# Advanced Automotive Electricity & Electronics

## Chapter 13 Electronics Fundamentals

## 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.<br>1. Identify semiconductor components.<br>2. Discuss where various electronic and semiconductor devices are used in vehicles.<br>3. Explain necessary precautions when working with semiconductor circuits.<br>4. Describe diodes and transistors work, and how to test them.<br>5. Identify electronic component failure causes.<br>**This chapter will help you prepare for the ASE Electrical/Electronic Systems (A6) certification test content area "A" (General Electrical/Electronic System Diagnosis).** |
| **Establish the Mood or Climate** | Provide a *WELCOME,* 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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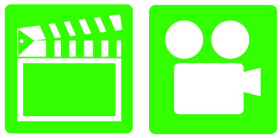
|  | **1. SLIDE 1 CH13 ELECTRONICS FUNDAMENTALS** |
|  | **Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/**<br>**WEB SITE IS CONSTANTLY UPDATED** |
|  | **2. SLIDE 2 EXPLAIN:** SEMICONDUCTORS |
| | **3. SLIDE 3 EXPLAIN Figure 13-1** N-type material. Silicon (Si) doped with a material (such as phosphorus) with five electrons in the outer orbit results in an extra free electron. |
|  | **DISCUSSION: DISCUSS DIFFERENCE BETWEEN ELECTRICITY & ELECTRONICS** |
|  | **4. SLIDE 4 EXPLAIN Figure 13-2** P-type material. Silicon (Si) doped with a material, such as boron (B), with three electrons in the outer orbit results in a hole capable of attracting an electron. |
| | **5. SLIDE 5 SUMMARY OF SEMICONDUCTORS** |
| | **6. SLIDE 6 EXPLAIN Figure 13-3** Unlike charges attract & current carriers (electrons/holes) move toward junction. |
| | **7. SLIDE 7 EXPLAIN FREQUENTLY ASKED QUESTION & NOTE** |
|  | **8. SLIDE 8 SUMMARY OF SEMICONDUCTORS** |
| | **9. SLIDE 9 EXPLAIN DIODES** |
| | **10. SLIDE 10 EXPLAIN Figure 13-4** A diode is a component with P-type and N-type materials together. The negative electrode is called the cathode and the positive electrode is called the anode. |
| | **11. SLIDE 11 EXPLAIN Figure 13-5** Diode connected to a battery with correct polarity (battery positive to P type and battery negative to N-type). Current flows through the diode. This condition is called forward bias. |
|  | **12. SLIDE 12 EXPLAIN Figure 13-6** Diode connected with reversed polarity. No current flows across the junction between the P-type and N-type materials. This connection is called reverse bias |

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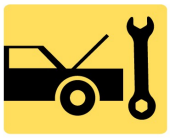
|---|---|
|  | **13. SLIDE 13 EXPLAIN Figure 13-7** Diode symbol and electrode names. The stripe on one end of a diode represents the cathode end of the diode. |
| | **14. SLIDE 14 EXPLAIN FREQUENTLY ASKED QUESTION & NOTE** |
|  | **DEMONSTRATION: DEMONSTRATE TO STUDENTS ON A PROJECT BOARD TO SHOW HOW A DIODE WORKS & HOW IT IS TESTED** |
|  | **TRAINER TASK: HAVE STUDENTS DUPLICATE THE ABOVE DEMO ON THEIR PROJECT BOARDS** |
|  | **15. SLIDE 15 EXPLAIN: DIODES** |
|  | **16. SLIDE 16 EXPLAIN TECH TIP** |
|  | **17. SLIDE 17 EXPLAIN: ZENER DIODES** |
| | **18. SLIDE 18 EXPLAIN Figure 13-8** Zener diode blocks current flow until a certain voltage is reached, then it permits current to flow. |
| | **19. SLIDE 19: EXPLAIN** HIGH-VOLTAGE SPIKE PROTECTION |
| | **20. SLIDE 20 EXPLAIN Figure 13-9** (a) Notice that when the coil is being energized, the diode is reverse biased and the current is blocked from passing through the diode. The current flows through the coil in the normal direction. (b) When the switch is opened, the magnetic field surrounding the coil collapses, producing a high-voltage surge in the reverse polarity of the applied voltage. This voltage surge forward biases the diode, and the surge is dissipated harmlessly back through the windings of the coil. |
| | **21. SLIDE 21 EXPLAIN Figure 13-10** A diode connected to both terminals of the air conditioning compressor clutch used to reduce the high-voltage spike that results when a coil (compressor clutch coil) is de-energized . |
|  | **22. SLIDE 22 EXPLAIN Figure 13-11** Spike protection diodes are commonly used in computer-controlled circuits to prevent damaging high-voltage surges that |

