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Diagnosis and Troubleshooting of Automotive Electrical, Electronic, and Computer Systems

Fifth Edition

By

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Chapter 30: Computer Sensors

PROFESSIONAL TECHNICIAN

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PEARSON AUTOMOTIVE

ENGINE COOLANT TEMPERATURE SENSORS

Purpose and Function

- Computer-equipped vehicles use an **engine coolant temperature (ECT)** sensor.
- When the engine is cold, the fuel mixture must be richer to prevent stalling and engine stumble.
- The ECT sensor is also used as an important input for the following:
  – Cold engine start up air-fuel ratio calculation
  – Idle air control (IAC) position
  – Canister purge on/off times
  – Idle speed

ENGINE COOLANT TEMPERATURE SENSORS
Purpose and Function

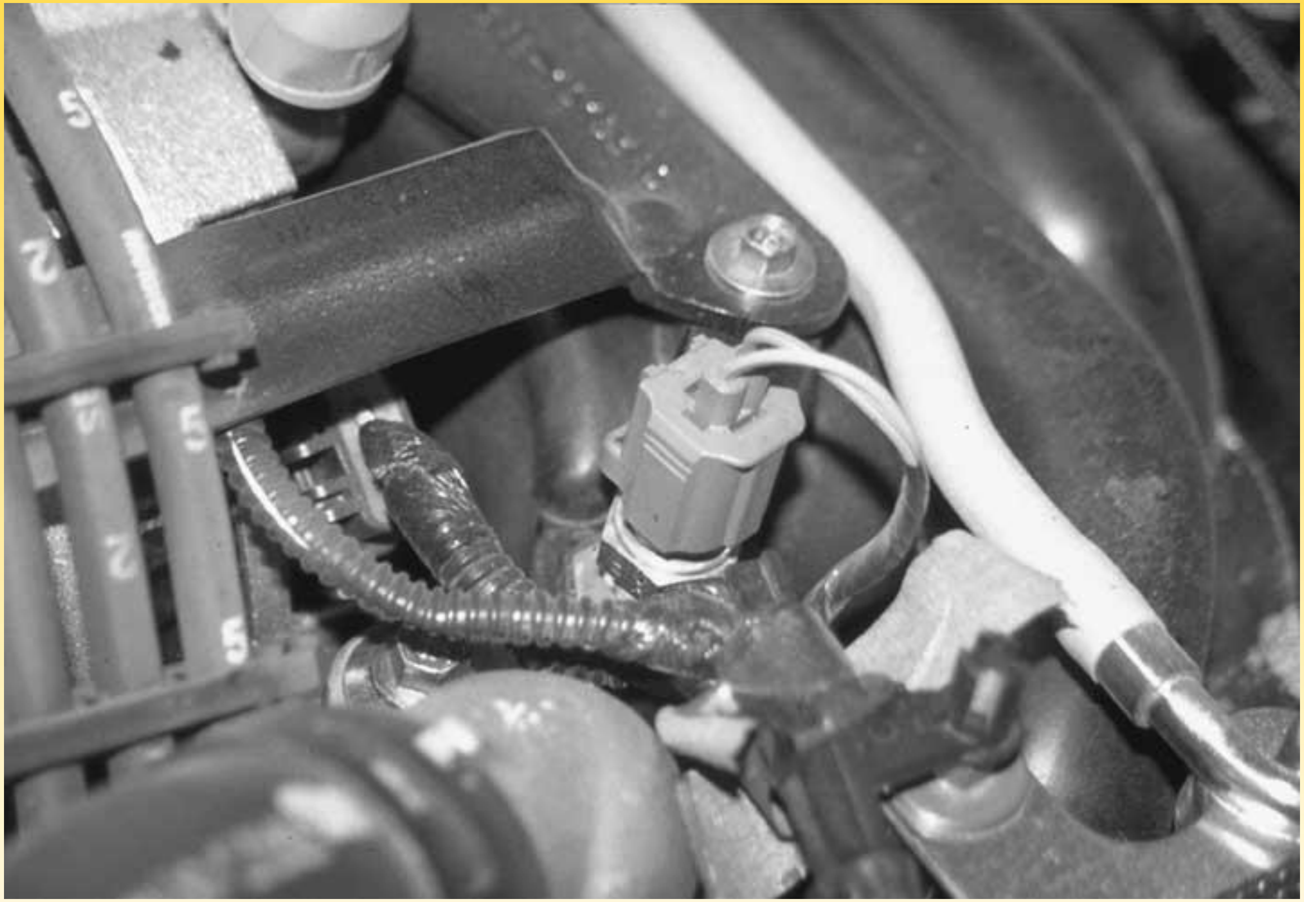

FIGURE 30-1 A typical engine coolant temperature (ECT) sensor. ECT sensors are located near the thermostat housing on most engines.

ENGINE COOLANT TEMPERATURE SENSORS

Construction and Operation

- Engine coolant temperature sensors are constructed of a semiconductor material that decreases in resistance as the temperature of the sensor increases.
- Coolant sensors have very high resistance when the coolant is cold and low resistance when the coolant is hot.
- This is referred to as having a **negative temperature coefficient (NTC),** which is opposite to the situation with most other electrical components.

ENGINE COOLANT TEMPERATURE SENSORS

Construction and Operation

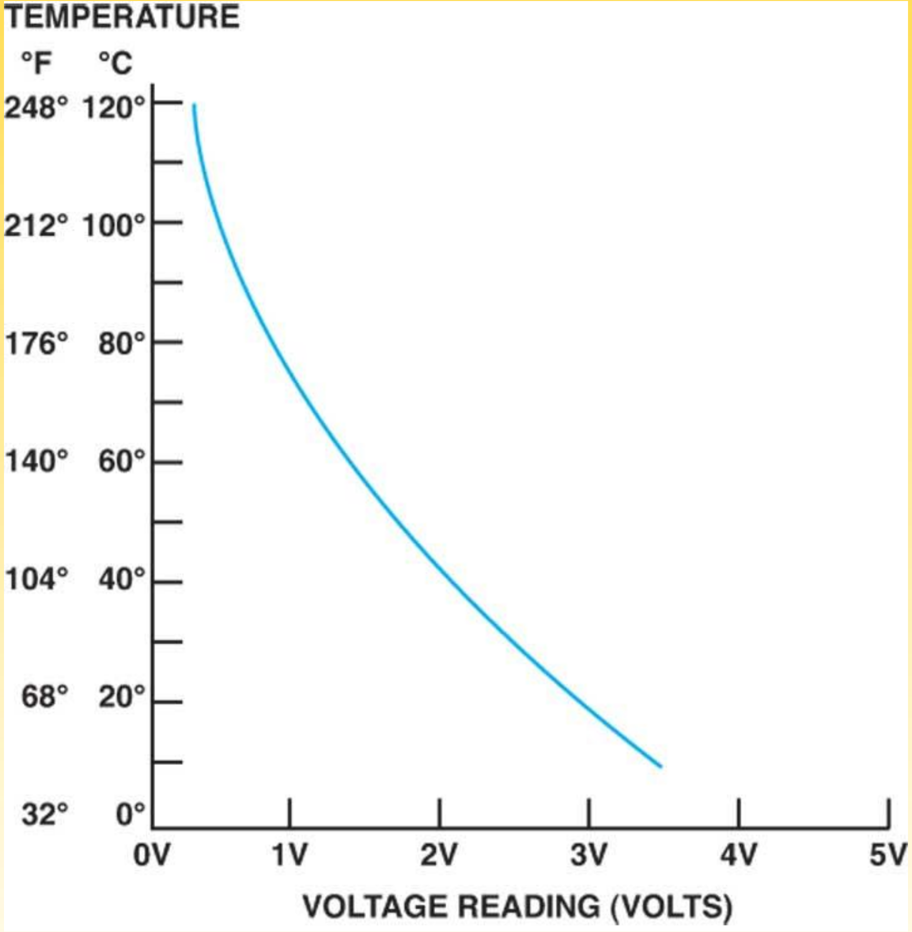

FIGURE 30-2 A typical ECT sensor temperature versus voltage curve.

ENGINE COOLANT TEMPERATURE SENSORS

Stepped ECT Circuits

- Some vehicle manufacturers use a step-up resistor to effectively broaden the range of the ECT sensor.
- Chrysler and General Motors vehicles use the same sensor as a nonstepped ECT circuit, but instead the computer of these vehicles applies the sensor voltage through two different resistors.

ENGINE COOLANT TEMPERATURE SENSORS

Stepped ECT Circuits

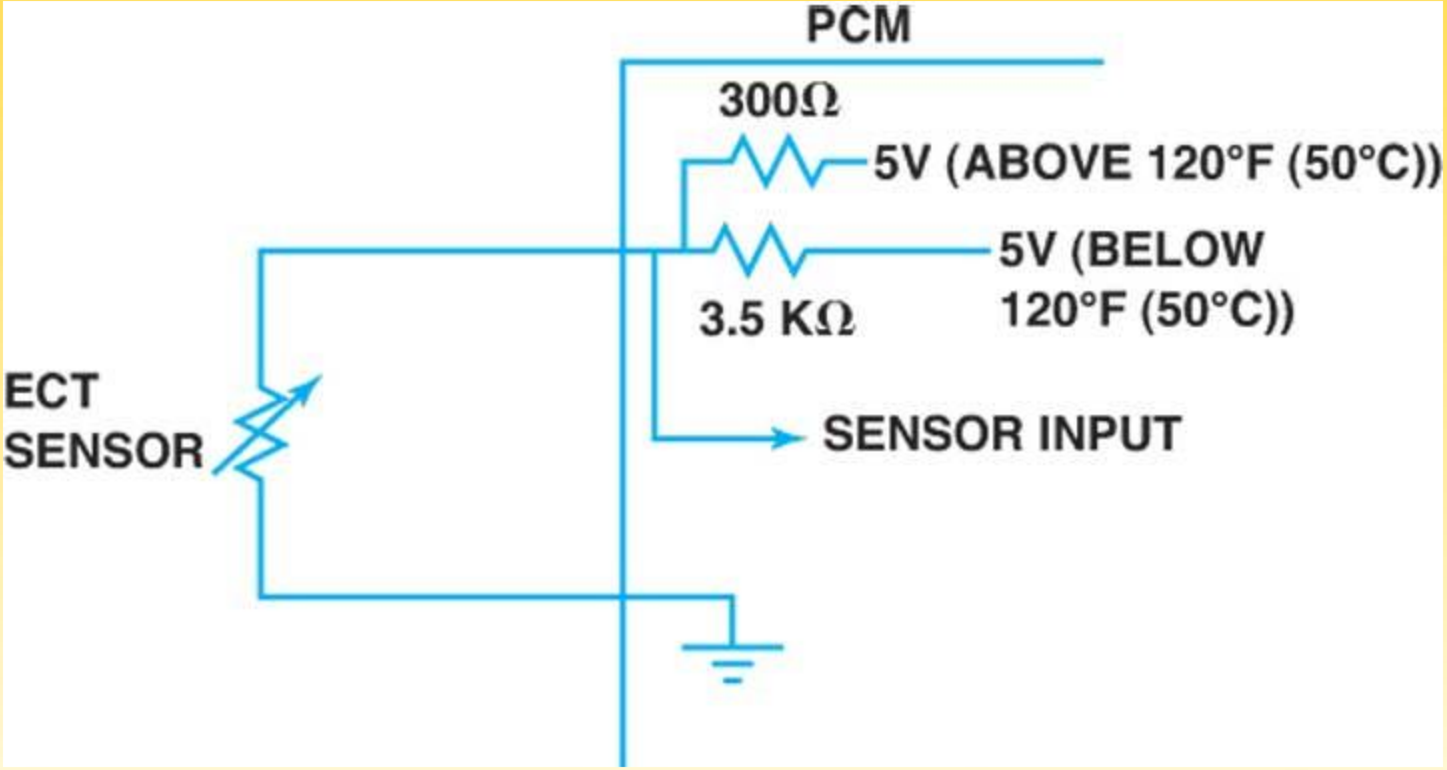

FIGURE 30-3 A typical two-step ECT circuit showing that when the coolant temperature is low, the PCM applies a 5-volt reference voltage to the ECT sensor through a higher resistance compared to when the temperature is higher.

ENGINE COOLANT TEMPERATURE SENSORS

Stepped ECT Circuits

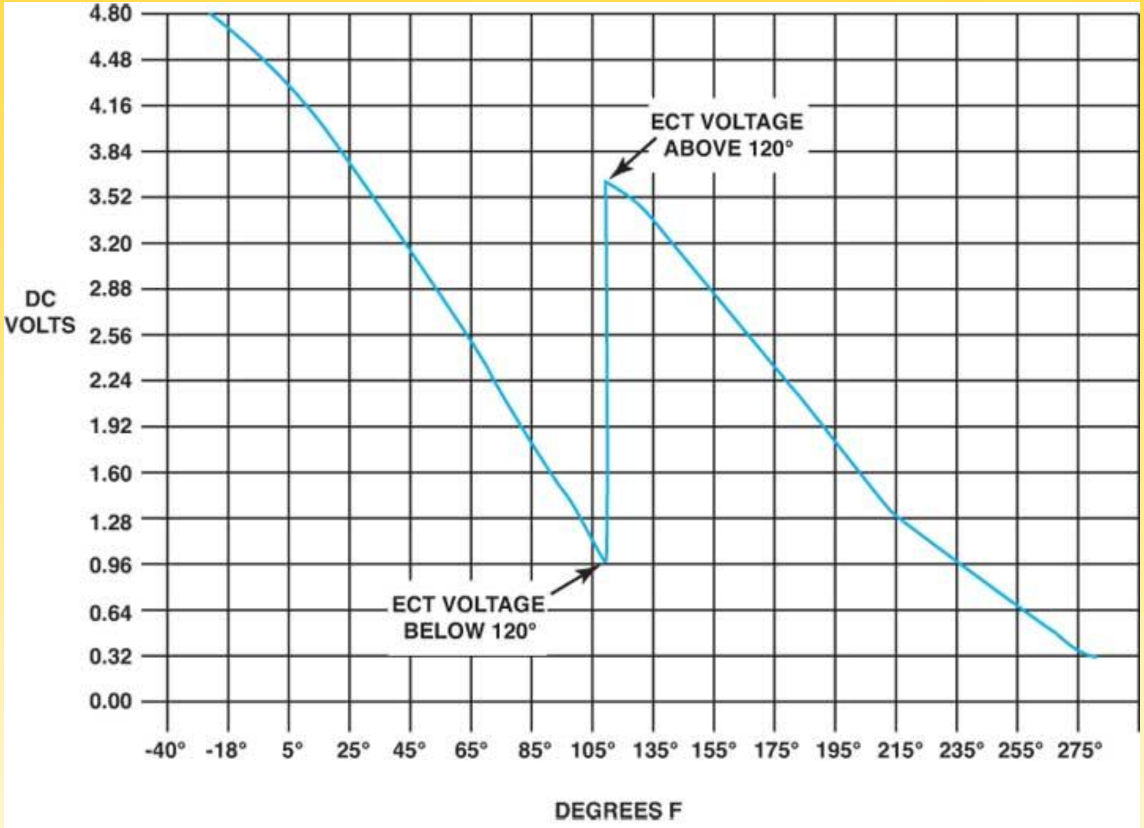

FIGURE 30-4 The transitions between steps usually occur at a temperature that would not interfere with cold engine starts or the cooling fan operation. In this example, the transition occurs when the sensor voltage is about 1 volt and rises to about 3.6 volts.

