Typical ECM/PCM Inputs

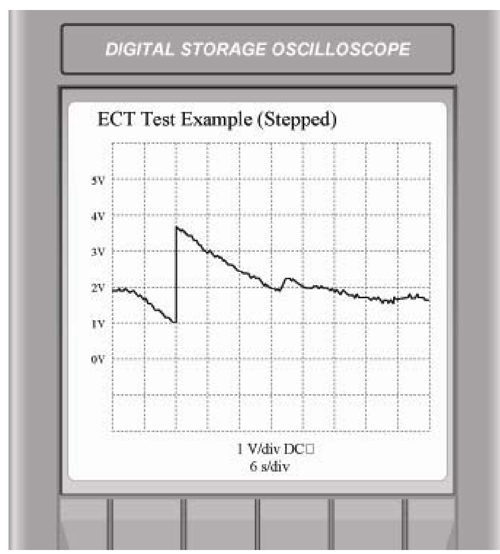
The computer system components fall into two categories: sensors (inputs) and controlled components (outputs).

Each system has sensors. Not every system has all the ones listed, but every system has some from this list. The basic inputs to the computer are engine speed, coolant temperature, intake air temperature, ambient air pressure, engine load, throttle plate position, exhaust gas oxygen content, detonation or knock, accessory load, vehicle speed, transmission shift position, clutch and gear position.

Engine Coolant Temperature Sensor

This sensor is a thermistor that is used to measure temperature changes in engine coolant. This means as the temperature increases, the resistance of the sensor decreases. The thermistor receives a 5V reference voltage through a set of pull-up resistors inside the ECM/PCM. The sensor signal will vary from approximately 4.7V cold to 0.4V hot. The ECM/PCM provides sensor ground.

Its signal is used by the ECM/PCM to control fuel delivery, spark timing, torque converter clutch, canister purge, EGR, idle speed and electric cooling fan operation.



Typical ECM/PCM Inputs (continued)

Air Temperature Sensor

This sensor is a thermistor that is used to measure temperature changes in air temperature. This means as the temperature increases, the resistance of the sensor decreases. The thermistor receives a 5V reference voltage through a set of pull-up resistors inside the ECM/PCM. The sensor signal will vary from approximately 4.7V cold to 0.4V hot. The ECM/PCM provides the sensor ground.

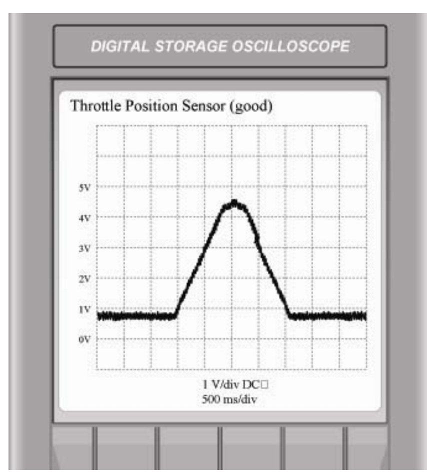
Its signal is used by the ECM/PCM to control fuel delivery and spark timing. This sensor has many different names. It has been called Air Charge Temperature Sensor, Manifold Air Temperature Sensor and Inlet Air Temperature Sensor.

Transmission Temperature Sensor

This sensor is a thermistor that is used to measure temperature changes in transmission fluid temperature. This means as the temperature increases, the resistance of the sensor decreases. The thermistor receives a 5V reference voltage through a set of pull-up resistors inside the ECM/PCM. The sensor signal will vary from approximately 4.7V cold to 0.4V hot. The ECM/PCM provides the sensor ground.

Throttle Position Sensor

The Throttle Position Sensor (TPS) is a potentiometer that is used for Driver demand. It is supplied with 5V reference and ground signals from the ECM/PCM. These are typically shared with other sensors. The throttle position signal is controlled by the position of a wiper arm that is connected to the throttle shaft. The majority of these sensors increase voltage proportionally as the throttle opens. This is not to be confused with a throttle switch that signals an open and closed throttle. The TPS is used by the ECM/PCM for fuel control, automatic transmission operations, A/C Compressor Cutout and Clear Flood Mode.



