

# Light Vehicle Diesel Engines 1<sup>E</sup>

## Chapter 17 DIESEL ENGINE ELECTRONICS

### Opening Your Class

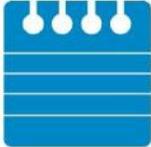
KEY ELEMENT	EXAMPLES
Introduce Content	This Light Vehicle Diesel Engines 1st text provides complete coverage of light duty diesel engine components, operation, and diagnosis. It correlates material to task lists specified by ASE and NATEF and emphasizes a problem-solving approach. Chapter features include Tech Tips, Frequently Asked Questions, and Real World Fixes..www.jameshalderman.com contains Videos, Animations, and NATEF Task Sheets for use in the lab and classroom
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"><li>1. Prepare for the ASE Light Vehicle Diesel Engine (A9) ASE certification test content area "A" General Diagnosis and "F" Fuel System Diagnosis and Repair.</li><li>2. Explain the characteristics of electricity.</li><li>3. Differentiate between conductors, insulators, and semiconductors.</li><li>4. Explain the units of electrical measurement.</li><li>5. List the parts of a complete circuit.</li><li>6. Discuss the types of electrical circuit faults.</li><li>7. Explain how to detect and measure electrical voltage, current, and resistance.</li><li>8. Discuss the purpose of terminals, connectors, relays, and switches.</li><li>9. Explain the operation of speed sensors and throttle position (TP) sensors</li></ol>
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:** This lesson plan is based on the 1<sup>st</sup> Edition Chapter Images found on Jim's web site @ [www.jameshalderman.com](http://www.jameshalderman.com)

**LINK CHP 17\_Chapter Images USE BELOW LINK**

[http://www.jameshalderman.com/books\\_a9.html](http://www.jameshalderman.com/books_a9.html)

**NOTE:** You can use Chapter Images or Power Point files: Though out Power Point Presentations, you will find questions and answers on slides that can be used for discussion.

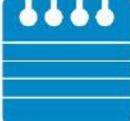
ICONS	Ch017 DIESEL ENGINE ELECTRONICS
         	<p><b>1. SLIDE 1 CH17 DIESEL ENGINE ELECTRONICS</b></p> <p>Check for <b>ADDITIONAL VIDEOS &amp; ANIMATIONS</b>  @ <a href="http://www.jameshalderman.com/">http://www.jameshalderman.com/</a>  <b>WEB SITE IS CONSTANTLY UPDATED</b></p> <p>At the beginning of this class, you can download the crossword puzzle &amp; Word Search from the links below to familiarize your class with the terms in this chapter &amp; then discuss them</p> <p><a href="http://www.jameshalderman.com/books_a9.html">http://www.jameshalderman.com/books_a9.html</a></p> <p><b>Crossword Puzzle (Microsoft Word) (PDF)</b>  <b>Word Search Puzzle (Microsoft Word) (PDF)</b></p> <p><b>2. SLIDE 2 EXPLAIN Figure 17-1</b> In an atom (left), electrons orbit protons in the nucleus just as planets orbit the sun in our solar system (right)</p> <p><b>3. SLIDE 3 EXPLAIN Figure 17-2</b> nucleus of an atom has a positive (+) charge and the surrounding electrons have a negative (-) charge.</p> <p><b>4. SLIDE 4 EXPLAIN Figure 17-3</b> figure shows a balanced atom. The number of electrons is the same as the number of protons in the nucleus.  <b><u>SHOW ANIMATION ON AN ATOM (FIGURE 17-3) COPPER ATOM</u></b></p> <p><b>5. SLIDE 5 EXPLAIN Figure 17-4</b> Unlike charges attract and like charges repel.</p> <p><b><u>DISCUSSION: DISCUSS FLOW OF ELECTRICAL CURRENT AND HOW THE CONSTANT FLOW, OR JUMPING OF ELECTRONS, CREATES CURRENT</u></b></p>