TESTING THE ENGINE COOLANT TEMPERATURE SENSOR

- **Testing the ECT Using a Multimeter**
- **Testing the ECT Sensor Using a Scan Tool**

TESTING THE ENGINE COOLANT TEMPERATURE SENSOR

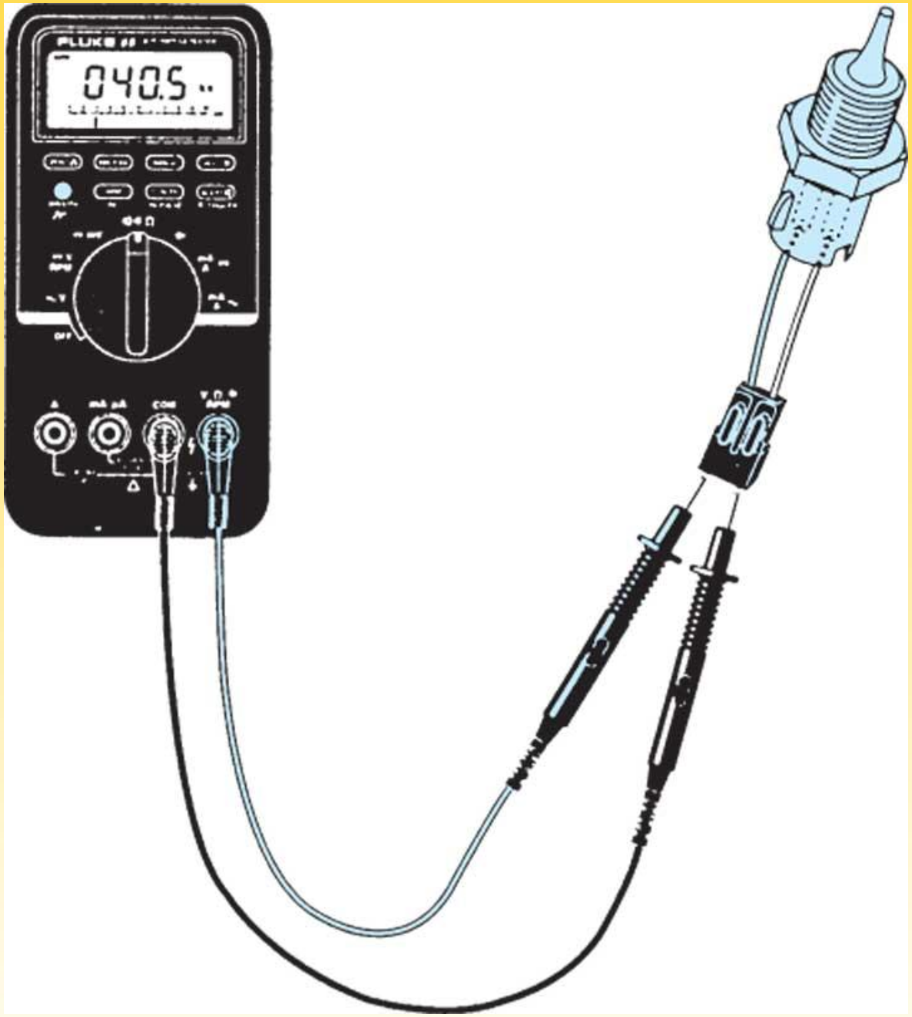

FIGURE 30-5 Measuring the resistance of the ECT sensor. The resistance measurement can then be compared with specifications. *(Courtesy of Fluke Corporation)*

TESTING THE ENGINE COOLANT TEMPERATURE SENSOR

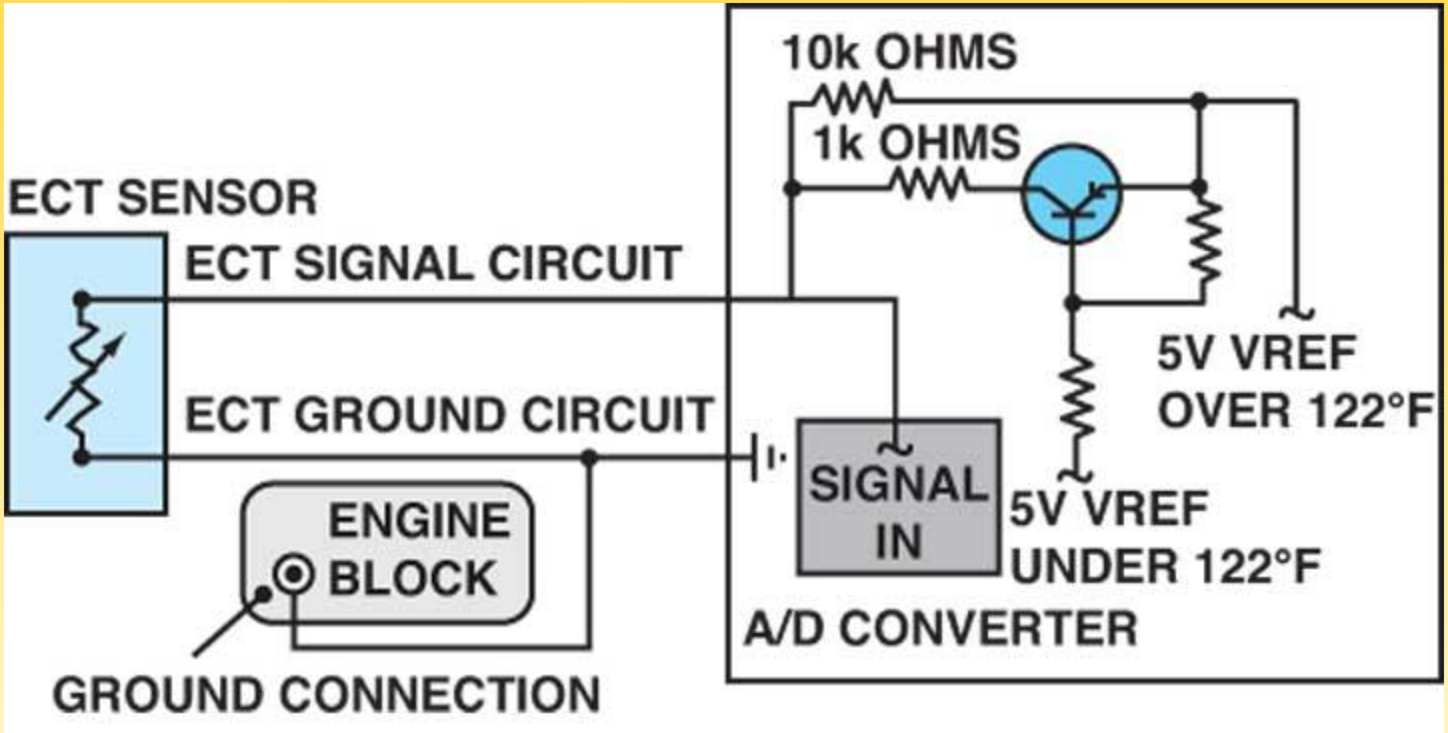

FIGURE 30-6 When the voltage drop reaches approximately 1.20 volts, the PCM turns on a transistor. The transistor connects a 1-kΩresistor in parallel with the 10 kΩresistor. Total circuit resistance now drops to around 909 ohms. This function allows the PCM to have full binary control at cold temperatures up to approximately 122° F, and a second full binary control at temperatures greater than 122° F.

TESTING THE ENGINE COOLANT TEMPERATURE SENSOR

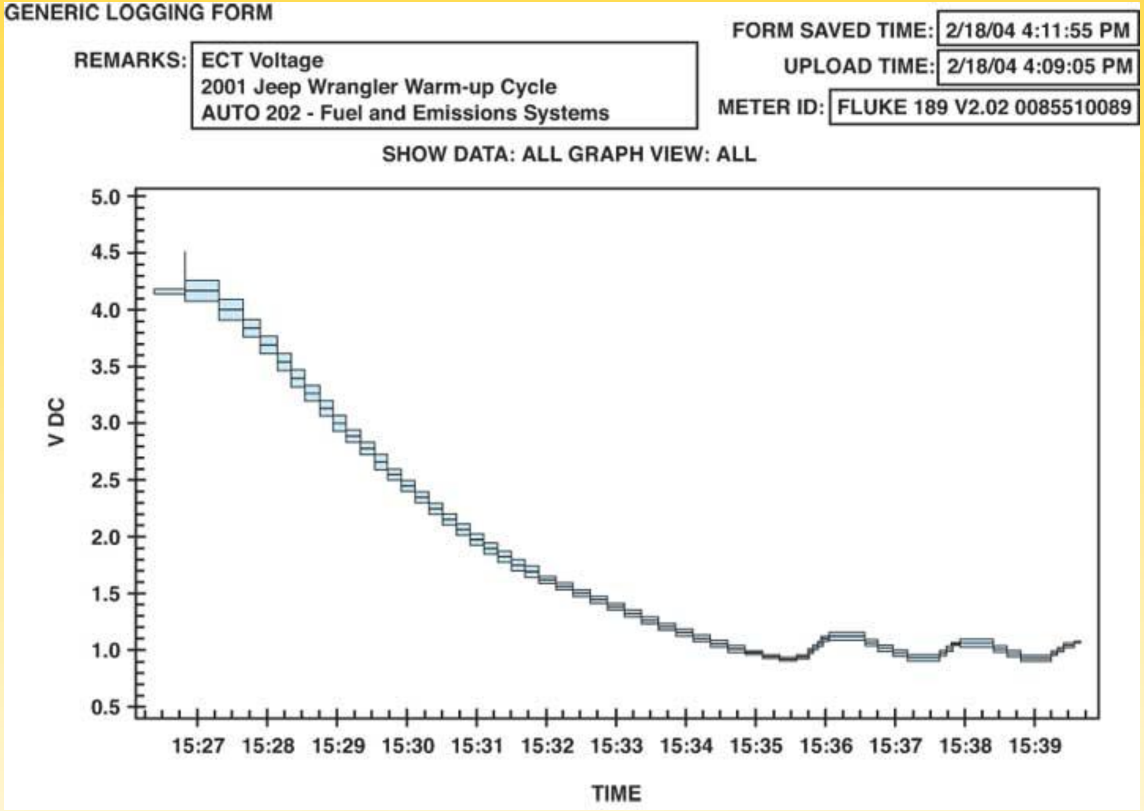

FIGURE 30-7 A chart showing the voltage decrease of the ECT sensor as the temperature increases from a cold start. The bumps at the bottom of the waveform represent temperature decreases when the thermostat opens and is controlling coolant temperature.

INTAKE AIR TEMPERATURE SENSOR

- The **intake air temperature (IAT)** sensor is a negative temperature coefficient (NTC) thermistor because it decreases in resistance as the temperature of the sensor increases.
- The IAT sensor can be located in one of the following locations:
  - In the air cleaner housing
  - In the air duct between the air filter and the throttle body
  - Built into the mass airflow (MAF) or airflow sensor
  - Screwed into the intake manifold where it senses the temperature of the air entering the cylinders

INTAKE AIR TEMPERATURE SENSOR

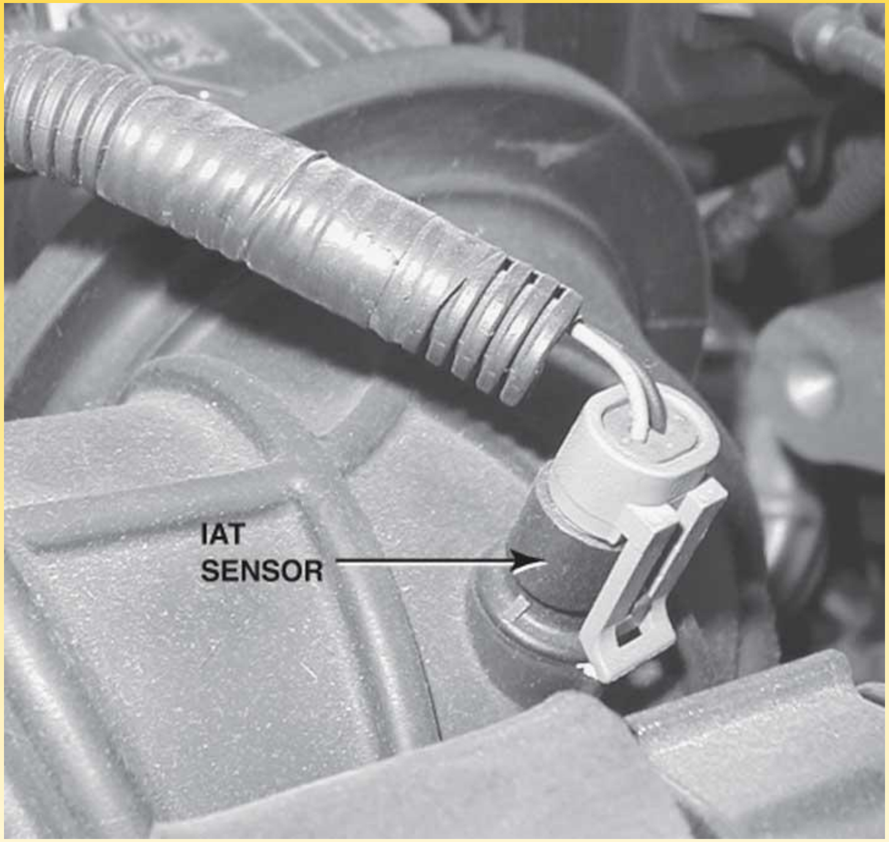

FIGURE 30-8 The IAT sensor on this General Motors 3800 V-6 engine is in the air passage duct between the air cleaner housing and the throttle plate.

TESTING THE INTAKE AIR TEMPERATURE SENSOR

- If the intake air temperature sensor circuit is damaged or faulty, a diagnostic trouble code (DTC) is set and the malfunction indicator lamp (MIL) may or may not be on, depending on the condition and the type and model of the vehicle.

WHAT EXACTLY IS AN NTC SENSOR?

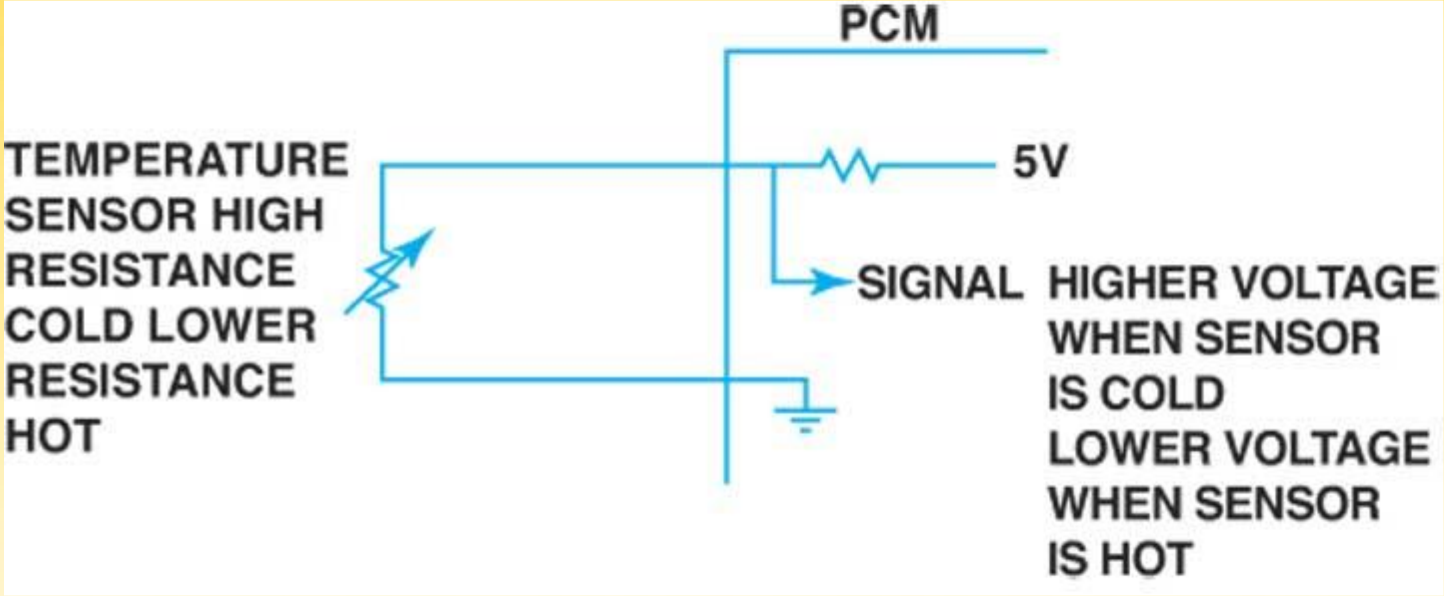

FIGURE 30-9 A typical temperature sensor circuit.

TEMPERATURE SENSOR DIAGNOSTIC TROUBLE CODES

- The OBD II diagnostic trouble codes that relate to temperature sensors include both high- and low-voltage codes, as well as intermittent codes.

THROTTLE POSITION SENSORS

- **Purpose and Function**
- **Parts and Operation**

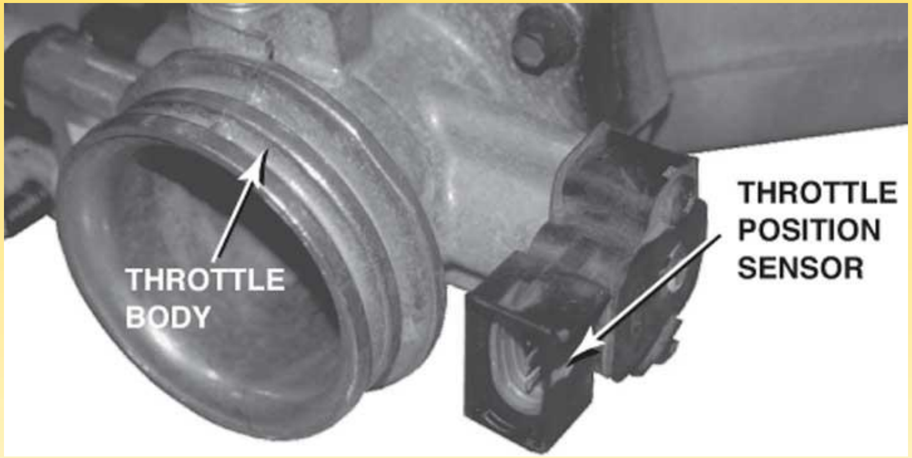

FIGURE 30-10 A typical TP sensor mounted on the throttle plate of this port-injected engine.