Typical ECM/PCM Inputs (continued)

Throttle Position Sensor (continued)

The operating range of a TPS is usually 0.5V-4.8V. If the ECM/PCM detects the sensor exceeding these limits it will set a code, which will indicate an open or short for that sensor circuit. For example, the ECM/PCM expects to see a voltage of about 0.5 volts at idle. If voltage is zero or 5 volts, a code will be set. Always check manufacturer specifications for the specific vehicle you are working on.

TPS Response Chart	
Percentage of Throttle Opening	**Signal Voltage**
0	.56 – .70
10	.90 – 1.50
20	1.16 – 1.76
30	1.40 – 2.02
40	1.66 – 2.28
50	1.92 – 2.54
60	2.16 – 2.76
70	2.42 – 3.02
80	2.66 – 3.28
90	2.92 – 3.54
100	3.74 – 3.76

Another scan tool display regarding the TPS is the “clear flood” mode, which begins whenever the engine is cranking (spinning below 300 RPM) and TPS signal is above 3.5 volts. The ECM/PCM’s logic interprets this information as the procedure for starting an engine that is over fueled. Clear flood mode allows the engine to continue to fire but cuts off or greatly reduces fuel delivery.

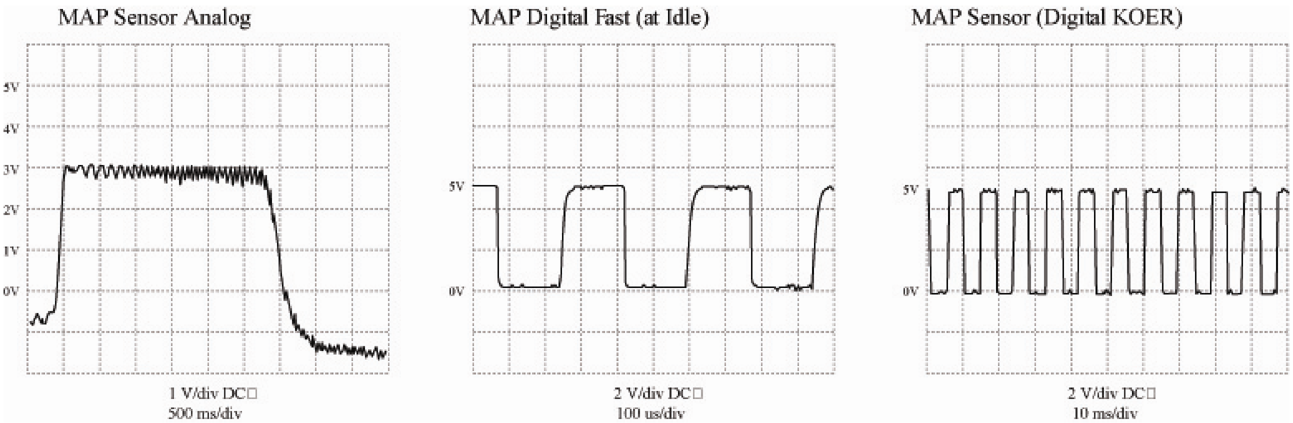
Manifold Absolute Pressure Sensor (Speed Density)

The signal from the MAP Sensor is one of the most important inputs to the ECM/PCM. This sensor converts intake manifold pressure into a voltage or frequency signal that increases in direct proportion to manifold pressure. Under KOEO conditions, the pressure in the intake manifold is the same as the surrounding air (barometric pressure). Even though a separate BARO sensor is not used, the control module calculates the barometric pressure by sampling the MAP reading prior to cranking. At this point, manifold pressure should be equal, or be very close to, atmospheric pressure (30" Hg or approximately 102 kPa at sea level).

