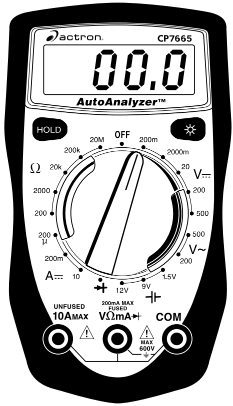
AutoAnalyzer™

OPERATING INSTRUCTIONS



CP7665

SAFETY GUIDELINES

TO PREVENT ACCIDENTS THAT COULD RESULT IN SERIOUS INJURY AND/OR DAMAGE TO YOUR VEHICLE OR TEST EQUIPMENT, CAREFULLY FOLLOW THESE SAFETY RULES AND TEST PROCEDURES

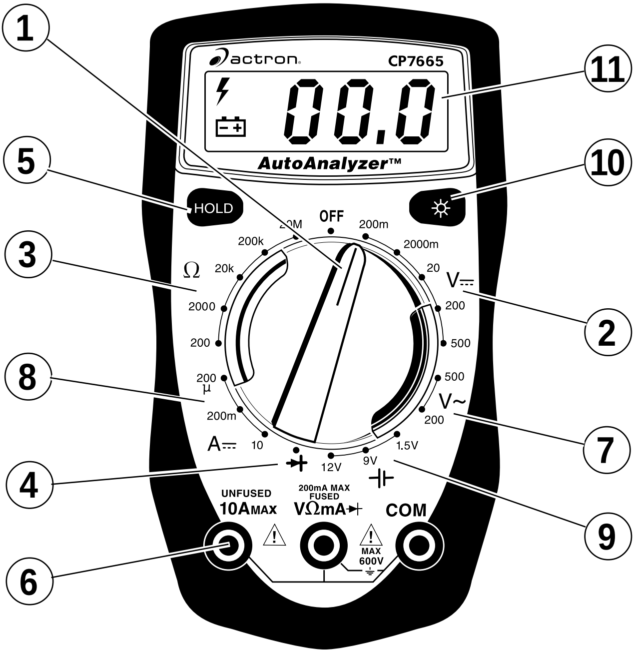
- Always wear approved eye protection.
- Always operate the vehicle in a well ventilated area. Do not inhale exhaust gases – they are very poisonous!
- Always keep yourself, tools and test equipment away from all moving or hot engine parts.
- Always make sure the vehicle is in **park** (Automatic transmission) or **neutral** (manual transmission) and that the **parking brake is firmly set.** Block the drive wheels.
- Never lay tools on vehicle battery. You may short the terminals together causing harm to yourself, the tools or the battery.
- Never smoke or have open flames near vehicle. Vapors from gasoline and charging battery are highly flammable and explosive.
- Never leave vehicle unattended while running tests.
- Always keep a fire extinguisher suitable for gasoline/electrical/ chemical fires handy.
- Always use extreme caution when working around the ignition coil, distributor cap, ignition wires, and spark plugs. These components contain **High Voltage** when the engine is running.
- Always turn ignition key OFF when connecting or disconnecting electrical components, unless otherwise instructed.
- Always follow vehicle manufacturer's warnings, cautions and service procedures.

CAUTION:

Some vehicles are equipped with safety air bags. You *must* follow vehicle service manual cautions when working around the air bag components or wiring. If the cautions are not followed, the air bag may open up unexpectedly, resulting in personal injury. Note that the air bag can still open up several minutes after the ignition key is off (or even if the vehicle battery is disconnected) because of a special energy reserve module.

Section 1. Multimeter Basic Functions

Digital multimeters or DMMs have many special features and functions. This section defines these features and functions, and explains how to use these functions to make various measurements.



Functions and Display Definitions

1. **ROTARY SWITCH**
   Switch is rotated to turn multimeter ON/OFF and select a function.

2. **DC VOLTS**
   This function is used for measuring DC (Direct Current) Voltages in the range of 0 to 500V.

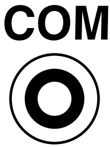
3. **OHMS**
   This function is used for measuring the resistance of a component in an electrical circuit in the range of 0.1Ω to 20MΩ. (Ω is the electrical symbol for Ohms)

4. **DIODE CHECK**
   This function is used to check whether a diode is good or bad.

5. **HOLD**
   Press HOLD button to retain data

on display. In the hold mode, the "H" annunciator is displayed.

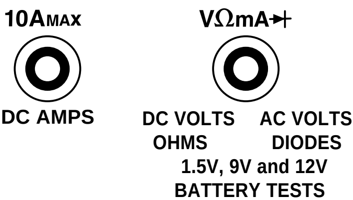
6. **TEST LEAD JACKS**



BLACK Test Lead is always inserted in the COM jack.

RED Test Lead is inserted in the jack corresponding to the multimeter rotary switch setting.

Always connect TEST LEADS to the multimeter before connecting them to the circuit under test!!



7. **AC VOLTS**
   This function is used for measuring AC Voltages in the range of 0 to 500V.

8. **DC AMPS**
   This function is used for measuring DC (Direct Current) Amps in the range of 0 to 10A.

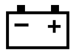
9. **1.5V, 9V, AND 12V BATTERY TEST**

   This function is used to test 1.5V, 9V, and 12V batteries under load.

10. **DISPLAY LIGHT**
    Press button to illuminate the display.

11. **DISPLAY**
    Used to display all measurements and multimeter information.

    Low Battery – If this symbol appears in the lower left corner of the display, then replace the internal 9V battery. (See Fuse and Battery replacement on page 7.)



High Voltage indicator

Overrange Indication – If “1” or “-1” appears on the left side of the display, then the multimeter is set to a range that is too small for the present measurement being taken. Increase the range until this disappears. If it does not disappear after all the ranges for a particular function have been tried, then the value being measured is too large for the multimeter to measure. (See Setting the Range on page 6.)

Zero Adjustment
The multimeter will automatically zero on the Volts, Amps and Battery Test functions.

Automatic Polarity Sensing
The multimeter display will show a minus (-) sign on the DC Volts and DC Amps functions when test lead hook-up is reversed.

Setting the Range

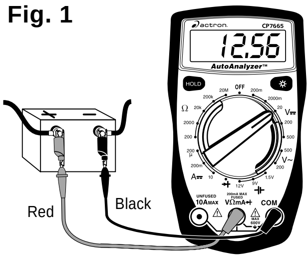
Two of the most commonly asked questions about digital multimeters are <u>What does Range mean?</u> and <u>How do I know what Range the multimeter should be set to?</u>

What Does Range mean?

Range refers to the largest value the multimeter can measure with the rotary switch in that position. If the multimeter is set to the 20V DC range, then the highest voltage the multimeter can measure is 20V in that range.