THROTTLE POSITION SENSORS

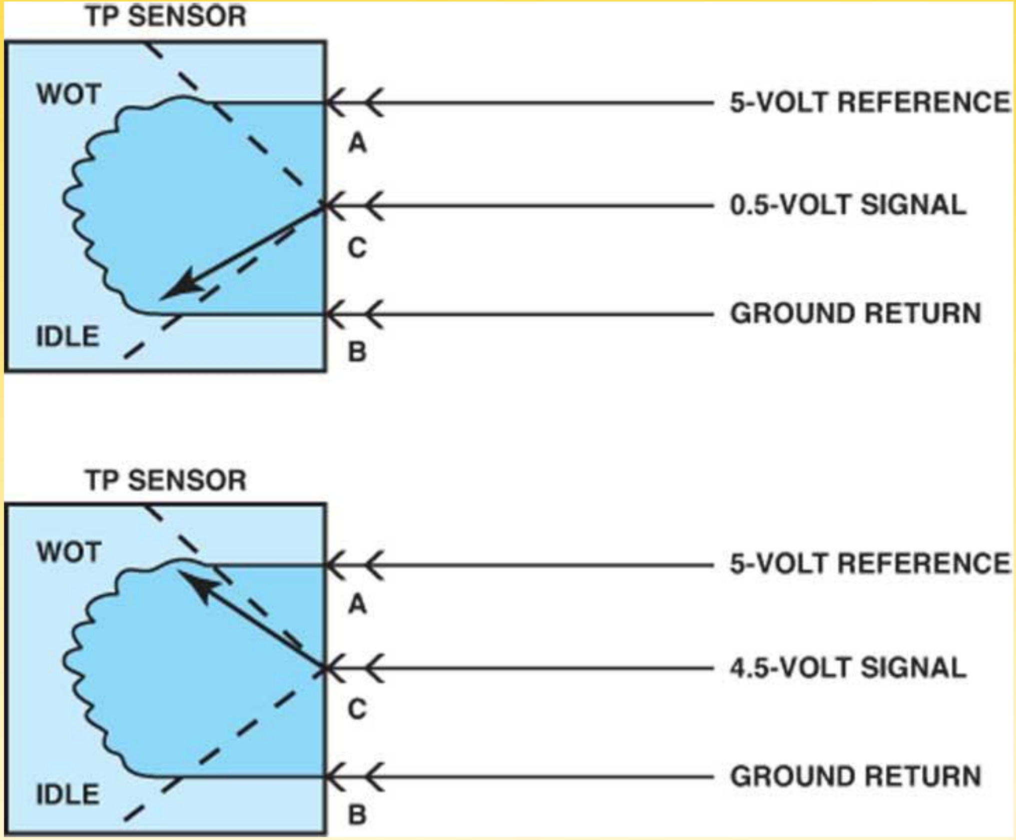

FIGURE 30-11 The signal voltage from a throttle position increases as the throttle is opened because the wiper arm is closer to the 5-volt reference. At idle, the resistance of the sensor winding effectively reduces the signal voltage output to the computer.

TP SENSOR COMPUTER INPUT FUNCTIONS

- The computer senses this change in throttle position and changes the fuel mixture and ignition timing.
- The throttle position (TP) sensor used on fuel-injected vehicles acts as an “electronic accelerator pump.”
- The PCM supplies the TP sensor with a regulated voltage that ranges from 4.8 to 5.1 volts.

PCM USES FOR THE TP SENSOR

- The TP sensor is used by the powertrain control module (PCM) for the following reasons.
  - **Clear Flood Mode**
  - **Torque Converter Clutch Engagement and Release**
  - **Rationality Testing for MAP and MAF Sensors**
  - **Automatic Transmission Shift Points**
  - **Target Idle Speed (Idle Control Strategy)**
  - **Air-Conditioning Compressor Operation**
  - **Backs Up Other Sensors**

TESTING THE THROTTLE POSITION SENSOR

- A TP sensor can be tested using one or more of the following tools:
  - A digital voltmeter with three test leads connected in series between the sensor and the wiring harness connector or back probing using T-pins.
  - A scan tool or a specific tool recommended by the vehicle manufacturer.
  - A breakout box that is connected in series between the computer and the wiring harness connector(s).
  - An oscilloscope.

TESTING THE THROTTLE POSITION SENSOR

FIGURE 30-12 A meter lead connected to a T-pin that was gently pushed along the signal wire of the TP sensor until the point of the pin touched the metal terminal inside the plastic connector.

TESTING THE THROTTLE POSITION SENSOR

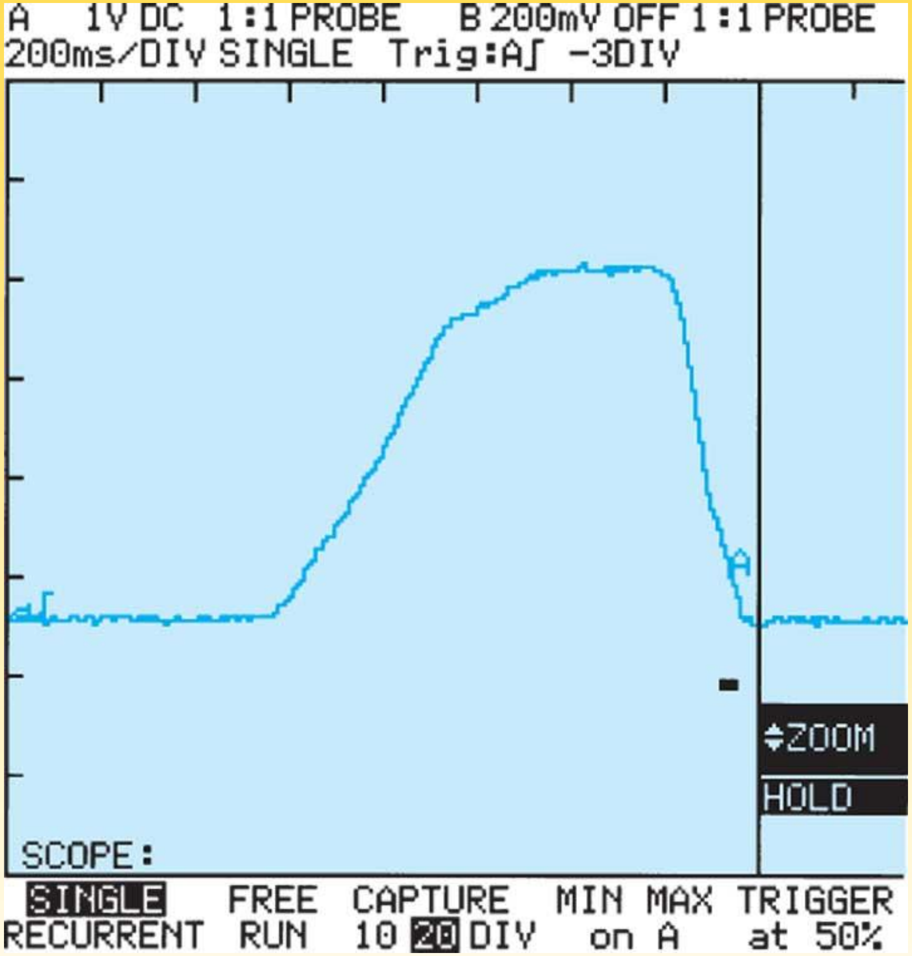

FIGURE 30-13 A typical waveform of a TP sensor signal as recorded on a DSO when the accelerator pedal was depressed with the ignition switch on (engine off). Clean transitions and the lack of any glitches in this waveform indicate a good sensor. *(Courtesy of Fluke Corporation)*

TESTING THE THROTTLE POSITION SENSOR

Testing a TP Sensor Using the MIN/MAX Function

- To perform a MIN/MAX test of the TP sensor, manually set the meter to read higher than 4 volts.
  - Connect the red meter lead to the signal wire and the black meter lead to a good ground on the ground return wire at the TP sensor.
  - With the ignition on, engine off, slowly depress and release the accelerator pedal from inside the vehicle.
  - Check the minimum and maximum voltage reading on the meter display. Any 0 or 5-volt reading would indicate a fault or short in the TP sensor.

CHECK POWER AND GROUND BEFORE CONDEMNING A BAD SENSOR

FIGURE 30-14 Checking the 5-volt reference from the computer being applied to the TP sensor with the ignition switch on (engine off).

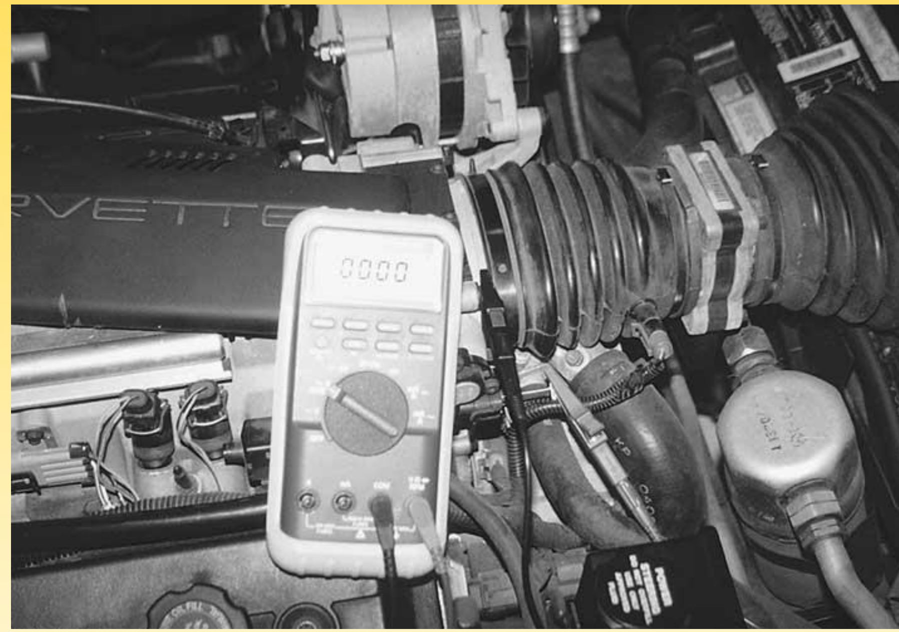

FIGURE 30-15 Checking the voltage drop between the TP sensor ground and a good engine ground with the ignition on (engine off). A reading of greater than 0.6 volt (600 mV) represents a bad computer ground.

TESTING THE TP SENSOR USING A SCAN TOOL

- A scan tool can be used to check for proper operation of the throttle position sensor using the following steps.
  - With the key on, engine off, the TP sensor voltage display should be about 0.5 volt but can vary from as low as 0.3 volt to as high as 1.2 volts.
  - Check the scan tool display for the percentage of throttle opening. The reading should be zero and gradually increase in percentage as the throttle is depressed.
  - The idle air control (IAC) counts should increase as the throttle is opened and decrease as the throttle is closed. Start the engine and observe the IAC counts as the throttle is depressed.
  - Start the engine and observe the TP sensor reading.

TP SENSOR DIAGNOSTIC TROUBLE CODES

- The diagnostic trouble codes (DTCs) associated with the throttle position sensor include the following:

Diagnostic Trouble Code	Description	Possible Causes
P0122	TP sensor low voltage	▪ TP sensor internally shorted-to-ground ▪ TP sensor wiring shorted-to-ground ▪ TP sensor or wiring open
P0123	TP sensor high voltage	▪ TP sensor internally shorted to 5-volt reference ▪ TP sensor wiring shorted-to-voltage
P0121	TP sensor signal does not agree with MAP	▪ Defective TP sensor ▪ Incorrect vehicle-speed (VS) sensor signal ▪ MAP sensor out-of-calibration or defective

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSORS

- The **manifold absolute pressure (MAP) sensor** is used by the engine computer to sense engine load.
  - The typical MAP sensor consists of a ceramic or silicon wafer sealed on one side with a perfect vacuum and exposed to intake manifold vacuum on the other side.
- **Silicon-Diaphragm Strain Gauge MAP Sensor**
- **Capacitor-Capsule MAP Sensor**
- **Ceramic Disc Map Sensor**

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSORS

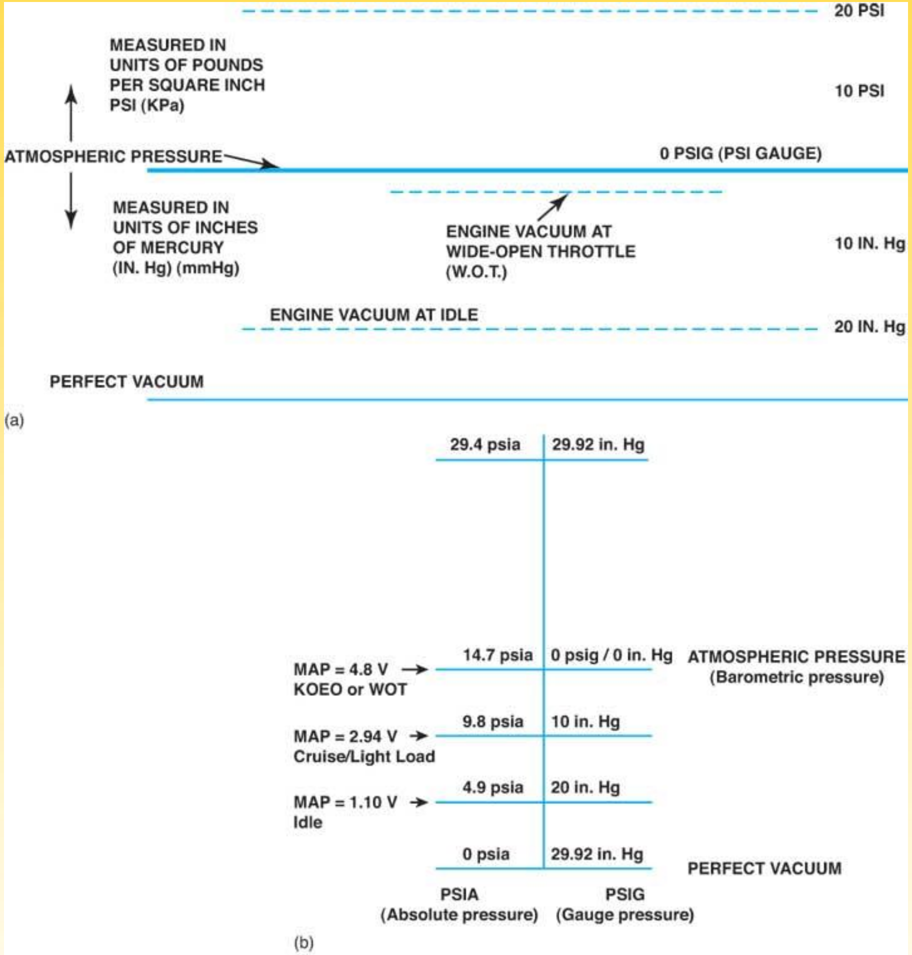

FIGURE 30-16 (a) As an engine is accelerated under a load, the engine vacuum drops. This drop in vacuum is actually an increase in absolute pressure in the intake manifold. A MAP sensor senses all pressures greater than that of a perfect vacuum. (b) The relationship between absolute pressure, vacuum, and gauge pressure.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSORS

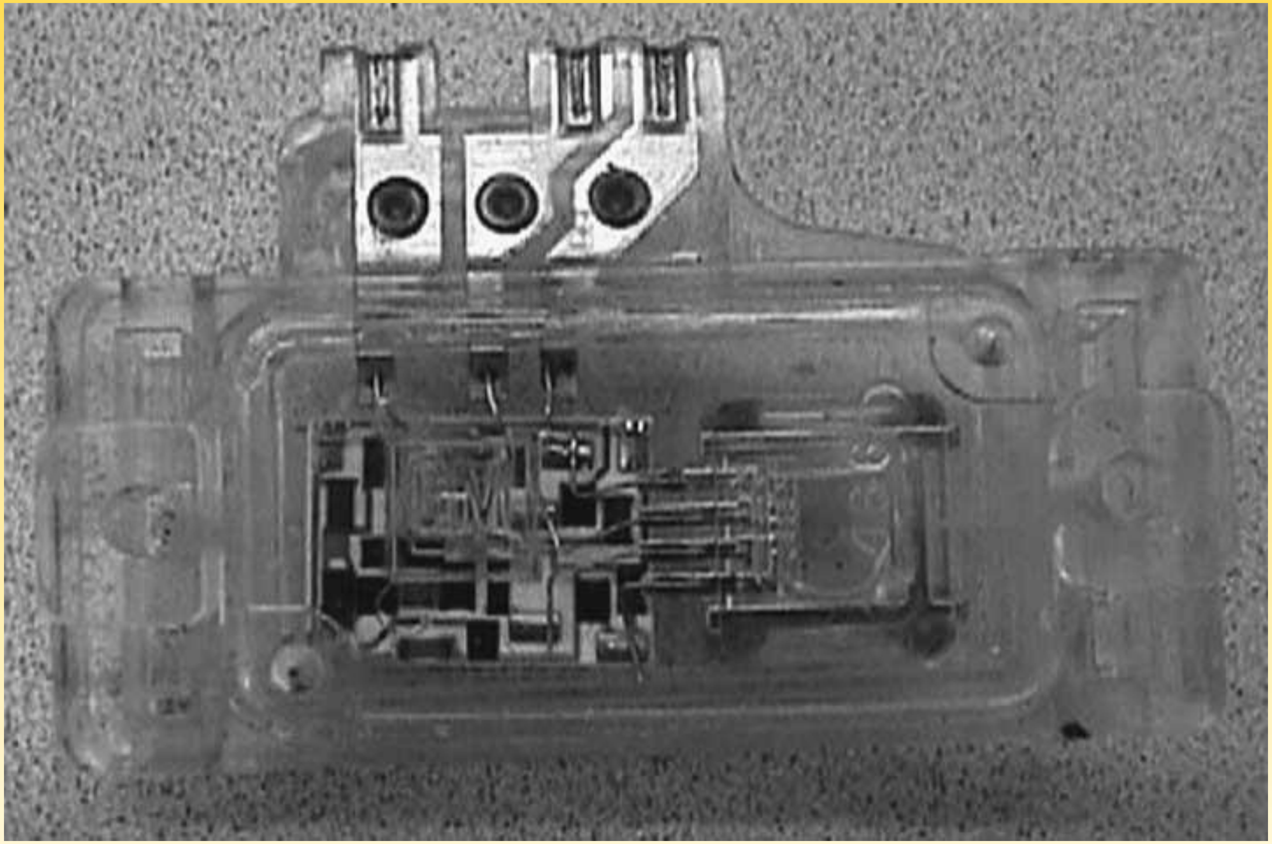

FIGURE 30-17 A plastic MAP sensor used for training purposes showing the electronic circuit board and electrical connections.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSORS

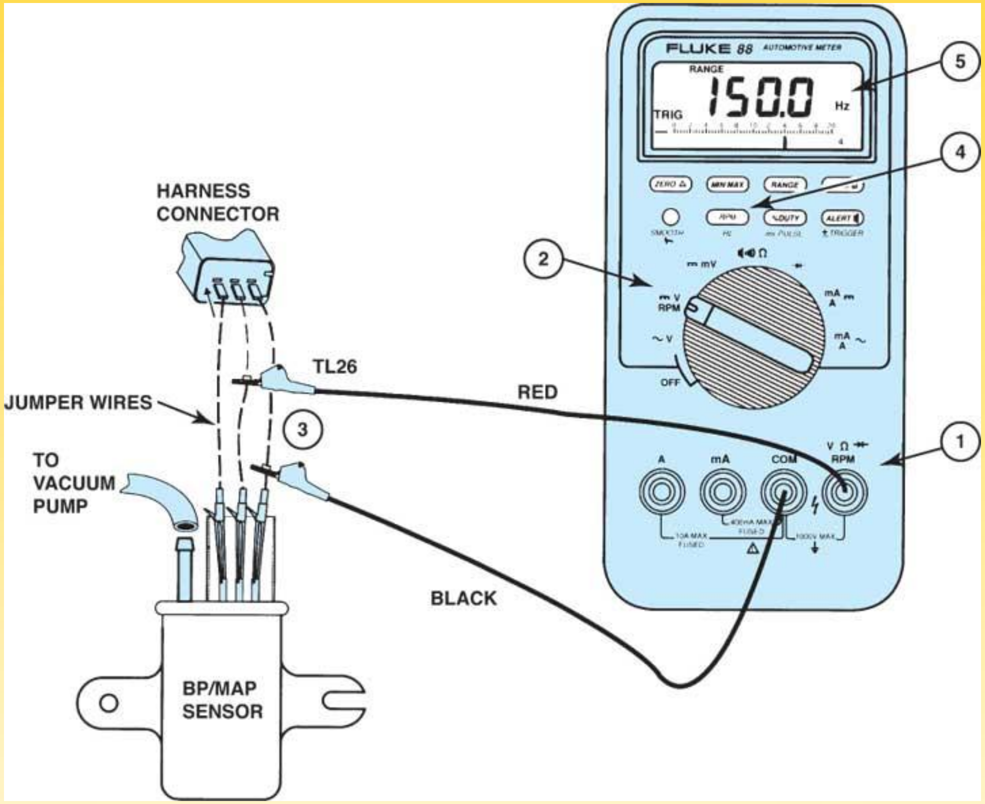

FIGURE 30-18 A DMM set to test a MAP sensor.(1) Connect the red meter lead to the V meter terminal and the black meter lead to the COM meter terminal. (2) Select DC volts. (3) Connect the test leads to the sensor signal wire and the ground wire. (4) Select hertz (Hz) if testing a MAP sensor whose output is a varying frequency; otherwise keep it on DC volts. (5) Read the change of frequency as the vacuum is applied to the sensor. Compare the vacuum reading and the frequency (or voltage) reading to the specifications. *(Courtesy of Fluke Corporation)*

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSORS

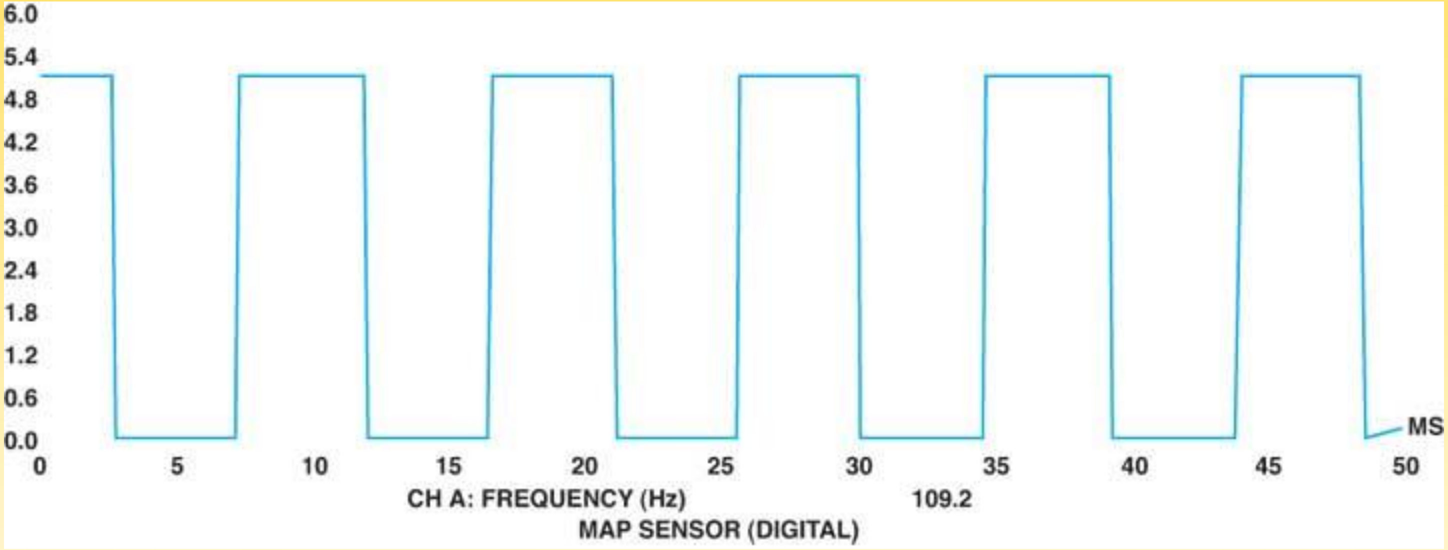

FIGURE 30-19 A waveform of a typical digital MAP sensor.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSORS

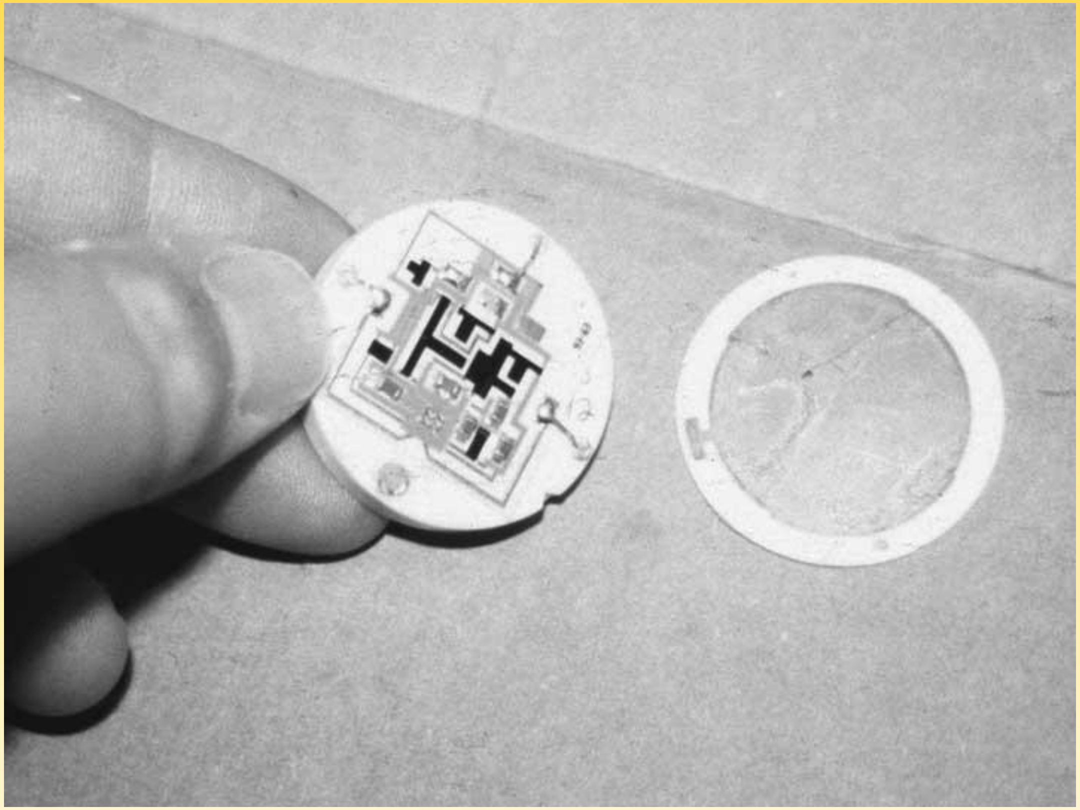

FIGURE 30-20 Shown is the electronic circuit inside a ceramic disc MAP sensor used on many Chrysler engines. The black areas are carbon resistors that are applied to the ceramic, and lasers are used to cut lines into these resistors during testing to achieve the proper operating calibration.

PCM USES OF THE MAP SENSOR

- The PCM uses the MAP sensor to determine the following:
  - **The load on the engine.**
  - **Altitude, fuel, and spark control calculations.**
  - **EGR system operation.**
  - **Detect deceleration (vacuum increases).**
  - **Monitor engine condition.**
  - **Load detection for returnless-type fuel injection.**
  - **Altitude and MAP sensor values.**

PCM USES OF THE MAP SENSOR

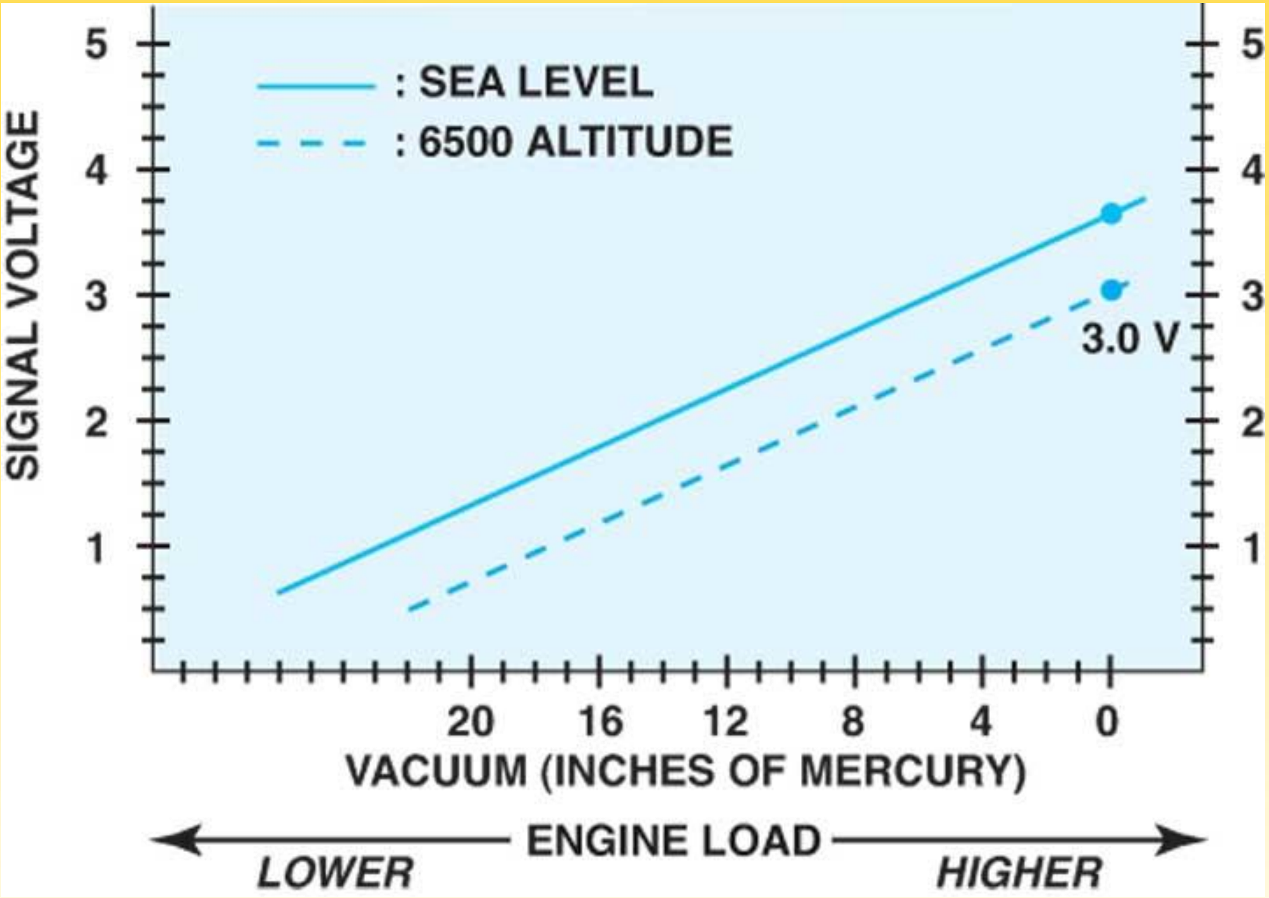

FIGURE 30-21 Altitude affects the MAP sensor voltage.

BAROMETRIC PRESSURE SENSOR

- A **barometric pressure (BARO) sensor** is similar in design, but it senses more subtle changes in barometric absolute pressure (atmospheric air pressure).
- It is vented directly to the atmosphere.
- The **barometric manifold absolute pressure (BMAP)** sensor is actually a combination of a BARO and MAP sensor in the same housing.

TESTING THE MAP SENSOR USING A DMM

- Most pressure sensors operate on 5 volts from the computer and return a signal (voltage or frequency) based on the pressure (vacuum) applied to the sensor.
- If a MAP sensor is being tested, make certain that the vacuum hose and hose fittings are sound and making a good, tight connection to a manifold vacuum source on the engine.

TESTING THE MAP SENSOR USING A DMM

- Four different types of test instruments can be used to test a pressure sensor:
  - A digital voltmeter with three test leads connected in series between the sensor and the wiring harness connector
  - A scope connected to the sensor output, power, and Ground
  - A scan tool or a specific tool recommended by the vehicle manufacturer
  - A breakout box connected in series between the computer and the wiring harness connection(s).

TESTING THE MAP SENSOR USING A SCAN TOOL

- A scan tool can be used to test a MAP sensor by monitoring the injector pulse width (in milliseconds) when vacuum is being applied to the MAP sensor using a hand-operated vacuum pump.

FIGURE 30-22 A typical hand-operated vacuum pump.

MAP/BARO DIAGNOSTIC TROUBLE CODES

- The diagnostic trouble codes (DTCs) associated with the MAP and BARO sensors include:

Diagnostic Trouble Code	Description	Possible Causes
P0106	BARO sensor out-of-range at key on	▪ MAP sensor fault ▪ MAP sensor O-ring damaged or missing
P0107	MAP sensor low voltage	▪ MAP sensor fault ▪ MAP sensor signal circuit shorted-to-ground ▪ MAP sensor 5-volt supply circuit open
P0108	Map sensor high voltage	▪ MAP sensor fault ▪ MAP sensor O-ring damaged or missing ▪ MAP sensor signal circuit shorted-to-voltage

AIR FLOW SENSORS

- Port electronic fuel-injection systems that use air flow volume for fuel calculation usually have a movable vane in the intake stream.
- The vane is part of the **vane air flow (VAF)** sensor.
- The vane is deflected by intake air flow.

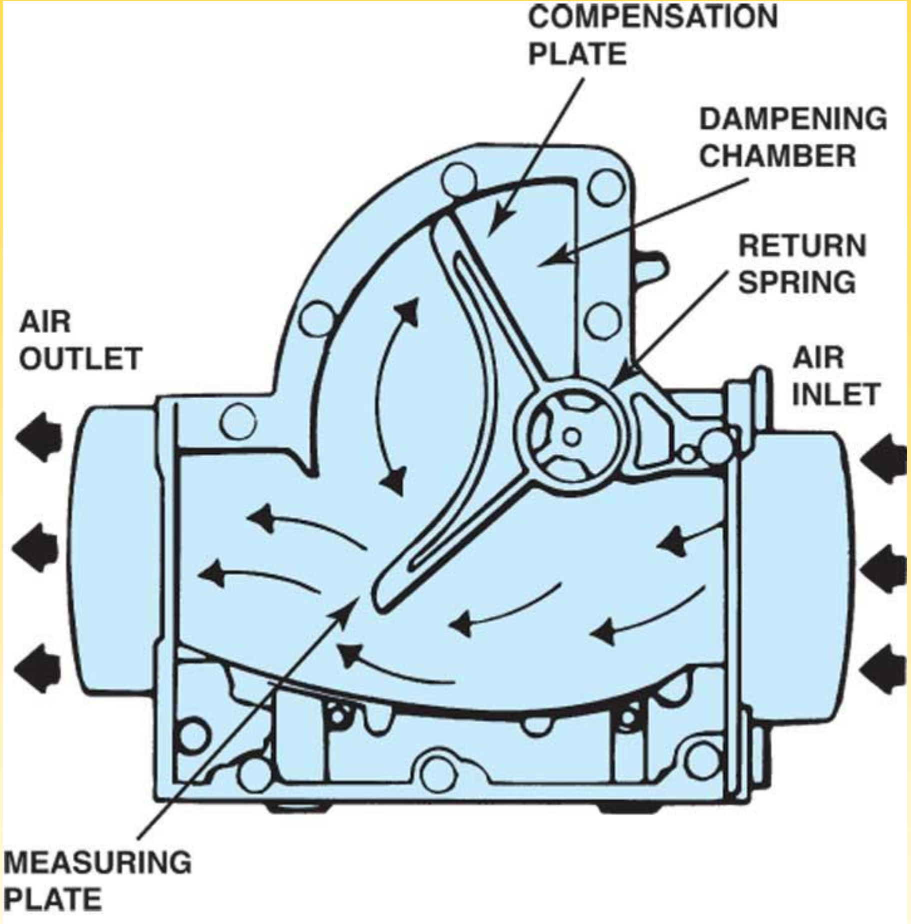

FIGURE 30-23 A vane air flow (VAF) sensor.

