ARTICLE BEGINNING

2000 ENGINE PERFORMANCE
General Motors Theory & Operation - Cars
Except Metro & Prizm

Alero, Bonneville, Camaro, Catera, Cavalier, Century, Corvette, DeVille, Eldorado, Firebird, Grand Am, Grand Prix, Impala, Intrigue, LeSabre, Lumina, Malibu, Monte Carlo, Park Avenue, Regal, Saturn, Seville, Sunfire

INTRODUCTION

This article covers basic description and operation of engine performance-related systems and components. Read this article before diagnosing vehicles or systems with which you are not completely familiar.

AIR INDUCTION SYSTEM

AIRFLOW SENSING

Mass Airflow Sensor

The Mass Airflow (MAF) sensor measures flow of air entering the engine in grams per second. This measurement of airflow is a reflection of engine load (throttle opening and air volume), similar to the relationship of engine load to MAP or vacuum sensor signal. Mass Airflow (MAF) signal should remain relatively constant at cruise, gradually changing with throttle angle, and rapidly changing on sudden acceleration or deceleration. The PCM uses MAF information to control fuel delivery. Sensor produces a frequency signal which cannot be easily measured in testing (32-150 Hertz). This varying signal is proportional to airflow.

Speed Density

On models equipped with MAP and IAT sensors, the speed density method is used to compute the airflow rate. PCM uses manifold pressure and temperature signals to calculate the airflow rate to the PCM. The MAP sensor responds to manifold vacuum changes due to engine load and speed changes.

The PCM sends a voltage signal to MAP sensor. Manifold pressure changes result in resistance changes in MAP sensor. By monitoring MAP sensor output voltage, PCM determines manifold pressure. If MAP sensor fails, PCM will supply a fixed MAP value and use the TP sensor to control fuel.

MULTI-RAM SYSTEM DIAGNOSIS (CATERA 3.0L)

Multi-ram system uses variable air induction tuning to achieve maximum performance and efficiency over all engine operating ranges. System consists of an intake plenum switchover valve and an intake resonance switchover valve. Intake manifold contains the intake plenum switchover valve. Vacuum operated valve is a moveable divider which changes airflow in intake manifold.

Intake resonance switchover valve is located in air intake duct in front of engine. This moveable divider changes the tuning of air intake system. Vacuum to valves is controlled by an Engine Control Module (ECM) controlled solenoid valve. By opening and closing valves independently, in different combinations, 4 different airflow configurations can be created. Each configuration is optimized to a particular set of engine operating conditions.

If a malfunction is detected in either valve, a diagnostic trouble code will set. For testing procedures, see appropriate SELF-DIAGNOSTICS article. For wiring schematics, see appropriate wiring diagram in WIRING DIAGRAMS article.

SUPERCHARGER (3.8L VIN 1)

Supercharger system consists of a belt-driven supercharger, by-pass valve, by-pass valve actuator and a normally-energized, PCM-controlled boost control solenoid.

The belt-driven supercharger compresses the air charge entering the intake manifold. This creates a surplus volume of oxygen, promoting more complete combustion which in turn provides more power.

At idle, when intake manifold vacuum is high, manifold vacuum overcomes by-pass valve actuator spring tension, pulling by-pass valve open. This causes boost pressure to recirculate back into the supercharger inlet. As engine load increases, manifold vacuum drops. This allows by-pass valve actuator spring tension to overcome the reduced manifold signal, closing the by-pass valve and allowing supercharger boost to occur.

At higher engine speed and load when reduced boost pressure is desired, the PCM de-energizes the boost control solenoid. This allows intake manifold boost pressure to act upon the side of the by-pass valve actuator diaphragm opposite of side exposed to manifold vacuum. Boost pressure will then overcome diaphragm spring pressure, opening by-pass valve and reducing boost pressure.

COMPUTERIZED ENGINE CONTROLS

The computerized engine control system monitors and controls a variety of engine/vehicle functions. The computerized engine control system is primarily an emission control system which is designed to maintain a 14.7:1 air/fuel ratio under most operating conditions. When the ideal air/fuel ratio is maintained, the 3-way catalytic converter can control oxides of nitrogen (NOx), hydrocarbon (HC) and carbon monoxide (CO) emissions.

The computerized engine control system consists of the master controller (PCM or ECM), input devices (sensors and switches) and output signals.

POWERTRAIN CONTROL MODULE

For exact location of Powertrain Control Module (PCM), see PCM LOCATION in appropriate SELF-DIAGNOSTICS article or COMPONENT LOCATIONS in appropriate SYSTEM & COMPONENT TESTING article. On some models, the PCM may be referred to as an Electronic Control Module (ECM). Although the 2 units may process different signals, the 2 terms are interchangeable.

The PCM contains the Arithmetic Logic Unit (ALU), Central Processing Unit (CPU), power supply and system memories. The PCM has a "learning" ability which allows it to make minor corrections for fuel system variations. If battery power to PCM is interrupted, a vehicle performance change may be noticed. This will correct itself and normal performance will return if vehicle is allowed to "relearn" optimum control conditions. This is accomplished by driving vehicle at normal operating temperature, under part throttle, moderate acceleration and idle conditions.

Arithmetic Logic Unit

The Arithmetic Logic Unit (ALU) is an internal component of the PCM which converts electrical signals, received by PCM from various engine sensors, into digital signals for use by the CPU.

Central Processing Unit

Digital signals received by the Central Processing Unit (CPU) are used to perform all mathematical computations and logic functions necessary to deliver proper air/fuel mixture. CPU also calculates spark timing and idle speed. The CPU commands operation of emission control, "closed loop" fuel control and diagnostic system.

Power Supply

Power for PCM reference output signals (5 volts) and control devices (12 volts) is received from the battery (through ignition circuit when ignition switch is in ON position). Keep alive memory power is received directly from battery.

Memories

PCM uses 4 types of memories:

* Read Only Memory (ROM) - ROM is programmed information that can only be read by PCM. The ROM program cannot be changed. If battery voltage is removed, ROM information will be retained.
* Random Access Memory (RAM) - RAM is the scratch pad for the CPU. Data input, diagnostic codes and results of calculations are constantly updated and temporarily stored in RAM. If battery voltage is removed from PCM, all information stored in RAM is lost.
* Programmable Read Only Memory (PROM) - PROM is factory programmed engine calibration data which "tailors" PCM for specific transmission, engine, emission, vehicle weight and rear axle ratio applications. The PROM can be removed from

PCM. If battery voltage is removed, PROM information will be retained. An Electronically Erasable Programmable Read Only Memory (EEPROM) is used on some models. This is the same as a PROM except it can be electronically reprogrammed by the manufacturer using special equipment.

* Electronically Erasable Programmable Read Only Memory (EEPROM) - Some models may use an EEPROM. This is the same as a PROM except it can be electronically reprogrammed by the manufacturer using special equipment.

NOTE: Components are grouped into 2 categories. The first category covers INPUT DEVICES, which control or produce voltage signals monitored by the control unit. The second category covers OUTPUT SIGNALS, which are components controlled by the control unit.

