SLIDE 17 EXPLAIN Figure 7-11** 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 dash.
DISCUSSION: HAVE STUDENTS TALK ABOUT NUMBERS USED TO INDICATE GENERAL AREAS FOR CONNECTION LOCATIONS. WHY IS THERE NEED TO SEPARATE VEHICLE INTO DIFFERENT AREAS TO SIMPLIFY REPAIRS? WHAT IS DIFFERENCE BETWEEN EVEN & ODD NUMBERED CONNECTORS?
18. **SLIDE 18 EXPLAIN Figure 7-12** 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).
19. **SLIDE 19 EXPLAIN Figure 7-13** The symbol for light bulbs shows the filament inside a circle, which represents the glass ampoule of the bulb
20. **SLIDE 20 EXPLAIN Figure 7-14** 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 brushless design.
21. **SLIDE 21 EXPLAIN Figure 7-15** Resistor symbols vary depending on the type of resistor.
22. **SLIDE 22 EXPLAIN Figure 7-16** rheostat uses only two wires—one is connected to a voltage source and the other is attached to the movable arm.
23. **SLIDE 23-24 EXPLAIN SCHEMATIC SYMBOLS**
25. **SLIDE 25 EXPLAIN Figure 7-17** 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.
26. **SLIDE 26 EXPLAIN Figure 7-18** grid like symbol represents an electrically heated element. Symbol represents a cigarette lighter or heated rear window

ICONS



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DISCUSSION: TALK ABOUT SYMBOLS USED TO REPRESENT CAPACITORS ON WIRING DIAGRAMS. WHY ARE 2 DIFFERENT SYMBOLS NEEDED FOR CAPACITORS?

27. SLIDE 27 **EXPLAIN** Figure 7-19 Dashed outline represents a portion (part) of a component.
28. SLIDE 28 **EXPLAIN** Figure 7-20 Solid box represents an entire component.
29. SLIDE 29 **EXPLAIN** Figure 7-21 Symbol represents a component that is case grounded.
30. SLIDE 30 **EXPLAIN NOTE**

DEMONSTRATION: SHOW STUDENTS HOW TO USE A COPY OF A WIRING DIAGRAM AND HIGHLIGHTER TO TRACE CIRCUITS FOR TESTING OR REPAIR.

31. SLIDE 31 **EXPLAIN** Figure 7-22 (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, called a “ganged switch.”
32. SLIDE 32 **EXPLAIN** Figure 7-23 (a) symbol for a normally open (N.O.) momentary switch (b) symbol for a normally closed (N.C.) momentary switch.
33. SLIDE 33 **EXPLAIN SCHEMATIC SYMBOLS**
34. SLIDE 34 **EXPLAIN NOTE**

35. SLIDE 35 **EXPLAIN TECH TIP**

36. SLIDE 36 **EXPLAIN**: RELAY TERMINAL ID
37. SLIDE 37 **EXPLAIN** FIGURE 7-24 Using a marker and color-coding the various parts of the circuit makes the circuit easier to understand and helps diagnosing electrical problems easier.

ICONS

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38. **SLIDE 38 EXPLAIN** Figure 7-25 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.
39. **SLIDE 39 EXPLAIN** Figure 7-26 cross-sectional view of a typical 4-terminal relay. Current flowing through coil (terminals 86 and 85) causes movable arm (called armature) to be drawn toward coil magnet. Contact points complete electrical circuit connected to terminals 30 & 87.
40. **SLIDE 40 EXPLAIN** Figure 7-27 typical relay showing the schematic of the wiring in the relay



DISCUSSION: HAVE STUDENTS TALK ABOUT OPERATION OF NORMALLY OPEN AND NORMALLY CLOSED RELAYS. WHAT ARE THE APPLICATIONS FOR NORMALLY OPEN RELAYS? WHAT ARE THE APPLICATIONS FOR NORMALLY CLOSED RELAYS?



41. **SLIDE 41 EXPLAIN** FIGURE 7.28 All schematics are shown in their normal, nonenergized position
42. **SLIDE 42 EXPLAIN** Figure 7-29 typical horn circuit. Note that relay contacts supply the heavy current to operate horn when horn switch simply completes a low-current circuit to ground, causing relay contacts to close. **87. SLIDES 87-88 READ & EXPLAIN TEXT**
43. **SLIDE 43 EXPLAIN** Figure 7-30 When relay or solenoid coil current is turned off, the stored energy in coil flows through clamping diode and effectively reduces voltage spike.



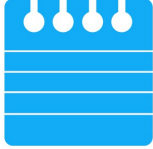









DISCUSSION: ASK STUDENTS TO TALK ABOUT CONTROLLING RELAY VOLTAGE SPIKES. HOW DOES DIODE USED IN A RELAY COIL CIRCUIT ELIMINATE VOLTAGE SPIKES?



