chapter 22

CIRCUIT TESTERS AND DIGITAL METERS

OBJECTIVES: After studying Chapter 22, the reader will be able to: • Prepare for ASE Electrical/Electronic Systems (A6) certification test content area "A" (General Electrical/Electronic System Diagnosis). • Explain how to set up and use a digital meter to read voltage, resistance, and current. • Explain meter terms and readings. • Interpret meter readings and compare to factory specifications. • Discuss how to properly and safely use meters.

KEY TERMS: • AC/DC clamp-on DMM 213 • DMM 209 • DVOM 209 • Inductive ammeter 213 • OL 211 • Test light 209

INTRODUCTION

Electricity has to be measured and tested with testers or meters because it cannot be seen. Testers used to detect and measure electricity and electrical circuits include:

- Fused jumper wires
- Test lights
- Meters

FUSED JUMPER WIRE

PURPOSE AND FUNCTION A fuse jumper wire is used to check a circuit by bypassing the switch or to provide a power or ground to a component. A fused jumper wire, also called a lead, can be purchased or made by the service technician. **SEE FIGURE 22–1.**

It should include the following features:

- **Fuse.** A typical fused jumper wire has a blade-type fuse that can be easily replaced. A 10 ampere fuse (red color) is often the value used.
- **Alligator clip ends.** Alligator clips on the ends allow the fused jumper wire to be clipped to a ground or power source while the other end is attached to the power side or ground side of the unit being tested.
- **Good-quality insulated wire.** Most purchased jumper wire is about 14 gauge stranded copper wire with a flexible rubberized insulation to allow it to move easily even in cold weather.

USES OF A FUSED JUMPER WIRE A fused jumper wire can be used to help diagnose a component or circuit by performing the following procedures.

- **Supply power or ground.** If a component, such as a horn, does not work, a fused jumper wire can be used to supply power and/or ground. Start by unplugging the electrical connector from the device and connect a fused jumper lead to the power terminal. Another fused jumper wire may be needed to provide the ground. If the unit works, the problem is in the power-side or ground-side circuit.

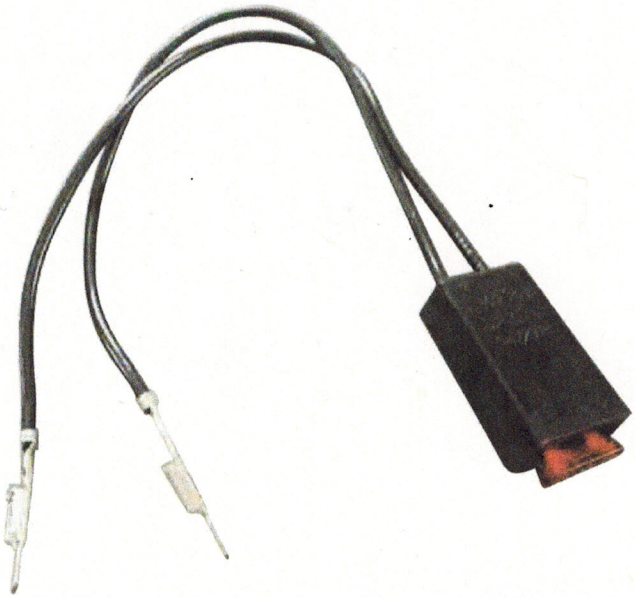


FIGURE 22–1 A technician-made fused jumper lead, which is equipped with a red 10 ampere fuse. This fused jumper wire uses terminals for testing circuits at a connector instead of alligator clips.

CAUTION: Never use a fused jumper wire to bypass any resistance or load in the circuit. The increased current flow could damage the wiring and could blow the fuse on the jumper lead. Be *very* cautious when working on or around any computer circuit. Permanent damage to the computer or electronic module could result if power or ground goes to the wrong circuit.