INPUT DEVICES

Vehicles are equipped with different combinations of input devices. Not all devices are used on all models. To determine the input devices used on a specific model, see appropriate wiring diagram in WIRING DIAGRAMS article, or see COMPONENT LOCATIONS in appropriate SYSTEM & COMPONENT TESTING article. The available input signals include the following:

A/C Request Signal

The air conditioner mode selector is mounted on instrument panel. This mode selector provides a simple "on" (A/C request) signal which is monitored by the PCM. PCM uses this signal to determine control of A/C clutch relay (if equipped) and to adjust idle speed when A/C compressor clutch is engaged. On some models, PCM may also activate electric cooling fan when this signal is present. If this signal is not present on A/C-equipped vehicles, vehicle may idle rough when A/C compressor cycles. To check function of the A/C mode selector, perform functional check of A/C mode selector. See appropriate SYSTEM & COMPONENT TESTING article.

A/C Pressure Sensor

Some models are equipped with an air conditioner pressure sensor which is used to inform PCM of A/C system pressure. PCM uses this signal to determine A/C compressor load on the engine to control idle speed with IAC valve. Failure in A/C pressure sensor circuit or with A/C pressure sensor should set a related diagnostic trouble code and A/C compressor clutch will become inoperative. A fixed high pressure value will exist if the ground circuit to sensor is faulty.

A/C Pressure Switches

A/C high and low pressure switches may be used in the PCM-monitored A/C request signal circuit. Switches are normally closed, completing the circuit between ignition and PCM. PCM will engage or disengage A/C clutch relay based upon status of this circuit. When system refrigerant pressure increases beyond a certain point, high side switch will open, causing A/C request line voltage to drop. If system refrigerant level decreases, causing refrigerant pressure to drop below normal, low side pressure switch will open, once again causing A/C request line voltage to drop. Switches may be used as normal clutch cycling devices or as safety devices which prevent compressor damage in the event of excessively high or low refrigerant pressure.

A/C Temperature Sensors

Air conditioner high side and low side temperature sensors inform PCM of A/C system temperature levels. Low temperature signal will cause A/C compressor to disengage. High temperature levels help PCM determine control of A/C compressor relative to cooling fans and idle speed.

Accelerator Pedal Position Sensor

The Accelerator Pedal Position (APP) sensor is mounted on accelerator pedal assembly or throttle body. Three separate signal, ground and 5-volt reference circuits are used to connect APP sensor and Throttle Actuator Control (TAC) module. The amount of voltage on signal circuit sent to TAC module varies depending on accelerator pedal position. The TAC module uses this signal to control throttle position through the throttle body actuator assembly.

The PCM monitors TP sensor signal and compares it with the commanded throttle position signal from APP sensor. A diagnostic trouble code will set if both sensor signals are not within a calibrated value of each other.

Battery Voltage

Battery voltage is monitored by PCM. If battery voltage swings low, a weak spark or improper fuel control may result. To compensate for low battery voltage, PCM may increase idle speed, advance ignition timing, increase ignition dwell or enrich the air/fuel mixture. If voltage swings excessively high or low, PCM may set a charging system diagnostic trouble code and illuminate the Malfunction Indicator Light (MIL).

Brake Switch Feedback

Models equipped with cruise control systems may monitor the brake switch circuit to determine when to engage and disengage cruise control. On vehicles equipped with a Torque Converter Clutch (TCC), one circuit of brake switch is in series with the power supply for the TCC solenoid located in the transmission/transaxle.

Camshaft Position Sensor (2.2L & 2.4L - Cavalier & Sunfire)

Camshaft Position (CMP) sensor is located on rear side of engine block (2.2L), or on top of cylinder head in camshaft housing (2.4L). CMP sensor is used to determine crankshaft-to-camshaft position so that PCM can determine which cylinder is ready to be fueled by injector. Sensor is also used to determine which cylinder is misfiring when a misfire is present. A problem in the circuit will set a related diagnostic trouble code.

Camshaft Position Sensor (3.1L & 3.4L)

A 3-wire Camshaft Position (CMP) sensor is located at top of timing cover, behind water pump. As camshaft sprocket turns, sensor magnet activates a Hall Effect switch in CMP sensor. This signal is generated whenever cylinder No. 1 is at TDC of its compression stroke.

This signal is used by PCM, in conjunction with signals from the 3X and 24X crankshaft position sensors, to fire ignition coils and trigger the fuel injectors in sequential firing order. If sensor should fail while engine is running, engine will continue to run using the last calculated CMP sensor signal to maintain sequential fuel injection mode. Upon restart, engine will run with a 1-in-6 chance of being correct. When incorrect, engine will run rough.

Camshaft Position Sensor (3.5L)

Camshaft Position (CMP) sensor signal, when combined with the Crankshaft Position (CKP) sensor signal, enables PCM to determine exactly which cylinder is on a firing stroke. This allows PCM to properly synchronize the ignition system, fuel injectors and knock control. The CMP sensor has a power, ground and signal circuit. The power and ground circuits are supplied by the PCM and are also connected to the CKP sensor.

Camshaft Position Sensor (3.8L)

The 3.8L C3I system uses a 3-wire, Hall Effect switch Camshaft Position (CMP) sensor mounted on timing cover behind the water pump. As camshaft sprocket rotates, the Hall Effect switch alternately grounds and opens a 12-volt signal circuit to the ignition module. The constant grounding and opening of this circuit results in a toggling on/off signal which is interpreted by ignition module as a TDC No. 1 compression signal. The ignition module passes this signal on to the PCM. The camshaft signal, in conjunction with 3X and 18X crankshaft signals, allows PCM to properly time ignition and fuel injection. Also see CRANKSHAFT (3X/18X) SENSOR (3.8L).

If sensor should fail while engine is running, engine will continue to run using the last calculated CMP sensor signal to maintain sequential fuel injection mode. Upon restart, engine will run with a 1-in-6 chance of being correct. When incorrect, engine will run rough. For additional information, see
COMPUTER CONTROLLED COIL IGNITION under IGNITION SYSTEM.

Camshaft Position Sensor (4.6L)

Camshaft Position (CMP) sensor is located on rear cylinder bank in front of exhaust camshaft. Sensor extends into rear cylinder head and is sealed with an "O" ring. CMP sensor is not adjustable.

As rear cylinder bank exhaust camshaft turns, a steel pin on its drive sprocket passes over the magnetic CMP sensor. This creates an on/off signal sent to ignition control module similar to crankshaft position sensors. Sensor produces on/off pulse for every one revolution of camshaft or every 2 revolutions of crankshaft. This allows ignition control module to recognize camshaft position.

Camshaft Position Sensor (5.7L)

The Camshaft Position (CMP) sensor is mounted through top of engine block, at the rear of valley cover. The CMP sensor works in conjunction with a 1X reluctor wheel attached at the rear of the camshaft. The CMP sensor is used to determine if a cylinder is on a firing or exhaust stroke. As camshaft rotates, a magnetic field produced by CMP sensor magnet is interrupted. This produces a signal which is sent to PCM. The PCM uses this signal in combination with Crankshaft Position (CKP) sensor 24X signal to determine crankshaft position and stroke.

Unlike the CKP sensor signal, the CMP sensor signal is not necessary to start and operate the engine. The PCM can determine the position of a particular cylinder using the CKP 24X signal.

Crankshaft (7X) Sensor (2.2L & 2.4L)

The 7X signal is generated by a PM generator crankshaft sensor which is mounted through the side of the engine block. See CRANKSHAFT POSITION SENSOR. The PCM uses this signal from the electronic Ignition Control Module (ICM) to calculate engine RPM, crankshaft position and injector pulse width. Engine will not start or run if this circuit is open or grounded. A problem in this circuit will also set a related diagnostic trouble code.