ICONS	Ch017 DIESEL ENGINE ELECTRONICS
   	<p><u><b>ELECTRON FLOW</b></u></p> <p><b><u>DEMONSTRATION: USE MAGNETS TO DEMONSTRATE HOW OPPOSITES FORCES ATTRACT AND LIKE FORCES REPEL. SHOW HOW MAGNETS ATTRACT AND REPEL EACH OTHER DEPENDING ON THE ORIENTATION OF THEIR POLES.</u></b></p> <p>6. <b>SLIDE 7 EXPLAIN</b> Figure 17-5 conductor is any element that has one to three electrons in its outer orbit.</p> <p>7. <b>SLIDE 7 EXPLAIN</b> Figure 17-6 Copper is an excellent conductor of electricity because it has just one electron in its outer orbit, making it easy to be knocked out of its orbit and flow to other nearby atoms. This causes electron flow, which is definition of electricity.</p>
  <p>QUESTION</p>   <p>QUESTION</p> 	<p><b>DISCUSS FREQUENTLY ASKED QUESTION</b></p> <p><b><u>DISCUSSION: HAVE STUDENTS DISCUSS DIFFERENT CONDUCTORS. WHY IS COPPER MOST COMMONLY USED CONDUCTOR IN ELECTRICAL SYSTEMS.</u></b></p> <p>8. <b>SLIDE 8 EXPLAIN</b> Figure 17-7 Insulators are elements with five to eight electrons in the outer orbit.</p> <p>9. <b>SLIDE 9 EXPLAIN</b> Figure 17-8 Semiconductor elements contain exactly four electrons in the outer orbit</p> <p><b><u>DISCUSSION: DISCUSS INSULATORS &amp; REASON THEY MAKE POOR CONDUCTORS. WHAT IS RELATIONSHIP BETWEEN NUMBER OF ELECTRONS AN INSULATOR MATERIAL HAS &amp; ITS ABILITY TO ACQUIRE &amp; RELEASE ELECTRONS?</u></b></p> <p><b>COMPLETE <u>TASK SHEET ON ELECTRICAL FUNDAMENTALS</u></b></p>

ICONS	Ch017 DIESEL ENGINE ELECTRONICS
	<p><b>SEARCH INTERNET: RESEARCH AMPERAGE REQUIRED FOR VARIOUS APPLIANCES, SMALL ELECTRONIC DEVICES. DO THESE SAME DEVICES USE SAME NUMBER OF AMPERES AROUND WORLD? ASK STUDENTS TO RANK CURRENT DRAWN BY DIFFERENT AUTOMOBILE ACCESSORIES, I.E. HEADLIGHTS &amp; IP PANEL LIGHTS.</b></p>
	<p>10. SLIDE 10 EXPLAIN Figure 17-9 Current electricity is the movement of electrons through a conductor</p> <p>11. SLIDE 11 EXPLAIN Figure 17-10 Conventional theory states that current flows through circuit from positive (+) to negative (-). Automotive electricity uses the conventional theory</p>
	<p>12. SLIDE 12 EXPLAIN Figure 17-11 One ampere is the movement of 1 coulomb (6.28 billion billion electrons) past a point in 1 second.</p> <p>13. SLIDE 13 EXPLAIN Figure 17-12 ammeter is installed in the path of the electrons similar to a water meter used to measure the flow of water in gallons per minute. <b>The ammeter displays current flow in amperes.</b></p>
	<p>14. SLIDE `4 EXPLAIN Figure 17-13 Voltage is electrical pressure that causes electrons to flow through a conductor</p> <p>15. SLIDE 15 EXPLAIN Figure 17-14 This digital multimeter set to read DC volts is being used to test the voltage of a vehicle battery. Most multimeters can also measure resistance (ohms) and current flow (amperes).</p>
	<p><b><u>DEMONSTRATION: SHOW HOW DMM MEASURES VOLTAGE. USE TRAINER TO SHOW STUDENTS MEASURING VOLTAGE</u></b></p>
	<p>16. SLIDE 16 EXPLAIN Figure 17-15 Resistance to flow of electrons through conductor measured in ohms</p>
	<p><b><u>ANIMATION: VOLTAGE &amp; RESISTANCE (FIGURE 17-15)</u></b></p>

