

Automotive Technology 6th Edition

Chapter 48 ELECTRONIC FUNDAMENTALS

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This Automotive Technology 6th text provides complete coverage of automotive components, operation, design, and troubleshooting. It correlates material to task lists specified by ASE and ASEducation (NATEF) and emphasizes a problem-solving approach. Chapter features include Tech Tips, Frequently Asked Questions, Case Studies, Videos, Animations, and ASEducation (NATEF) Task Sheets.
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 learning objectives to students as listed below: <ol style="list-style-type: none"> 1. Discuss how semiconductors and diodes work. 2. Discuss the different uses of diodes. 3. Explain transistors, field-effect transistors, phototransistors, integrated circuits, transistor gates, and operational amplifiers. 4. Discuss the electronic components failure causes, how to test diodes and transistors, how to avoid electrostatic discharge, and converters and inverters.
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.

NOTE: Lesson plan is based on 6th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

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NOTE: You can use Chapter Images or possibly Power Point files:

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1. TITLE SLIDE 1 ELECTRONIC FUNDAMENTALS

2. SLIDE 2 EXPLAIN Figure 48-1 N-type material. Silicon (Si) doped with a material (phosphorus) with 5 electrons in outer orbit results in extra free electron.

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DISCUSSION: DISCUSS difference between electricity & electronics

3. SLIDE 3 EXPLAIN Figure 48-2 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.

DISCUSS FREQUENTLY ASKED QUESTION:

What Is Hole Theory? Current flow is expressed as the movement of electrons from one atom to another. In semiconductor and electronic terms, the movement of electrons fills the holes of P-type material. Therefore, as the holes are filled with electrons, the unfilled holes move opposite to the flow of electrons. This concept of hole movement is called hole theory of current flow. The holes move in the direction opposite to that of electron flow. For example, think of an egg carton, where if an egg is moved in one direction, the holes created move in the opposite direction. • SEE FIGURE 48-3.

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4. **SLIDE 4 EXPLAIN Figure 48-3** Unlike charges attract and the current carriers (electrons and holes) move toward the junction.
5. **SLIDE 5 EXPLAIN Figure 48-4** 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.
6. **SLIDE 6 EXPLAIN Figure 48-5** 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.
7. **SLIDE 7 EXPLAIN Figure 48-6** 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.
8. **SLIDE 8 EXPLAIN Figure 48-7** Diode symbol and electrode names. The stripe on one end of a diode represents the cathode end of the diode.

DISCUSS FREQUENTLY ASKED QUESTION:

What Is the Difference Between Electricity and Electronics? Electronics usually means that solid-state devices are used in the electrical circuits. Electricity as used in automotive applications usually means electrical current flow through resistance and loads without use of diodes, transistors, or other electronic devices.

EXPLAIN TECH TIP: "Burn In" to Be Sure

A common term heard in the electronic and computer industry is burn in, which means to operate an electronic device, such as a computer, for a period from several hours to several days. Most electronic devices fail in infancy, or during first few hours of operation. This early failure occurs if there is a manufacturing defect, especially at the P-N junction of any semiconductor device. The junction usually fails after only a few operating cycles. What does this information mean to the average person? When purchasing a personal or business computer, have

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the computer burned in before delivery. This step helps ensure that all of the circuits have survived infancy and that the chances of chip failure are greatly reduced. Purchasing sound or television equipment that has been on display may be a good value, because during its operation as a display model, the burn-in process has been completed. The automotive service technician should be aware that if a replacement electronic device fails shortly after installation, the problem may be a case of early electronic failure.

NOTE: Whenever there is a failure of a replacement part, the technician should always check for excessive voltage or heat to and around the problem component.

DEMONSTRATION: Demonstrate to students on a TRAINER or Project Board to show how a DIODE Works & tested

9. **SLIDE 9 EXPLAIN Figure 48-8** Zener diode blocks current flow until a certain voltage is reached, then it permits current to flow.
10. **SLIDE 10 EXPLAIN Figure 48-9a** 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.
11. **SLIDE 11 EXPLAIN Figure 48-9b** 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.
12. **SLIDE 12 EXPLAIN Figure 48-10** 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.
13. **SLIDE 13 EXPLAIN Figure 48-11** Spike protection diodes are commonly used in computer-controlled circuits to prevent damaging high-voltage surges that occur any time current flowing through a coil is stopped.