TEST LIGHT

NON-POWERED TEST LIGHT

A 12-volt test light is one of the simplest testers that can be used to detect electricity. A **test light** is simply a light bulb with a probe and a ground wire attached. **SEE FIGURE 22–2.**

A test light is used to detect battery voltage potential at various test points. Battery voltage cannot be seen or felt, and can be detected only with test equipment. The ground clip is connected to a clean ground on either the negative terminal of the battery or a clean metal part of the body and the probe touched to terminals or components. If the test light comes on, this indicates that voltage is available. **SEE FIGURE 22–3.**

A purchased test light should be labeled a "12-volt test light." Do not purchase a test light designed for household current (110 or 220 volts), as it will not light with 12 to 14 volts.

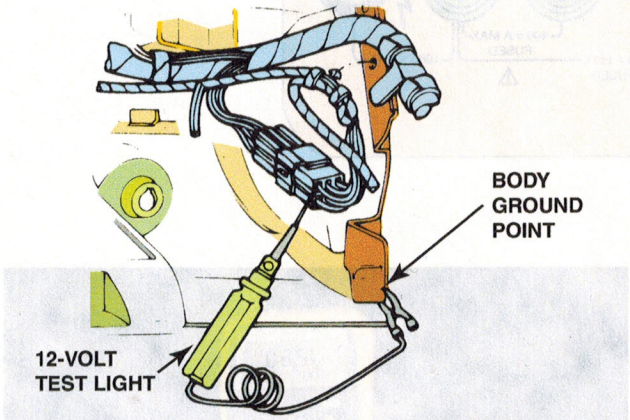


FIGURE 22–2 A 12-volt test light is attached to a good ground while probing for power.

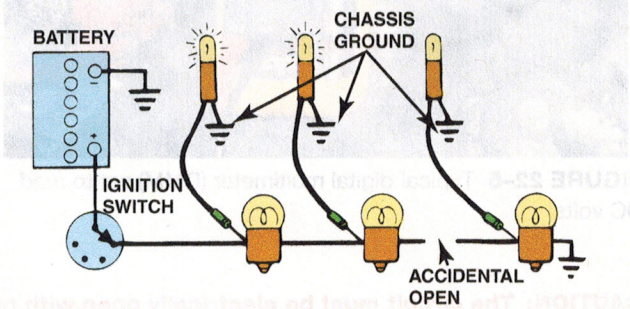


FIGURE 22–3 A test light can be used to locate an open in a circuit. Note that the test light is grounded at a different location than the circuit itself.

USES OF A 12-VOLT TEST LIGHT

A 12-volt test light can be used to check the following:

- **Electrical power.** If the test light lights, then there is power available. It will not, however, indicate the voltage level or if there is enough current available to operate an electrical load. It only indicates that there is enough voltage and current to light the test light (about 0.25A).
- **Grounds.** A test light can be used to check for grounds by attaching the clip of the test light to the positive terminal of the battery or any positive 12-volt electrical terminal. The tip of the test light can then be used to touch the ground wire. If there is a ground connection, the test light will light.

DIGITAL METERS

TERMINOLOGY

Digital multimeter (DMM) and **digital volt-ohm-meter (DVOM)** are terms commonly used to describe digital meters. **SEE FIGURE 22–4.**

The common abbreviations for the units that many meters can measure are often confusing. **SEE CHART 22–1** for the most commonly used symbols and their meanings.

MEASURING VOLTAGE

A voltmeter measures the *pressure* or potential of electricity in units of volts. A voltmeter is connected to a circuit in parallel. Voltage can be measured by selecting either AC or DC volts.

- **DC volts (DCV).** This setting is the most common for automotive use. Use this setting to measure battery voltage and voltage to all lighting and accessory circuits.
- **AC volts (ACV).** This setting is used to check some computer sensors and to check for unwanted AC voltage from alternators.
- **Range.** The range is automatically set for most meters but can be manually adjusted if needed. **SEE FIGURES 22–5 AND 22–6** on page 211.