ICONS	Ch017 DIESEL ENGINE ELECTRONICS
	<p><b><u>DEMONSTRATION:</u> SHOW HOW DMM MEASURES VOLTAGE. USE <u>PROJECT BOARD</u> TO SHOW STUDENTS MEASURING RESISTANCE</b></p>
	<p><b><u>HOMEWORK: SEARCH INTERNET:</u> HAVE STUDENTS USE INTERNET TO RESEARCH ELECTRICAL CURRENT. ASK THEM TO WORK IN GROUPS OF 3 OR 4 TO PREPARE SLIDE PRESENTATIONS FOR CLASS. HAVE CLASS DISCUSS INFORMATION PRESENTED IN EACH PRESENTATION.</b></p>
	<p>17. SLIDE 17 EXPLAIN Figure 17–16 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</p>
	<p><b><u>Ohm's Law, Current (View) (Download)</u></b>  <b><u>Ohm's Law, Resistance (View) (Download)</u></b>  <b><u>Ohm's Law, Volt (View) (Download)</u></b></p>
	<p>18. SLIDE 18 EXPLAIN FIGURE 17–17 electrical switch opens circuit and no current flows. The switch could also be on the return (ground) path wire</p>
	<p><b><u>DISCUSSION:</u> Ask students to discuss ground path. Why doesn't a separate ground wire have to be run from the battery to each electrical load? Ask students to discuss how and why a short-to-voltage occurs. What is the reason that a short-to-voltage may or may not blow a fuse?</b></p>
	<p><b><u>Complete Task Sheet on Electrical Circuits</u></b></p>
	<p>19. SLIDE 19 EXPLAIN FIGURE 17–18 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</p>
	<p>20. SLIDE 20 EXPLAIN FIGURE 17–19 Typical section of a wiring diagram. Notice that wire color changes at connection C210. “0.8” represents metric wire size in square millimeters.</p>

ICONS	Ch017 DIESEL ENGINE ELECTRONICS
	<p><b><u>DEMONSTRATION:</u> PROCURE A WIRING HARNESS TO SHOW STUDENTS VARIOUS COLORS OF WIRES IN HARNESS</b></p>
	<p>20. <b>SLIDE 20 EXPLAIN FIGURE 17–20</b> Electrical and electronic symbols used in automotive wiring and circuit diagrams. Both the conventional and the global symbols are shown side-by-side to make reading schematics easier. The global symbols are used by many vehicle manufacturers.</p>
	<p><b><u>DISCUSSION:</u> HAVE THE STUDENTS TALK ABOUT THE VARIOUS COLORS OF THE WIRES IN A WIRING HARNESS. WHAT IS THE SIGNIFICANCE OF DIFFERENT COLORS?</b></p>
	<p><b><u>DEMONSTRATION:</u> SHOW STUDENTS HOW TO USE A COPY OF A WIRING DIAGRAM AND HIGHLIGHTER TO TRACE CIRCUITS FOR TESTING OR REPAIR.</b></p>
	<p><b><u>DISCUSSION:</u> HAVE STUDENTS DISCUSS THE SYMBOLS USED TO INDICATE MALE AND FEMALE CONNECTORS. WHY IS BATTERY SIDE OF CONNECTOR FEMALE &amp; NOT MALE? WHAT DO SHORTER AND LONGER LINES ON BATTERY SYMBOL MEAN? HOW IS WIRING SHOWN?</b></p>
	<p><b><u>LAB HANDS-ON TASK:</u> STUDENTS COMPLETE <u>WORKSHEET</u> ON HIGHLIGHTING WIRING DIAGRAMS</b></p>
	<p>21. <b>SLIDE 21 EXPLAIN Figure 17-21</b> EG of common causes of open circuits. Some of these causes are often difficult to find.</p>
	<p>22. <b>SLIDE 22 EXPLAIN FIGURE 17–22</b> short circuit permits electrical current to bypass some or all of resistance</p>
	<p>23. <b>SLIDE 23 EXPLAIN FIGURE 17–23</b> fuse or circuit breaker opens circuit to prevent possible overheating damage in event of a short circuit.</p>
	<p>24. <b>SLIDE 24 EXPLAIN FIGURE 17–24</b> short-to-ground affects power side of circuit. Current flows directly to ground return, bypassing some or all of electrical loads in circuit. There is no current in circuit past short. Short-to-ground will also cause fuse to blow.</p>