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14. **SLIDE 14 EXPLAIN** Figure 48-12 **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.
15. **SLIDE 15 EXPLAIN** Figure 48-13 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.

16. **SLIDE 16 EXPLAIN** Figure 48-14 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.

DISCUSS FREQUENTLY ASKED QUESTION:
How Does an LED Emit Light? LED contains a chip that houses P-type and N-type materials. Junction between these regions acts as a barrier to flow of electrons between two materials. When a voltage of 1.5 to 2.2 volts is applied to correct polarity, current flows across junction. As electrons enter P-type material, it combines with holes in material and releases energy in form of light (called photons). The intensity and color the light produces depends on materials used in the manufacture of the semiconductor. LEDs are



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very efficient compared to conventional incandescent bulbs, which depend on heat to create light. LEDs generate very little heat, with most of the energy consumed converted directly into light. LEDs are reliable and are being used for taillights, brake lights, daytime running lights, and headlights in some vehicles.

[Potentiometer \(View\) \(Download\)](#)

[Relay \(View\) \(Download\)](#)

[Transistors \(View\) \(Download\)](#)

17. **SLIDE 17 EXPLAIN Figure 48-15** Typical photodiodes. They are usually built into a plastic housing so that the photodiode itself may not be visible.
18. **SLIDE 18 EXPLAIN Figure 48-16** Symbol for a photodiode. The arrows represent light striking the P-N junction of the photodiode.
19. **SLIDE 19 EXPLAIN Figure 48-17** Either symbol may be used to represent a photoresistor.
20. **SLIDE 20 EXPLAIN Figure 48-18** Symbol and terminal identification of an SCR.

DISCUSS CHART 48-1 resistance changes opposite to that of a copper wire with changes in temperature.

21. **SLIDE 21 EXPLAIN Figure 48-19** Wiring diagram for center high-mounted stoplight (CHMSL) using SCRs.
22. **SLIDE 22 EXPLAIN Figure 48-20** Symbols used to represent a thermistor.

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.

23. **SLIDE 23 EXPLAIN Figure 48-21** Rectifier bridge contains 6 diodes; 3 on each side are mounted in an aluminum-finned unit to keep diode cool
24. **SLIDE 24 EXPLAIN Figure 48-22** 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

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collector and the emitter.

25. SLIDE 25 **EXPLAIN** FIGURE 48–23 The three terminals of a field-effect transistor (FET) are called the source, gate, and drain.

DISCUSS FREQUENTLY ASKED QUESTION:

Is a Transistor Similar to a Relay? Yes, in many cases a transistor is similar to a relay. Both use a low current to control a higher current circuit. • **SEE CHART 48–2.** A relay can only be on or off. A transistor can provide a variable output if base is supplied a variable current input.

DISCUSS CHART 48-2 Comparison between control (low-current) & high-current circuits of a transistor compared to a mechanical relay.

DEMONSTRATION: Demonstrate to students on an Project Board to show how a TRANSISTOR Works & How it is tested Hold a **DISCUSSION** on TRANSISTORS on the visible differences between Bipolar, Phototransistor, CMOS, FET, etc.

DEMONSTRATION Transistors: Show Examples of different transistors: Bipolar, Phototransistor, CMOS, FET, etc. Ask them to look for visible differences between these transistors.

DISCUSS FREQUENTLY ASKED QUESTION:

What Is a Darlington Pair? A Darlington pair consists of two transistors wired together. This arrangement permits a very small current flow to control a large current flow. The Darlington pair is named for Sidney Darlington, an American physicist for Bell Laboratories from 1929 to 1971. Darlington amplifier circuits are commonly used in electronic ignition systems, computer engine control

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circuits, and many other electronic applications. • SEE FIGURE 48–24.

26. **SLIDE 26 EXPLAIN FIGURE 48–24** A Darlington pair consists of two transistors wired together, allowing for a very small current to control a larger current flow circuit.

DISCUSS FREQUENTLY ASKED QUESTION:

What Does the Arrow Mean on a Transistor Symbol? The arrow on a transistor symbol is always on the emitter and points toward the N-type material. The arrow on a diode also points toward the N-type material. To know which type of transistor is being shown, note which direction arrow points.