Typical ECM/PCM Inputs (continued)

Manifold Absolute Pressure Sensor (Speed Density) continued

This signal provides engine load input and is used by the ECM/PCM for regulating fuel delivery, spark timing and EGR operation. When the engine is running, a negative pressure (vacuum) is present in the intake manifold. This pressure reduction causes MAP voltage or frequency to drop.



There are three wires connected to the MAP Sensor including a 5V supply, a signal output and a signal return (ground).

There are two types of MAP sensors; one provides an analog voltage signal while the other provides a frequency signal.

Note: *Some later vehicles may use a MAP sensor in conjunction with a MAF.*

Mass Airflow Sensor

The MAF sensor measures the amount of air entering the engine. This is an engine load signal that is used by the ECM/PCM to calculate the engine's fuel delivery and ignition timing requirements.

The scan tool can display this information in voltage (V), GPS (grams/second) or frequency (Hz), depending on the type of mass airflow sensor and the vehicle manufacturer.

Typical ECM/PCM Inputs (continued)

Mass Airflow Sensor (continued)

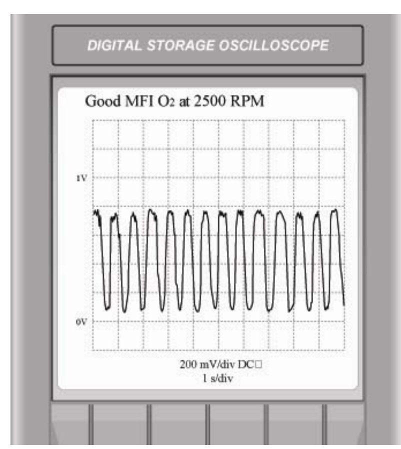
In most systems, the data value should increase as the throttle is opened with the engine running.

Oxygen Sensor

The Oxygen Sensor measures the oxygen content in the exhaust gas mixture. A Stoichiometric air/fuel ratio must be maintained if the catalytic converter is to perform to its full potential. The oxygen sensor is an integral part of the control circuit that continuously assures a correct composition of the air/fuel mixture.

The Zirconia Dioxide Oxygen Sensor

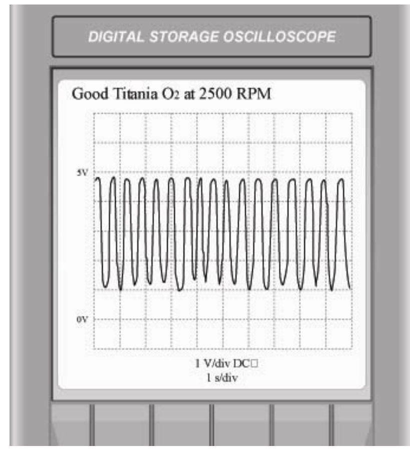
The most popular type of Oxygen Sensor in automotive use is the Zirconia Dioxide type of Oxygen Sensor which generates a voltage proportionate to the oxygen content of the exhaust. When the oxygen in the exhaust is high (lean mixture), the voltage produced is low. The voltage range is 0 to 1 volt.



Typical ECM/PCM Inputs (continued)