EXAMPLE: Measuring Vehicle Battery Voltage (See Fig. 1)

Fig. 1



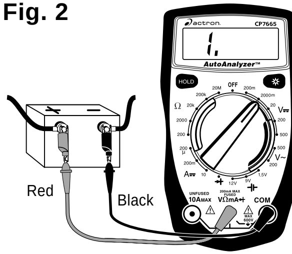
Let's assume the multimeter is connected to the battery and set to the 20V range.

The display reads 12.56. This means there is 12.56V across the battery terminals.

Now assume we set the multimeter to the 2000mV range. (See Fig. 2)

The multimeter display now shows a "1" and nothing else. This means the multimeter is being **overranged** or in other words the value being measured is larger than the current range. The range should be increased until a value is shown on

Fig. 2



the display. If you are in the highest range and the multimeter is still showing that it is overranging, then the value being measured is too large for the multimeter to measure.

How do I know what Range the multimeter should be set to?

The multimeter should be set in the lowest possible range without overranging.

EXAMPLE: Measuring an unknown resistance

Let's assume the multimeter is connected to an engine coolant sensor with unknown resistance. (See Fig. 3)

Start by setting the multimeter to the largest OHM range. The display reads 0.0Ω or a short circuit.

Fig. 3

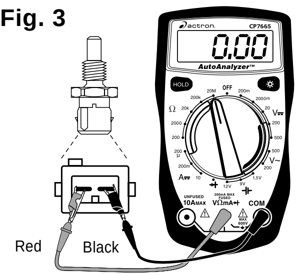


Fig. 4

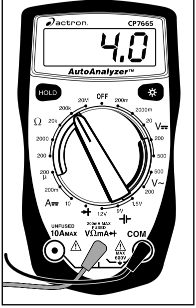


Fig. 5

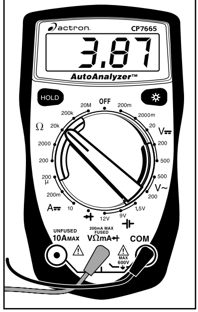
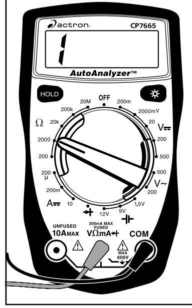


Fig. 6



This sensor can't be shorted so reduce the range setting until you get a value of resistance.

At the 200KΩ range the multimeter measured a value of 4.0. This means there is 4KΩ of resistance across the engine coolant sensor terminals. (See Fig. 4)

If we change the multimeter to the 20KΩ range (See Fig. 5) the display shows a value of 3.87KΩ. The actual value of resistance is 3.87KΩ and not 4KΩ that was measured in the 200KΩ range. This is very important because if the manufacturer specifications say that the sensor should read 3.8-3.9KΩ at 70°F then on the 200KΩ range the sensor would be defective, but at the 20KΩ range it would test good.

Now set the multimeter to the 2000Ω range. (See Fig. 6) The display will indicate an overrange condition because 3.87KΩ is larger than 2KΩ.

This example shows that by decreasing the range you increase the accuracy of your measurement. When you change the range, you change the location of the decimal point. This changes the accuracy of the measurement by either increasing or decreasing the number of digits after the decimal point.

Battery and Fuse Replacement

Important: A 9 Volt battery must be installed before using the digital multimeter. (see procedure below for installation)

Battery Replacement

1. **Turn multimeter rotary switch to OFF position.**
2. **Remove test leads from multimeter.**
3. **Remove screws from back of multimeter.**
4. **Remove back cover.**
5. **Install a new 9 Volt battery.**
6. **Re-assemble multimeter.**

Fuse Replacement

1. **Turn multimeter rotary switch to OFF position.**
2. **Remove test leads from multimeter.**

3. **Remove screws from back of multimeter.**
4. **Remove back cover.**
5. **Remove fuse.**
6. **Replace fuse with same size and type as originally installed!**
   5mm x 20mm, 200mA, 250V, fast acting.
7. **Re-assemble multimeter.**

Measuring DC Voltage

This multimeter can be used to measure DC voltages in the range from 0 to 500V. You can use this multimeter to do any DC voltage measurement called out in the vehicle service manual. The most common applications are measuring voltage drops, and checking if the correct voltage arrived at or is being produced by a sensor or a particular circuit.

To measure DC Voltages (see Fig. 7):

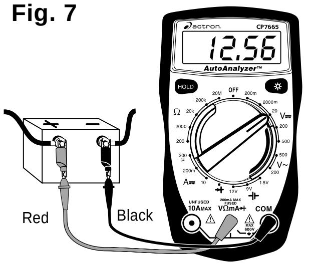
1. **Insert BLACK test lead into COM test lead jack.**
2. **Insert RED test lead into VΩmA→| test lead jack.**
3. **Connect RED test lead to positive (+) side of voltage source.**
4. **Connect BLACK test lead to negative (-) side of voltage source.**

   NOTE: If you don't know which side is positive (+) and which side is negative (-), then arbitrarily connect the RED test lead to one side and the BLACK to the other. The multimeter automatically senses polarity and will display a minus (-) sign when negative polarity is measured. If you switch the RED and BLACK test leads, positive polarity will now be indicated on the display. Measuring negative voltages causes no harm to the multimeter.
5. **Turn multimeter rotary switch to desired voltage range.**

   If the approximate voltage is unknown, start at the largest voltage range and decrease to the appropriate range as required. (See Setting the Range on page 6)
6. **View reading on display - Note range setting for correct units.**

   NOTE: 200mV = 0.2V

Fig. 7

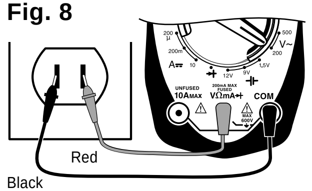


Measuring AC Voltage

This multimeter can be used to measure AC voltages in the range from 0 to 500V.

To measure AC Voltages (see Fig. 8):

Fig. 8



1. **Insert BLACK test lead into COM test lead jack.**
2. **Insert RED test lead into VΩmA→+ test lead jack.**
3. **Connect RED test lead to one side of voltage source.**
4. **Connect BLACK test lead to other side of voltage source.**
5. **Turn multimeter rotary switch to desired voltage range.**

   If the approximate voltage is unknown, start at the largest voltage range and decrease to the appropriate range as required. (See Setting the Range on page 6)
6. **View reading on display.**

   NOTE: 200mV = 0.2V

Measuring Resistance

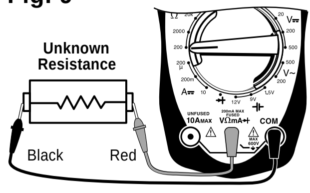
Resistance is measured in electrical units called ohms (Ω). The digital multimeter can measure resistance from 0.1Ω to 20MΩ (or 20,000,000 ohms). Infinite resistance is shown with a “1” on the left side of display (See Setting the Range on page 6). You can use this multimeter to do any resistance measurement called out in the vehicle service manual. Testing ignition coils, spark plug wires, and some engine sensors are common uses for the OHMS (Ω) function.