AIR FLOW SENSORS

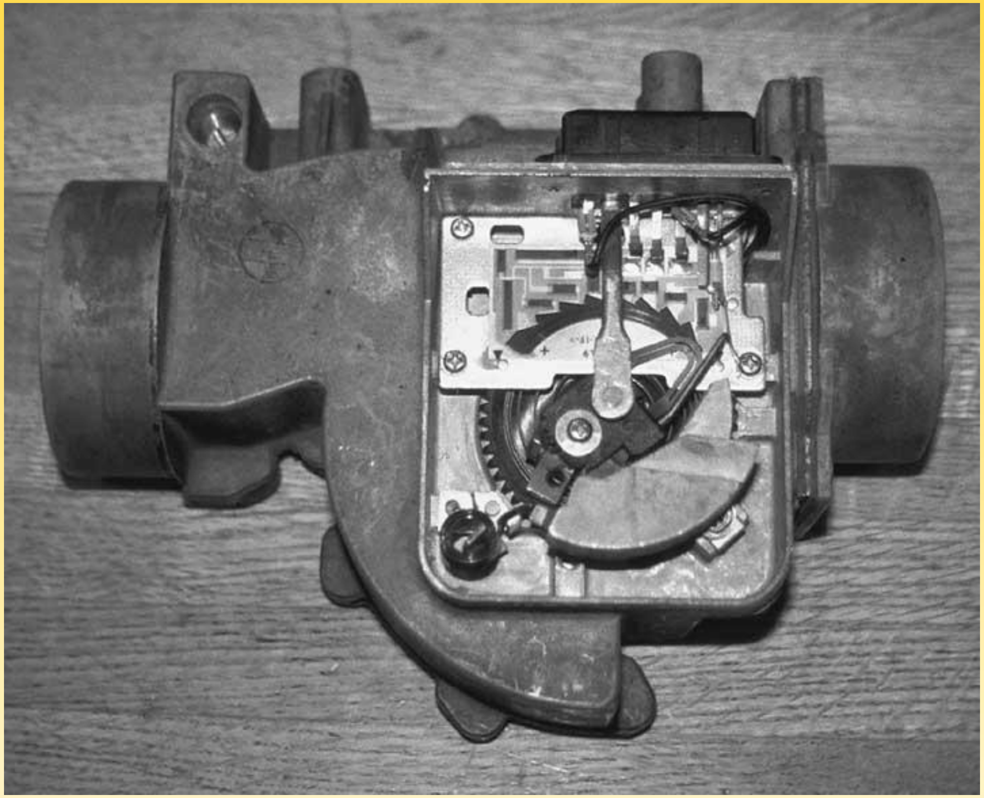

FIGURE 30-24 A typical air vane sensor with the cover removed. The movable arm contacts a carbon resistance path as the vane opens. Many air vane sensors also have contacts that close to supply voltage to the electric fuel pump as the air vane starts to open when the engine is being cranked and air is being drawn into the engine.

MASS AIR FLOW SENSOR

- There are several types of mass air flow sensors.
  - **Hot Film Sensor**
    - **Analog**
    - **Digital**
  - **Hot Wire Sensor**
    - **Burn-off Circuit**

MASS AIR FLOW SENSOR

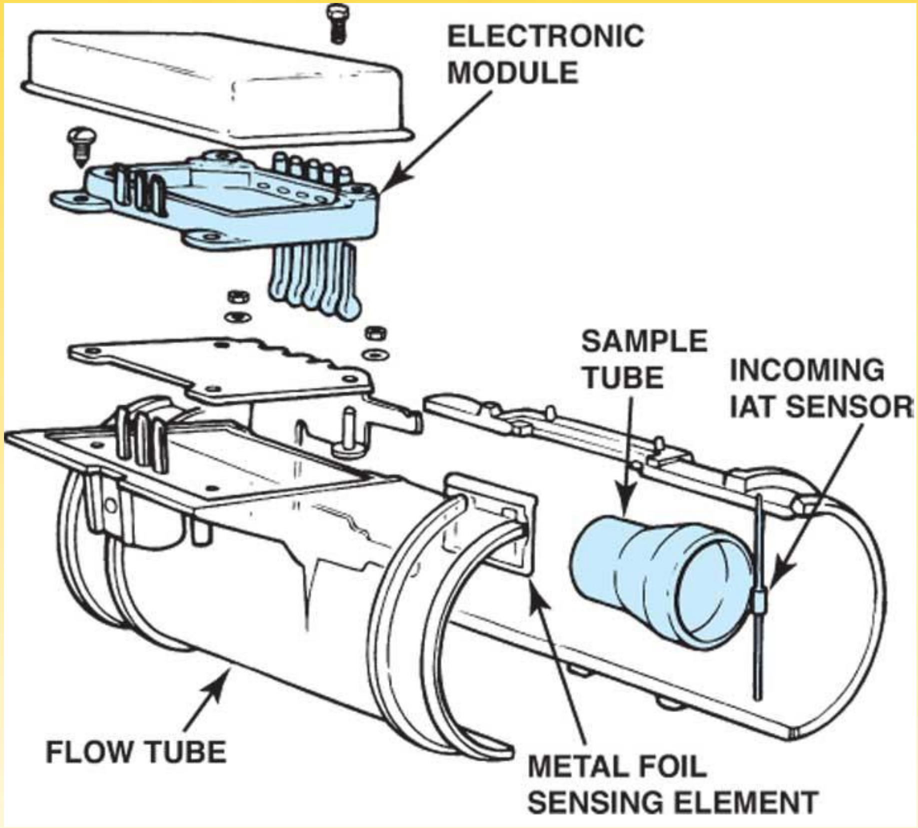

FIGURE 30-25 This five-wire mass air flow sensor consists of a metal foil sensing unit, an intake air temperature (IAT) sensor, and the electronic module.

MASS AIR FLOW SENSOR

FIGURE 30-26 The sensing wire in a typical hot wire mass air flow sensor.

PCM USES FOR AIR FLOW SENSORS

- The PCM uses the information from the air flow sensor for the following purposes:
  - Air flow sensors are used mostly to determine the amount of fuel needed and base pulse-width numbers.
  - Air flow sensors back up the TP sensor in the event of a loss of signal or an inaccurate throttle position sensor signal.

TESTING MASS AIR FLOW SENSORS

- Start the testing of a MAF sensor by performing a thorough visual inspection. Look at all the hoses that direct and send air, especially between the MAF sensor and the throttle body.
- Also check the electrical connector for:
  - Corrosion
  - Terminals that are bent or pushed out of the plastic connector
  - Frayed wiring

TESTING MASS AIR FLOW SENSORS

- **MAF Sensor Output Test**
- **Tap Test**
- **Digital Meter Test of an MAF Sensor**
- **Contaminated Sensor Test**
- **MAF-Related Diagnostic Trouble Codes**

WHAT IS FALSE AIR?

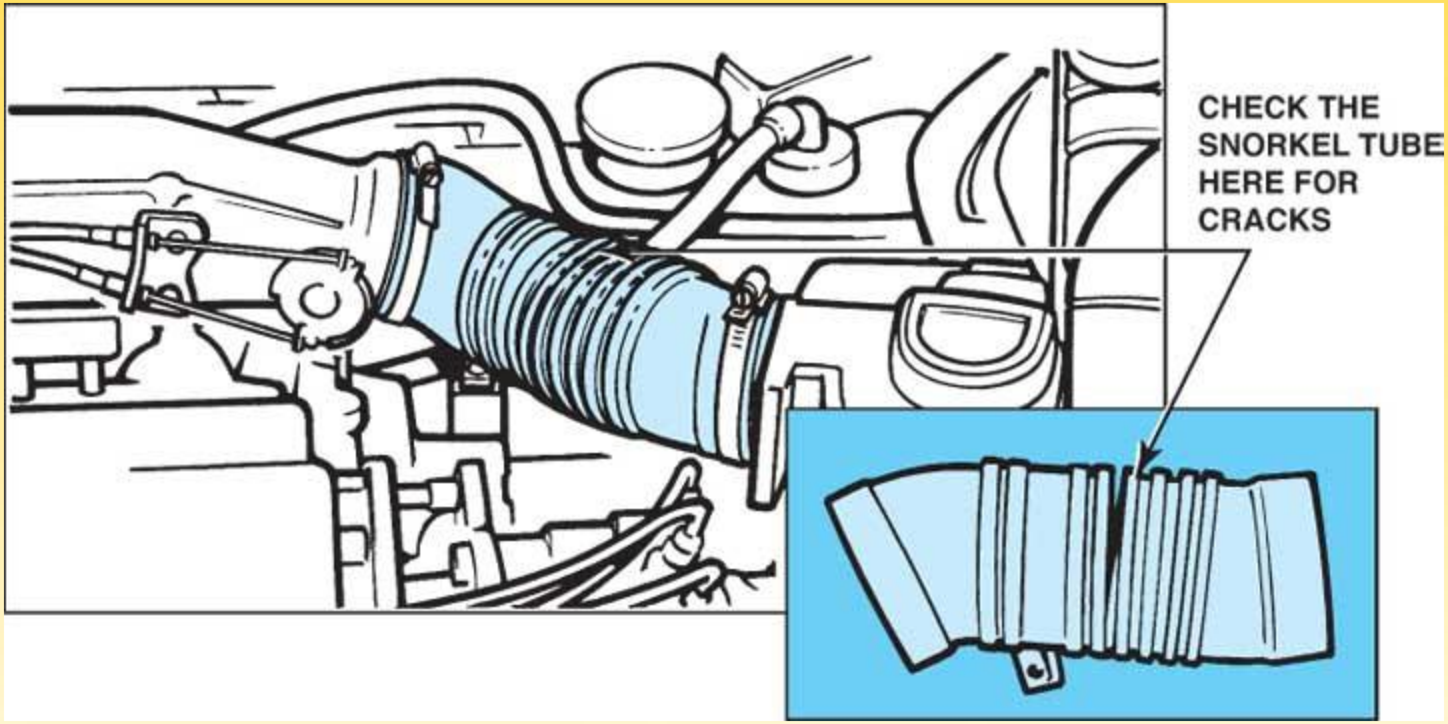

FIGURE 30-28 Carefully check the hose between the MAF sensor and the throttle plate for cracks or splits that could create extra (false) air into the engine that is not measured by the MAF sensor.

THE RICHRUNNING TOYOTA

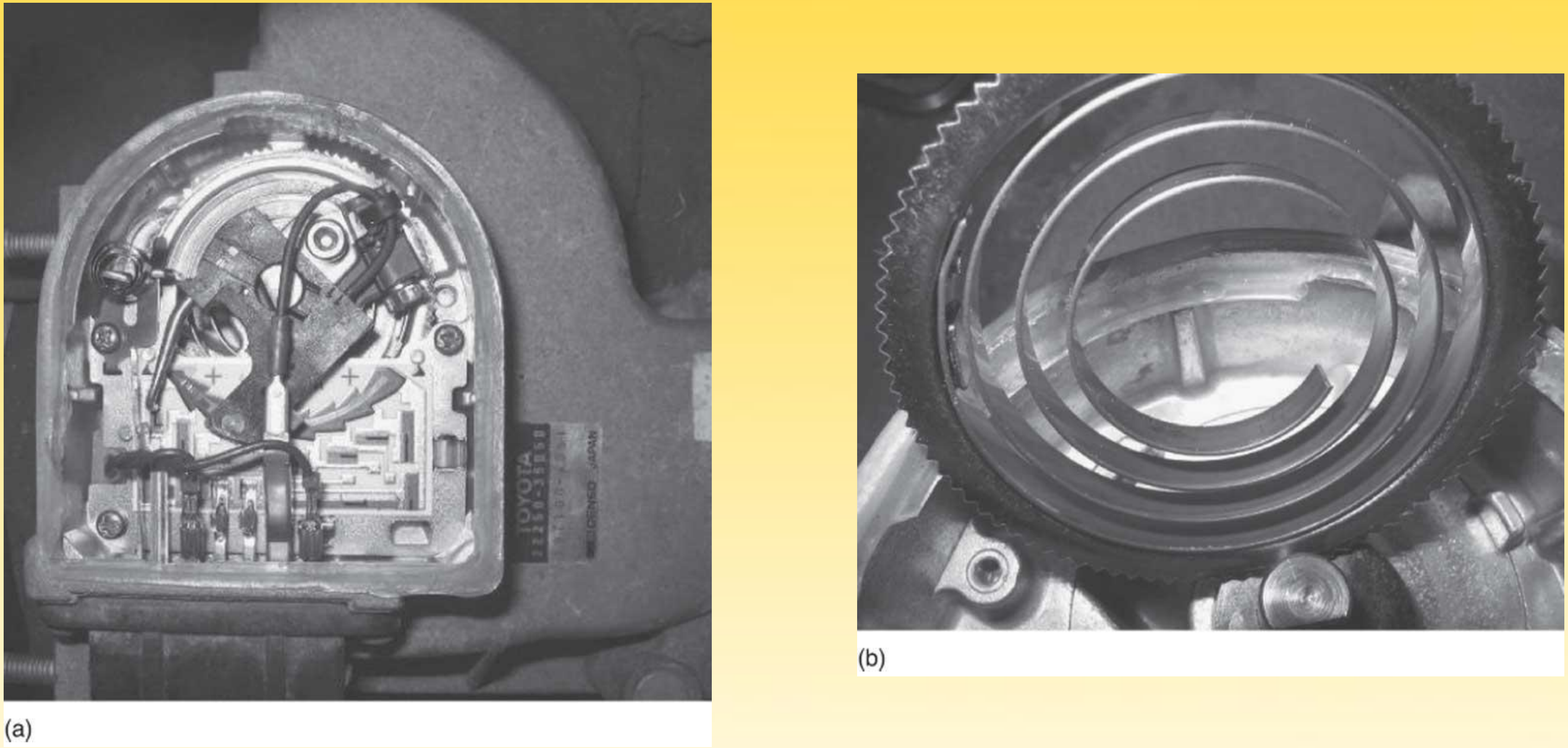

FIGURE 30-29 (left) Air flow sensor with the protective cover removed. (right) Broken air flow vane return spring.

OXYGEN SENSORS

- Most automotive computer systems use a sensor in the exhaust system to measure the oxygen content of the exhaust.
  - These sensors are called oxygen sensors (O2S).
- The oxygen sensor is installed in the exhaust manifold or located downstream from the manifold in the exhaust pipe.

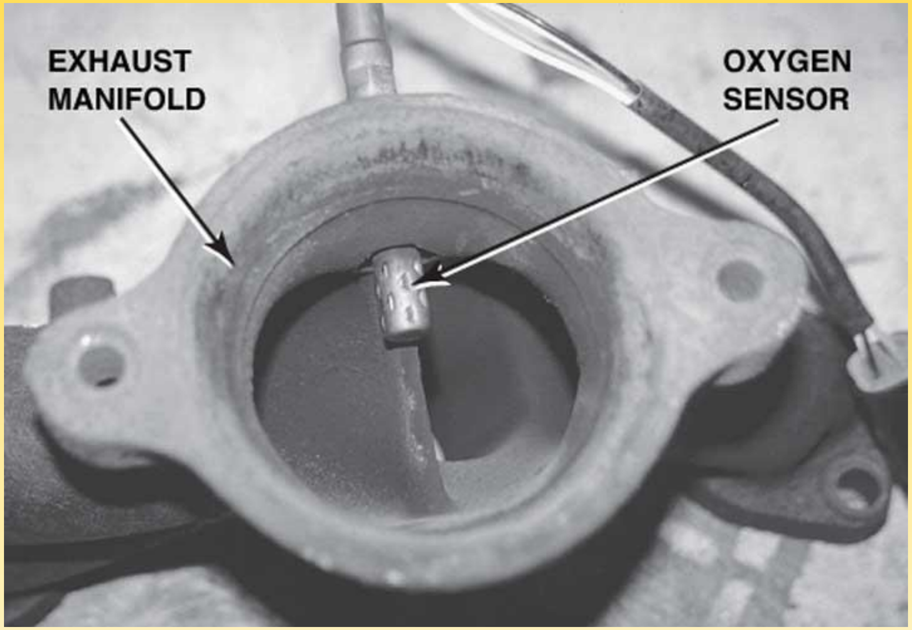

FIGURE 30-30 Many fuel-control oxygen sensors are located in the exhaust manifold near its outlet so that the sensor can detect the presence or absence of oxygen in the exhaust stream for all cylinders that feed into the manifold.