Crankshaft (3X/7X) Sensor (3.1L)

A 7X crankshaft signal is generated by a 2-wire, Permanent Magnet (PM) generator Crankshaft Position (CKP) sensor which is mounted through side of engine block. See CRANKSHAFT POSITION SENSOR. Ignition module converts this 7X signal to a 3X signal which is passed on to the PCM. The 7X signal is used by the ignition control module to determine which ignition coil to fire. The 3X signal is used by the PCM to determine RPM, crankshaft position, injector timing and to compute ignition timing at engine speeds greater than 1200 RPM.

Crankshaft (24X) Sensor (3.1L & 3.4L)

The 24X signal is generated by a 3-wire Hall Effect switch located in an aluminum mounting bracket and bolted to the front left side of the engine timing chain cover. The Hall Effect switch alternately grounds and opens a 12-volt signal circuit to PCM. An air gap separates the Hall Effect switch from a magnet. An interrupter ring containing 24 equally-spaced blades is mounted on the vibration damper and rotates with the crankshaft.

When the Hall Effect switch is shielded from the magnetic field generated by the magnet by one of the interrupter blades, the 12-volt signal circuit is not grounded by the Hall Effect switch. When the Hall Effect switch is exposed to the magnetic field, the 12-volt signal circuit is grounded by the Hall Effect switch. The constant grounding and opening of this circuit results in an on/off signal which is interpreted by the PCM as an RPM (engine speed) signal. PCM uses the 24X signal to compute ignition timing at engine speeds less than 1200 RPM. At speeds greater than 1200 RPM, PCM uses the 3X crankshaft signal to compute ignition timing.

Crankshaft (3X/18X) Sensor (3.8L)

The 3.8L C3I system uses a 4-wire, dual (3X and 18X) Hall

Effect switch Crankshaft Position (CKP) sensor. Sensor is located in an aluminum mounting bracket bolted to the front left side of the engine timing chain cover. Sensor contains 2 Hall Effect switches. Each Hall Effect switch alternately grounds and opens individual 12-volt signal circuits to ignition module.

An air gap separates each Hall Effect switch from a magnet. Two interrupter rings are mounted on the vibration damper and rotate with the crankshaft. The inner interrupter ring contains 3 unevenly-spaced, unequal-width blades. The outer interrupter ring contains 18 evenly-spaced, equal-width blades.

When the Hall Effect switch is shielded from the magnetic field generated by the magnet by one of the interrupter blades, the 12-volt signal circuit is not grounded by the Hall Effect switch. When each Hall Effect switch is exposed to the magnetic field, the 12-volt signal circuit is grounded by the Hall Effect switch. The constant grounding and opening of these 12-volt signal circuits result in a toggling on/off signal which the ignition module interprets as RPM (engine speed).

The comparison on these 2 differing signals generated by the 3X and 18X Hall Effect switches enables ignition control module to verify synch pulse accuracy. The 3X and 18X signals are passed on to the PCM which uses these signals to determine crankshaft position, RPM and necessary spark timing adjustments. For additional information, see COMPUTER CONTROLLED COIL IGNITION under IGNITION SYSTEM.

Crankshaft (4X/24X) Sensor (5.7L)

The Crankshaft Position (CKP) sensor is located on right-side of engine, behind starter. The CKP sensor is a dual-magneto, resistive type sensor. The dual micro switches within the sensor monitor both notches of a reluctor wheel which is mounted on the rear of the crankshaft. By monitoring the reluctor wheel, CKP sensor produces both 24X and 4X signals. PCM uses 24X signal to determine if a particular cylinder is on the firing or exhaust stroke. PCM uses the 4X signal for tachometer output, spark control, fuel control, certain diagnostics and to identify a cylinder misfire.

The CKP sensor signal must be available for engine to start. A diagnostic trouble code should set if CKP sensor signal is out of range, or if a cylinder misfire is detected.

Crankshaft Position Sensor

The 2.2L, 3.1L and 4.6L Direct Ignition System (DIS) and the 2.4L Integrated Direct Ignition (IDI) system Crankshaft Position (CKP) sensor is a 2-wire, Permanent Magnet (PM) generator which protrudes through the side of the engine block to within .050" (1.3 mm) of an internally-mounted crankshaft reluctor ring. The reluctor ring is a special trigger wheel (notches) cast into the crankshaft. An extra notch in the reluctor ring delineates TDC for cylinder No. 1. As crankshaft rotates, notches in reluctor ring change the magnetic field at the tip of the CKP sensor. This creates an induced AC voltage signal in the sensor windings, resulting in reference signals which are sent to PCM by ignition control module. This allows PCM to compute crankshaft position and RPM and fire appropriate ignition coil at the proper time. On 3.1L, an additional crankshaft signal is generated by a 24X Hall Effect sensor.

On 3.5L, CKP sensor is actually 2 sensors within a single housing. Each sensor has a separate power, ground and signal circuit. The PCM supplies 12 volts and a ground path to both sensors and are also connected to Camshaft Position (CMP) sensor. Two separate signal circuits connect the CKP sensor to the PCM.

The PCM can use 3 different modes of decoding crankshaft position. During normal operation, the PCM performs an Angle Based calculation using both signals to determine crankshaft position. The dual sensor allows the engine to run even if one signal is lost. If either signal is lost, the PCM switches to a Time Based method of calculating crankshaft position. If system operates in Time "A" mode, PCM uses only the signal from sensor "A". Time "B" mode indicates that sensor "B" signal is being used. If the lost signal is restored, PCM will continue to operate in Time Based mode until the next key cycle. PCM reverts back to Angle Mode on the next key start if fault is no longer present. A fault in sensor "A" will set a different trouble code than sensor "B".

On 3.8L, CKP sensor utilizes a 4-wire dual Hall Effect switch mounted near vibration damper. Sensor monitors vibration damper position (crankshaft position) and sends signals to ignition control module, which passes these signals on to the PCM. These signals provide PCM with a TDC position reference for each piston, as well as supplying an engine speed (RPM) signal.

Engine Coolant Temperature Sensor

The Engine Coolant Temperature (ECT) sensor is a thermistor (temperature sensitive resistor) located in an engine coolant passage. The PCM supplies and monitors a 5-volt signal to ECT sensor through a resistor in PCM. This monitored 5-volt signal is then reduced by resistance of the engine coolant temperature. When coolant temperatures are low, ECT sensor resistance is high, and a high monitored voltage signal is seen by the PCM. When coolant temperatures are high, ECT sensor resistance is low, and a low monitored voltage is seen by the PCM. After engine start-up, temperature should rise steadily to about 194øF (90øC), then stabilize when thermostat opens.

Engine coolant temperature signal is used in the control of most systems the PCM controls (i.e., fuel delivery, ignition timing, idle speed, emission control devices). After a vehicle has been parked overnight, ECT and IAT sensor signals (resistance and temperature) should be close to same reading. An ECT sensor which is out of calibration will not set a diagnostic trouble code but will cause fuel delivery and driveability problems. Failure in ECT sensor circuit (open or short to ground) will cause monitored voltage to swing high or low and should set a related diagnostic trouble code.

Engine Coolant Level Switch

PCM checks engine coolant level continuously. If coolant level is low at any time, PCM will send information through the serial data to the Instrument Panel Cluster (IPC) to illuminate the "Low Coolant Level" warning light.

Engine Oil Level Switch

PCM checks engine oil level during engine start-up. If oil level switch indicates oil level is low, PCM will send this information through the serial data to the Instrument Panel Cluster (IPC) to illuminate the "Low Oil Level" warning light.