To measure Resistance (see Fig. 9):

1. **Turn circuit power OFF.**

   To get an accurate resistance measurement and avoid possible damage to the digital multimeter and electrical circuit under test, turn off all electrical power in the circuit where the resistance measurement is being taken.

Fig. 9



2. **Insert BLACK test lead into COM test lead jack.**
3. **Insert RED test lead into VΩmA→+ test lead jack.**
4. **Turn multimeter rotary switch to 200Ω range.**

   Touch RED and BLACK multimeter leads together and view reading on display.

   Display should read typically 0.2Ω to 1.5Ω.

   If display reading was greater than 1.5Ω, check both ends of test leads for bad connections. If bad connections are found, replace test leads.
5. **Connect RED and BLACK test leads across component where you want to measure resistance.**

   When making resistance measurements, polarity is not important. The test leads just have to be connected across the component.
6. **Turn multimeter rotary switch to desired OHM range.**

   If the approximate resistance is unknown, start at the largest OHM range and decrease to the appropriate range as required.

7. **View reading on display - Note range setting for correct units.**

   NOTE: 2KΩ = 2,000Ω; 2MΩ = 2,000,000Ω

   If you want to make precise resistance measurements, then subtract the test lead resistance found in Step 4 above from the display reading in Step 7. It is a good idea to do this for resistance measurements less than 10Ω.

Measuring DC Current

This multimeter can be used to measure DC current in the range from 0 to 10A. Unlike voltage and resistance measurements where the multimeter is connected across the component you are testing, current measurements must be made with the multimeter in series with the component. Isolating current drains and short circuits are some DC Current applications.

Fig. 10

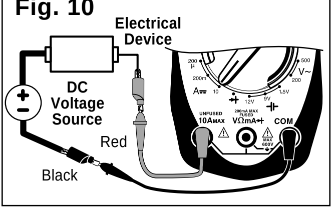
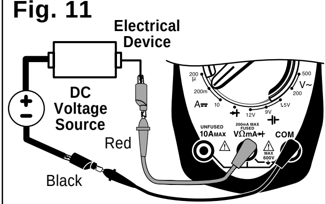


Fig. 11



To measure DC Current (see Figs. 10 & 11):

1. **Insert BLACK test lead into COM test lead jack.**
2. **Insert RED test lead into "10A" test lead jack or "mA" test lead jack.**
3. **Disconnect or electrically open circuit where you want to measure current.**

   This is done by:

   - Disconnecting wiring harness.
   - Disconnecting wire from screw-on type terminal.
   - Unsolder lead from component if working on printed circuit boards.
   - Cut wire if there is no other possible way to open electrical circuit.
4. **Connect RED test lead to one side of disconnected circuit.**
5. **Connect BLACK test lead to remaining side of disconnected circuit.**
6. **Turn multimeter rotary switch to 10A DC position, 200mA or 200µA position.**
7. **View reading on display.**

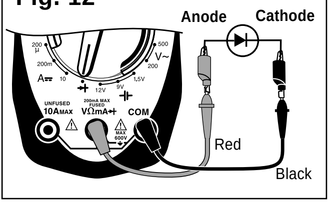
   If minus (-) sign appears on display, then reverse RED and BLACK test leads.

Testing Diodes

A diode is an electrical component that allows current to only flow in one direction. When a positive voltage, generally greater than 0.7V, is applied to the anode of a diode, the diode will turn on and allow current to flow. If this same voltage is applied to the cathode, the diode would remain off and no current would flow. Therefore, in order to test a diode, you must check it in both directions (i.e. anode-to-cathode, and cathode-to-anode). Diodes are typically found in alternators on automobiles.

Performing Diode Test (see Fig. 12):

Fig. 12



1. **Insert BLACK test lead into COM test lead jack.**
2. **Insert RED test lead into VΩmA→+ test lead jack.**
3. **Turn multimeter rotary switch to →+ function.**
4. **Touch RED and BLACK test leads together to test continuity.**

   Check display – should reset to 0.00.
5. **Disconnect one end of diode from circuit.**

   Diode must be totally isolated from circuit in order to test its functionality.
6. **Connect RED and BLACK test leads across diode and view display.**

   Display will show one of three things:

   - A typical voltage drop of around 0.7V.
   - A voltage drop of 0 volts.
   - A “1” will appear indicating the multimeter is overranged.
7. **Switch RED and BLACK test leads and repeat Step 6.**
8. **Test Results**

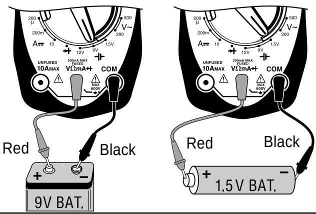
   If the display showed:

   - A voltage drop of 0 volts in both directions, then the diode is shorted and needs to be replaced.
   - A “1” appears in both directions, then the diode is an open circuit and needs to be replaced.
   - The diode is good if the display reads around 0.5V–0.7V in one direction and a “1” appears in the other direction indicating the multimeter is overranged.

Testing 1.5V, 9V and 12V Batteries

Test Procedure (see Fig. 13):

Fig. 13



1. **Insert BLACK test lead into COM test lead jack.**
2. **Insert RED test lead into VΩmA▶| test lead jack.**
3. **Turn multimeter rotary switch to 1.5V, 9V or 12V ⊣⊢ range.**
4. **Connect RED test lead to positive (+) terminal of battery.**
5. **Connect BLACK test lead to negative (-) terminal of battery.**
6. **View reading on display.**

Section 2. Automotive Testing

The digital multimeter is a very useful tool for trouble-shooting automotive electrical systems. This section describes how to use the digital multimeter to test the starting and charging system, ignition system, fuel system, and engine sensors. The digital multimeter can also be used for general testing of fuses, switches, solenoids, and relays.

General Testing

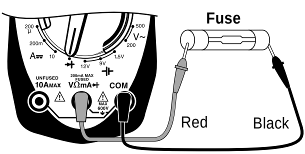
The digital multimeter can be used to test fuses, switches, solenoids, and relays.

Testing Fuses

This test checks to see if a fuse is blown.

To test Fuses (see Fig. 14):

Fig. 14



1. **Insert BLACK test lead into COM test lead jack.**
2. **Insert RED test lead into VΩmA▶| test lead jack.**
3. **Turn multimeter rotary switch to 2000Ω function.**
4. **Connect RED and BLACK test leads to opposite ends of fuse.**
   - **If the reading is zero -** Fuse is good.
   - **If the reading is overrange -** Fuse is blown and needs to be replaced.

