CAUTION: An ammeter must be installed in series with the circuit to measure the current flow in the circuit. If a meter set to read amperes is connected in parallel, such as across a battery, the meter or the leads may be destroyed, or the fuse will blow, by the current available across the battery. Some DMMs beep if the unit selection does not match the test lead connection on the meter. However, in a noisy shop, this beep sound may be inaudible.

Digital meters require that the meter leads be moved to the ammeter terminals. Most digital meters have an ampere scale that can accommodate a maximum of 10 amperes. See the Tech Tip "Fuse Your Meter Leads!"

INDUCTIVE AMMETERS

OPERATION Inductive ammeters do not make physical contact with the circuit. Inductive ammeters have the advantage of being able to read much higher amperages than 10 amperes. A sensor is used to detect the strength of the magnetic field surrounding the wire carrying the current. The ammeter then uses the strength of the magnetic field to measure the electrical current. **SEE FIGURE 22–11.**

AC/DC CLAMP-ON DIGITAL MULTIMETERS An **AC/DC clamp-on digital multimeter** is a useful meter for automotive diagnostic work. **SEE FIGURE 22–12.**

The major advantage of the clamp-on-type meter is that there is no need to break the circuit to measure current (amperes). Simply clamp the jaws of the meter around the power lead(s) or ground lead(s) of the component being measured and read the display. Most clamp-on meters can also measure alternating current, which is helpful in the diagnosis of an alternator problem. Volts, ohms, frequency, and temperature can also be measured with the typical clamp-on DMM, but conventional meter leads should be used. The inductive clamp is used to measure only amperes.

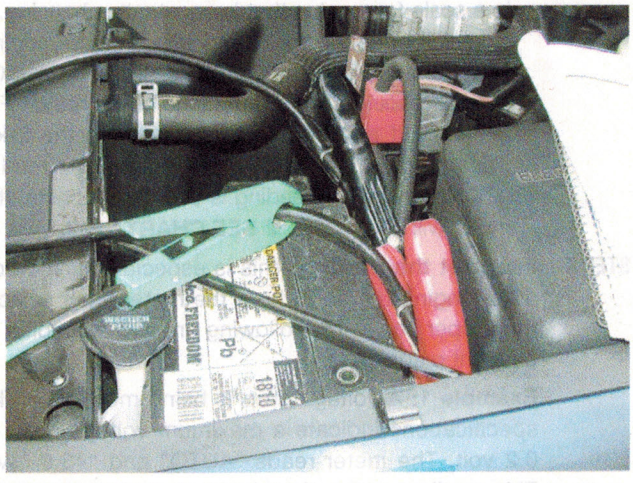

FIGURE 22–11 An inductive ammeter clamp is used with all starting and charging testers to measure the current flow through the battery cables.

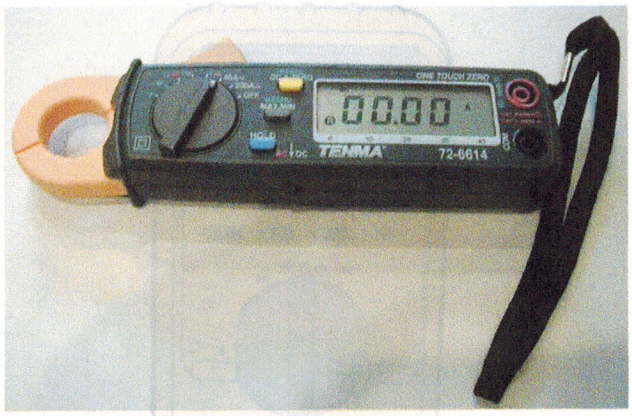

FIGURE 22–12 A typical mini clamp-on-type digital multimeter. This meter is capable of measuring alternating current (AC) and direct current (DC) without requiring that the circuit be disconnected to install the meter in series. The jaws are simply placed over the wire and current flow through the circuit is displayed.

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 the selected range. For example, the meter will display OL if 12 volts are being measured but the meter has been set to read a maximum of 4 volts. Auto-ranging 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 will read 00.0 if the resistance is zero, so "nothing" in this case indicates continuity (zero resistance), whereas OL indicates infinity 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 22–13.**

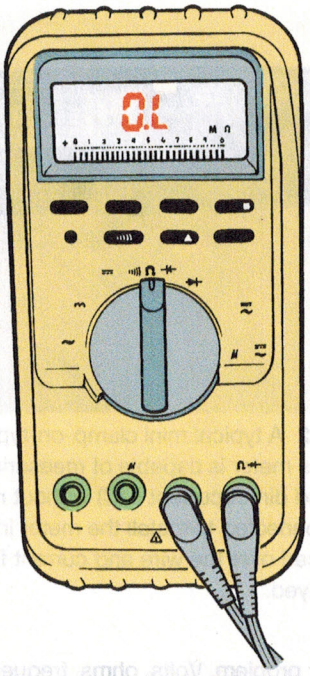

FIGURE 22–13 Typical digital multimeter showing OL (over limit) on the readout with the ohms (Ω) unit selected. This usually means that the unit being measured is open (infinity resistance) and has no continuity.

