

Automotive Technology 6th Edition

Chapter 42 CIRCUIT TESTERS & DIGITAL METERS

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 ASEEducation (NATEF) and emphasizes a problem-solving approach. Chapter features include Tech Tips, Frequently Asked Questions, Case Studies, Videos, Animations, and ASEEducation (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 the chapter learning objectives to the students as listed: <ol style="list-style-type: none">1. Discuss how to safely use a fused jumper wire, a test light, and a logic probe.2. Explain how to safely and properly use a digital meter to read voltage, resistance, and current, and compare the readings to factory specifications.3. Discuss diode check, pulse width, and frequency.4. Describe the prefixes used with electrical units and how to read digital meters.
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.

NOTE: This lesson plan is based on the 6th Edition Chapter Images found on Jim's web site @

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

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1. SLIDE 1 CIRCUIT TESTERS & DIGITAL METERS

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Videos

DEMONSTRATION: Show students how to test a circuit with a fused jumper

2. **SLIDE 2 EXPLAIN** Figure 42-1 technician-made fused jumper lead equipped with a red 10 ampere fuse. Fused jumper wire uses terminals for testing circuits at a connector instead of alligator clips.

HOST a DISCUSSION about uses of a fused jumper wire. If a device works when connected to a fused jumper wire, what is determined?

3. **SLIDE 3 EXPLAIN** Figure 42-2 12 volt test light is attached to a good ground while probing for power.

4. **SLIDE 4 EXPLAIN** Figure 42-3 Test light can be used to locate an open in a circuit. Test light is grounded at a different location than the circuit itself.

5. **SLIDE 5 EXPLAIN** Figure 42-4 LED test light can be easily made using low cost components and an old ink pen. With the 470 ohm resistor in series with LED, this tester only draws 0.025 ampere (25 milliamperes) from circuit being tested. This low current draw helps assure technician that circuit or component being tested will not be damaged by excessive current flow.

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DEMONSTRATION: 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 & discuss when it should be used.

Test lamps should not be used on any circuits connected to a PCM due to voltages used in electronic components

6. **SLIDE 6 EXPLAIN** Figure 42-5 logic probe connected to vehicle battery. When tip probe is connected to circuit, it can check for power, ground, or a pulse.

HANDS-ON TASK: Have students use Figure 42-5 to construct an LED test lamp, and then have them use it to test a circuit or component.

[Circuit Test, Test Light \(View\)](#) ([Download](#))

7. **SLIDE 7 EXPLAIN FIGURE 42-6** Typical digital multimeter. The black meter lead is always placed in the COM terminal. The red meter test lead should be in the volt-ohm terminal, except when measuring current in amperes.

DISCUSS CHART 42-1 Common symbols and abbreviations used on digital meters.

DEMONSTRATION: Show logic probe and proper way to connect it to a power and ground source & component to be checked.

SLIDE 7 READ & EXPLAIN TEXT

8. **SLIDE 8 EXPLAIN FIGURE 42-7** Typical digital multimeter (DMM) set to read DC volts.
9. **SLIDE 9 EXPLAIN** Figure 42-8 (a) typical autoranging digital multimeter automatically selects the proper scale to read the voltage being tested. The scale selected is usually displayed on the meter face. Note that the display indicates



“4,” meaning that this range can read up to 4 volts.

- 10. **SLIDE 10 EXPLAIN Figure 42-8 (b)** A typical autoranging digital multimeter automatically selects the proper scale to read the voltage being tested. The scale selected is usually displayed on the 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 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 the limit of the scale selected.
- 11. **SLIDE 11 EXPLAIN Figure 42-9** Typical digital multimeter (DMM) set to read DC volts.

DISCUSS FREQUENTLY ASKED QUESTION:

How Much Voltage Does an Ohmmeter Apply?