MEASURING RESISTANCE

An ohmmeter measures the resistance in ohms of a component or circuit section when no current is flowing through the circuit. An ohmmeter contains a battery (or other power source) and is connected in series with the component or wire being measured. Note the following facts about using an ohmmeter.

- Zero ohms on the scale means that there is no resistance between the test leads, thus indicating continuity or a continuous path for the current to flow in a closed circuit.
- Infinity means no connection, as in an open circuit.
- Ohmmeters have no required polarity even though red and black test leads are used for resistance measurement.

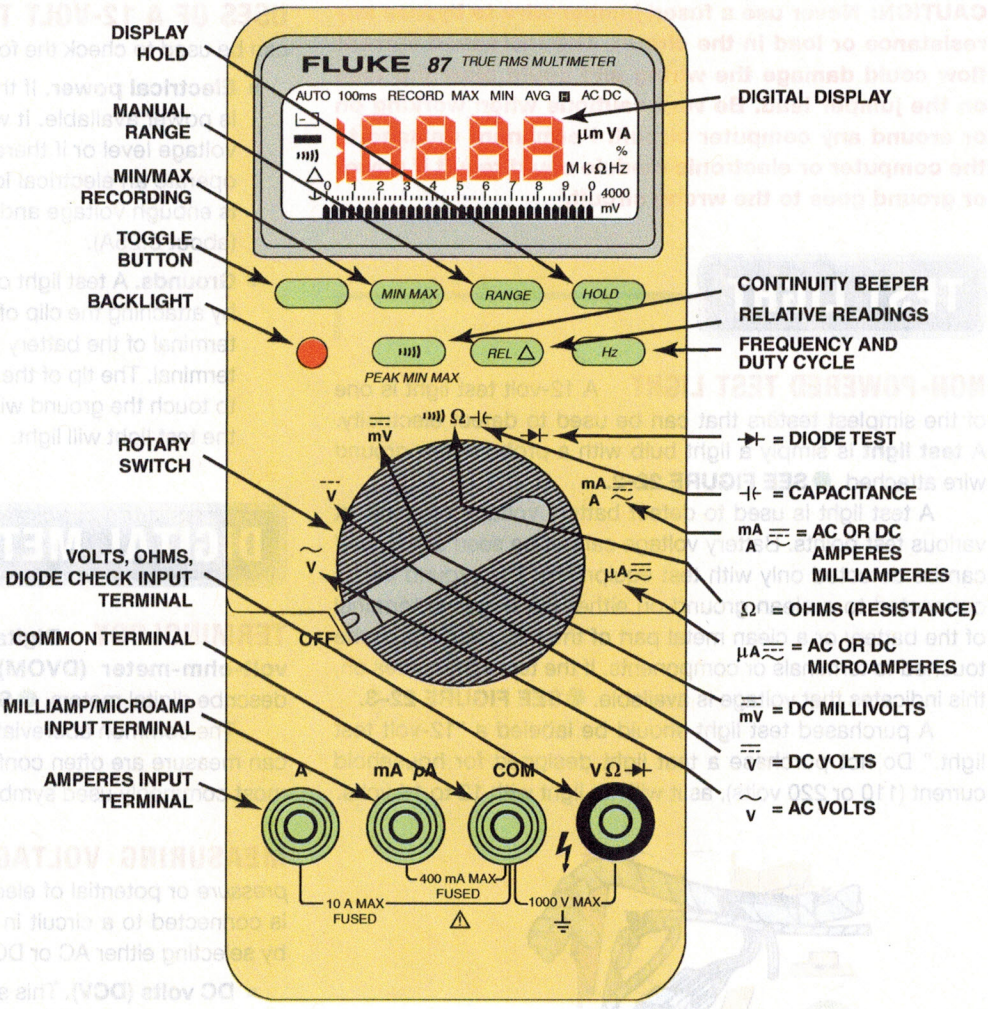


FIGURE 22–4 Typical digital multimeter. The black meter lead is always placed in the COM terminal. The red meter test lead should be in the volt–ohm terminal except when measuring current in amperes.