THINK OF MONEY Digital meter displays can often be confusing. The display for a battery measured as 12 1/2 volts would be 12.50 V, just as $12.50 is 12 dollars and 50 cents. A 1/2 volt reading on a digital meter will be displayed as 0.50 V, just as $0.50 is half of a dollar. It is more confusing when low values are displayed. For example, if a voltage reading is 0.063 volt, an auto-ranging meter will display 63 millivolts (63 mV), or 63/1,000 of a volt, or $63 of $1,000. (It takes 1,000 mV to equal 1 volt.) Think of millivolts as one-tenth of a cent, with 1 volt being $1.00. Therefore, 630 millivolts are equal to $0.63 of $1.00 (630 tenths of a cent, or 63 cents). To avoid confusion, try to manually range the meter to read base units (whole volts). If the meter is ranged to base unit volts, 63 millivolts would be displayed as 0.063 or maybe just 0.06, depending on the display capabilities of the meter.

HOW TO READ DIGITAL METERS

STEPS TO FOLLOW Getting to know and use a digital meter takes time and practice. The first step is to read, understand, and follow all safety and operational instructions that come with the meter. Use of the meter usually involves the following steps.

STEP 1 **Select the proper unit of electricity for what is being measured.** This unit could be volts, ohms (resistance), or amperes (amount of current flow). If the meter is not auto-ranging, select the proper scale for the anticipated reading. For example, if a 12-volt battery is being measured, select a meter reading range that is higher than the voltage but not too high. A 20- or 30 volt range will accurately show the voltage of a 12-volt battery. If a 1,000-volt scale is selected, a 12-volt reading may not be accurate.

STEP 2 **Place the meter leads into the proper input terminals.**

- The black lead is inserted into the common (COM) terminal. This meter lead usually stays in this location for all meter functions.
- The red lead is inserted into the volt, ohm, or diode check terminal usually labeled "VΩ" when voltage, resistance, or diodes are being measured.
- When current flow in amperes is being measured, most digital meters require that the red test lead be inserted in the ammeter terminal, usually labeled "A" or "mA."

CAUTION: If the meter leads are inserted into ammeter terminals, even though the selector is set to volts, the meter may be damaged or an internal fuse may blow if the test leads touch both terminals of a battery.

STEP 3 **Measure the component being tested.** Carefully note the decimal point and the unit on the face of the meter.

- **Meter lead connections.** If the meter leads are connected to a battery backward (red to the battery negative, for example), the display will still show the correct reading, but a negative sign (−) will be displayed in front of the number. The correct polarity is not important when measuring resistance (ohms) except where indicated, such as measuring a diode.
- **Auto-range.** Many meters automatically default to the auto-range position and the meter will display the value in the most readable scale. The meter can be manually ranged to select other levels or to lock in a scale for a value that is constantly changing. If a 12-volt battery is measured with an auto-ranging meter, the correct reading of 12.0 is given. "AUTO" and "V" should show on the face of the meter. For example, if a meter is manually set to the 2-kΩ (kilohm) scale, the highest that the meter will read is 2,000 ohms. If the reading is over 2,000 ohms, the meter will display OL. **SEE CHART 22–2.**

STEP 4 **Interpret the reading.** This is especially difficult on auto-ranging meters, where the meter itself selects the proper scale. The following are two examples of different readings.

Example 1: A voltage drop is being measured. The specifications indicate a maximum voltage drop of 0.2 volt. The meter reads "AUTO" and "43.6 mV." This reading means that the voltage drop is 0.0436 volt, or 43.6 mV, which is far lower than the 0.2 volt (200 millivolts). Because the number showing on the

	VOLTAGE BEING MEASURED					
	0.01 V (10 mV)	0.150 V (150 mV)	1.5 V	10.0 V	12.0 V	120 V
Scale Selected	Voltmeter will display:					
200 mV	10.0	150.0	OL	OL	OL	OL
2 V	0.100	0.150	1.500	OL	OL	OL
20 V	0.1	1.50	1.50	10.00	12.00	OL
200 V	00.0	01.5	01.5	10.0	12.0	120.0
2 kV	00.00	00.00	000.1	00.10	00.12	0.120
Auto-range	10.0 mV	15.0 mV	1.50	10.0	12.0	120.0
	RESISTANCE BEING MEASURED					
	10 ohms	100 ohms	470 ohms	1 kΩ	220 kΩ	1 MΩ
Scale Selected	Ohmmeter will display:					
400 ohms	10.0	100.0	OL	OL	OL	OL
4 kilohms	010	100	0.470 k	1000	OL	OL
40 kilohms	00.0	0.10 k	0.47 k	1.00 k	OL	OL
400 kilohms	000.0	00.1 k	00.5 k	0.10 k	220.0 k	OL
4 megohms	00.00	0.01 M	0.05 M	00.1 M	0.22 M	1.0 M
Auto-range	10.0	100.0	470.0	1.00 k	220 k	1.00 M
	CURRENT BEING MEASURED					
	50 mA	150 mA	1.0 A	7.5 A	15.0 A	25.0 A
Scale Selected	Ammeter will display:					
40 mA	OL	OL	OL	OL	OL	OL
400 mA	50.0	150	OL	OL	OL	OL
4 A	0.05	0.00	1.00	OL	OL	OL
40 A	0.00	0.000	01.0	7.5	15.0	25.0
Auto-range	50.0 mA	150.0 mA	1.00	7.5	15.0	25.0