Oil level is checked once per ignition cycle and also after ignition is turned off to allow oil enough time to drain back into oil pan.

Engine Oil Pressure Sensor

PCM checks engine oil pressure continuously. If engine oil pressure sensor indicates high or low oil pressure at any time, PCM will set a related diagnostic trouble code.

Engine Oil Pressure Switch

PCM checks engine oil pressure continuously. If engine oil pressure switch indicates low oil pressure at any time, PCM will send information through the serial data to the Instrument Panel Cluster (IPC) to illuminate the "Low Oil Pressure" warning light.

Fuel Level Sensor

PCM uses fuel level sensor input to determine expected amount of fuel vapor pressure or vacuum within the fuel tank. Scan tool can display fuel level in percent for diagnostic purposes. A problem in this circuit will set a related diagnostic trouble code.

Fuel Pump Feedback

On some models, the fuel pump circuit between the fuel pump relay and fuel pump is monitored by PCM. This enables PCM to determine when the fuel pump relay is energized and voltage is being delivered to fuel pump. Voltage monitored on this circuit is also used in calculations to determine changes in idle speed, air/fuel ratio and ignition dwell. Failure in this monitored circuit should set a related diagnostic trouble code.

Fuel Tank Vapor Pressure Sensor

Fuel tank vapor pressure sensor is similar to MAP sensor. It is used to measure the difference between the air pressure or vacuum in the fuel tank and outside air pressure. PCM supplies a 5-volt reference and ground to the sensor, and sensor sends a voltage signal of 0.1-4.9 volts back to the PCM. When air pressure in fuel tank is equal to the outside air pressure, as when fuel cap is removed, the output voltage of the sensor will be from 1.3-1.7 volts.

Gear Switches

Gear switches are located inside automatic transmission. Switches may be normally open or closed, and change status depending upon internal hydraulic pressures. High gear switch information is used by PCM in controlling emission components and engagement of Torque Converter Clutch (TCC).

Generator "L" Light Circuit

On models where generator is controlled by the PCM, PCM can use the "L" circuit to control generator operation during starting. If PCM is disabling the generator, scan tool will display ACTIVE, or when the disable operation of generator is active. PCM also supplies about 5 volts through the "L" circuit to generator. If generator becomes inoperative, PCM senses the fault through the "L" circuit and commands the Instrument Panel Circuit (IPC) to illuminate the VOLTS light.

Generator "F" Field Circuit

PCM monitors the duty cycle of the generator through the "F" circuit. As generator load increases, PCM can adjust idle speed accordingly. If Instrument Panel Cluster (IPC) does not see any activity from the "F" circuit, IPC will illuminate the VOLTS light.

Ignition/Crank Signal

The PCM monitors initial cranking (RPM) signal to determine when the engine is being started. This information is used for starting enrichment. If this signal is intermittent or not available, hard starting or a no-start condition will result.

Intake Air Temperature Sensor

The Intake Air Temperature (IAT) sensor is a thermistor (temperature sensitive resistor) mounted in the intake manifold. The PCM supplies and monitors a 5-volt signal to IAT sensor through a resistor in PCM. This monitored 5-volt signal is then reduced by resistance of the intake air temperature. Low intake air temperature produces high resistance, while high intake air temperature produces low resistance. By monitoring this voltage, PCM determines manifold air temperature. IAT sensor signal is used to make fuel control calculations according to incoming air density.

Intake air temperature should read close to ambient temperature with engine cold, and rise as underhood temperature increases. After a vehicle has been parked overnight, IAT and ECT sensor signals (resistance and temperature) should be close to the same reading. An IAT sensor which is out of calibration will not set a Diagnostic Trouble Code (DTC), but will cause fuel delivery and driveability problems. Failure in IAT sensor circuit (open or short to ground) will cause monitored voltage to swing high or low and should set a related DTC.

Knock Sensor

The knock sensor is a piezoelectric device which detects abnormal engine vibrations (spark knock) in the engine. This vibration results in the production of a very low AC signal which is sent from the knock sensor back to knock sensor module, if equipped (mounted on PCM), or to the EEPROM/PROM portion of PCM on models not equipped with a knock senor module. The PCM will then retard spark timing until engine knock ceases. Some models use 2 knock sensors.

For additional information on knock sensor operation, see IGNITION TIMING SYSTEMS under IGNITION SYSTEM. Failure in knock sensor circuit should set a related Diagnostic Trouble Code (DTC). If a related DTC is not present and knock sensor system is suspected as the cause of a driveability problem, perform a functional check of the knock sensor. See appropriate SYSTEM & COMPONENT TESTING article.

Manifold Absolute Pressure Sensor

The Manifold Absolute Pressure (MAP) sensor measures changes in manifold pressure. Changes in manifold pressure result from engine load and speed changes. The MAP sensor converts these changes in manifold pressure into a voltage output signal to PCM (about 1.5 volts at idle to about 4.5 volts at WOT). The PCM can monitor these signals and adjust air/fuel ratio and ignition timing under various operating conditions.

If MAP sensor fails, PCM will substitute a fixed MAP value and will use the TP sensor to control fuel delivery. Failure in MAP sensor circuit should set a related Diagnostic Trouble Code (DTC). If a related DTC is not present and MAP sensor is suspected of causing a driveability problem, perform a functional check of MAP sensor. See appropriate SYSTEM & COMPONENT TESTING article.

Mass Airflow Sensor

The Mass Airflow (MAF) sensor measures flow of air entering the engine in grams per second. This measurement of airflow is a reflection of engine load (throttle opening and air volume), similar to the relationship of engine load to MAP or vacuum sensor signal. MAF signal should remain relatively constant at cruise, gradually changing with throttle angle and rapidly changing on sudden acceleration. PCM uses MAF information to control fuel delivery. Sensor produces a frequency signal which cannot be easily measured in testing (32-150 Hertz). This varying signal is proportional to airflow. Failure in MAF sensor circuit should set a related diagnostic trouble code.

CAUTION: DO NOT attempt to measure oxygen sensor output voltage using a conventional voltmeter. Current drain of voltmeter could damage sensor. Oxygen sensor voltage signal can be measured using a 10-megohm (minimum input impedance) digital voltmeter.

Oxygen Sensor

The Oxygen Sensor (O2S) is mounted in the exhaust system where it monitors oxygen content of exhaust gases. Four oxygen sensors are used on some models. The oxygen content causes the Zirconia/Platinum-tipped oxygen sensor to produce a voltage signal which is proportional to exhaust gas oxygen concentration (0-3 percent) compared to outside oxygen (20-21 percent). This voltage signal is low (about 0.1 volt) when a lean mixture is present and high (about 1.0 volt) when a rich mixture is present. As PCM compensates for a lean or rich condition, this voltage signal constantly fluctuates between high and low, crossing a .45-volt reference voltage supplied by PCM on the oxygen sensor signal line. This is referred to as "cross counts".

The oxygen sensor will not function properly (produce voltage) until its temperature reaches about 600øF (316øC). On some models, oxygen sensor is equipped with a sensor heating element. This type of sensor is referred to as Heated Oxygen Sensor (HO2S). This allows the sensor to reach operating temperature sooner and prevents fuel system from re-entering "open loop" mode due to a cooled sensor (which is a normal occurrence during prolonged idle).

Heated oxygen sensors are mounted before and after Three-Way Catalyst (TWC). PCM monitors voltage produced by heated oxygen sensors and compares both values to determine catalyst efficiency. Rear mounted HO2S is normal when activity appears lazy or inactive, indicating TWC is functioning properly.