The Titania Oxygen Sensor

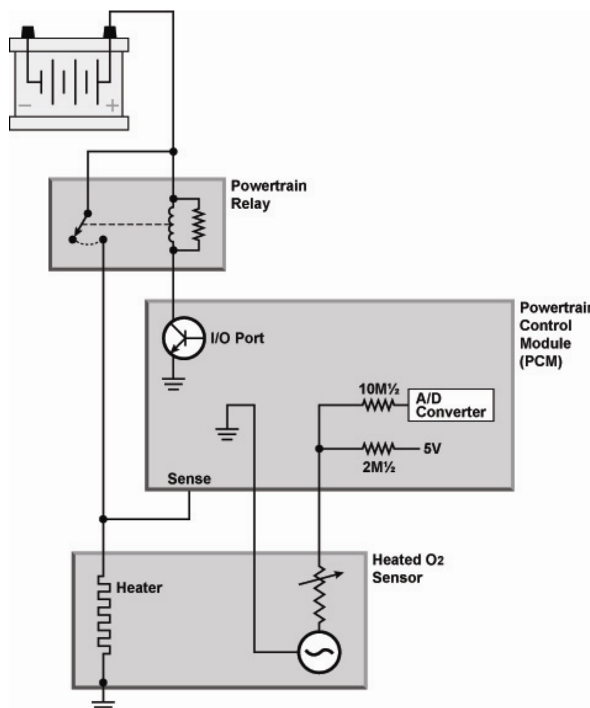
The Titania Oxygen Sensor is a variable resistor type sensor. The ECM/PCM supplies the sensor with a reference voltage and a ground. As the oxygen content in the exhaust changes, the resistance of the oxygen sensor changes. Depending on a rich or lean condition, the changing oxygen sensor resistance causes the reference voltage to rise or fall. A lean condition will cause the Titania oxygen sensor to output a high voltage signal. The O2 Sensor is used to control fuel delivery while in closed loop, during light load, and steady cruise operation. The O2 Sensor is ignored while in open loop or during wide open throttle operation. The voltage range is typically 0 to 5 volts.



The Planar Oxygen Sensor

Another type of oxygen sensor is the AF sensor, also called a broadband planar sensor or Lean Air Fuel sensor (LAF). The AF sensor used in some applications resembles the heated Zirconia sensor in appearance only. The AF sensor improves overall efficiency by keeping the fuel control system in closed-loop during a much wider range of driving conditions. Subsequently, instead of using preprogrammed, open loop air/fuel ratios in many situations, the ECM/PCM fine-tunes the mixture much more closely based on the actual oxygen readings from the exhaust.

AF sensors may be configured as seven-wire, five wire, or four-wire sensors. AF sensors are used as the pre-catalyst (upstream) oxygen sensors. On a four-wire AF sensor, two wires are power and ground for the sensor heater, and the other two wires are used for the exhaust mixture signal.



The oxygen sensor heater is designed to heat the oxygen sensor thimble to a minimum of 1200°F. This temperature is double that of an early four-wire sensor and is required for the AF sensor to properly sample the exhaust oxygen content. When the AF sensor heater is commanded on by the ECM/PCM, approximately 8 amps of current should be flowing through the circuit.

Typical ECM/PCM Inputs (continued)

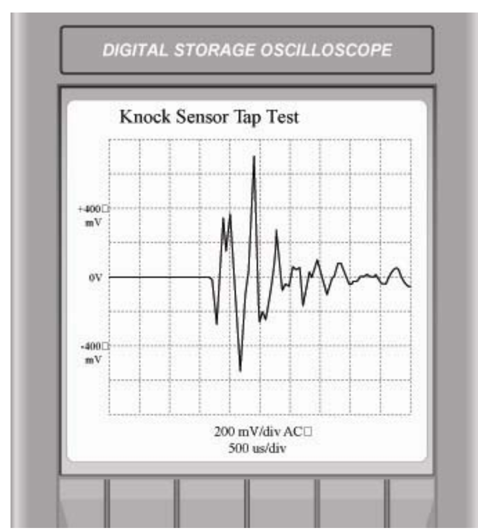
Oxygen Sensor (continue)

The ECM/PCM controls the voltage to a fixed voltage. It is difficult to confirm the AF sensor voltage without a scan tool as the voltages at the terminals are fixed and any change is noted within the ECM/PCM itself.

The voltage signal is proportional to the change in the air/fuel mixture. This allows the ECM/PCM to more accurately judge the exact air/fuel ratio under a wide variety of conditions and quickly adjust the amount of injector pulse. Think of the AF sensor as a generator that is capable of changing polarity.