OXYGEN SENSORS

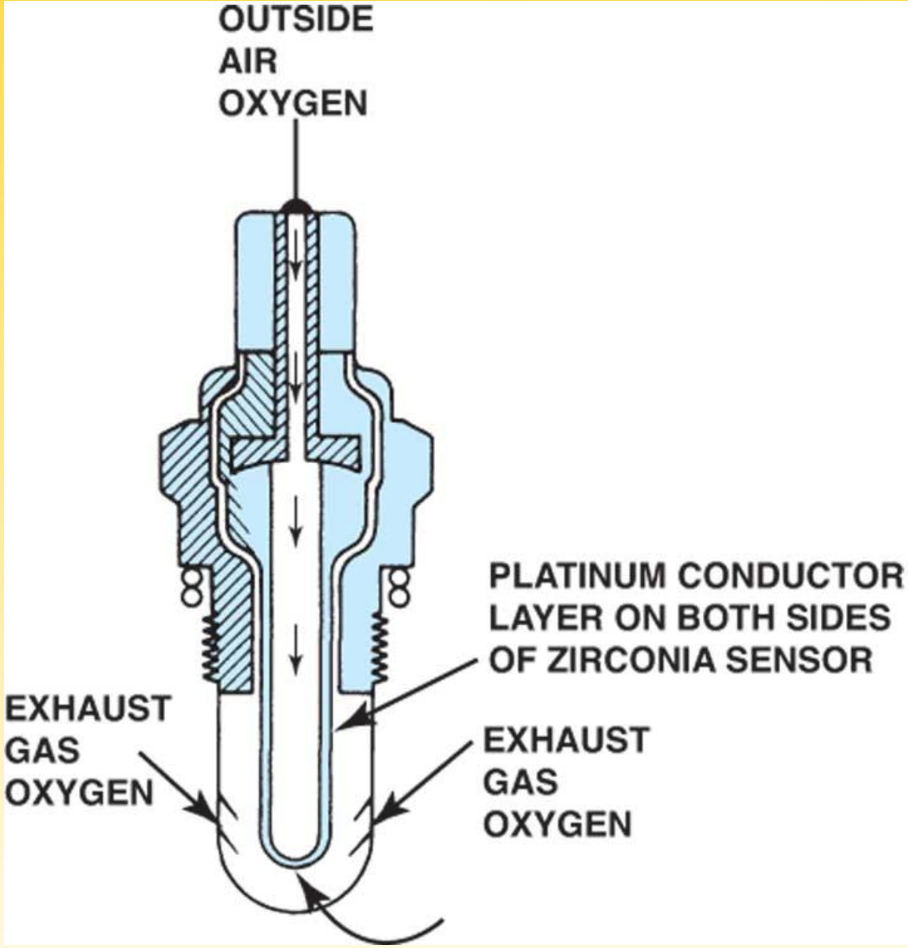

FIGURE 30-31 A cross-sectional view of a typical zirconia oxygen sensor.

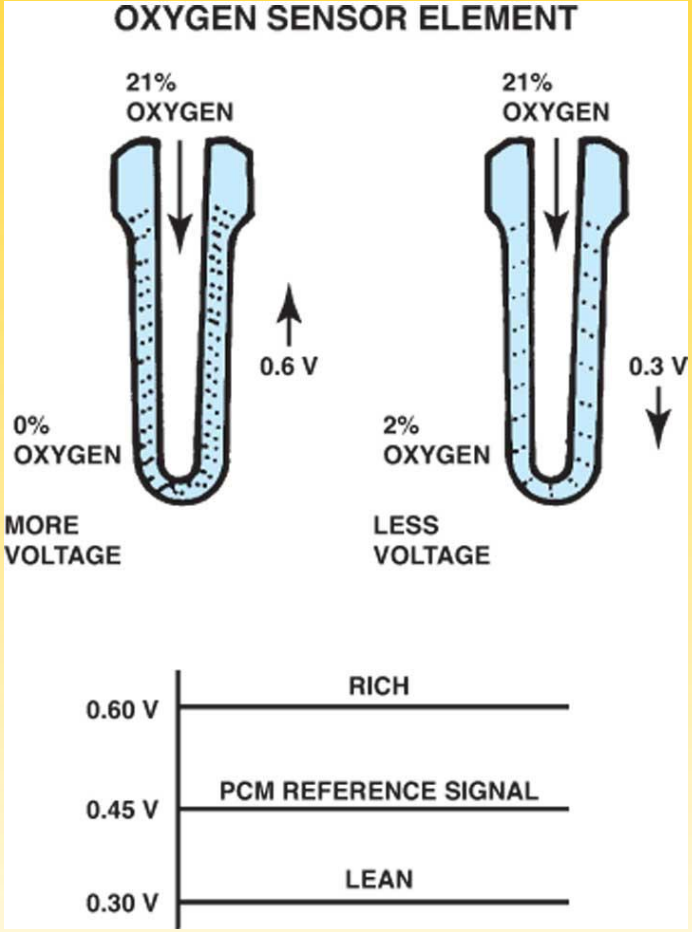

FIGURE 30-32 A difference in oxygen content between the atmosphere and the exhaust gases enables an O2S sensor to generate voltage.

OXYGEN SENSORS

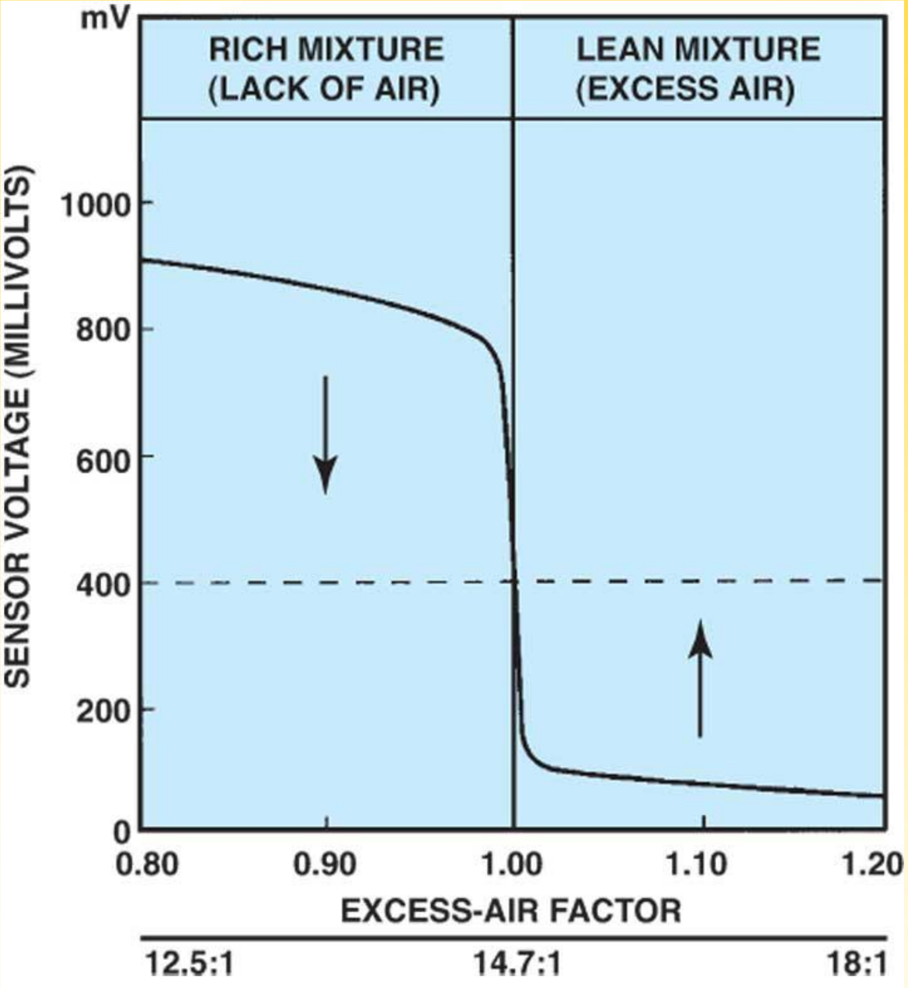

FIGURE 30-33 The oxygen sensor provides a quick response at the stoichiometric air-fuel ratio of 14.7:1.

OXYGEN SENSORS

- There are several different designs of oxygen sensors, including:
  - **One-wire oxygen sensor.**
  - **Two-wire oxygen sensor.**
  - **Three-wire oxygen sensor.**
  - **Four-wire oxygen sensor.**

ZIRCONIA OXYGEN SENSORS

- The most common type of oxygen sensor is made from zirconia (zirconium dioxide).
- It is usually constructed using powder that is pressed into a thimble shape and coated with porous platinum material that acts as electrodes. All zirconia sensors use 18-mm diameter threads with a washer.

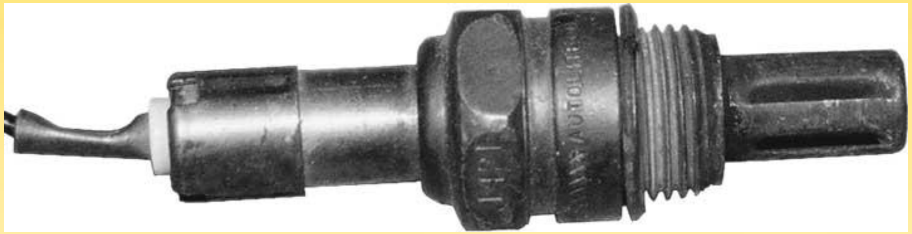

FIGURE 30-34 A typical zirconia oxygen sensor.

WHERE IS HO2S1?

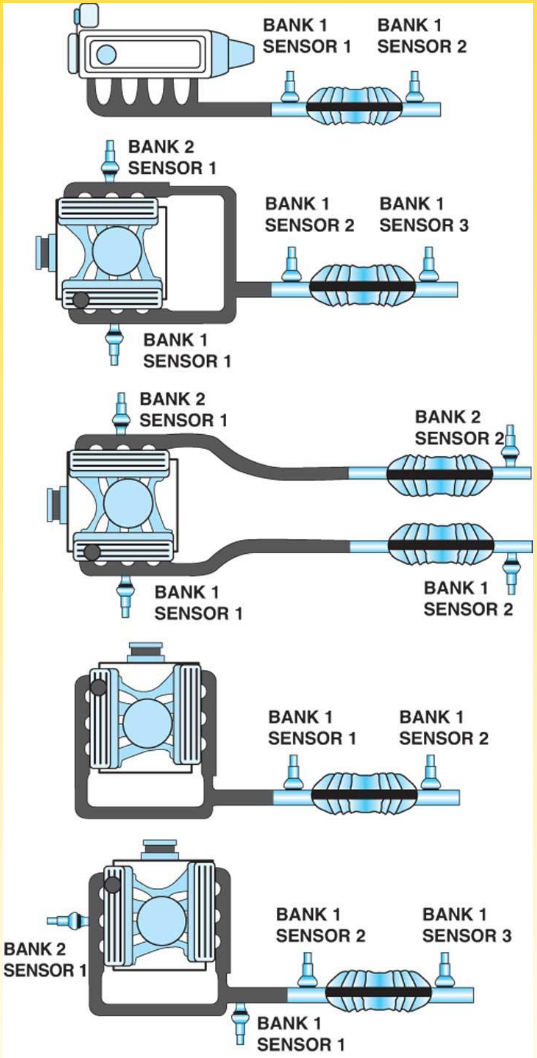

FIGURE 30-35 Number and label designations for oxygen sensors. Bank 1 is the bank where cylinder number 1 is located.

TITANIA OXYGEN SENSORS

- The titania (titanium dioxide) oxygen sensor does not produce a voltage but rather the presence of oxygen in the exhaust.
- All titania oxygen sensors are a four-terminal variable resistance unit with a heating element.
- A titania sensor samples exhaust air only and uses a reference voltage from the PCM.
- Titania oxide oxygen sensors use a 14-mm thread and are not interchangeable with zirconia oxygen sensors.

WIDE-BAND OXYGEN SENSORS

- A **wide-band oxygen sensor,** also called a **lean air-fuel (LAF) ratio sensor** or a linear air-fuel ratio sensor, allows engines to operate as lean as 23:1 and still maintain closed-loop operation.
- This type of sensor usually uses five wires.
  - One power wire
  - One ground wire for the electric heater
  - Three sensor wires

WIDE-BAND OXYGEN SENSORS

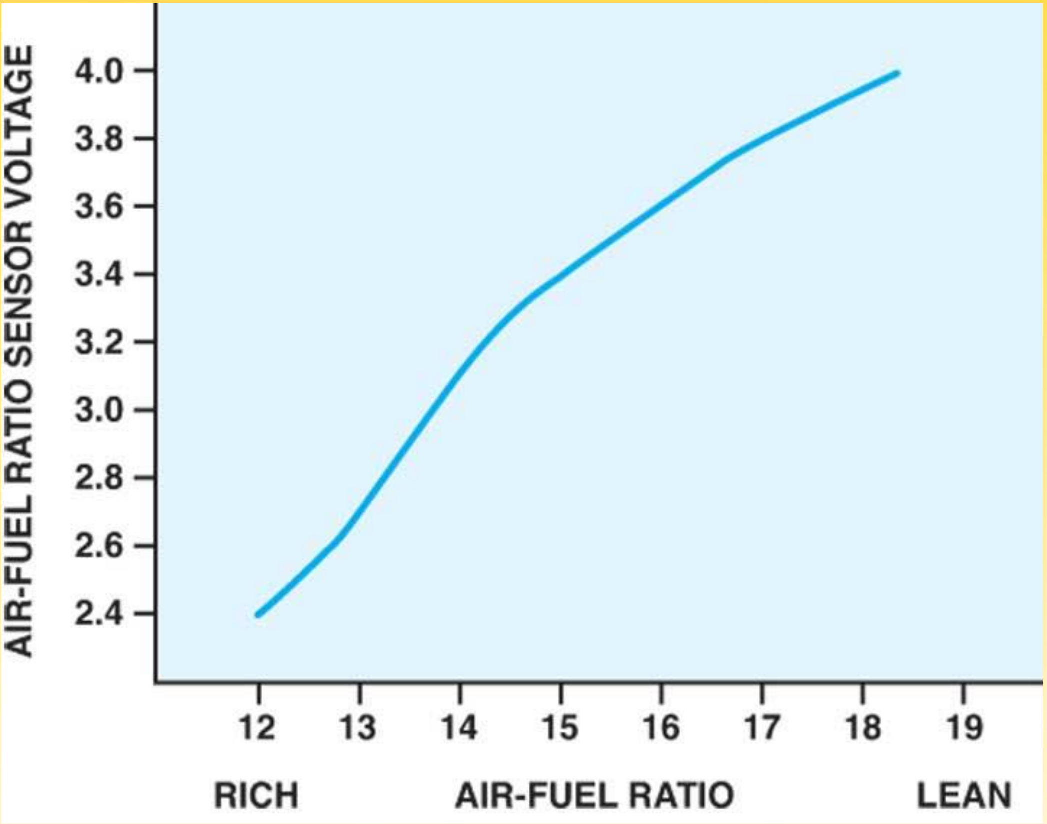

FIGURE 30-36 The output of a typical air-fuel mixture sensor showing that the voltage increases as the exhaust becomes leaner, which is opposite from normal oxygen sensors.

CLOSED LOOP AND OPEN LOOP

- The amount of fuel delivered to an engine is determined by the powertrain control module (PCM) based on inputs from the engine coolant temperature (ECT), throttle position (TP) sensor, and others until the oxygen sensor is capable of supplying a usable signal.
- When the PCM alone is determining the amount of fuel needed, it is called **open-loop operation.**

PCM USES OF THE OXYGEN SENSOR

- **Fuel Control**
- **Fuel Trim**
- **Diagnosis**

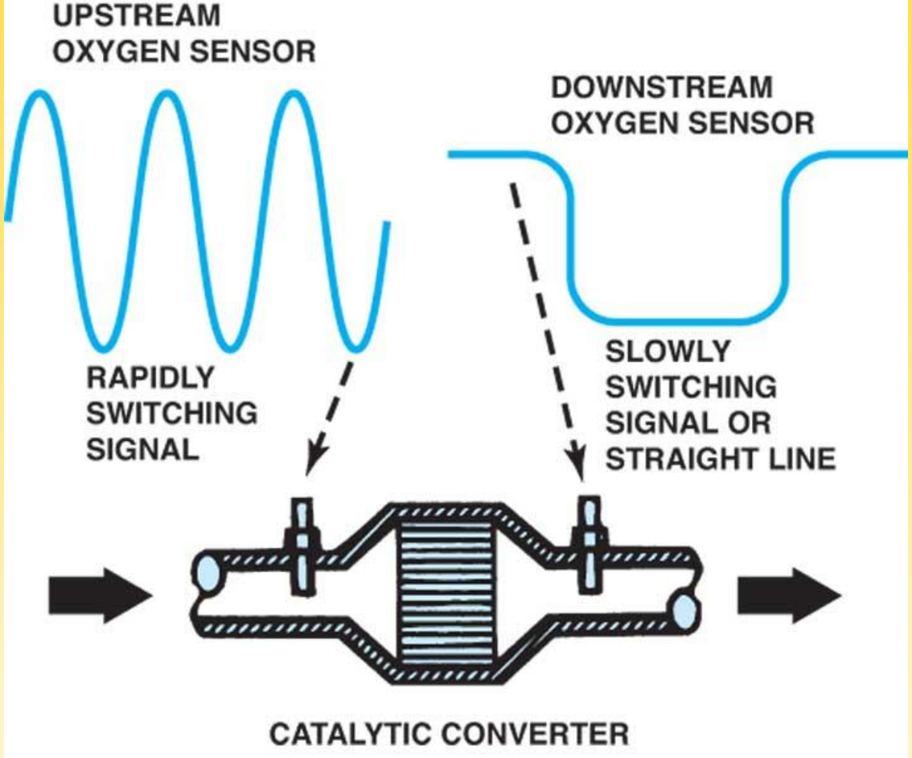

FIGURE 30-37 The OBD II catalytic converter monitor compares the signals of the upstream and downstream oxygen sensor to determine converter efficiency.

TESTING AN OXYGEN SENSOR USING A DIGITAL VOLTMETER

- The oxygen sensor can be checked for proper operation using a digital high-impedance voltmeter.
  - With the engine off, connect the red lead of the meter to the oxygen sensor signal wire. See Figure 30-38.
  - Start the engine and allow it to reach closed-loop operation.
  - In closed-loop operation, the oxygen sensor voltage should be constantly changing as the fuel mixture is being controlled.