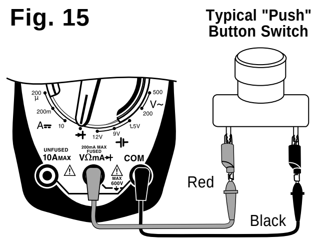
NOTE: Always replace blown fuses with same type and rating.

Testing Switches

This test checks to see if a switch “Opens” and “Closes” properly.

To test Switches (see Fig. 15):

Fig. 15



1. **Insert BLACK test lead into COM test lead jack.**
2. **Insert RED test lead into VΩmA▶| test lead jack.**
3. **Turn multimeter rotary switch to 2000Ω function.**
4. **Connect BLACK test lead to one side of switch.**
5. **Connect RED test lead to other side of switch.**
   - **If the reading is zero -** The switch is closed.
   - **If the reading is overrange -** The switch is open.
6. **Operate switch.**
   - **If the reading is zero** - The switch is closed.

- **If the reading is overrange -** The switch is open.

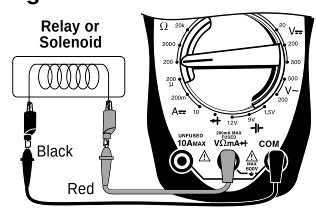
7. **Repeat Step 6 to verify switch operation.**

Testing Solenoids and Relays

This test checks to see if a solenoid or relay has a broken coil. If the coil tests good, it is still possible that the relay or solenoid is defective. The relay can have contacts that are welded or worn down, and the solenoid may stick when the coil is energized. This test does not check for those potential problems.

To test Solenoids and Relays (see Fig. 16):

Fig. 16



1. **Insert BLACK test lead into COM test lead jack.**
2. **Insert RED test lead into VΩmA→⊢ test lead jack.**
3. **Turn multimeter rotary switch to 200Ω function.**

   Most solenoids and relay coil resistances are less than 200Ω.

4. **Connect BLACK test lead to one side of coil.**
5. **Connect RED test lead to other side of coil.**
6. **View reading on display.**
   - Typical solenoid / relay coil resistances are 200Ω or less.
   - Refer to vehicle service manual for the device's resistance range.

   If meter overranges, turn multimeter rotary switch to next higher range. (see Setting the Range on page 6)

7. **Test Results**

   Good Solenoid / Relay Coil: Display in Step 6 is within manufacturers specification.

   Bad Solenoid / Relay Coil:

   - Display in Step 6 is not within manufacturers specifications.
   - Display reads overrange on every ohms range indicating an open circuit.

NOTE: Some relays and solenoids have a diode placed across the coil.

Starting/Charging System Testing

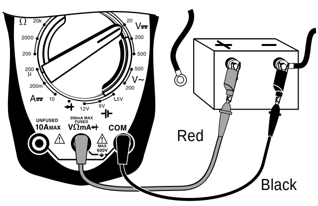
The starting system "turns over" the engine. It consists of the battery, starter motor, starter solenoid and/or relay, and associated wiring and connections. The charging system keeps the battery charged when the engine is running. This system consists of the alternator, voltage regulator, battery, and associated wiring and connections. The digital multimeter is a useful tool for checking the operation of these systems.

No Load Battery Test

Before you do any starting/charging system checks, you must first test the battery to make sure it is fully charged.

Test Procedure (see Fig. 17):

Fig. 17



1. **Turn Ignition Key OFF.**
2. **Turn ON headlights for 10 seconds to dissipate battery surface charge.**
3. **Insert BLACK test lead into COM test lead jack.**
4. **Insert RED test lead into VΩmA→+ test lead jack.**
5. **Disconnect positive (+) battery cable.**
6. **Connect RED test lead to positive (+) terminal of battery.**
7. **Connect BLACK test lead to negative (-) terminal of battery.**
8. **Turn multimeter rotary switch to 20V DC range.**
9. **View reading on display.**
10. **Test Results.**

    Compare display reading in Step 9 with the following chart.

Voltage	Percent Battery is Charged
12.60V or greater	100%
12.45V	75%
12.30V	50%
12.15V	25%

If battery is not 100% charged, then charge it before doing anymore starting/charging system tests.

Engine Off Battery Current Draw

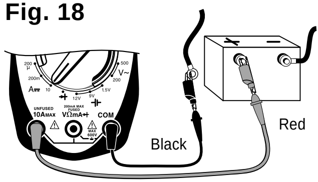
This test measures the amount of current being drawn from the battery when the ignition key and engine are both off. This test helps to identify possible sources of excessive battery current drain, which could eventually lead to a “dead” battery.

1. **Turn Ignition Key and all accessories OFF.**

   Make sure trunk, hood, and dome lights are all OFF.

   (See Fig. 18)

Fig. 18



2. **Insert BLACK test lead into COM test lead jack.**
3. **Insert RED test lead into "10A" (or "mA") test lead jack.**
4. **Disconnect positive (+) battery cable.**
5. **Connect RED test lead to positive (+) battery terminal.**
6. **Connect BLACK test lead to positive (+) battery cable.**

   NOTE: Do not start vehicle during this test, because multimeter damage may result.

7. **Turn multimeter rotary switch to 10A DC (or 200 mA) position.**
8. **View reading on display.**
   - Typical current draw is 100mA. (1mA = 0.001A)
   - Refer to vehicle service manual for manufacturers specific Engine Off Battery Current Draw.

   NOTE: Radio station presets and clocks are accounted for in the 100mA typical current draw.

9. **Test Results.**

   Normal Current Draw: Display reading in Step 8 is within manufacturers specifications.

   Excessive Current Draw:

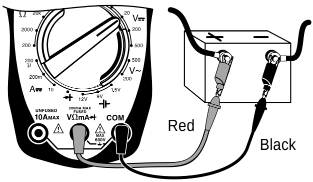
   - Display reading in Step 8 is well outside manufacturers specifications.
   - Remove Fuses from fuse box one at a time until source of excessive current draw is located.
   - Non-Fused circuits such as headlights, relays, and solenoids should also be checked as possible current drains on battery.
   - When source of excessive current drain is found, service as necessary.

Cranking Voltage - Battery Load Test

This test checks the battery to see if it is delivering enough voltage to the starter motor under cranking conditions.

Test Procedure (see Fig. 19):

Fig. 19



1. **Disable ignition system so vehicle won't start.**

   Disconnect the primary of the ignition coil or the distributor pick-up coil or the cam/crank sensor to disable the ignition system. Refer to vehicle service manual for disabling procedure.