Knock Sensor

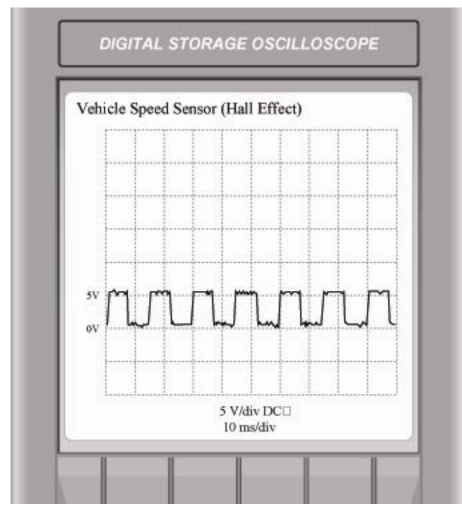
The Knock Sensor is a piezo-electric device. Piezoelectricity is a phenomenon that occurs when pressure is exerted upon a certain substance, such as a crystal. When vibration occurs, a pressure is created upon the internal knock sensor crystal. This pressure causes the Knock Sensor to emit a voltage that increases in proportion to the vibration. The ECM/PCM uses knock information as one of the factors in its spark timing calculation. Perhaps the biggest problem with the Knock Sensor is the transmission of false signals. Engine noises or electrical interference can cause the Knock Sensor to incorrectly signal the ECM/PCM to retard spark timing. Make sure that the Knock Sensor wire is routed away from high voltage or high current electrical leads.



Typical ECM/PCM Inputs (continued)

Vehicle Speed Sensors

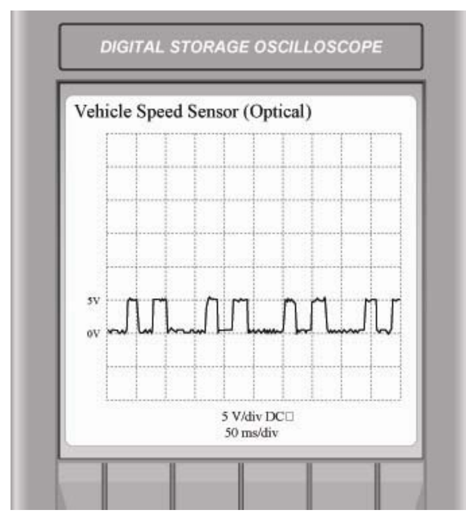
The ECM/PCM uses the vehicle's speed to anticipate driver demands as well as determine when to engage some output devices, such as EGR and TCC. The ECM/PCM uses the VSS input to calculate road speed. In addition, the controller can calculate the distance the vehicle has traveled by counting the number of VSS pulses it receives over a predetermined time frame.



Many vehicle speed sensors are a permanent magnet generator, commonly referred to as a PM generator. The sensor produces an AC voltage as it rotates, similar to a pickup coil in a distributor.

Most early applications used a separate buffer assembly. The buffer is an A to D (analog to digital) converter. It converts the analog AC voltage signal to an on/off or digital signal. This digital signal is sent to the ECM/PCM. Depending on the application, the DC signal may also go to the cruise control system or the speedometer.

On later systems the AC signal is typically sent directly to the ECM/PCM. The ECM/PCM converts the AC voltage to a DC signal and then sends the signal to the speedometer and other systems or control modules.



There are two other types of vehicle speed/distance sensors. The first type is a three-wire Hall Effect device that senses transmission output shaft speed. This sensor produces a digital signal and supplies the computer with approximately 8 voltage pulses for each output shaft revolution. The computer supplies the sensor a power supply as well as a 5V reference signal and sensor return (ground).

The second type of vehicle speed sensor is the optical sensor. This consists of a light emitting diode (LED) and a phototransistor. This VSS receives a 5-volt reference signal from the ECM/PCM. As the drive on the sensor is rotated, the 5-volt signal from the ECM/PCM is pulled to ground. This 0- to 5-volt pulse occurs approximately 8 times every revolution.