At temperatures less than the normal operating range of the sensor, engine will function in "open loop" mode and PCM will not make air/fuel adjustments based upon oxygen sensor signals but will use TP sensor and MAP or MAF values to determine air/fuel ratio from a table built into memory. When PCM reads a voltage signal greater than .45 volt from the oxygen sensor, PCM will begin to alter commands to injector to produce either a leaner or richer mixture.

Once the engine has entered "closed loop", a cooled-down sensor or a fault in the oxygen sensor circuit (open or shorted circuit) is the only condition which can return it to "open loop". Failure in oxygen sensor circuit should set a related diagnostic trouble code.

Park/Neutral Position Switch

The Park/Neutral Position (PNP) switch is connected to transmission gear selector. PNP switch signals PCM when transmission is in Park, Neutral or Drive. Information from PNP switch is used by PCM for determining control of IAC valve, TCC and EGR. To check PNP switch, perform functional check of switch. See appropriate SYSTEM & COMPONENT TESTING article. If vehicle is driven with PNP switch disconnected, idle quality will be affected and a possible false related diagnostic trouble code may be set.

Power Steering Pressure Switch

The Power Steering Pressure (PSP) switch informs PCM of engine load conditions that exist when steering wheel is turned from center to full lock position. PCM uses information to help control idle speed, and on some models, A/C clutch. To check PSP switch, perform functional check of switch. See appropriate SYSTEM & COMPONENT TESTING article.

RPM Reference Signal

The RPM is monitored by PCM through tach/pulse signals produced by either the ignition control module or crankshaft position sensor (Hall Effect signal on C3I, PM generator signal on DIS and IDI). These signals are used by PCM for determining control of timing, fuel delivery, EGR function and idle speed.

Throttle Position Sensor

The Throttle Position (TP) sensor is a variable mechanical resistor connected directly to the throttle shaft linkage. The TP sensor has 3 wires connected to it. One is connected to a 5-volt reference voltage supply from PCM, the second is connected to PCM ground and the third is the signal return which is monitored by PCM. The voltage signal from the TP sensor varies from closed throttle (.5-1.0 volt) to wide open throttle (4.5-5.0 volts). This signal is used by PCM for determining control of fuel, idle speed, spark timing and converter clutch. Failure in TP sensor circuit should set a related diagnostic trouble code.

Throttle Position Switch

Throttle position switch is incorporated into Idle Speed Control (ISC) motor. Throttle position switch informs PCM when throttle lever is contacting ISC plunger. This allows PCM to determine when to control idle speed. When throttle is open sufficiently to relieve pressure from the ISC plunger, switch will open and PCM will no longer attempt to control idle speed.

Transmission Fluid Temperature Sensor

Transmission fluid temperature sensor is a thermistor (temperature sensitive resistor) and is located in valve body. High sensor resistance produces high signal input voltage which corresponds to low fluid temperature. Low sensor resistance produces low signal input voltage which corresponds to high fluid temperature. PCM uses transmission fluid temperature sensor signal to determine TCC apply and release schedules, hot mode determination and shift quality. Failure in transmission fluid temperature sensor circuit should set a related diagnostic trouble code.

Transmission Range Switch

Transmission range switch is mounted on transaxle assembly. Transmission range switch inputs to PCM indicate which gear is selected. Information from transmission range switch is used by PCM for determining control of IAC valve, timing and canister purge operation. To check transmission range switch, perform functional check of switch. See appropriate SYSTEM & COMPONENT TESTING article. If vehicle is driven with transmission range switch disconnected, idle quality will be affected and a possible false related diagnostic trouble code may be set.

Vehicle Speed Sensor

The Vehicle Speed Sensor (VSS) is a Permanent Magnet (PM) generator mounted in transaxle/transmission. The VSS sends a pulsing AC voltage signal to PCM, which PCM converts into miles per hour (MPH). VSS signal is used by PCM in controlling TCC and shift solenoids. Signal may also be used for instrument cluster speedometer and cruise control system. Failure in VSS circuit should set a related diagnostic trouble code.

OUTPUT SIGNALS

NOTE: Vehicles are equipped with different combinations of

PCM-controlled components. Not all components listed below are used on every vehicle. For theory and operation on each output component, refer to system indicated after component.

A/C Compressor Clutch
See MISCELLANEOUS CONTROLS.

Air Injection System
See EMISSION SYSTEMS.

Boost Control Solenoid (Supercharger)
See AIR INDUCTION SYSTEM.

Canister Purge Control Solenoid
See EMISSION SYSTEMS.

Coil-Near-Plug (CNP) Ignition
See IGNITION SYSTEM.

Computer Controlled Coil Ignition (C3I)
See IGNITION SYSTEM.

Cooling Fan Relay
See ELECTRIC COOLING FAN under MISCELLANEOUS CONTROLS.

Digital EGR Valve
See EMISSION SYSTEMS.

Direct Ignition System (DIS)
See IGNITION SYSTEM.

EGR Control Solenoid
See EMISSION SYSTEMS.

Electronic Variable Orifice (EVO) Actuator
See MISCELLANEOUS CONTROLS.

Fuel Injectors
See FUEL CONTROL under FUEL SYSTEM.

Fuel Pump & Fuel Pump Relay
See FUEL DELIVERY under FUEL SYSTEM.

HOT Light Or Coolant Temperature (TEMP) Light
See MISCELLANEOUS CONTROLS.

Idle Air Control (IAC) Valve
See IDLE SPEED under FUEL SYSTEM.

Integrated Direct Ignition (IDI)
See IGNITION SYSTEM.

Linear EGR Valve
See EMISSION SYSTEMS.

Knock Sensor Operation
See IGNITION SYSTEM.

Malfunction Indicator Light (MIL)
See SELF-DIAGNOSTIC SYSTEM.

Self-Diagnostics
See SELF-DIAGNOSTIC SYSTEM.

Serial Data
See SELF-DIAGNOSTIC SYSTEM.

Shift Light
See MISCELLANEOUS CONTROLS.

Shift Solenoids (Electronically-Controlled Transmission)
See MISCELLANEOUS CONTROLS.

Throttle Actuator
See THROTTLE ACTUATOR CONTROL SYSTEM.

Torque Converter Clutch
See MISCELLANEOUS CONTROLS.

FUEL SYSTEM

FUEL DELIVERY

Fuel Pump

An in-tank electric fuel pump delivers fuel to injectors through an in-line fuel filter. The pump is designed to supply fuel pressure in excess of vehicle requirements. The pressure relief valve in the fuel pump controls maximum fuel pump pressure.

A pressure regulator mounted in fuel rail, keeps fuel to injectors at a constant pressure. Excess fuel is returned to fuel tank through regulator return line. For fuel pressure specifications, see appropriate SERVICE & ADJUSTMENT SPECIFICATIONS article.

When the ignition switch is turned to ON position, PCM will turn on the electric fuel pump by energizing the fuel pump relay. The PCM will continue to energize relay if the engine is running or cranking (PCM is receiving reference pulses from the ignition control module). If no reference pulses exist, PCM de-energizes fuel pump relay within 2 seconds after ignition is turned on. For additional information, see FUEL PUMP RELAY.

Fuel Pump Relay

When ignition switch is turned to the ON position, PCM will turn on electric fuel pump by energizing the fuel pump relay. PCM will keep relay energized if engine is running or cranking (PCM is receiving reference pulses from ignition control module). If no reference pulses exist, PCM turns pump off within 2 seconds after key on.