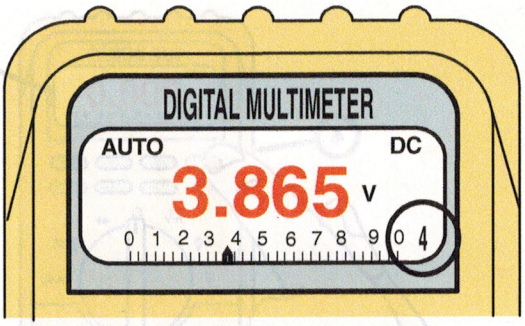
SYMBOL	MEANING
AC	Alternating current or voltage
DC	Direct current or voltage
V	Volts
mV	Millivolts (1/1,000 volt)
A	Amperes (amps)
mA	Milliampers (1/1,000 amp)
%	Percentage (duty cycle)
Ω	Ohms
K Ω	Kilohm (1,000 ohms)
M Ω	Megohm (1,000,000 Ohm)
Hz	Hertz (frequency)
kHz	Kilohertz (1,000 cycles per second)
ms	Milliseconds

CHART 22–1

Common symbols and abbreviations used on digital meters.

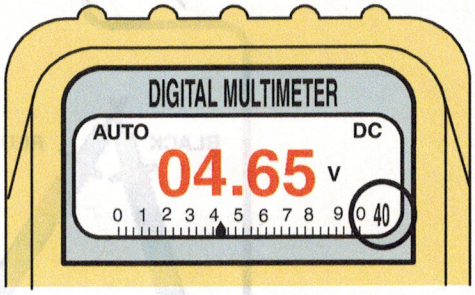
FIGURE 22–5 Typical digital multimeter (DMM) set to read DC volts.

CAUTION: The circuit must be electrically open with no voltage present when using an ohmmeter. If current is flowing when an ohmmeter is connected, the reading will be incorrect and the meter can be destroyed.



BECAUSE THE SIGNAL READING IS BELOW 4 VOLTS, THE METER AUTORANGES TO THE 4-VOLT SCALE. IN THE 4-VOLT SCALE, THIS METER PROVIDES THREE DECIMAL PLACES.

(a)



WHEN THE VOLTAGE EXCEEDED 4 VOLTS, THE METER AUTORANGES INTO THE 40-VOLT SCALE. THE DECIMAL POINT MOVES ONE PLACE TO THE RIGHT LEAVING ONLY TWO DECIMAL PLACES.

(b)

FIGURE 22–6 A typical auto-ranging digital multimeter automatically selects the proper scale to read the voltage being tested. The scale selected is usually displayed on the meter face. (a) Note that the display indicates "4," meaning that this range can read up to 4 volts. (b) 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 auto-ranging, the meter display would indicate OL if a reading exceeds the limit of the scale selected.

Different meters have different ways of indicating infinity resistance, or a reading higher than the scale allows. Examples of an over-limit display include:

- **OL,** meaning **over limit** or overload
- Flashing or solid number 1
- Flashing or solid number 3 on the left side of the display

Check the meter instructions for the exact display used to indicate an open circuit or over-range reading. ● **SEE FIGURES 22–7 AND 22–8.**

To summarize, open and zero readings are as follows:

0.00 Ω = Zero resistance (component or circuit has continuity)

OL = An open circuit (no current flows) or the reading is higher than the scale selected.