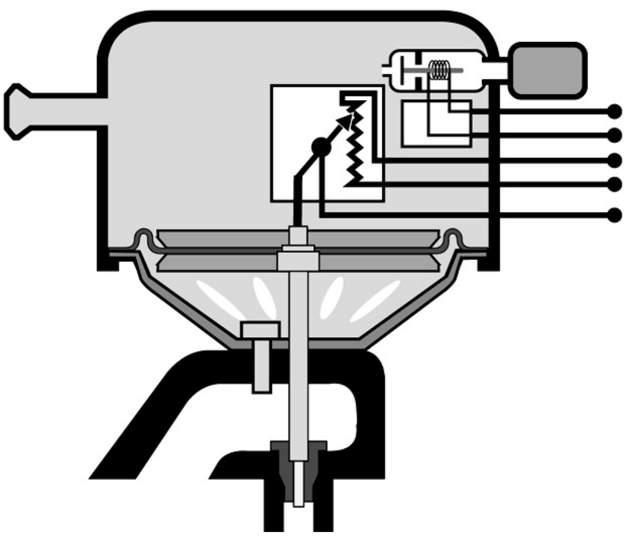
Typical ECM/PCM Inputs (continued)

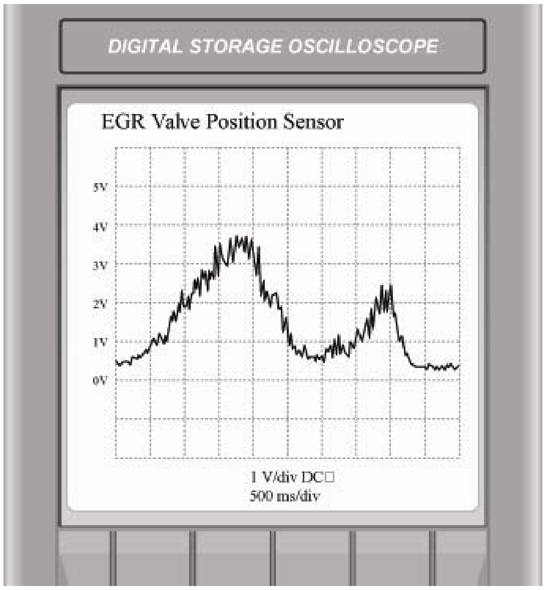
Exhaust Gas Recirculation Sensors

Position Sensor / Lift Sensor

An EGR valve position sensor (or lift sensor as referred to by some manufacturers) may be located at the top of, or integral to the EGR valve. The ECM/PCM uses this sensor to calculate the amount of pintle lift that occurs when the EGR valve is commanded open.

The variable resistor (potentiometer) uses a typical reference voltage of 5 volts on most applications and a return ground. The signal voltage output from the sensor is a voltage varying from 0.7-1.5 volts closed to 3-4 volts open.