As a back-up system to fuel pump relay, fuel pump is also activated by the oil pressure switch. The oil pressure switch is normally open until oil pressure reaches about 4 psi (.28 kg/cmý). If fuel pump relay fails, the oil pressure switch closes when oil pressure is obtained, operating the fuel pump. An inoperative fuel pump relay may result in extended cranking times due to the time required to build up oil pressure. Oil pressure switch may be combined into a single unit with an oil pressure gauge sender or sensor.

For additional information on fuel pump activation, see appropriate BASIC DIAGNOSTIC PROCEDURES and SYSTEM & COMPONENT TESTING articles.

Fuel Pressure Regulator

Fuel pressure regulator is a diaphragm-operated relief valve with injector pressure on one side and manifold pressure (vacuum) on the other. Pressure regulator compensates for engine load by increasing fuel pressure when low manifold vacuum is experienced.

During periods of high manifold vacuum, regulator-to-fuel tank return orifice is fully open, keeping fuel pressure on the low side of its regulated range. As throttle valve opens, vacuum to regulator diaphragm decreases, allowing spring tension to gradually close off return passage. At wide open throttle, when vacuum is at its lowest, return orifice is restricted, providing maximum fuel volume and maintaining constant fuel pressure to injectors.

FUEL CONTROL

The PCM, using input signals, determines adjustments to the air/fuel mixture in order to provide the optimum ratio for proper combustion under all operating conditions. Two types of fuel control systems are used: Multiport Fuel Injection (MFI) and Sequential Fuel Injection (SFI). These systems can operate in "open loop" or "closed loop" mode. Description of these modes is as follows:

Open Loop

When engine is cold and engine speed is greater than 400 RPM, PCM operates in "open loop" mode. In "open loop", PCM calculates air/fuel ratio based upon inputs from Engine Coolant Temperature (ECT), Intake Air Temperature (IAT) and Manifold Absolute Pressure (MAP) sensors. Engine will remain in "open loop" operation until oxygen sensor reaches normal operating temperature, engine coolant temperature reaches preset temperature, and a specific period of time has elapsed after engine start-up.

Closed Loop

When oxygen sensor has reached normal operating temperature, engine coolant temperature has reached a preset temperature and a specific period of time has passed since engine start-up, PCM operates in "closed loop". In "closed loop", PCM controls air/fuel ratio based upon oxygen sensor signals (in addition to other input parameters) to maintain as close to a 14.7:1 air/fuel mixture as possible. If oxygen sensor cools off (due to excessive idling) or a fault occurs in the oxygen sensor circuit, vehicle will once again enter "open loop" mode.

Battery Voltage Correction

PCM compensates for low battery voltage by increasing injector pulse width, increasing idle RPM and increasing ignition dwell time. PCM is able to perform these commands because of a built-in memory/learning function.

Fuel Cut-Off

Injectors are de-energized when ignition is turned off to prevent dieseling. Injectors will not be energized if RPM reference pulses are not received by the PCM, even with ignition on. This prevents flooding before starting. Fuel cut-off will also occur at high engine RPM to prevent internal damage to engine. On some models, fuel injector signals may also be cut off during periods of high speed, closed throttle deceleration (when fuel is not needed).

Multiport Fuel Injection (MFI)

Individual, electrically pulsed injectors (one per cylinder) are located in intake manifold fuel rails. These injectors are next to intake valves in cylinder head.

This system features simultaneous double-fire injection. Fuel injectors are pulsed once for each engine revolution, each spray providing 1/2 the fuel required for the combustion process. Thus, 2 injections of fuel (2 rotations of crankshaft) are mixed with incoming air to produce the fuel charge for each combustion cycle.

Constant fuel pressure is maintained to the injectors. Air/fuel mixture is regulated by amount of time injector stays open (pulse width). Various sensors provide information to the PCM to control pulse width.

Sequential Fuel Injection (SFI)

Injectors on these models are pulsed sequentially in spark plug firing order. The main differences between sequential and simultaneous systems are injectors, wiring and the PCM.

Constant fuel pressure is maintained to the injectors. Air/fuel mixture is regulated by amount of time injector stays open (pulse width). Various sensors provide information to the PCM to control pulse width.

IDLE SPEED

PCM controls engine idle speed based upon engine operating conditions. The PCM senses engine operating conditions and determines the best idle speed.

Idle Air Control Valve

The Idle Air Control (IAC) valve controls engine idle speed during engine load changes to prevent stalling. The IAC valve is mounted on throttle body or on upper manifold assembly, and controls the amount of air by-passed around the throttle plate. To control engine idle speed, the IAC valve moves its pintle in and out in steps referred to as "counts" (zero counts, fully seated; 255 counts, fully retracted). Counts can be measured using a scan tool plugged into the Data Link Connector (DLC).

Normal counts on an idling engine is usually about 4-60. When engine is idling, PCM determines proper positioning of IAC valve based on battery voltage, engine coolant temperature, engine load and engine RPM. If engine RPM is too low, pintle is retracted and more air is by-passed around the throttle plate to increase engine RPM. If engine RPM is too high, pintle is extended and less air is by-passed around the throttle plate to decrease engine RPM.

If IAC valve is disconnected or connected with engine running, IAC loses its reference point and has to be reset. Resetting of IAC is accomplished on some models by turning ignition on and off. On other models, driving vehicle at normal operating temperature and speed greater than 35 MPH with circuit properly connected may be necessary. Problems in IAC circuit should set a related diagnostic trouble code.

The IAC valve affects only the idle system. If valve is stuck fully open, excessive airflow into the manifold creates a high idle speed. Valve stuck closed allows insufficient airflow, resulting in low idle speed. For calibration purposes, several different design IAC valves are used. Ensure proper design valve is used during replacement.

IGNITION SYSTEM

DESCRIPTION

All vehicles are equipped with a high energy ignition system capable of producing in excess of 40,000 volts. Systems include the C3I system, DIS system and IDI system. Catera uses a simple DIS system which contains a coil pack which is directly controlled by the ECM. Camaro, Firebird and Corvette use a multiple-coil ignition system which utilizes 8 separate ignition coil/module assemblies mounted on the rocker covers. This system is also known as Coil-Near-Plug (CNP).

DIS (3.0L)

The 3.0L V6 is equipped with a distributorless ignition system. In this system, a pair of cylinders share one coil in the following arrangement: 1-4, 2-5 and 3-6. Each coil is connected to the spark plugs on companion cylinders. When appropriate ignition coil is fired, both companion cylinders are at TDC, one on the compression stroke, the other on the exhaust stroke.

The cylinder on the exhaust stroke requires little voltage to trigger the spark plug. This allows the balance of the voltage to trigger the spark plug on the compression stroke. This is referred to as the "waste spark" method.

The 3.0L DIS does not use an ignition module. The ignition coil is powered by an ignition feed circuit. The control circuits for each of the 3 ignition coils go directly to the ECM, which controls ignition coil triggering (sequence and timing).

DIS (3.5L)

The 3.5L V6 is equipped with a distributorless ignition system. In this system, an individual ignition coil is used for each cylinder. An ignition coil assembly consisting of 3 coils and one ignition control module is located in the center of each cam cover. This allows ignition coil to connect directly to spark plug and eliminates the need for secondary ignition wires.