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| | occur any time current flowing through a coil is stopped<br>23. **SLIDE 23** EXPLAIN **Figure 13-12** Zener diode is commonly used inside automotive computers to protect delicate electronic circuits from high-voltage spikes. A 35 volt Zener diode will conduct any voltage spike higher than 35 voltage resulting from the discharge of the fuel injector coil safely to ground through a current-limiting resistor in series with the Zener diode.<br>24. **SLIDE 24** EXPLAIN **Figure 13-13** despiking resistor is used in many automotive applications to help prevent harmful high-voltage surges from being created when magnetic field surrounding a coil collapses when coil circuit is opened. |
|  | **DEMONSTRATION DIODES: SHOW STUDENTS EXAMPLES OF ZENER AND LED DIODES. ASK THEM TO LOOK FOR VISIBLE DIFFERENCES BETWEEN THESE DIODES AND THE DIODES YOU WOULD FIND IN AN ALTERNATOR.** |
|  | **HOLD A DISCUSSION ON DIODES ON THE VISIBLE DIFFERENCES BETWEEN THESE DIODES AND THE DIODES YOU WOULD FIND IN AN ALTERNATOR.** |
|  | 25. **SLIDE 25** EXPLAIN: DIODE RATINGS<br>26. **SLIDE 26** EXPLAIN NOTE<br>27. **SLIDE 27** EXPLAIN: LIGHT-EMITTING DIODES<br>28. **SLIDE 28** EXPLAIN **Figure 13-14** typical light-emitting diode (LED). This particular LED is designed with a built-in resistor so that 12 volts DC may be applied directly to the leads without an external resistor. Normally a 300 to 500 ohm, 0.5 watt resistor is required to be attached in series with the LED, to control current flow to about 0.020 A (20 mA) or damage to the P-N junction may occur<br>29. **SLIDE 29** EXPLAIN **FREQUENTLY ASKED QUESTION & NOTE** |
|  | 30. **SLIDE 30** EXPLAIN Photodiodes |
|  | 31. **SLIDE 31** EXPLAIN **Figure 13-15** Typical photodiodes. They are usually built into a plastic housing so that the photodiode itself may not be visible.<br>32. **SLIDE 32** EXPLAIN **Figure 13-16** Symbol for a |