2. **Insert BLACK test lead into COM test lead jack.**

3. **Insert RED test lead into VΩmA⊣ test lead jack.**

4. **Connect RED test lead to positive (+) terminal of battery.**

5. **Connect BLACK test lead to negative (-) terminal of battery.**

6. **Turn multimeter rotary switch to 20V DC range.**

7. **Crank engine for 15 seconds continuously while observing display.**

8. **Test Results.**

   Compare display reading in Step 7 with chart below.

Voltage	Temperature
9.6V or greater	70 °F and Above
9.5V	60 °F
9.4V	50 °F
9.3V	40 °F
9.1V	30 °F
8.9V	20 °F
8.7V	10 °F
8.5V	0 °F

If voltage on display corresponds to above voltage vs. temperature chart, then cranking system is normal.

If voltage on display does not correspond to chart, then it is possible that the battery, battery cables, starting system cables, starter solenoid, or starter motor are defective.

Voltage Drops

This test measures the voltage drop across wires, switches, cables, solenoids, and connections. With this test you can find excessive resistance in the starter system. This resistance restricts the amount of current that reaches the starter motor resulting in low battery load voltage and a slow cranking engine at starting.

Test Procedure (see Fig. 20):

1. **Disable ignition system so vehicle won't start.**

   Disconnect the primary of the ignition coil or the distributor pick-up coil or the cam/crank sensor to disable the ignition system. Refer to vehicle service manual for disabling procedure.

2. **Insert BLACK test lead into COM test lead jack.**

3. **Insert RED test lead into VΩmA➔⊢ test lead jack.**

4. **Connect test leads.**

   Refer to Typical Cranking Voltage Loss Circuit (Fig. 20).

   - Connect RED and BLACK test leads alternately between 1 & 2, 2 & 3, 4 & 5, 5 & 6, 6 & 7, 7 & 9, 8 & 9, and 8 & 10.

5. **Turn multimeter rotary switch to 200mV DC range.**

   If multimeter overranges, turn multimeter rotary switch to the 2000mV DC range. (See Setting the Range on page 6)

6. **Crank engine until steady reading is on display.**

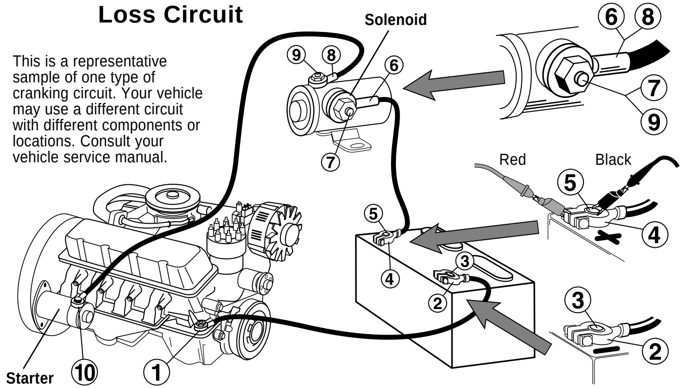
   - Record results at each point as displayed on multimeter.
   - Repeat Step 4 & 5 until all points are checked.

7. **Test Results –**

   Estimated Voltage Drop of Starter Circuit Components

Component	Voltage
Switches	300mV
Wire or Cable	200mV
Ground	100mV

Fig. 20 Typical Cranking Voltage Loss Circuit



Component	Voltage
Battery Cable Connectors	50mV
Connections	0.0V

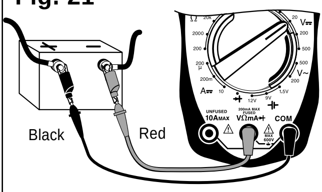
- Compare voltage readings in Step 6 with above chart.
- If any voltages read high, inspect component and connection for defects.
- If defects are found, service as necessary.

Charging System Voltage Test

This test checks the charging system to see if it charges the battery and provides power to the rest of the vehicles electrical systems (lights, fan, radio etc).

Test Procedure (see Fig. 21):

Fig. 21



1. **Insert BLACK test lead into COM test lead jack.**
2. **Insert RED test lead into VΩmA→+ test lead jack.**
3. **Turn multimeter rotary switch to 20V DC range.**
4. **Connect RED test lead to positive (+) terminal of battery.**
5. **Connect BLACK test lead to negative (-) terminal of battery.**
6. **Start engine - Let idle.**
7. **Turn off all accessories and view reading on display.**
   - Charging system is normal if display reads 13.2 to 15.2 volts.
   - If display voltage is not between 13.2 to 15.2 volts, then proceed to Step 13.
8. **Open throttle and Hold engine speed (RPM) between 1800 and 2800 RPM.**

   Hold this speed through Step 11 - Have an assistant help hold speed.
9. **View reading on display.**

   Voltage reading should not change from Step 7 by more than 0.5V.
10. **Load the electrical system by turning on the lights, windshield wipers, and setting the blower fan on high.**
11. **View reading on display.**

    Voltage should not drop down below about 13.0V.
12. **Shut off all accessories, return engine to curb idle and shut off.**

13. Test Results.

- If voltage readings in Steps 7, 9, and 11 were as expected, then charging system is normal.
- If any voltage readings in Steps 7, 9, and 11 were different then shown here or in vehicle service manual, then check for a loose alternator belt, defective regulator or alternator, poor connections, or open alternator field current.
- Refer to vehicle service manual for further diagnosis.

Ignition System Testing

The ignition system is responsible for providing the spark that ignites the fuel in the cylinder. Ignition system components that the digital multimeter can test are the primary and secondary ignition coil resistance, spark plug wire resistance and reluctance pick-up coil sensors.

Ignition Coil Testing

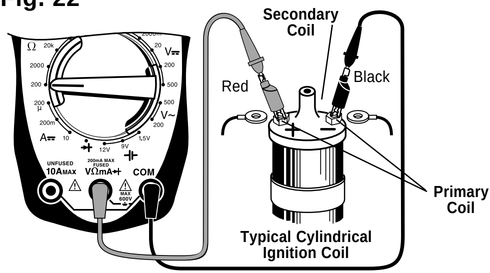
This test measures the resistance of the primary and secondary of an ignition coil. This test can be used for distributorless ignition systems (DIS) provided the primary and secondary ignition coil terminals are easily accessible.