ICONS	Ch017 DIESEL ENGINE ELECTRONICS
	<p><b><u>DEMONSTRATION:</u> DEMO BASIC ELECTRICAL CIRCUIT ON TRAINER. SHOW (FIGURE 4-1)WHAT HAPPENS WHEN CIRCUIT IS SHORTED TO GROUND</b></p>
	<p>25. SLIDE 25 EXPLAIN FIGURE 17–25 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.</p>
	<p><b>TRAINER TASK: ALLOW STUDENTS TO BLOW FUSE BY CREATING A SHORT CIRCUIT, OBSERVING WHAT IT TAKES TO CREATE SHORT CIRCUIT</b></p>
	<p><b><u>DEMONSTRATION:</u> SHOW STUDENTS HOW TO TEST A CIRCUIT WITH A FUSED JUMPER</b></p>
	<p><b><u>DISCUSSION:</u> DISCUSS USES OF FUSED JUMPER WIRE. IF A DEVICE WORKS WHEN CONNECTED TO A FUSED JUMPER WIRE, WHAT IS DETERMINED?</b></p>
	<p>26. SLIDE 26 EXPLAIN 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.</p>
	<p><b><u>DEMONSTRATION:</u> NON-POWERED TEST LIGHT WILL SHOW ONLY WHETHER CURRENT IS AVAILABLE. IT CANNOT DETERMINE HOW MUCH CURRENT OR EXACT VOLTAGE AVAILABLE. DEMONSTRATE A CONTINUITY TEST LIGHT FOR STUDENTS &amp; DISCUSS WHEN IT SHOULD BE USED.</b></p>
	<p><b>TEST LAMPS SHOULD NOT BE USED ON ANY CIRCUITS CONNECTED TO A PCM DUE TO VOLTAGES USED IN ELECTRONIC COMPONENTS</b></p>
	<p><b><u>Circuit Test, Test Light (View) (Download)</u></b></p>
	<p>26. SLIDE 26 EXPLAIN FIGURE 17–27 test light can be used to locate an open in a circuit. Note that the test light is grounded at a different location than the circuit itself.</p>



**EXPLAIN CHART 17-1 Common symbols & abbreviations used on digital meters.**

27. SLIDE 27 EXPLAIN FIGURE 17-28 digital multimeter. The black meter lead always is placed in the COM terminal. The red meter test lead should be in the volt-ohm terminal except when measuring current in amperes.



**DEMONSTRATE PROPER WAY TO CONNECT TEST LEADS TO DMM. POINT OUT INPUT TERMINALS ON DMM & FUNCTIONS. TELL STUDENTS THAT READING ON WRONG INPUT COULD DESTROY METER**



**Measure Battery Voltage Drop**

**Meter Usage Battery Volt Check**

**Meter Usage Check CAN Circuit**

**Meter Usage Measure Amps**

**Meter Usage Measure Frequency**

**Meter Usage Measure Ohms**

**Meter Usage Measure Volts**

**Meter Usage Testing Diode**



**DISCUSSION: HAVE STUDENTS DISCUSS VARIOUS SCALES AND SETTINGS ON A DMM. WHAT IS REASON THAT TEST RESULTS USING A DMM ARE MORE ACCURATE? DISCUSS THE AUTORANGE FEATURES**



28. SLIDE 28 EXPLAIN FIGURE 17-29 Typical digital multimeter (DMM) set to read DC volts.

29. SLIDE 29 EXPLAIN FIGURE 17-30 (a) typical autoranging digital multimeter automatically selects proper scale to read voltage being tested. The scale selected is usually displayed on meter face. Note that display indicates “4,” meaning that this range can read up to 4 volts. (b) typical autoranging digital multimeter automatically selects proper scale to read voltage being tested. The scale selected is usually displayed on meter face. The range is now set to the 40 volt scale, meaning that the meter can read up to 40 volts on the scale. Any