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| | photodiode. The arrows represent light striking the P-N junction of the photodiode. |
|  | **33. SLIDE 33 EXPLAIN** photoresistor |
| | **34. SLIDE 34 EXPLAIN Figure 13-17** Either symbol may be used to represent a photoresistor. |
| | **35. SLIDE 35 EXPLAIN** SCR |
| | **36. SLIDE 36 EXPLAIN Figure 13-18** Symbol and terminal identification of an SCR. |
| | **37. SLIDE 37 EXPLAIN Figure 13-19** Wiring diagram for center high-mounted stoplight (CHMSL) using SCRs. |
| | **38. SLIDE 38 EXPLAIN: THERMISTORS** |
| | **39. SLIDE 39 EXPLAIN Figure 13-20** Symbols used to represent a thermistor. |
| | **40. SLIDE 40 EXPLAIN CHART 13-1** The resistance changes opposite that of a copper wire with changes in temperature |
|  | **DEMONSTRATION THERMISTOR: SHOW STUDENTS A THERMISTOR AND EXPLAIN WHERE IT IS COMMONLY USED. USE A HEAT SOURCE TO TEST THE THERMISTOR, SHOWING THE RESISTANCE CHANGE. AN ECT SENSOR WILL WORK.** |
|  | **41. SLIDE 41 EXPLAIN** Rectifier Bridges |
| | **42. SLIDE 42 EXPLAIN Figure 13-21** Rectifier bridge contains 6 diodes; 3 on each side are mounted in an aluminum-finned unit to keep diode cool |
| | **43. SLIDE 43 EXPLAIN** Transistors |
| | **44. SLIDE 44 EXPLAIN FREQUENTLY ASKED QUESTION & NOTE** |
|  | **45. SLDIE 45 EXPLAIN CHART 13-2** Comparison between the control (low-current) and high-current circuits of a transistor compared to a mechanical relay. |
|  | **46. SLIDE 46 EXPLAIN Figure 13-22** Basic transistor operation. A small current flowing through the base and emitter of the transistor turns on the transistor and permits a higher amperage current to flow from the collector and the emitter. |
| | **47. SLIDE 47 EXPLAIN** Transistors |
| | **48. SLIDE 48 EXPLAIN Figure 13-23** Basic transistor |

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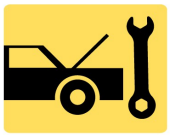
|---|---|
| | operation. A small current flowing through the base and emitter of the transistor turns on the transistor and permits a higher amperage current to flow from the collector and the emitter |
| | **49. SLIDE 49 EXPLAIN FREQUENTLY ASKED QUESTION & NOTE** |
|  | **50. SLIDE 50 EXPLAIN** field-effect transistor (FET) |
| | **51. SLIDE 51 EXPLAIN FIGURE 13–24** The three terminals of a field-effect transistor (FET) are called the source, gate, and drain |
| | **52. SLIDE 52 EXPLAIN FREQUENTLY ASKED QUESTION & NOTE** |
|  | **53. SLIDE 53 EXPLAIN FIGURE 13–25** A Darlington pair consists of two transistors wired together, allowing for a very small current to control a larger current flow circuit. |
| | **54. SLIDE 54 EXPLAIN** phototransistor |
| | **55. SLIDE 55 EXPLAIN FIGURE 13–26** Symbols for a phototransistor. (a) This symbol uses the line for the base; (b) this symbol does not |
|   | **DEMONSTRATION: DEMONSTRATE TO STUDENTS ON AN PROJECT BOARD TO SHOW HOW A TRANSISTOR WORKS & HOW IT IS TESTED** |
|  | **TRAINER TASK: HAVE STUDENTS DUPLICATE THE ABOVE DEMO ON AN ELECTRONICS TRAINER** |
|  | **HOLD A DISCUSSION ON TRANSISTORS ON THE VISIBLE DIFFERENCES BETWEEN BIPOLAR, PHOTOTRANSISTOR, CMOS, FET, ETC.** |
|   | **DEMONSTRATION TRANSISTORS: SHOW STUDENTS EXAMPLES OF DIFFERENT TRANSISTORS: BIPOLAR, PHOTOTRANSISTOR, CMOS, FET, ETC. ASK THEM TO LOOK FOR VISIBLE DIFFERENCES BETWEEN THESE TRANSISTORS.** |
|  | **56. SLIDE 56 EXPLAIN: INTEGRATED CIRCUITS** |
| | **57. SLIDE 57 EXPLAIN Figure 13-27** A typical automotive computer with the case removed to show all of the various electronic devices and integrated circuits (ICs). The CPU is an example of a DIP chip and the large red and orange devices are ceramic capacitors. |
| | **58. SLIDE 58 EXPLAIN FREQUENTLY ASKED** |