- **PNP: pointing in**
- **NPN: not pointing in**

27. **SLIDE 27 EXPLAIN FIGURE 48–25** Symbols for a phototransistor. (a) This symbol uses the line for the base; (b) this symbol does not.

28. **SLIDE 28 EXPLAIN Figure 48-26** 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.

DISCUSS FREQUENTLY ASKED QUESTION:

What Causes a Transistor or Diode to Blow?

Every automotive diode and transistor is designed to operate within certain voltage and amperage ranges for individual applications. For example, transistors used for switching are designed and constructed differently from transistors used for amplifying signals. Because each electronic component is designed to operate satisfactorily for its particular application, any severe change in operating current (amperes), voltage, or heat can destroy the junction. This failure can cause either an open circuit (no current flows)

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or a short (current flows through component all the time when component should be blocking current flow).

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29. SLIDE 29 **EXPLAIN** Figure 48-27 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.”

30. SLIDE 30 **EXPLAIN** Figure 48-28 Symbol for an operational amplifier (op-amp).

EXPLAIN TECH TIP: *Blinking LED Theft Deterrent*

A blinking (flashing) LED consumes only about 5 milliamperes (5/1,000 of 1 ampere, or 0.005 A). Most alarm systems use a blinking red LED to indicate that the system is armed. A fake alarm indicator is easy to make and install. A 470-ohm, 0.5-watt resistor limits current flow to prevent battery drain. The positive terminal (anode) of the diode is connected to a fuse that is hot at all times, such as the cigarette lighter. The negative terminal (cathode) of LED is connected to any ignition-controlled fuse. • SEE FIGURE 48-29. When the ignition is turned off, the power flows through LED to ground and LED flashes. To prevent distraction during driving, LED goes out when ignition is on. Therefore, this fake theft deterrent is “auto setting,” and no other action is required to activate it when you leave your vehicle except to turn off the ignition and remove the key, as usual.

31. SLIDE 31 **EXPLAIN** Figure 48-29 Schematic for a blinking LED theft deterrent.

DISCUSS FREQUENTLY ASKED QUESTION:

What Are Logic Highs and Lows? All computer circuits and most electronic circuits (such as gates) use various combinations of high and

low voltages. High voltages are typically those above 5 volts, and low is generally considered zero (ground). However, high voltages do not have to begin at 5 volts. High, or the number 1, to a computer is the presence of voltage above a certain level. For example, a circuit could be constructed where any voltage higher than 3.8 volts is considered high. Low, or the number 0, to a computer is the absence of voltage or a voltage lower than a certain value. For example, a voltage of 0.62 volt may be considered low. Various associated names and terms can be summarized.

- **Logic low = Low voltage = Number 0 = Reference low**
- **Logic high = Higher voltage = Number 1 = Reference high**

32. SLIDE 32 EXPLAIN Figure 48-30a 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).

33. SLIDE 33 EXPLAIN Figure 48-30b When the meter leads are reversed, the meter should read OL (over limit) because the diode is reverse biased and blocking current flow.

34. SLIDE 34 EXPLAIN Figure 48-31 If the red (positive) lead of ohmmeter (or a multimeter set to diode check) is touched to center and 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.

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35. **SLIDE 35 EXPLAIN Figure 48-32** 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.
36. **SLIDE 36 EXPLAIN Figure 48-33** 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.

WARNING: Always follow OEM safety precautions for discharging capacitors in DC-DC converter circuits.

WARNING: Do not touch terminals of battery being used to power an inverter. There is always a risk that those battery terminals could deliver a much greater shock than from batteries alone, if a motor or inverter should develop a fault.

37. **SLIDE 37 EXPLAIN Figure 48-34** 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.
38. **SLIDE 38 EXPLAIN Figure 48-35** switching (pulsing) MOSFETs create a waveform called a modified sine wave (solid lines) compared to a true sine wave (dotted lines).

Students complete Task Sheet on Electronic Fundamentals

HOMEWORK: SEARCH INTERNET: Have students use Internet to gather information on field-effect transistors, MOSFETS, & Darlington pairs.