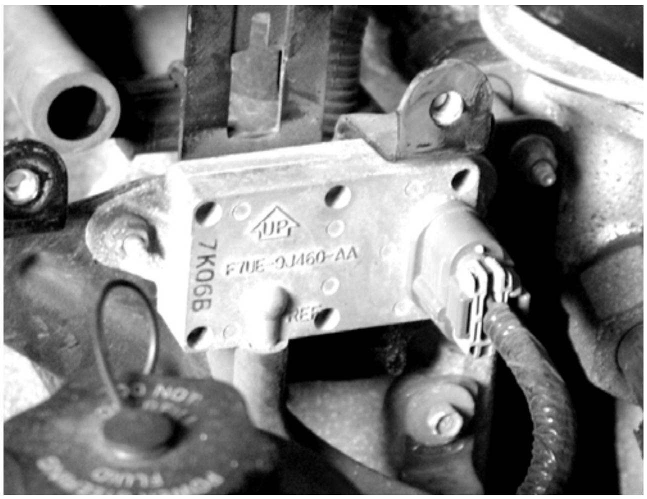


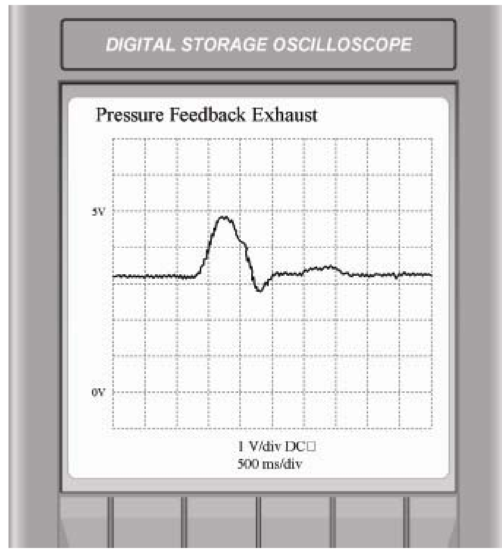


Typical ECM/PCM Inputs (continued)

Pressure Differential Sensor

Measuring the pressure drop caused by the EGR valve opening provides the ECM/PCM with a way of verifying EGR valve movement as well as flow. Most sensors use a reference voltage, signal and signal return (ground). A DVOM or DSO can be used to check the sensor.





EGR Temperature Sensor

A temperature sensor located within the EGR system may be used to check EGR flow. The voltage of the Exhaust Temperature Sensor will drop as the EGR valve opens and hot exhaust gas begins to flow into the intake manifold.

Typical ECM/PCM Inputs (continued)

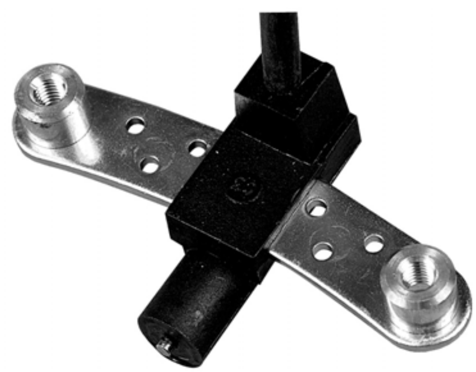
RPM Reference Signal

The RPM signal (sometimes called the TACH signal) is the most critical input to the ECM/PCM. A missing RPM signal will not allow the engine to run. The engine requires this signal in order to pulse the injectors. In many vehicles, this signal is used to activate a relay that supplies battery power to the fuel pump and/or ECM/PCM and injectors. This signal is used for fuel delivery and timing decisions as well as many other ECM/PCM outputs.

The EMS uses the input from the Crankshaft Position (CKP) Sensor and Camshaft Position (CMP) Sensor to calculate the RPM signal. There are three basic types of sensors that are used for this purpose. They are the:

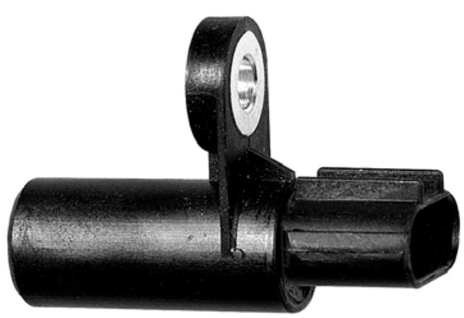
- Variable Reluctance Sensor
- Hall Effect Sensor
- Optical Sensor

The Variable Reluctance Sensor is an electromagnetic device that generates an AC voltage as teeth from a reluctor wheel pass through the sensor's magnetic field. This signal increases with engine RPM.