TESTING AN OXYGEN SENSOR USING A DIGITAL VOLTMETER

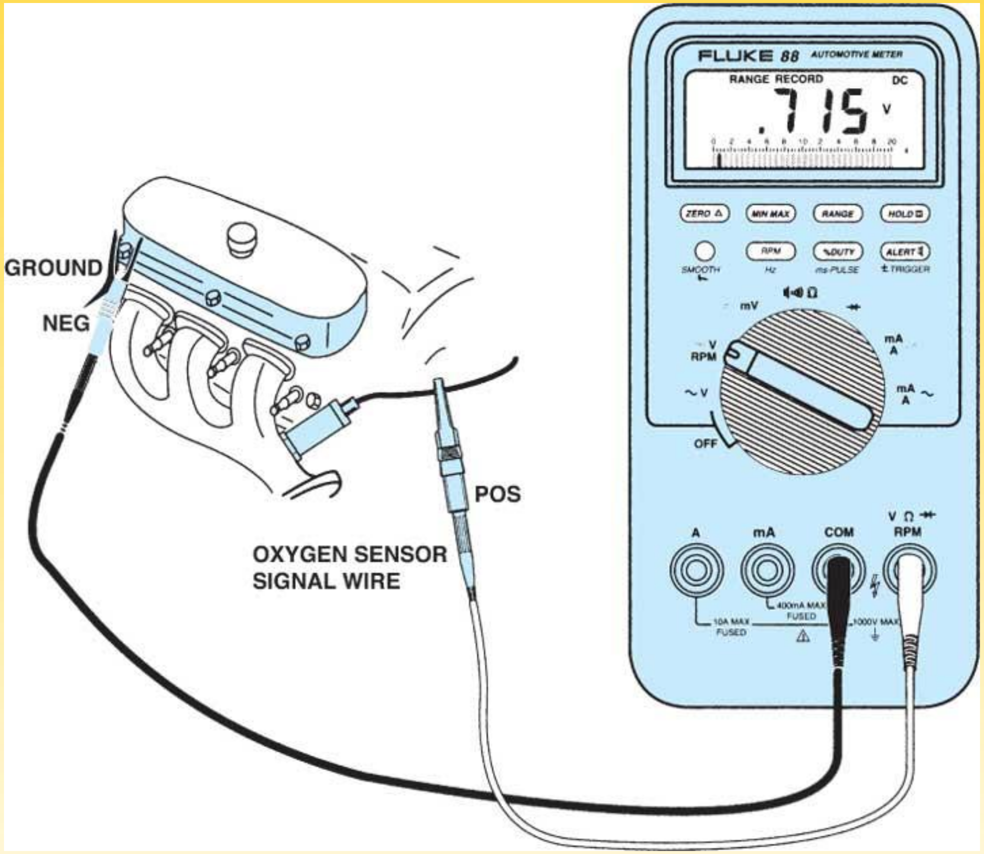

FIGURE 30-38 Testing an oxygen sensor using a DMM set on DC volts. With the engine operating in closed loop, the oxygen voltage should read over 800 mV and lower than 200 mV and be constantly fluctuating. *(Courtesy of Fluke Corporation)*

TESTING THE OXYGEN SENSOR USING THE MIN-MAX METHOD

- A digital meter set on DC volts can be used to record the minimum and maximum voltage with the engine running.
- A good oxygen sensor should be able to produce a value of less than 300 millivolts and a maximum voltage above 800 millivolts.
- Replace any oxygen sensor that fails to go above 700 millivolts or lower than 300 millivolts.

TESTING THE OXYGEN SENSOR USING THE MIN-MAX METHOD

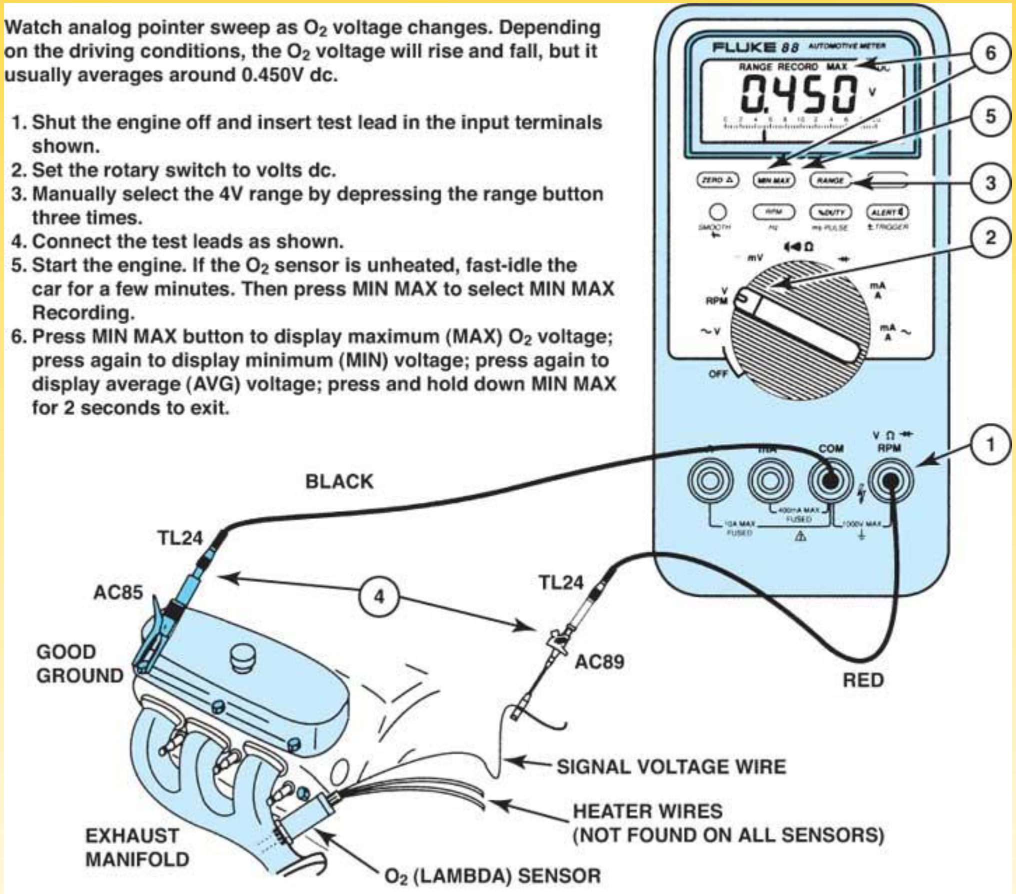

FIGURE 30-39 Using a digital multimeter to test an oxygen sensor using the MIN/MAX record function of the meter. *(Courtesy of Fluke Corporation)*

TESTING THE OXYGEN SENSOR USING THE MIN-MAX METHOD

FIGURE 30-40 A Chrysler DRB III scan tool is an excellent tool to use to test an oxygen sensor(s).

TESTING AN OXYGEN SENSOR USING A SCOPE

- A scope can also be used to test an oxygen sensor.
- Connect the scope to the signal wire and ground for the sensor (if it is so equipped).

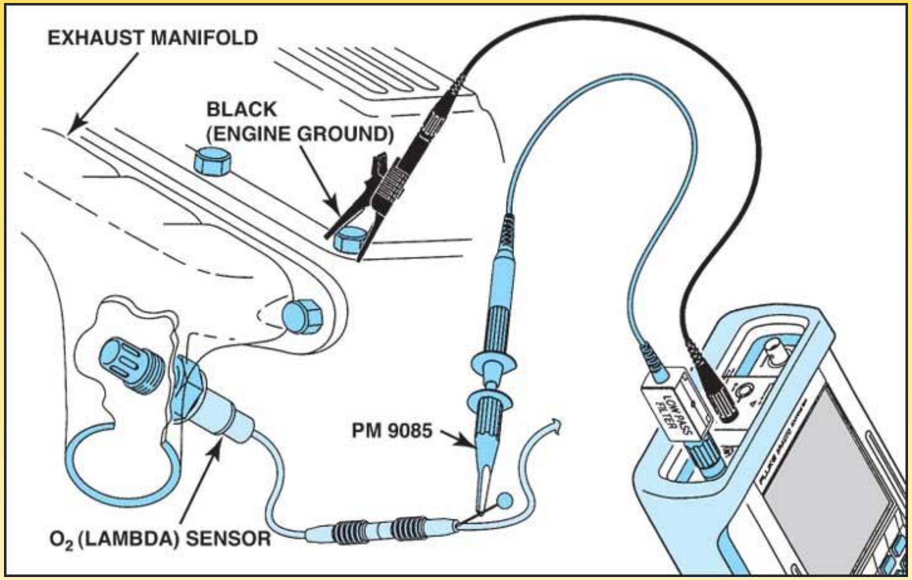

FIGURE 30-41 Connecting a handheld digital storage oscilloscope to an oxygen sensor signal wire. The use of the low-pass filter helps eliminate any lowfrequency interference from affecting the scope display. *(Courtesy of Fluke Corporation)*

TESTING AN OXYGEN SENSOR USING A SCOPE

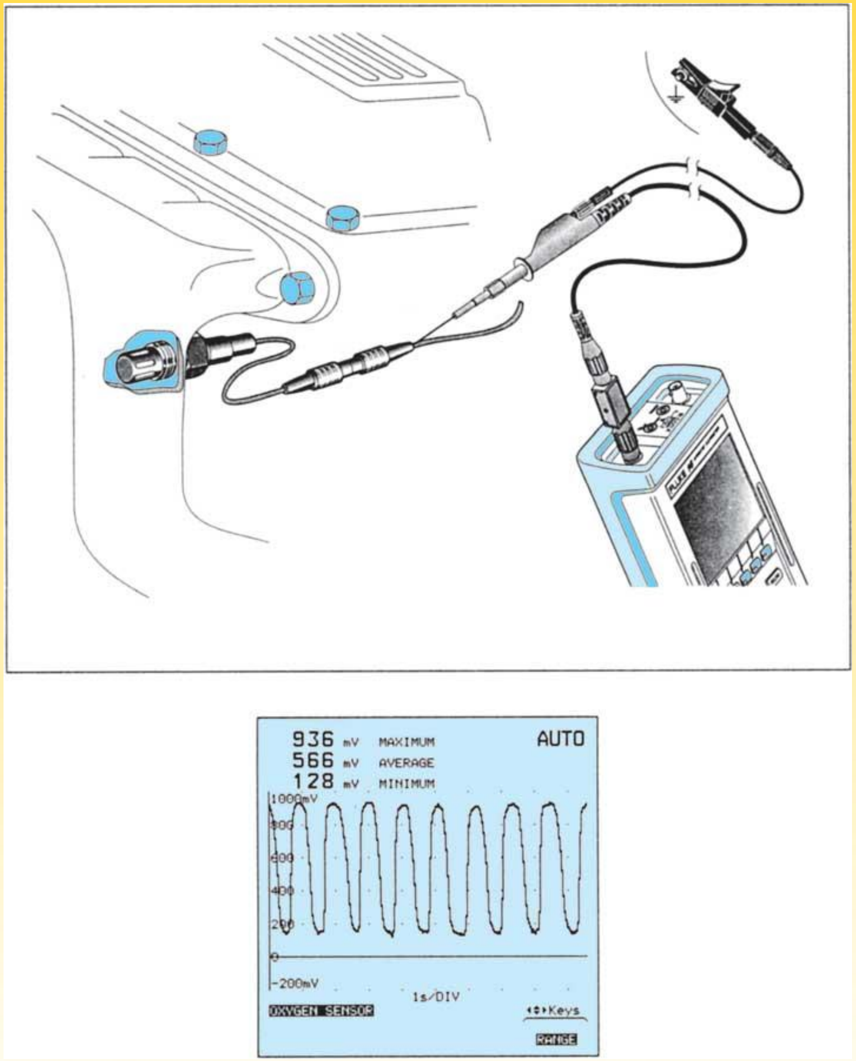

FIGURE 30-42 The waveform of a good oxygen sensor as displayed on a digital storage oscilloscope (DSO). Note that the maximum reading is above 800 mV and the minimum reading is less than 200 mV. *(Courtesy of Fluke Corporation)*

TESTING AN OXYGEN SENSOR USING A SCOPE

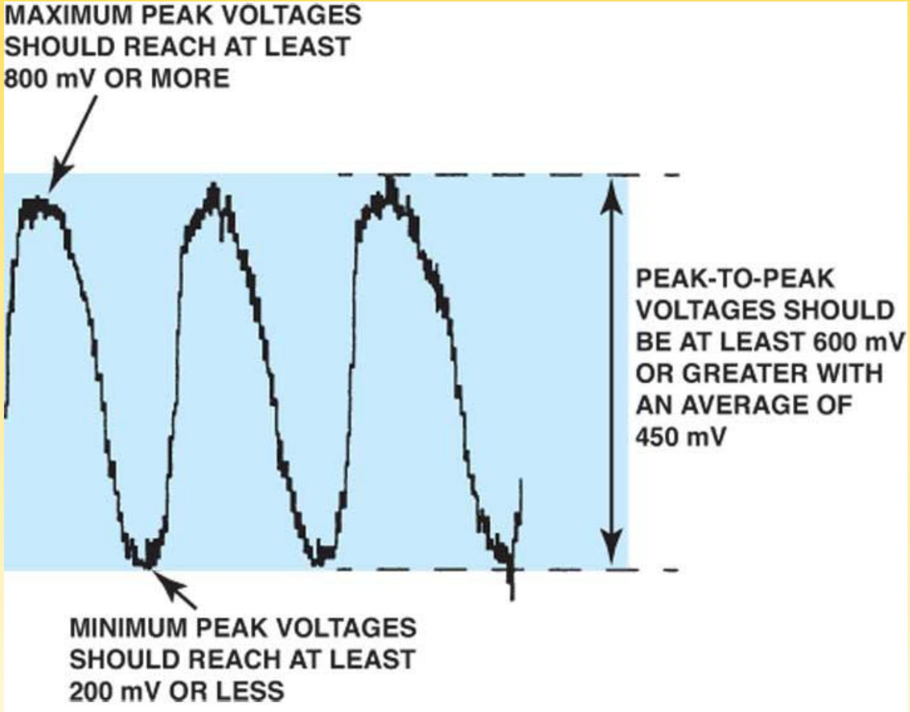

FIGURE 30-43 A typical good oxygen sensor waveform as displayed on a digital storage oscilloscope. Look for transitions that occur rapidly between 0.5 and 5.0 Hz. *(Courtesy of Fluke Corporation)*

TESTING AN OXYGEN SENSOR USING A SCOPE

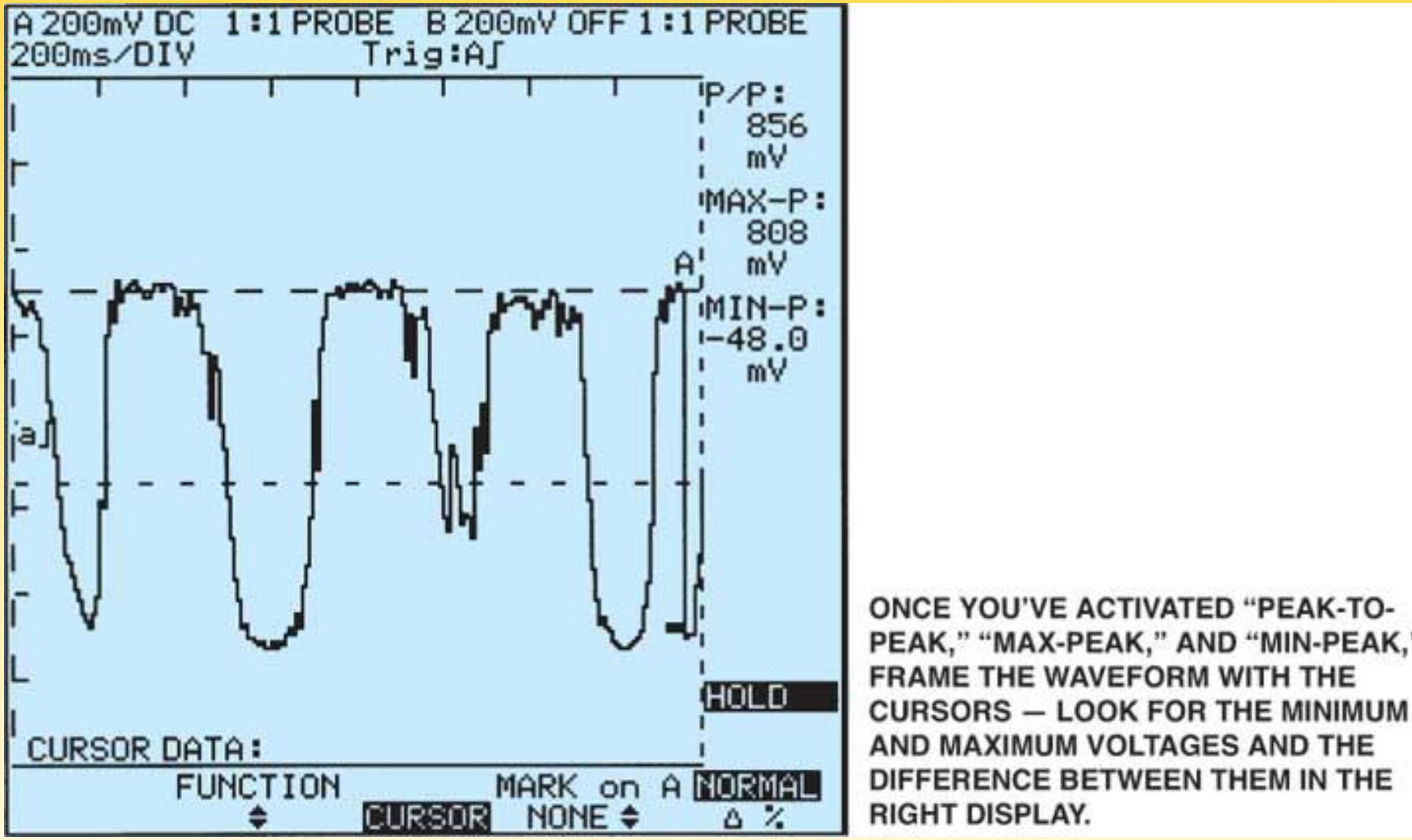

FIGURE 30-44 Using the cursors on the oscilloscope, the high- and low-oxygen sensor values can be displayed on the screen. *(Courtesy of Fluke Corporation)*