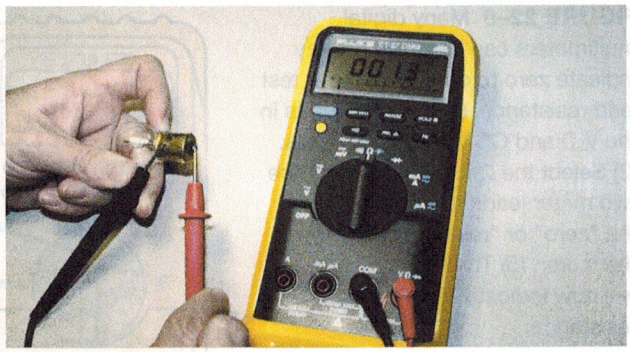


FIGURE 22–7 Using a digital multimeter set to read ohms (Ω) to test this light bulb. The meter reads the resistance of the filament.

MEASURING AMPERES An ammeter measures the flow of *current* through a complete circuit in units of amperes or milliamperes (1/1,000 of an ampere).

The ammeter has to be installed in the circuit (in series) so that it can measure all the current flow in that circuit, just as a water flow meter would measure the amount of water flow (cubic feet per minute, for example). ● **SEE FIGURE 22–9.**

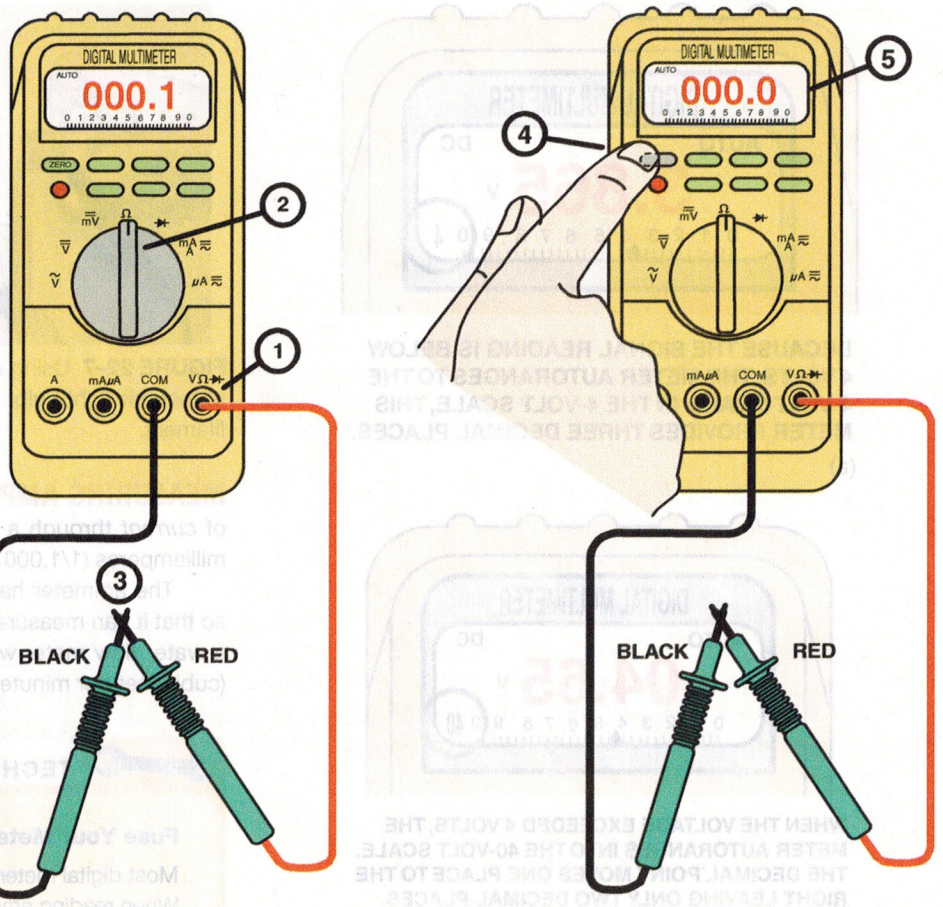
TECH TIP

Fuse Your Meter Leads!