The Hall Effect Sensor can be thought of as a solid-state ON/OFF switch. There are a variety of different Hall effect triggering components used including:

- Shutter Wheel (rotating vane cup mounted to distributor shaft)
- Slotted Flywheel Disc (slotted disc or ring attached to flywheel)
- Slotted Crankshaft Counterweight (notched crankshaft throw)

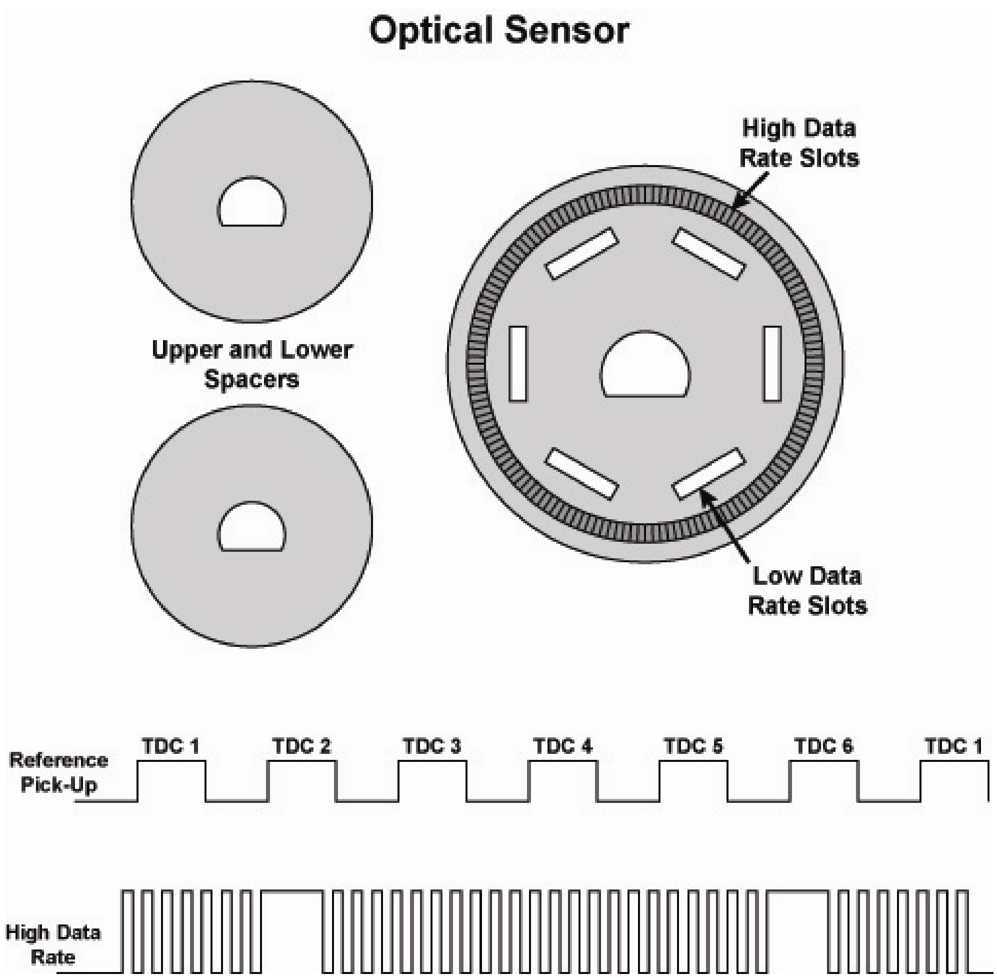


Typical ECM/PCM Inputs (continued)

RPM Reference Signal (continued)

Regardless of which type of Hall trigger is used, each one turns the Hall Effect sensor on and off by periodically deflecting a magnetic field away from the base of the Hall transistor.

Typically located in the distributor, the Optical Sensor uses a slotted disc that rotates between a pair of LEDs and phototransistors to generate crankshaft position and RPM signals (high- and low-resolution signals). Each phototransistor is used to turn a 5-volt signal from the controller on and off.



As the slots pass between the LEDs and the phototransistors, the transistors are toggled on and off. This occurs as the light beams from the LEDs are alternately interrupted. When the light beam from the LED strikes the phototransistor, the transistor turns on. This causes the 5-volt signal to be pulled low (0V-0.1V). When the rotating disc blocks the light beam, the transistor turns off. This causes the 5-volt signal to remain high.