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| | **QUESTION & NOTE** |
|  | **59. SLIDE 59 EXPLAIN: TRANSISTOR GATES**<br>**60. SLIDE 60 EXPLAIN Figure 13-28** Typical transistor AND gate circuit using two transistors. The emitter is always the line with the arrow. Notice that both transistors must be turned on before there will be voltage present at the point labeled "signal out."<br>**61. SLIDE 61 EXPLAIN FREQUENTLY ASKED QUESTION & NOTE** |
|  | **62. SLIDE 62 EXPLAIN OP-AMPS**<br>**63. SLIDE 63 EXPLAIN Figure 13-29** Symbol for an operational amplifier (op-amp). |
|  | **64. SLIDE 64: EXPLAIN ELECTRONIC COMPONENT FAILURE CAUSES**<br>**65. SLIDE 65: EXPLAIN NOTE**<br>**66. SLIDE 66: EXPLAIN Electronic Component Failure Causes**<br>**67. SLIDE 67: EXPLAIN CAUTION**<br>**68. SLIDE 68: EXPLAIN Electronic Component Failure Causes**<br>**69. SLIDE 69 EXPLAIN Figure 13-30** Schematic for a blinking LED theft deterrent |
|  | **70. SLIDE 70 EXPLAIN TECH TIP** |
|  | **71. SLIDE 71 EXPLAIN NOTE**<br>**72. SLIDE 72: EXPLAIN HOW TO TEST DIODES/TRANSISTORS**<br>**73. SLIDE 73 EXPLAIN Figure 13-31** To check a diode, select "diode check" on a digital multimeter. The display will indicate the voltage drop (difference) between the meter leads. The meter itself applies a low-voltage signal (usually about 3 volts) and displays the difference on the display. (a) When the diode is forward biased, the meter should display a voltage between 0.500 and 0.700 V (500 to 700 mV). (b) When the meter leads are reversed, the meter should read OL (over limit) because the diode is reverse biased and blocking current flow.<br>**74. SLIDES 74-75 EXPLAIN** CONVERTERS & INVERTERS |

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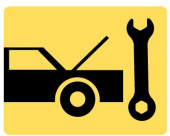
|---|---|
| | **76. SLIDE 76 EXPLAIN Figure 13-32** If the red (positive) lead of the ohmmeter (or a multimeter set to diode check) is touched to the center and the black (negative lead) touched to either end of the electrode, the meter should forward bias the P-N junction and indicate on the meter as low resistance. If the meter reads high resistance, reverse the meter leads, putting the black on the center lead and the red on either end lead. If the meter indicates low resistance, the transistor is a good PNP type. Check all P-N junctions in the same way. |
|  | **77. SLIDE 77 EXPLAIN Figure 13-33** DC to DC converter is built into most powertrain control modules (PCM) and is used to supply 5 volt reference called V-ref to many sensors used to control internal combustion engine. |
| | **78. SLIDE 78 EXPLAIN Figure 13-34** DC-DC converter is designed to convert 42 volts to 14 volts, to provide 14 V power to accessories on a hybrid electric vehicle operating with a 42 volt electrical system. |
|  | **79. SLIDE 79 EXPLAIN WARNING** |
|  | **80. SLIDE 80 EXPLAIN Figure 13-35** A typical circuit for an inverter designed to change direct current from a battery to alternating current for use by the electric motors used in a hybrid electric vehicle. |
|  | **81. SLIDE 81 EXPLAIN Figure 13-36** The switching (pulsing) MOSFETs create a waveform called a modified sine wave (solid lines) compared to a true sine wave (dotted lines). |
|  | **82. SLIDE 82 EXPLAIN WARNING** |
|  | **83. SLIDE 83: EXPLAIN** ELECTROSTATIC DISCHARGE |
|  | **STUDENTS COMPLETE TASK SHEET ON ELECTRONIC FUNDAMENTALS** |

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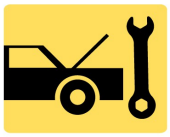
|  | HOMEWORK: SEARCH INTERNET: HAVE STUDENTS USE INTERNET TO GATHER INFORMATION ON FIELD-EFFECT TRANSISTORS, MOSFETS, & DARLINGTON PAIRS. ASK STUDENTS TO SHARE THEIR FINDINGS WITH THE CLASS ON NEXT DAY. |