Most digital meters include an ammeter capability. When reading amperes, the leads of the meter must be changed from volts or ohms (V or Ω) to amperes (A), milliamperes (mA), or microamperes (μA). A common problem may then occur the next time voltage is measured. Although the technician may switch the selector to read volts, often the leads are not switched back to the volt or ohm position. Because the ammeter lead position results in zero ohms of resistance to current flow through the meter, the meter or the fuse inside the meter will be destroyed if the 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 22–10.**

Do not think that this technique is for beginners only. Experienced technicians often get in a hurry and forget to switch the lead. A blade fuse is faster, easier, and less expensive to replace than a meter fuse or the meter itself. Also, if the soldering is done properly, the addition of an inline fuse holder and fuse does not increase the resistance of the meter leads. All meter leads have some resistance. If the meter is measuring very low resistance, touch the two leads together and read the resistance (usually no more than 0.2 ohm). Simply subtract the resistance of the leads from the resistance of the component being measured.

FIGURE 22–8 Many digital multimeters can have the display indicate zero to compensate for test lead resistance. (1) Connect leads in the V Ω and COM meter terminals. (2) Select the Ω scale. (3) Touch the two meter leads together. (4) Push the "zero" or "relative" button on the meter. (5) The meter display will now indicate zero ohms of resistance.



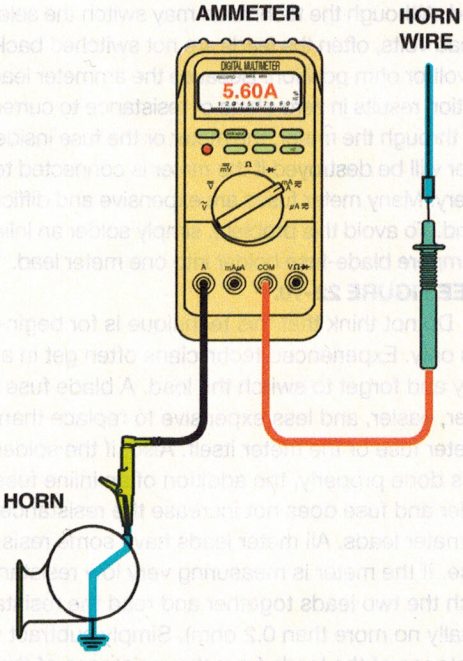


FIGURE 22–9 Measuring the current flow required by a horn requires that the ammeter be connected to the circuit in series and the horn button be depressed by an assistant.

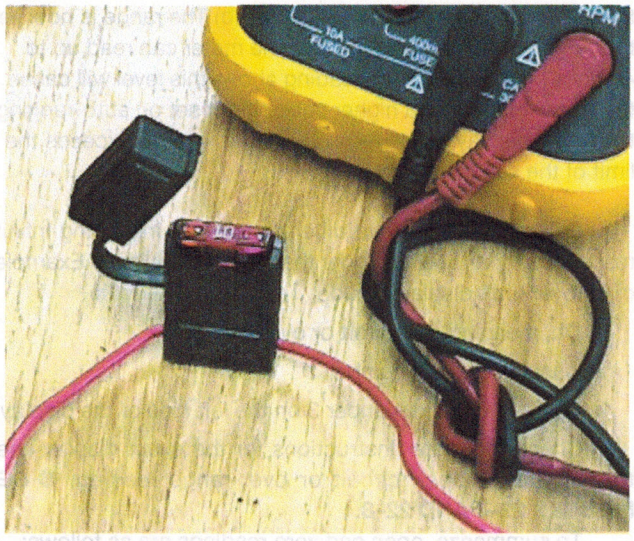


FIGURE 22–10 Note the blade-type fuse holder soldered in series with one of the meter leads. A 10 ampere fuse helps protect the internal meter fuse (if equipped) and the meter itself from damage that may result from excessive current flow if accidentally used incorrectly.