Test Procedure:

1. **If engine is HOT let it COOL down before proceeding.**
2. **Disconnect ignition coil from ignition system.**
3. **Insert BLACK test lead into COM test lead jack (see Fig. 22).**
4. **Insert RED test lead into VΩmA→+ test lead jack.**
5. **Turn multimeter rotary switch to 200Ω range.**
6. **Touch RED and BLACK multimeter leads together and view reading on display.**
7. **Connect test leads.**
   - Connect RED test lead to primary ignition coil positive (+) terminal.
   - Connect BLACK test lead to primary ignition coil negative (-) terminal.
   - Refer to vehicle service manual for location of primary ignition coil terminals.
8. **View reading on display.**

   Subtract test lead resistance found in Step 6 from above reading.
9. **If vehicle is DIS, repeat Steps 7 and 8 for remaining ignition coils.**
10. **Test Results - Primary Coil**
    - Typical resistance range of primary ignition coils is 0.3 - 2.0Ω.
    - Refer to vehicle service manual for your vehicles resistance range.

Fig. 22



11. **Turn multimeter rotary switch to 200kΩ range (see Fig. 23).**
12. **Move RED test lead to secondary ignition coil terminal.**
    - Refer to vehicle service

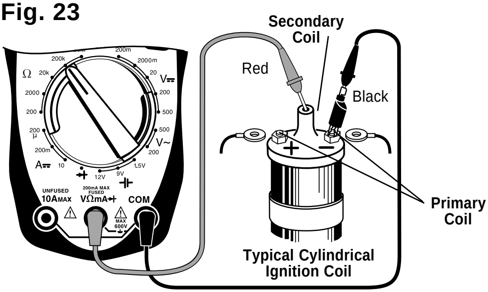


Fig. 23

manual for location of secondary ignition coil terminal.

- Verify BLACK test lead is connected to primary ignition coil negative (-) terminal.

13. View reading on display.

14. If vehicle is DIS, connect test leads to terminals of the secondary ignition coil. Repeat for remaining ignition coils.

15. Test Results - Secondary Coil

- Typical resistance range of secondary ignition coils is 6.0kΩ - 30.0kΩ.
- Refer to vehicle service manual for your vehicles resistance range.

16. Repeat test procedure for a HOT ignition coil.

NOTE: It is a good idea to test ignition coils when they are both hot and cold, because the resistance of the coil could change with temperature. This will also help in diagnosing intermittent ignition system problems.

17. Test Results - Overall

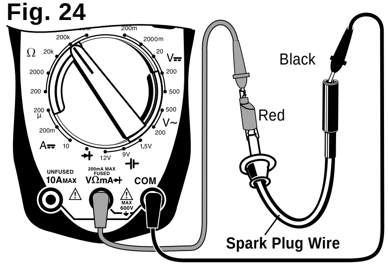
Good Ignition Coil: Resistance readings in Steps 10, 15 and 16 were within manufacturers specification.

Bad Ignition Coil: Resistance readings in Steps 10, 15 and 16 are not within manufacturers specification.

Ignition System Wires

This test measures the resistance of spark plug and coil tower wires while they are being flexed. This test can be used for distributorless ignition systems (DIS) provided the system does not mount the ignition coil directly on the spark plug.

Fig. 24



Test Procedure:

1. **Remove ignition system wires one at a time from engine.**
   - Always grasp ignition system wires <u>on the boot</u> when removing.
   - Twist the boots about a half turn while pulling gently to remove them.
   - Refer to vehicle service manual for ignition wire removal procedure.
   - Inspect ignition wires for cracks, chaffed insulation, and corroded ends.

   NOTE: Some Chrysler products use a “positive-locking” terminal electrode spark plug wire. These wires can only be removed from inside the distributor cap. Damage may result if other means of removal are attempted. Refer to vehicle service manual for procedure.

   NOTE: Some spark plug wires have sheet metal jackets with the following symbol: ➔◀━. This type of plug wire contains an “air gap” resistor and can only be checked with an oscilloscope.

2. **Insert BLACK test lead into COM test lead jack (see Fig. 24).**
3. **Insert RED test lead into VΩmA➔| test lead jack.**
4. **Connect RED test lead to one end of ignition wire and BLACK test lead to other end.**
5. **Turn multimeter rotary switch to 200KΩ range.**
6. **View reading on display while flexing ignition wire and boot in several places.**
   - Typical resistance range is 3KΩ to 50KΩ or approximately 10KΩ per foot of wire.
   - Refer to vehicle service manual for your vehicles resistance range.
   - As you flex ignition wire, the display should remain steady.
7. **Test Results**

   Good Ignition Wire: Display reading is within manufacturers specification and remains steady while wire is flexed.

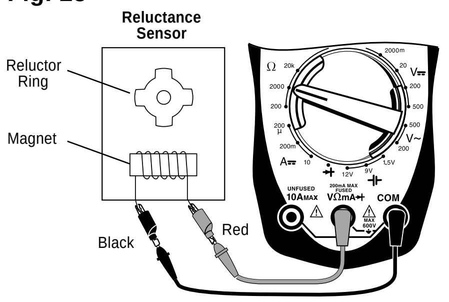
   Bad Ignition Wire: Display reading erratically changes as ignition wire is flexed or display reading is not within manufacturers specification.

Magnetic Pick-Up Coils – Reluctance Sensors

Reluctance sensors are used whenever the vehicle computer needs to know speed and position of a rotating object. Reluctance sensors are commonly used in ignition systems to determine camshaft and crankshaft position so the vehicle computer knows the optimum time to fire the ignition coil(s) and turn on the fuel injectors. This test checks the reluctance sensor for an open or shorted coil. This test does not check the air gap or voltage output of the sensor.

Test Procedure (see Fig. 25):

Fig. 25



1. **Insert BLACK test lead into COM test lead jack.**
2. **Insert RED test lead into VΩmA→+ test lead jack.**
3. **Connect RED test lead to either sensor pin.**
4. **Connect BLACK test lead to remaining sensor pin.**
5. **Turn multimeter rotary switch to 2000Ω range.**
6. **View reading on display while flexing sensor wires in several places.**
   - Typical resistance range is 150 - 1000Ω.
   - Refer to vehicle service manual for your vehicles resistance range.
   - As you flex sensor wires, the display should remain steady.
7. **Test Results**

   Good Sensor: Display reading is within manufacturers specification and remains steady while sensor wires are flexed.

   Bad Sensor: Display reading erratically changes as sensor wires are flexed or display reading is not within manufacturers specification.

Fuel System Testing

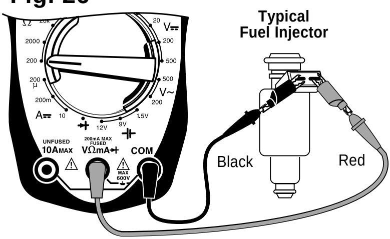
The requirements for lower vehicle emissions has increased the need for more precise engine fuel control. Auto manufacturers began using electronically controlled carburetors in 1980 to meet emission requirements. Today's modern vehicles use electronic fuel injection to precisely control fuel and further lower emissions. The digital multimeter can be used to measure fuel injector resistance.