TESTING AN OXYGEN SENSOR USING A SCOPE

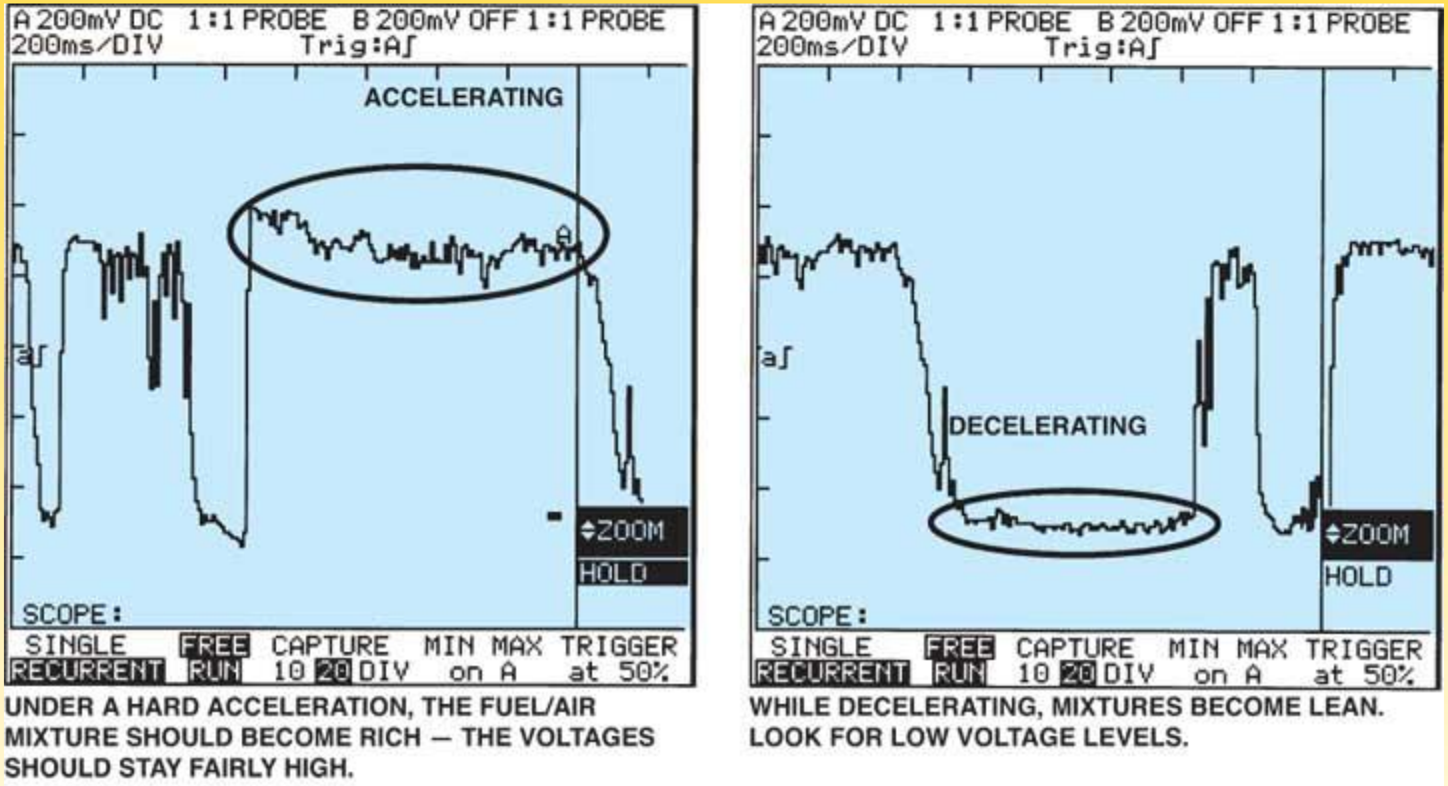

FIGURE 30-45 When the air-fuel mixture rapidly changes, such as during a rapid acceleration, look for a rapid response. The transition from low to high should be less than 100 ms. *(Courtesy of Fluke Corporation)*

FALSE O2S READINGS

- An oxygen sensor reading that is low could be due to other things besides a lean air-fuel mixture.
  - Remember, an oxygen sensor senses oxygen, not unburned gas, even though a high reading generally indicates a rich exhaust (lack of oxygen) and a low reading indicates a lean mixture (excess oxygen).
- **False Lean**
- **False Rich**

THE PROPANE OXYGEN SENSOR TEST

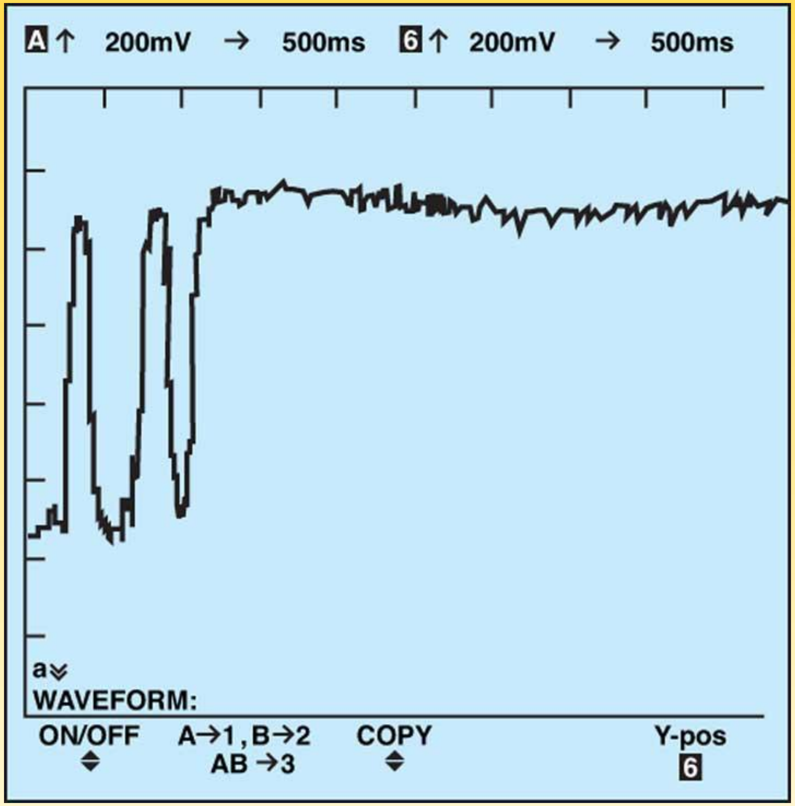

FIGURE 30-46 Adding propane to the air inlet of an engine operating in closed loop with a working oxygen sensor causes the oxygen sensor voltage to read high.

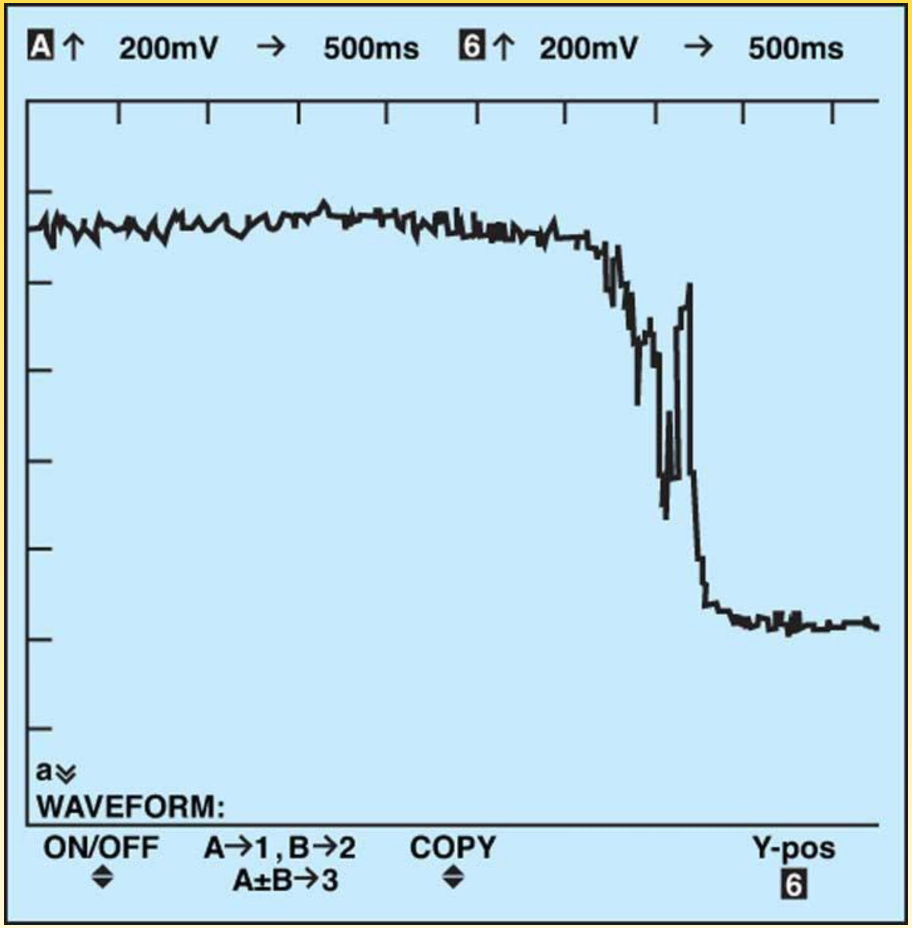

FIGURE 30-47 When the propane is shut off, the oxygen sensor should read below 200 mV.

POST-CATALYTIC CONVERTER OXYGEN SENSOR TESTING

- The oxygen sensor located behind the catalytic converter is used on OBD II vehicles to monitor converter efficiency.
- A changing air-fuel mixture is required for the most efficient operation of the converter.
- If the converter is working correctly, the oxygen content after the converter should be fairly constant.

POST-CATALYTIC CONVERTER OXYGEN SENSOR TESTING

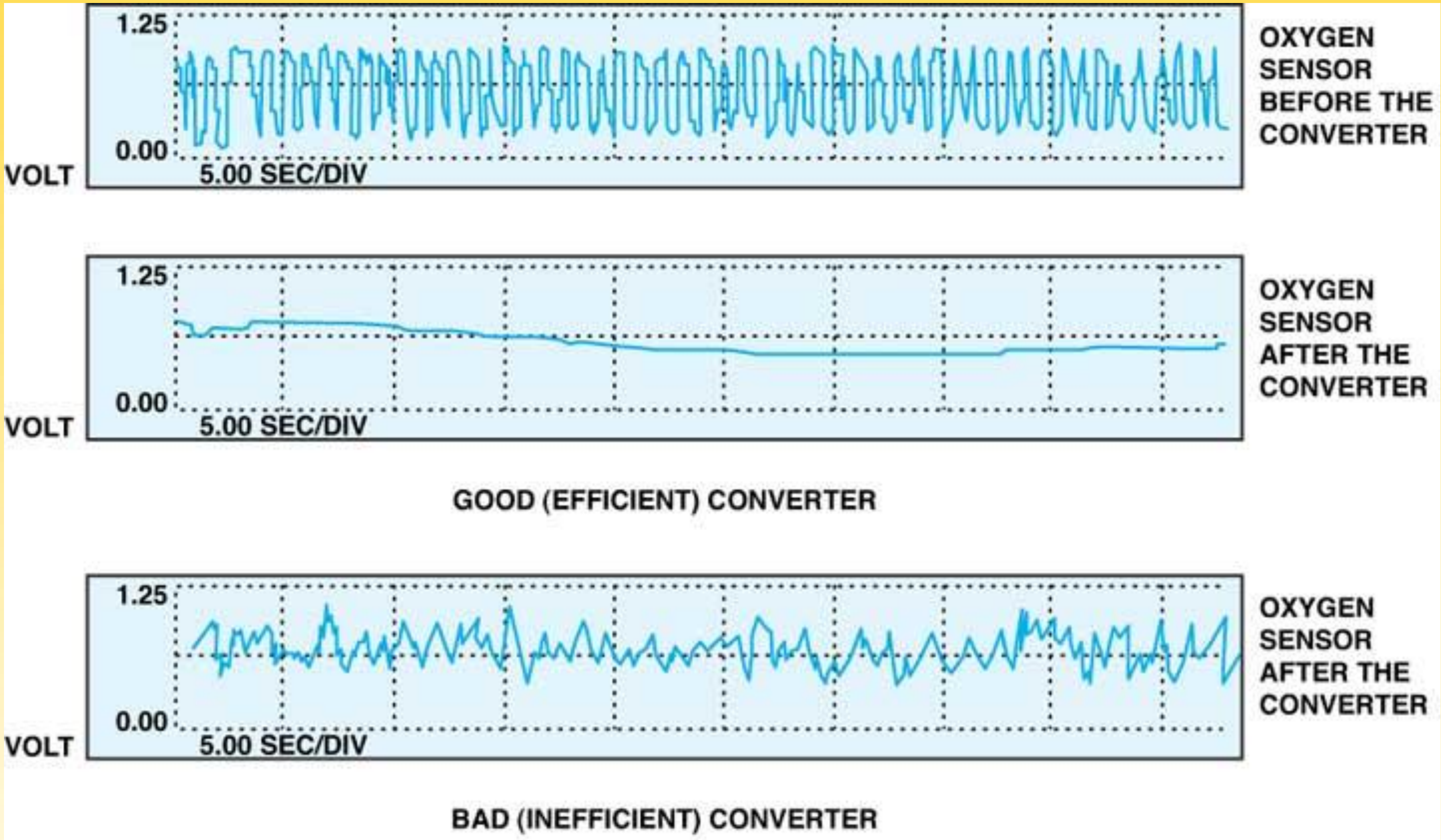

FIGURE 30-48 If the catalytic converter is efficient, the post-catalytic converter oxygen sensor should display very little activity.

OXYGEN SENSOR INSPECTION

- Whenever an oxygen sensor is replaced, the old sensor should be carefully inspected to help determine the cause of the failure.
- This is an important step because if the cause of the failure is not discovered, it could lead to another sensor failure.
- Inspection may reveal the following:
  - **Black sooty deposits,**
  - **White chalky deposits,**
  - **White sandy or gritty deposits**.
  - **Dark brown deposits,**

OXYGEN SENSOR-RELATED DIAGNOSTIC TROUBLE CODES

- Diagnostic trouble codes (DTCs) associated with the oxygen sensor include:

Diagnostic Trouble Codes	Description	Possible Causes
P0131	Upstream HO2S grounded	▪ Exhaust leak upstream of HO2S (bank 1) ▪ Extremely lean air-fuel mixture ▪ HO2S defective or contaminated ▪ HO2S signal wire shorted to ground
P0132	Upstream HO2S shorted	▪ Upstream HO2S (bank 1) shorted ▪ Defective HO2S ▪ Fuel contaminated HO2S
P0133	Upstream HO2S slow response	▪ Open or short in heater circuit ▪ Defective or fuel contaminated HO2S ▪ EGR or fuel system fault

SUMMARY

1. The ECT sensor is a high-authority sensor at engine start up and is used for closed loop control, as well as idle speed.
2. All temperature sensors decrease in resistance as the temperature increases. This is called negative temperature coefficient (NTC).
3. The ECT and IAT sensors can be tested by using a digital multimeter, and a scan tool.
4. Some vehicle manufacturers use a stepped ECT circuit inside the PCM to broaden the accuracy of the sensor.
5. A throttle position (TP) sensor is a three-wire variable resistor called a potentiometer.

SUMMARY

6. The three wires on the TP sensor include a 5-volt reference voltage from the PCM, plus the signal wire to the PCM, and a ground, which also goes to the PCM.
7. The TP sensor is used by the PCM for clear flood mode, torque converter engagement and release, automatic transmission shift points, as well as for rationality testing for the MAP and MAF sensor.
8. The TP sensor signal voltage should be about 0.5 volt at idle and increase to about 4.5 volts at wide-open throttle (WOT).
9. A TP sensor can be tested using a digital multimeter, a digital storage oscilloscope (DSO), or a scan tool.

SUMMARY

10. Three types of MAP sensors include:
    - Silicon-diaphragm strain gauge
    - Capacitor-capsule design
    - Ceramic disc design
11. A heavy engine load results in low intake manifold vacuum and a high MAP sensor signal voltage. A light engine load results in high intake manifold vacuum and a low MAP sensor signal voltage.
12. A MAP sensor is used to detect changes in altitude, as well as for checking other sensors and engine systems.
13. A mass air flow sensor actually measures the density and amount of air flowing into the engine, which results in accurate engine control.

SUMMARY

14. An oxygen sensor produces a voltage output signal based on the oxygen content of the exhaust stream. If the exhaust has little oxygen, the voltage of the oxygen sensor will be close to 1 volt (1,000 mV) and close to zero if there is high oxygen content in the exhaust.
15. Oxygen sensors can have one, two, three, four, or more wires, depending on the style and design
16. A wide-band oxygen sensor, also called a lean air-fuel (LAF) or linear air-fuel ratio sensor, can detect air-fuel ratios from as rich as 12:1 to as lean as 18:1.