The 2 ignition control modules control the ignition coils on each cylinder bank separately. The PCM controls the ignition control modules using 6 separate Ignition Control (IC) circuits. Firing sequence and timing are PCM controlled.

Because there are no secondary ignition wires, there is no energy loss due to ignition wire resistance. Also, since the firing is sequential, each ignition coil has 5 events to saturate as opposed to 2 in a "waste spark" system. Therefore, no energy is lost through the resistance a "waste spark" system would normally create.

COIL-NEAR-PLUG IGNITION

The Coil-Near-Plug (CNP) ignition system, used on Camaro, Firebird and Corvette, eliminates the need for a mechanical distributor. The CNP ignition system consists of 8 ignition coil/module assemblies, 8 separate Ignition Control (IC) circuits, Camshaft Position (CMP) sensor, 1X camshaft reluctor wheel, Crankshaft Position (CKP) sensor, 24X crankshaft reluctor wheel and a Powertrain Control Module (PCM).

Each individual coil/module assembly is mounted above its respective cylinder on the rocker covers, and are attached to spark plugs using short secondary wires. Each coil/module assembly is attached to the PCM with a separate IC circuit and are fired sequentially. Ignition timing decisions are made by PCM based on input from the crankshaft reference signal and various other sensors. PCM triggers and controls timing of each coil/module assembly individually.

COMPUTER CONTROLLED COIL IGNITION

The Computer Controlled Coil Ignition (C3I) system, used on 3.8L, eliminates the need for a mechanical distributor. The C3I ignition system consists of an ignition coil pack (3 coils), ignition control module, Hall Effect camshaft and crankshaft sensors, necessary wiring, and the ignition control and fuel metering portion of the PCM.

In the C3I system, each cylinder is paired with the cylinder that is opposite it in the firing order. Cylinder No. 1 is paired with No. 4, No. 2 with No. 5, and No. 3 with No. 6. Spark occurs simultaneously in the cylinder approaching the compression stroke and in the cylinder approaching the exhaust stroke. The cylinder on the exhaust stroke requires less voltage for the spark plug to fire. This leaves the bulk of the available voltage to fire the spark plug for the cylinder on the compression stroke. The process is repeated when the cylinders reverse roles. Each cylinder pair is fired by its own ignition coil.

Input signals from the Hall Effect (3X and 18X) dual crankshaft sensor and Hall Effect camshaft sensor are used by the ignition control module to determine when to trigger the appropriate coil pack. Ignition control module passes on camshaft sync-pulse signal to the PCM to initialize sequential fuel injector timing.

Ignition Coil Pack

On ignition coil pack, 3 separate twin tower coils are independently mounted over the C3I ignition control module. Each coil provides the spark for 2 simultaneously paired spark plugs. Each coil can be replaced separately.

Camshaft & Dual (3X & 18X) Crankshaft Sensors

The Camshaft Position (CMP) sensor is located on the timing cover behind water pump, near camshaft sprocket. The dual (3X and 18X) Crankshaft Position (CKP) sensor is located behind the crankshaft balancer.

The PCM uses camshaft "sync-pulse" signals (passed to PCM by the ignition control module) to determine the exact position of piston No. 1. Signal is used by PCM to properly initialize fuel injector firing. If CMP sensor fails, engine can be restarted and will run in sequential mode; however, odds are 1-in-6 that injectors will spray correctly without CMP sensor signal. This provides "walk home" protection against CMP sensor failure.

In addition to the camshaft sensor, the crankshaft sensor contains 2 Hall Effect switches mounted between the interrupter rings. The outer interrupter ring, located on the back side of the balancer, contains 18 evenly spaced blades, producing 18 pulses per crankshaft revolution. The inner ring has 3 unequal-width blades spaced at irregular intervals (10, 20 and 30 degrees apart).

The ignition control module monitors signals generated by the 2 Hall Effect switches. The 18X switch will change state once during the 10-degree gap of the 3X ring, twice during the 20-degree gap and 3 times during the 30-degree gap. The changing relationship between the 2 switch signals allows the ignition control module to identify the correct ignition coil to fire within the first 120 degrees of crankshaft rotation. This system provides for a faster start and a more accurate measurement of CKP sensor signals.

If the 3X signal to ignition control module is lost while the engine is running, the fuel injection system will continue to run in sequential mode; however, loss of 3X or 18X signal will prevent vehicle from restarting. If CMP sensor or dual CKP sensor signal is lost, a diagnostic trouble code will be set.

Fuel Control Signal

In addition to the RPM reference (18X) signal and fuel sync (camshaft) signals generated by the ignition control module, a fuel control reference signal must also be passed on to the PCM in order to inform PCM proper signals are being generated to the ignition control module. The fuel control signal is generated by the C3I module from calculations involving signals from the 18X and the 3X pulse rings.

DIRECT IGNITION SYSTEM & INTEGRATED DIRECT IGNITION

The Direct Ignition System (DIS) is a distributorless system used on 1.9L, 2.2L, 3.1L, 3.4L and 4.6L. The 2.4L uses a similar system referred to as the Integrated Direct Ignition (IDI) system. The operation of DIS is quite similar to operation of the C3I system. Systems consist of 2 (4-cylinder), 3 (V6) or 4 (V8) ignition coils, ignition control module (located under coil pack), a camshaft position sensor, 2 Hall Effect crankshaft position sensors, necessary wiring, and the ignition control and fuel metering portion of the PCM. On the 2.4L IDI system, ignition coils, ignition control module and spark plug connectors are all combined into one unit which plugs directly onto the spark plugs.

Spark is timed by a signal sent from a crankshaft position sensor mounted through side of engine block instead of from a crankshaft position sensor mounted at crankshaft pulley (such as C3I). This signal is received by PCM (through ignition control module) and is used to trigger each coil at the proper time. See CRANKSHAFT POSITION SENSOR under INPUT DEVICES. As with the C3I system, each cylinder is fired consecutively with the cylinder opposite it in the firing order. On V8, cylinder No. 1 is paired with No. 4, No. 2 with No. 5, No. 3 with No. 8 and No. 6 with No. 7. On V6, cylinder No. 1 is paired with No. 4, No. 2 with No. 5, and No. 3 with No. 6. On 4-cylinder, cylinder No. 1 is paired with No. 4 and cylinder No. 2 is paired with No. 3. Each pair of cylinders is fired by its own ignition coil.

On all models except Saturn and 4.6L, crankshaft position sensor is mounted on bottom of ignition control module, or near the ignition control module. On Saturn, crankshaft position sensor is mounted on side of engine block. On 4.6L, crankshaft position sensors ("A" and "B") are mounted on side of engine block between cylinders No. 4 and 6. On all models, the crankshaft position sensor protrudes through the side of engine block to within .05" (1.3 mm) of an internally-mounted crankshaft reluctor ring. Sensor position is not adjustable.

The reluctor is a piece of metal, cast with the crankshaft. On all models except 4.6L, reluctor has 7 slots machined into it, 6 of which are equally spaced (60 degrees apart). The seventh slot is spaced about 10 degrees from one of the other slots and generates a synchronization pulse signal. On 4.6L, reluctor has 24 evenly spaced notches machined into it and an additional 8 unevenly spaced notches for a total of 32. On all models, as crankshaft rotates, notches in reluctor ring change the magnetic field at the tip of position sensor. This creates an induced AC voltage signal in the sensor windings, resulting in RPM reference signals which are sent to PCM by the ignition control module. This allows PCM to compute crankshaft position and RPM.