CHART 22–2

Sample meter readings using manually set and auto-ranging selection on the digital meter control.

meter face is much larger than the specifications, many beginner technicians are led to believe that the voltage drop is excessive.

NOTE: Pay attention to the units displayed on the meter face and convert to whole units.

Example 2: A spark plug wire is being measured. The reading should be less than 10,000 ohms for each foot in length if the wire is okay. The wire being tested is 3-ft long (maximum allowable resistance is 30,000 ohms). The meter reads "AUTO" and "14.85 kΩ." This reading is equivalent to 14,850 ohms.

NOTE: When converting from kilohms to ohms, make the decimal point a comma.

Because this reading is well below the specified maximum allowable, the spark plug wire is okay.

PURCHASE A DIGITAL METER THAT WILL WORK FOR AUTOMOTIVE USE Try to purchase a digital meter that is capable of reading the following:

- DC volts
- AC volts
- DC amperes (up to 10 A or more is helpful)
- Ohms (Ω) up to 40 MΩ (40 million ohms)
- Diode check

Additional features for advanced automotive diagnosis include:

- Frequency (hertz, abbreviated Hz)
- Temperature probe (°F and/or °C)
- Pulse width (millisecond, abbreviated ms)
- Duty cycle (%)

SUMMARY

1. *Digital multimeter* (DMM) and *digital volt-ohm-milliammeter* (DVOM) are terms commonly used for electronic high impedance test meters.
2. Ammeters measure current and must be connected in series in the circuit.
3. Voltmeters measure voltage and are connected in parallel.
4. Ohmmeters measure resistance of a component and must be connected in series, with the circuit or component disconnected from power.

REVIEW QUESTIONS

1. How is a test light able to detect electricity?
2. How is an ammeter connected to an electrical circuit?
3. Why must an ohmmeter be connected to a disconnected circuit or component?

CHAPTER QUIZ

1. Inductive ammeters work because of what principle?
   a. Magic
   b. Electrostatic electricity
   c. A magnetic field surrounds any wire carrying a current
   d. Voltage drop as it flows through a conductor
2. A meter used to measure amperes is called a(n) _____.
   a. Amp meter **b.** Ampmeter
   c. Ammeter **d.** Coulomb meter
3. A voltmeter should be connected to the circuit being tested _____.
   a. In series
   b. In parallel
   c. Only when no power is flowing
   d. Both a and c
4. An ohmmeter should be connected to the circuit or component being tested _____.
   a. With current flowing in the circuit or through the component
   b. When connected to the battery of the vehicle to power the meter
   c. Only when no power is flowing (electrically open circuit)
   d. Both b and c
5. A meter set to read ohms and connected to light bulb terminals reads OL. This reading means that the bulb is _____.
   a. Bad
   b. Is reading what it should (good)
   c. Bulb filament is electrically open
   d. Both a and c
6. A meter is set to read DC volts on the 4-volt scale. The meter leads are connected at a 12-volt battery. The display will read _____.
   a. 0.00 **b.** OL
   c. 12 V **d.** 0.012 V
7. What could happen if the meter leads were connected to the positive and negative terminals of the battery while the meter and leads were set to read amperes?
   a. Could blow an internal fuse or damage the meter
   b. Would read volts instead of amperes
   c. Would display OL
   d. Would display 0.00
8. The highest amount of resistance that can be read by a meter set to the 2-kΩ scale is _____.
   a. 2,000 ohms
   b. 200 ohms
   c. 200 kΩ (200,000 ohms)
   d. 20,000,000 ohms
9. If a digital meter face shows 0.93 when set to read kΩ, the reading means _____.
   a. 93 ohms
   b. 930 ohms
   c. 9,300 ohms
   d. 93,000 ohms
10. A reading of 432 shows on the face of the meter set to the millivolt scale. The reading means _____.
    a. 0.432 volt
    b. 4.32 volts
    c. 43.2 volts
    d. 4,320 volts