## ICONS

## Ch017 DIESEL ENGINE ELECTRONICS



reading above this level will cause the meter to reset to a higher scale. If not set on autoranging, the meter display would indicate OL if a reading exceeds limit of scale selected

- 30. SLIDE 30 EXPLAIN Figure 17–31** Using a DMM set to read ohms ( $\Omega$ ) to test this light bulb. Meter reads resistance of filament

### OVER LIMIT DISPLAY DOES NOT MEAN THE METER IS READING “NOTHING”

- 31. SLIDE 31 EXPLAIN FIGURE 17–32** Many DMM can have display indicate zero to compensate for test lead resistance. (1) Connect leads in v and COM meter terminals. (2) Select 2 scale. (3) Touch 2 meter leads together. (4) Push “zero” or ”relative” button on meter. (5) Meter display will now indicate zero ohms of resistance.

- 31. SLIDE 31 EXPLAIN FIGURE 17–33** Measuring the current flow required by a horn requires that the ammeter be connected to the circuit in series and the horn button be depressed by an assistant.

### EXPLAIN TECH TIP Fuse Your Meter Leads

- 32. SLIDE 32 EXPLAIN FIGURE 17–34** Note blade-type fuse holder soldered in series with one of meter leads. A 10-ampere fuse helps protect internal meter fuse (if equipped) and meter itself from damage that may result from excessive current flow if accidentally used incorrectly.

- 33. SLIDE 33 EXPLAIN FIGURE 17–35** inductive ammeter clamp is used with all starting and charging testers to measure the current flow through the battery cables.

- 34. SLIDE 34 EXPLAIN FIGURE 17–36** typical mini clamp-on-type digital multimeter. This meter is capable of measuring alternating current (AC) and direct current (DC) without requiring that circuit be disconnected to install meter in series. The jaws are simply placed over wire and current flow through circuit is displayed.

ICONS	Ch017 DIESEL ENGINE ELECTRONICS
	<p><b>STUDENTS COMPLETE NATEF TASK SHEET CHECK ELECTRICAL CIRCUITS WITH A TEST LIGHT; DETERMINE NECESSARY ACTION.</b></p>
	<p><b>STUDENTS COMPLETE NATEF TASK SHEET CHECK ELECTRICAL CIRCUITS USING FUSED JUMPER WIRES; DETERMINE NECESSARY ACTION</b></p>
	<p><b>STUDENTS DO NATEF TASK SHEET DEMONSTRATE PROPER USE OF DIGITAL MULTIMETER (DMM) DURING DIAGNOSIS OF ELECTRICAL CIRCUIT PROBLEMS, INCLUDING: SOURCE VOLTAGE, VOLTAGE DROP, CURRENT FLOW, &amp; RESISTANCE</b></p>
	<p><b>35. SLIDE 35 EXPLAIN Terminals and Connectors &amp; EXPLAIN Figure 17-37</b> Some terminals have seals attached to help seal the electrical connections.</p>
	<p><b>36. SLIDE 36 EXPLAIN Figure 17-38</b> Separate a connector by opening the lock and pulling the two apart</p>
	<p><b>37. SLIDE 37 EXPLAIN Figure 17-39</b> secondary locks help retain the terminals in the connector.</p>
	<p><b>38. SLIDE 38 EXPLAIN Figure 17-40</b> Use small removal tool, sometimes called a pick, to release terminals from the connector.</p>
	<p><b><u>DEMONSTRATION:</u> DEMO SEVERAL DIFFERENT TYPES OF CONNECTORS, INCLUDING THOSE WITH CONNECTOR POSITION ASSURANCE CLIPS. EXPLAIN THAT IT'S NECESSARY TO GUARANTEE THAT CONNECTORS WILL STAY TOGETHER IN SUPPLEMENTAL RESTRAINT SYSTEMS.</b></p>
	<p><b><u>DEMONSTRATE REMOVAL OF TERMINALS FROM SEVERAL DIFFERENT TYPES OF CONNECTORS. MAKE SURE TO HAVE PROPER TERMINAL REMOVAL TOOLS AVAILABLE FOR TEACHING STUDENTS ABOUT DIFFERENT CONNECTORS.</u></b></p>
	<p><b>39. SLIDE 39 EXPLAIN FIGURE 17-41</b> 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).</p>