44. **SLIDE 44 EXPLAIN:** RELAY TERMINAL ID



45. **SLIDE 45 EXPLAIN TECH TIP**

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	AN INOPERATIVE CIRCUIT INVOLVING A RELAY CAN BE DIVIDED IN 1/2 FOR TESTING. HIGH-CURRENT AND LOW-CURRENT SIDES CAN BE TESTED SEPARATELY TO DETERMINE WHICH SIDE OF CIRCUIT IS INOPERATIVE.
	46. SLIDE 46 EXPLAIN Figure 7-31 resistor used in parallel with the coil windings is a common spike reduction method used in many relays.
	47. SLIDE 47 EXPLAIN : RELAY TERMINAL ID LAB HANDS-ON TASK: STUDENTS COMPLETE WORKSHEET ON HIGHLIGHTING WIRING DIAGRAMS
	48. SLIDE 48 EXPLAIN FREQUENTLY ASKED QUESTION 49. SLIDE 49 - REAL WORLD FIX
 	STUDENTS COMPLETE NATEF TASK SHEET: USE WIRING DIAGRAMS DURING DIAGNOSIS OF ELECTRICAL CIRCUIT PROBLEMS
	50. SLIDE 50 EXPLAIN : LOCATING AN OPEN CIRCUIT 51. SLIDE 51 EXPLAIN : COMMON POWER/GROUND
	52. SLIDE 52 EXPLAIN Figure 7-32 typical wiring diagram showing multiple switches & bulbs powered by one fuse. DEMONSTRATION: USE TRAINER FOR AN OPEN CIRCUIT. HAVE STUDENTS WORK THROUGH CIRCUIT TROUBLESHOOTING PROCEDURE WITH YOU. EXPLAIN REASON FOR TESTING SIMPLE THINGS FIRST. TRY OUT THIS EXERCISE BEFORE CLASS TO MAKE SURE IT WORKS PROPERLY FOR DEMONSTRATING TO STUDENTS.
	53. SLIDE 53 EXPLAIN : CIRCUIT TROUBLESHOOTING PROCEDURE
	54. SLIDE 54 EXPLAIN Figure 7-33 To add additional lighting, simply tap into an existing light wire & connect

ICONS**Ch7 Wiring Schematics & Circuit Testing**

a relay. Whenever 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 auxiliary lights without overloading the existing light circuit.

55. **SLIDE 55 EXPLAIN** Figure 7-34 Always check simple things first. Check fuse for circuit you are testing. Maybe a fault in another circuit controlled by same fuse could have caused fuse to blow. Use a test light to check that both sides of fuse have voltage

56. **SLIDE 56 EXPLAIN TECH TIP**

DISCUSSION: DISCUSS CIRCUIT BREAKER METHOD OF TESTING FOR A SHORT-TO-GROUND CIRCUIT. WHY IS THIS A BETTER ALTERNATIVE THAN FUSE REPLACEMENT METHOD?

57. **SLIDE 57 EXPLAIN:** LOCATING SHORT CIRCUIT

58. **SLIDE 58 EXPLAIN** FREQUENTLY ASKED QUESTION

59. **SLIDE 59 EXPLAIN:** LOCATING SHORT CIRCUIT

60. **SLIDE 60 EXPLAIN 2 NOTES & CAUTION**

61. **SLIDES 61-62 EXPLAIN:** LOCATING SHORT CIRCUIT

63. **SLIDE 63 EXPLAIN** Figure 7-35 (a) After removing the blown fuse, a pulsing circuit breaker is connected to the terminals of fuse. (b) circuit breaker causes current to flow, then stop, then flow again, through circuit up to point of the short-to-ground. By observing the Gauss gauge, location of short is indicated near where the needle stops moving due to the magnetic field created by the flow of current through the wire.

64. **SLIDE 64 EXPLAIN** Figure 7-36 Gauss gauge can be used to determine the location of a short circuit even behind a metal panel.

DEMONSTRATION: SHOW STUDENTS HOW A GAUSS GAUGE WORKS. HAVE THEM USE GAUSS GAUGE TO CHECK FOR A SHORTED WIRE.

ICONS



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65. SLIDE 65 **EXPLAIN** Figure 7-37 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.

66. SLIDES 66-67 **EXPLAIN TECH TIPS**

DISCUSSION: HAVE STUDENTS DISCUSS FOUR METHODS OF TESTING FOR A SHORT-TO-GROUND CIRCUIT. WHICH METHOD WOULD BE EASIEST, & WHICH WOULD BE MOST DIFFICULT? WHY?

68. SLIDE 68 **EXPLAIN: ELECTRICAL TROUBLESHOOTING GUIDE**

69. SLIDE 69 **EXPLAIN** Figure 7-38 To check for a short-to-ground using a tone generator, connect black transmitter lead to a good chassis ground & red lead to load side of fuse terminal. Turn the transmitter on and check for tone signal with the receiver. Using a wiring diagram, follow strongest signal to short-to-ground. There will be no signal beyond the fault, either a short-to-ground as shown or an open circuit.

70. SLIDE 70 **EXPLAIN NOTE**

DEMONSTRATION: RAISE A VEHICLE ON A LIFT. HAVE STUDENTS INSPECT & LOCATE AREAS WHERE POTENTIAL ELECTRICAL OR ELECTRONIC PROBLEMS COULD OCCUR FROM HEAT OR MOVEMENT OF A WIRING HARNESS.

71. SLIDE 71 **EXPLAIN REAL WORLD FIX**

72. SLIDE 72 **EXPLAIN FIGURE 7-39** Antistatic spray can be used by customers to prevent being shocked when they touch a metal object like the door handle

NATEF TASK SHEET: LOCATE SHORTS, GROUNDS, OPENS, & RESISTANCE PROBLEMS IN ELECTRICAL/ELECTRONIC CIRCUITS; DETERMINE NECESSARY ACTION.

NATEF TASK SHEET: IDENTIFY AND INTERPRET ELECTRICAL/ELECTRONIC SYSTEM CONCERN; DETERMINE NECESSARY ACTION