- 1. **Most digital meters set to measure ohms (resistance) apply 0.3 to 1 volts. Voltage comes from meter itself to measure resistance. 2 things are important to remember: Component or circuit must be disconnected from any electrical circuit while the resistance is being measured.**
- 2. **Because meter itself applies voltage (even though it is low), a meter set to measure ohms can damage electronic circuits. Computer chips can be easily damaged if subjected to only a few milliamperes of current, similar to amount an ohmmeter applies when a resistance measurement is being performed.**

- 12. **SLIDE 2 EXPLAIN FIGURE 42-10** Many digital multimeters can have the display indicate zero to compensate for test lead resistance. (1) Connect leads in the V and COM meter terminals. (2) Select the scale. (3) Touch the two meter leads together. (4) Push the “zero” or “relative” button on the meter. (5) The meter display now indicates zero ohms of resistance.
- 13. **SLIDE 13 EXPLAIN FIGURE 42-11** Measuring the current flow required by a horn requires that the ammeter be connected to the circuit in series and horn button be depressed by an assistant

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EXPLAIN TECH TIP: Fuse Your Meter Leads!

Most digital meters include an ammeter capability. When reading amperes, leads of meter must be changed from volts or ohms (V or Ω) to amperes (A), milliamperes (mA), or microamperes (μ A). A common problem may occur the next time voltage is measured. Although technician may switch selector to read volts, often leads are not switched back to volt or ohm position. Because the ammeter lead position results in zero ohms of resistance to current flow through meter, the meter or fuse inside meter is destroyed if meter is connected to a battery. Many meter fuses are expensive and difficult to find. To avoid this problem, simply solder an inline 10-ampere blade-fuse holder into one meter lead. • **SEE FIGURE 42-12.** Do not think that this technique is for beginners only. Experienced technicians often get in a hurry and forget to switch lead. A blade fuse is faster, easier, and less expensive to replace than a meter fuse, or meter itself. Also, if soldering is done properly, addition of an inline fuse holder and fuse does not increase the resistance of the meter leads.

WARNING Do not use a meter equipped with an external add-on fuse when testing a high-voltage circuit to prevent possible shock hazard.

14. **SLIDE 14 EXPLAIN** FIGURE 42-12 Note blade-type fuse holder soldered in series with one of the meter leads. A 10-ampere fuse helps protect internal meter fuse (if equipped), and the meter itself, from damage that may result from excessive current flow, if accidentally used incorrectly.
15. **SLIDE 15 EXPLAIN** FIGURE 42-13 An inductive ammeter clamp is used with all starting and charging testers to measure the current flow through battery cables.

DISCUSS FREQUENTLY ASKED QUESTION:

What Does “CE” Mean on Many Meters?

The “CE” means that the meter meets the newest European Standards and the CE mark stands for **Conformité Européenne**, which is



**French for “European Conformity.”**

16. SLIDE 16 **EXPLAIN** FIGURE 42–14 A typical mini clamp-on-type digital multimeter. This meter is capable of measuring alternating current (AC) and direct current (DC) without requiring that the circuit be disconnected to install the meter in series. The jaws are simply placed over wire and current flow through the circuit is displayed.

EXPLAIN TECH TIP: Over-Limit Display Does Not Mean the Meter Is Reading “Nothing”

The meaning of the over-limit display on a digital meter often confuses beginning technicians. When asked what the meter is reading when an over limit (OL) is displayed on the meter face, the response is often, “Nothing.” Many meters indicate over limit or over load, which simply means that the reading is over the maximum that can be displayed for selected range. For example, meter displays OL if 12 volts are being measured, but the meter has been set to read a maximum of 4 volts. Autoranging meters adjust the range to match what is being measured. Here OL means a value higher than the meter can read (unlikely on the voltage scale for automobile usage), or infinity when measuring resistance (ohms). Therefore, OL means infinity when measuring resistance or an open circuit is being indicated. The meter reads 00.0 if the resistance is zero, so “nothing” in this case indicates continuity (zero resistance), whereas OL indicates infinite resistance. Therefore, when talking with another technician about a meter reading, make sure you know exactly what the reading on the face of the meter means. Also be sure that you are connecting the meter leads correctly. • **SEE FIGURE 42–15.**

17. SLIDE 17 **EXPLAIN** FIGURE 42–15 Typical digital multimeter showing **OL (over limit)** on the readout with the ohms (Ω) unit selected. This usually means that the unit being measured is open (infinity resistance) and has no continuity.

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DEMONSTRATE proper way to connect test leads to a DMM. Point out input terminals on DMM & their functions. Tell students that reading on wrong input could destroy meter.