Measuring Fuel Injector Resistance

Fuel injectors are similar to solenoids. They contain a coil that is switched ON and OFF by the vehicle computer. This test measures the resistance of this coil to make sure it is not an open circuit. Shorted coils can also be detected if the specific manufacturer resistance of the fuel injector is known.

Test Procedure (see Fig. 26):

Fig. 26



1. **Insert BLACK test lead into COM test lead jack.**
2. **Insert RED test lead into VΩmA⏵| test lead jack.**
3. **Turn multimeter rotary switch to 200Ω range.**

   Touch RED and BLACK multimeter leads together and view reading on display.

   Display should read typically 0.2 - 1.5Ω.

   If display reading was greater than 1.5Ω, check both ends of test leads for bad connections. If bad connections are found, replace test leads.

4. **Disconnect wiring harness from fuel injector - Refer to vehicle service manual for procedure.**
5. **Connect RED and BLACK test leads across fuel injector pins.**

   Make sure you connect test leads across fuel injector **and not** the wiring harness.

6. **Turn multimeter rotary switch to desired OHM range.**

   If the approximate resistance is unknown, start at the largest OHM range and decrease to the appropriate range as required.

7. **View reading on display - Note range setting for correct units.**
   - If display reading is 10Ω or less, subtract test lead resistance found in Step 3 from above reading.
   - Compare reading to manufacturers specifications for fuel injector coil resistance.

- This information is found in vehicle service manual.

8. **Test Results**

   Good Fuel Injector resistance: Resistance of fuel injector coil is within manufacturers specifications.

   Bad Fuel Injector resistance: Resistance of fuel injector coil is not within manufacturers specifications.

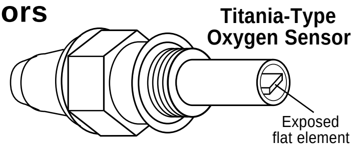
   NOTE: If resistance of fuel injector coil is within manufacturers specifications, the fuel injector could still be defective. It is possible that the fuel injector is clogged or dirty and that is causing your driveability problem.

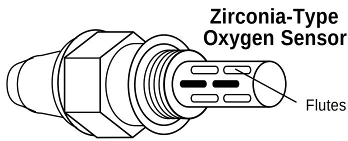
Testing Engine Sensors

In the early 1980's, computer controls were installed in vehicles to meet Federal Government regulations for lower emissions and better fuel economy. To do its job, a computer-controlled engine uses electronic sensors to find out what is happening in the engine. The job of the sensor is to take something the computer needs to know, such as engine temperature, and convert it to an electrical signal which the computer can understand. The digital multimeter is a useful tool for checking sensor operation.

Oxygen (O_2) Type Sensors

The Oxygen Sensor produces a voltage or resistance based on the amount of oxygen in the exhaust stream. A low voltage (high resistance) indicates a lean exhaust (too much oxygen), while a high voltage (low resistance) indicates a rich exhaust (not enough oxygen). The computer uses this voltage to adjust the air/fuel ratio. The two types of O_2 Sensors commonly in use are Zirconia and Titania. Refer to illustration for appearance differences of the two sensor types.

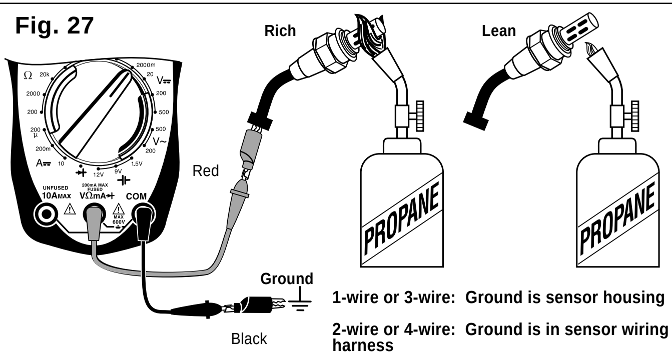




Test Procedure (see Fig. 27):

1. **If engine is HOT, let it COOL down before proceeding.**
2. **Remove Oxygen Sensor from vehicle.**
3. **Insert BLACK test lead into COM test lead jack.**
4. **Insert RED test lead into VΩmA→| test lead jack.**

Fig. 27



5. **Test heater circuit.**

- If sensor contains 3 or more wires, then your vehicle uses a heated O_2 sensor.
- Refer to vehicle service manual for location of heater pins.
- Connect RED test lead to either heater pin.
- Connect BLACK test lead to remaining heater pin.
- Turn multimeter rotary switch to 200Ω range.
- View reading on display.
- Compare reading to manufacturer's specification in vehicle service manual.
- Remove both test leads from sensor.

6. **Connect BLACK test lead to sensor GROUND pin.**

- If sensor is 1-wire or 3-wire, then GROUND is sensor housing.
- If sensor is 2-wire or 4-wire, then GROUND is in sensor wiring harness.
- Refer to vehicle service manual for Oxygen Sensor wiring diagram.

7. **Connect RED test lead to sensor SIGNAL pin.**

8. **Test Oxygen Sensor.**

- Turn multimeter rotary switch to...

  – 2000mV range for Zirconia Type Sensors.

  – 200KΩ range for Titania Type Sensors.
- Light propane torch.
- Firmly grasp sensor with a pair of locking pliers.
- Thoroughly heat sensor tip as hot as possible, but not “glowing.” Sensor tip must be at 660°F to operate.
- Completely surround sensor tip with flame to deplete sensor of oxygen (Rich Condition).
- Multimeter display should read...

  – 600mV or greater for Zirconia Type Sensors.

  – an Ohmic(Resistance) value for Titania Type Sensors. Reading will vary with flame temperature.
- While still applying heat to sensor, move flame such that oxygen can reach sensor tip (Lean Condition).
- Multimeter display should read...

  – 400mV or less for Zirconia Type Sensors.

  – an overrange condition for Titania Type Sensors. (See Setting the Range on page 6.)

9. **Repeat Step 8 a few times to verify results.**

10. **Extinguish Flame, let sensor cool, and remove test leads.**

11. **Test Results.**

Good Sensor:

- Heater Circuit resistance is within manufacturer's specification.
- Oxygen Sensor output signal changed when exposed to a rich and lean condition.

Bad Sensor:

- Heater Circuit resistance is not within manufacturer's specification.

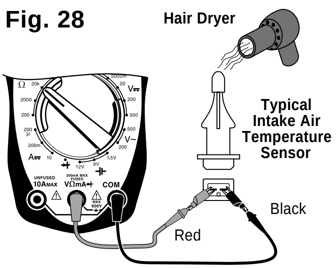
- Oxygen Sensor output signal did not change when exposed to a rich and lean condition.
- Oxygen sensor output voltage takes longer than 3 seconds to switch from a rich to a lean condition.