## ICONS

## Ch017 DIESEL ENGINE ELECTRONICS



40. **SLIDE 40 EXPLAIN FIGURE 17-42** Notice that to create a good crimp, open part of the terminal is placed in the jaws of the crimping tool toward the anvil or the W-shape part.
41. **SLIDE 41 EXPLAIN FIGURE 17-43** All hand-crimped splices or terminals should be soldered to be assured of a good electrical connection.
42. **SLIDE 42 EXPLAIN FIGURE 17-44** butane torch especially designed for use Bon heat shrink applies heat without an open flame, which could cause damage.
43. **SLIDE 43 EXPLAIN FIGURE 17-45** typical crimp-and-seal connector. This type of connector is first lightly crimped to retain ends of wires and then it is heated. The tubing shrinks around wire splice, and thermoplastic glue melts on inside to provide an effective weather-resistant seal.
44. **SLIDE 44 EXPLAIN FIGURE 17-46** Heating the crimp-and-seal connector melts the glue and forms an effective seal against moisture.



**STUDENTS COMPLETE NATEF TASK SHEET REMOVE AND REPLACE TERMINAL END FROM CONNECTOR; REPLACE CONNECTORS AND TERMINAL ENDS**



**COMPLETE NATEF TASK SHEET REPAIR WIRING HARNESS (INCLUDING CAN/BUS SYSTEMS)**



**COMPLETE NATEF TASK SHEET PERFORM SOLDER REPAIR OF ELECTRICAL WIRING**



45. **SLIDE 45 EXPLAIN FIGURE 17-47** 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 ampere through the relay coil. The movable arm then closes the contacts (#30 to #87) and can often handle 30 amperes or more.
46. **SLIDE 46 EXPLAIN FIGURE 17-48** cross-sectional view of typical four-terminal relay. Current flowing through coil (terminals 86 and 85) causes movable arm (called armature) to be drawn toward coil magnet. The contact points complete electrical circuit connected to terminals 30 and 87.

ICONS	Ch017 DIESEL ENGINE ELECTRONICS
	<p>47. <b>SLIDE 47 EXPLAIN FIGURE 17-49</b> typical relay showing schematic of wiring in relay</p> <p>48. <b>SLIDE 48 EXPLAIN FIGURE 17-50</b> All schematics are shown in their normal, non-energized position.</p>
	<p><b>ANIMATION: ELECTROMAGNETISM IN RELAY: Relay</b></p>
	<p>49. <b>SLIDE 49 EXPLAIN FIGURE 17-51</b> typical horn circuit. Note that relay contacts supply heavy current to operate horn when horn switch simply completes low-current circuit to ground, causing relay contacts to close.</p>
	<p><b><u>NATEF TASK SHEET INSPECT &amp; TEST SWITCHES, CONNECTORS, RELAYS, SOLENOID SOLID STATE DEVICES, AND WIRES OF ELECTRICAL/ELECTRONIC CIRCUITS; PERFORM NECESSARY ACTION</u></b></p>
	<p>50. <b>SLIDE 50 EXPLAIN FIGURE 17-52</b> 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 PCM. Change in voltage at pin 46 indicates how much resistance circuit has, which is used to detect gear selected.</p>
	<p>51. <b>SLIDE 51 EXPLAIN FIGURE 17-53</b> magnetic sensor uses permanent magnet surrounded by a coil of wire. The notches on rotating shaft create a variable magnetic field strength around the coil. When a metallic section is close to sensor magnetic field is stronger because metal is a better conductor of magnetic lines of force than air.</p>
	<p>52. <b>SLIDE 52 EXPLAIN FIGURE 17-54</b> Hall-Effect sensor produces an on-off voltage signal whether it is used with a blade or a notched wheel.</p>
	<p>53. <b>SLIDE 53 EXPLAIN FIGURE 17-55</b> 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).</p>