18. SLIDE 18 **EXPLAIN** FIGURE 42-16 Always look at the meter display when measurement is being made, especially if using an autoranging meter.
19. SLIDE 19 **EXPLAIN** FIGURE 42-17 When reading AC voltage signals, a true RMS meter (such as a Fluke 87) provides a different reading than an average responding meter (such as a Fluke 88). The only place this difference is important is when a reading is to be compared with a specification.

DISCUSS CHART 42-2 conversion chart showing decimal point location for prefixes.

DISCUSS CHART 42-3 Sample meter readings, using manually set and autoranging selection on meter control.

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

[Bulb Test, Meter \(View\) \(Download\)](#)

[Circuit Test, Amps, Meter \(View\) \(Download\)](#)

[Circuit Test, Meter \(View\) \(Download\)](#)

[Meter Usage Measure Amps \(View\) \(Download\)](#)

[Meter Usage Measure Frequency \(View\)\(Download\)](#)

[Meter Usage Measure Ohms \(View\) \(Download\)](#)

[Meter Usage Testing Diode \(View\) \(Download\)](#)

[Test Bulb \(View\) \(Download\)](#)

[Tone Generator \(View\) \(Download\)](#)

20. SLIDE 20 **EXPLAIN** Figure 42-18 meter display shows 052.2 AC volts. Notice that the zero beside 5 indicates that meter can read over 100 volts AC with a resolution of 0.1 volt.

SAFETY Meter Usage on Hybrid-Electric Vehicles Many hybrid-electric vehicles use system voltage as high as 650 volts DC. Be sure to follow all OEM testing procedures. If a voltage measurement is needed be sure to use a meter and test leads that

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are designed to insulate against high voltages. The International Electrotechnical Commission (IEC) has several categories of voltage standards for meter and meter leads. These categories are ratings for overvoltage protection and are rated **CAT I, CAT II, CAT III, and CAT IV**. Higher category rating, greater protection against voltage spikes caused by high-energy circuits. Under each category, there are various energy and voltage ratings.

CAT I meter is used for low-energy voltage measurements, such as at wall outlets in the home. Meters with a CAT I rating are usually rated at 300 to 800 volts.

CAT II This higher rated meter is typically used for checking higher energy level voltages at the fuse panel in the home. Meters with a CAT II rating are usually rated at 300 to 600 volts.

CAT III This minimum-rated meter should be used for hybrid vehicles. The CAT III category is designed for high-energy levels and voltage measurements at the service pole at the transformer. Meters with this rating are usually rated at 600 to 1,000 volts.

CAT IV CAT IV meters are for clamp-on meters only. If a clamp-on meter also has meter leads for voltage measurements, that part of the meter is rated as CAT III.

NOTE: Always use the highest CAT rating meter, especially when working with hybrid vehicles. A CAT III, 600-volt meter is safer than a CAT II, 1,000-volt meter because of the energy level of the CAT ratings. Therefore, for best personal protection, use only meters and meter leads that are CAT III-or CAT IV-rated when measuring voltage on a hybrid vehicle. • **SEE FIGURES 42–19 AND 42–20.**

21. **SLIDE 21 EXPLAIN FIGURE 42–19** Be sure to use only a meter that is CAT III-rated when taking electrical voltage measurements on a hybrid vehicle.
22. **SLIDE 22 EXPLAIN FIGURE 42–20** Always use meter leads that are CAT III-rated on a meter that is also CAT III-rated, to maintain the protection needed when working on hybrid vehicles.

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23. FRAMES 1-23 OPTIONAL DMM DEMO EXPLAIN

ASEEDUCATION Task Sheet Check electrical circuits with a test light; determine necessary action.



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ASEEDUCATION Task Sheet Check electrical circuits using fused jumper wires; determine necessary action.



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ASEEDUCATION Task Sheet Demonstrate proper use of digital multimeter (DMM) during diagnosis of electrical circuit problems, including: source voltage, voltage drop, current flow, & resistance



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HOMEWORK 2: Have students use INTERNET to research digital multimeters used in the automotive repair field. Ask them to list four to five meters, their main features, and the cost of each meter. Have students determine which meter they think would be the best purchase and explain their choice and reasoning to the class.