Temperature Type Sensors

A temperature sensor is a thermistor or a resistor whose resistance changes with temperature. The hotter the sensor gets, the lower the resistance becomes. Typical thermistor applications are engine coolant sensors, intake air temperature sensors, transmission fluid temperature sensors, and oil temperature sensors.

Test Procedure (see Fig. 28):

Fig. 28



1. **If engine is HOT let it COOL down before proceeding.**

   Make sure all engine and transmission fluids are at outside air temperature before proceeding with this test!

2. **Insert BLACK test lead into COM test lead jack.**
3. **Insert RED test lead into VΩmA▸| test lead jack.**
4. **Disconnect wiring harness from sensor.**
5. **If testing Intake Air Temperature Sensor - Remove it from vehicle.**

   All other temperature sensors can remain on vehicle for testing.

6. **Connect RED test lead to either sensor pin.**
7. **Connect BLACK test lead to remaining sensor pin.**
8. **Turn multimeter rotary switch to desired OHM range.**

   If the approximate resistance is unknown, start at the largest OHM range and decrease to the appropriate range as required. (See Setting the Range on page 6.)

9. **View and record reading on display.**
10. **Disconnect multimeter test leads from sensor and reconnect sensor wiring.**

    This step does not apply to intake air temperature sensors. For intake air temperature sensors, leave multimeter test leads still connected to sensor.

11. **Heat up sensor.**

    If testing Intake Air Temperature Sensor:

    - To heat up sensor dip sensor tip into boiling water, or…
    - Heat tip with a lighter if sensor tip is metal **or** a hair dryer if sensor tip is plastic.
    - View and record smallest reading on display as sensor is heated.
    - You may need to decrease the

range to get a more accurate reading.

For all other temperature sensors:

- Start engine and let idle until upper radiator hose is warm.
- Turn ignition key OFF.
- Disconnect sensor wiring harness and reconnect multimeter test leads.
- View and record reading on display.

12. Test Results.

Good Sensor:

- Temperature sensors HOT resistance is at least 300Ω less than its COLD resistance.
- The key point is that the COLD resistance decreases with increasing temperature.

Bad Sensor:

- There is no change between the temperature sensors HOT resistance from the COLD resistance.
- The temperature sensor is an open or a short circuit.

Position Type Sensors

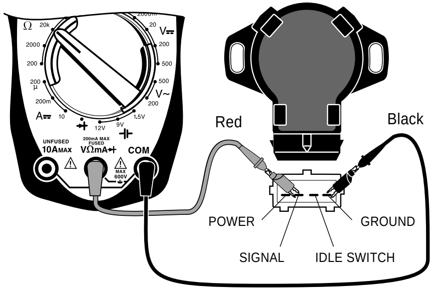
Position sensors are potentiometers or a type of variable resistor. They are used by the computer to determine position and direction of movement of a mechanical device. Typical position sensor applications are throttle position sensors, EGR valve position sensors, and vane air flow sensors.

Test Procedure (see Fig. 29):

1. **Insert BLACK test lead into COM test lead jack.**
2. **Insert RED test lead into VΩmA→+ test lead jack.**
3. **Disconnect wiring harness from sensor.**
4. **Connect Test Leads.**
   - Connect RED test lead to sensor POWER pin.
   - Connect BLACK test lead to sensor GROUND pin.
   - Refer to vehicle service manual for location of sensor POWER and GROUND pins.
5. **Turn multimeter rotary switch to 20KΩ range.**

Fig. 29

Typical Toyota Throttle Position Sensor



6. **View and record reading on display.**
   - Display should read some resistance value.
   - If multimeter is overranging, adjust the range accordingly. (See Setting the Range on page 6.)
   - If multimeter overranges on largest range, then sensor is an open circuit and is defective.
7. **Move RED test lead to sensor SIGNAL pin.**
   - Refer to vehicle service manual for location of sensor SIGNAL pin.
8. **Operate Sensor.**

   Throttle Position Sensor:
   - Slowly move throttle linkage from closed to wide open position.
   - Depending on hook-up, the display reading will **either** increase **or** decrease in resistance.
   - The display reading should **either** start at **or** end at the approximate resistance value measured in Step 6.
   - Some throttle position sensors have an Idle or Wide Open Throttle (WOT) switch in addition to a potentiometer.
   - To test these switches, follow the Testing Switches test procedure on page 13.
   - When you are told to operate switch, then move throttle linkage.

   Vane Air Flow Sensor:
   - Slowly open vane "door" from closed to open by pushing on it with a pencil or similar object. This will not harm sensor.
   - Depending on hook-up, the display reading will **either** increase **or** decrease in resistance.
   - The display reading should **either** start at **or** end at the approximate resistance value measured in Step 6.
   - Some vane air flow sensors have an idle switch and an intake air temperature sensor in addition to a potentiometer.
   - To test idle switch see Testing Switches on page 13.
   - When you are told to operate switch, then open vane "door".
   - To test intake air temperature sensor see Temperature Type Sensors on page 29.

   EGR Valve Position
   - Remove vacuum hose from EGR valve.
   - Connect hand vacuum pump to EGR valve.
   - Gradually apply vacuum to slowly open valve. (Typically, 5 to 10 in. of vacuum fully opens valve.)
   - Depending on hook-up, the display reading will **either** increase **or** decrease in resistance.
   - The display reading should **either** start at **or** end at the approximate resistance value measured in Step 6.
9. **Test Results.**

   Good Sensor: Display reading gradually increases **or** decreases in resistance as sensor is opened and closed.

   Bad Sensor: There is no change in resistance as sensor is opened or closed.

Electrical Specifications

DC Volts
Range: 200mV, 2000mV, 20V, 200V
Accuracy : ±(0.5% rdg + 2 dgts)

Range: 500V
Accuracy: ±(0.8% rdg + 2 dgts)

AC Volts
Range: 200V, 500V
Accuracy : ±(1.2% rdg + 10 dgts)

DC Current
Range: 200μA
Accuracy: ±(1.0% rdg + 2 dgts)

Range: 200mA
Accuracy: ±(1.2% rdg + 2 dgts)

Range: 10A
Accuracy: ±(2.0% rdg + 5 dgts)

Resistance
Range: 200Ω
Accuracy: ±(0.8% rdg + 5 dgts)

Range: 2000Ω, 20KΩ, 200KΩ
Accuracy: ±(0.8% rdg + 2 dgts)

Range: 20MΩ
Accuracy: ±(1.0% rdg + 5 dgts)

Battery Test
Range: 1.5V, 9V, 12V
Accuracy: ±(10% rdg + 2 dgts)

Diode Test
Resolution: 1mV