IGNITION TIMING SYSTEMS

NOTE: Unlike other type ignition systems, IDI does not use a by-pass circuit. Ignition timing on this system is constantly in EST mode.

Ignition Timing Advance

At engine speeds less than 400 RPM, the ignition control module controls spark advance by triggering coils at a predetermined interval based only on engine speed. At engine speeds greater than 400 RPM (EST mode), the PCM takes over control of the ignition timing.

PCM controls ignition timing based upon input signals from the engine RPM reference line (ignition control module), engine coolant temperature sensor, intake air temperature sensor, throttle position sensor, knock sensor, vehicle speed sensor and the MAF or MAP sensor.

The PROM portion of the PCM has a programmed spark advance curve based on engine speed. Spark timing is calculated by PCM whenever an ignition pulse is present. Spark advance is controlled only when engine is running (not during cranking). Input signal values are used by PCM to modify PROM information, increasing or decreasing spark advance to achieve maximum performance with minimum emissions. To check ignition system operation, see appropriate BASIC DIAGNOSTIC PROCEDURES and SYSTEM & COMPONENT TESTING articles.

Ignition systems used are one of 4 types of distributorless ignition systems. See DESCRIPTION. All ignition systems use the same 4 basic ignition circuits. The 3.8L C3I system uses the same ignition control module-to-PCM circuits, with the addition of fuel control and fuel sync (camshaft) signals that the CNP, DIS, IDI and distributor type ignition systems use. For description of fuel control and sync signals, see DESCRIPTION.

The ignition control module is connected to the PCM by 4 EST circuits. Circuits perform the following functions:

* By-Pass - When an engine speed signal of about 400 RPM is received by the PCM, PCM considers engine to be running and applies 5 volts to the ignition control module on the by-pass wire This causes ignition control module to switch timing control over to the variable timing control

circuit in the PCM. An open or grounded by-pass circuit will set a related diagnostic trouble code in PCM memory. The engine will run at base timing plus a small amount of advance.

* EST - When 5 volts is present on the by-pass circuit and ignition control module has turned control of engine timing over to PCM, the PCM advances or retards spark on this circuit based on calculations involving the reference signal and other sensor input signals. If base timing is incorrectly set, entire advance curve will be incorrect.
* Ground - This is the reference ground circuit. It is grounded at distributor and PCM, ensuring no voltage drop occurs in the EST circuit which could affect ignition operation.
* Reference (RPM) - Alternating current signals from the PM generator (CNP, DIS and IDI) or Hall Effect sensors (C3I) are converted by the ignition control module converter to digital signals for use by PCM. This supplies RPM data and crankshaft position reference to PCM. Because the signal on this circuit is used as an injector trigger reference, engine will not run if circuit is open or grounded.

Knock Sensor Operation

In conjunction with the ignition system, a knock sensor retard system is used. System consists of a knock sensor, knock sensor module (if equipped) and PCM. When detonation (engine knock) occurs, knock sensor produces a low voltage AC signal. This signal inputs to the PROM or knock sensor module (if equipped) located internal of PCM.

PCM supplies a 5-volt DC reference signal on the knock sensor signal line. Internal circuitry of the knock sensor will pull this voltage down to about 2.5 volts. When detonation (engine knock) occurs, the knock sensor produces an AC voltage signal which rides on the 2.5-volt DC signal back to the knock sensor module or PCM. The voltage and frequency of this signal depends upon knock signals received by the knock sensor. The PCM will retard ignition control timing until signals from knock sensor cease.

Failure in knock sensor circuit should set a related diagnostic trouble code. If a related diagnostic trouble code is not present and the knock sensor system is suspected as the cause of a driveability problem, perform a functional check of the knock sensor. See appropriate SYSTEM & COMPONENT TESTING article.

EMISSION SYSTEMS

NOTE: To determine emission systems usage, see appropriate EMISSION APPLICATIONS article.

AIR INJECTION SYSTEM

Air injection system helps reduce hydrocarbon (HC), carbon monoxide (CO) and oxides of nitrogen (NOx) exhaust emissions by injecting air into the exhaust system. The induction of additional air promotes further oxidation (combustion) of unburned and partially burned exhaust gases. During cold engine operation, air is injected into exhaust manifold. This quickly warms up catalytic converter and oxygen sensor. When vehicle warms up, air is diverted to atmosphere or to the catalytic converter. See CATALYTIC CONVERTER.

Air Pump (Electric)

Air pump is a sealed, non-serviceable, electric-motor type. Pump is energized by a PCM-controlled air pump relay, which is activated when fuel system is functioning in "open loop" mode and/or less than a predetermined amount of time has passed since relay was energized. See ELECTRIC AIR PUMP RELAY.

Check Valve

The check valve prevents the backflow of exhaust gases into the air injection system. The check valve closes when exhaust gas pressure in exhaust manifold exceeds pressure delivered by pump. This occurs when air pump by-passes at high speeds, air delivery is switched to catalytic converter, air is diverted to atmosphere or air cleaner, or air pump malfunctions.

Electric Air Pump Relay

When vehicle is cold ("open loop" mode), PCM provides a ground for the electric air pump relay. When relay is energized, power is supplied to the electric air pump. When fuel system goes into "closed loop" or electric air pump has been on for more than a precalibrated period, the PCM opens the ground circuit. When relay is de-energized, air is diverted to the atmosphere until air pump stops spinning, or an internal stop valve closes when relay is de-energized.

CATALYTIC CONVERTER

Three-Way Catalytic Converter

A Three-Way Catalytic Converter (TWC) is used on all vehicles to reduce exhaust emissions. This type of converter reduces hydrocarbon (HC), carbon monoxide (CO) and oxides of nitrogen (NOx) levels.

Converter contains a reducing agent (Rhodium and Platinum) to reduce NOx and an oxidizing agent (Palladium and Platinum) to oxidize HC and CO. This causes HC and CO to oxidize (break down with the addition of oxygen and heat) into the harmless base elements: water (H_2O) and carbon dioxide (CO_2). Oxygen is removed from NOx, causing it to reduce to the harmless base elements nitrogen (N) and oxygen (O_2).

EXHAUST GAS RECIRCULATION

The Exhaust Gas Recirculation (EGR) system is designed to reduce oxides of nitrogen (NOx) emissions by lowering combustion temperatures. This is accomplished when a metered amount of exhaust gas is recirculated into the intake manifold and mixed with the air/fuel mixture.

The 2 types of EGR systems used are pulse width modulated negative backpressure EGR using an EGR solenoid and either ported or manifold vacuum, and digital or linear EGR.

On PCM-controlled EGR systems using a solenoid, PCM controls ported or manifold vacuum to EGR valve through solenoid valve. Solenoid may be normally open or normally closed depending upon application.

PCM uses engine coolant temperature, throttle position and manifold pressure signals to determine vacuum solenoid operation. During cold engine operation and idle, EGR is not desired; therefore PCM causes solenoid to block vacuum to EGR valve. During warm engine operation and at speeds greater than idle, vacuum is allowed through solenoid, opening the EGR valve. To check EGR system, perform functional check of EGR system. See appropriate SYSTEM & COMPONENT TESTING article.

Digital EGR System

The digital EGR valve is designed to accurately supply EGR to engine, independent of intake manifold vacuum. The valve controls EGR flow from exhaust to intake manifold through 3 internally-mounted solenoids. When each solenoid is energized, a pintle is lifted to allow exhaust gas to flow through valve. Solenoids are energized individually, in pairs or together to provide 7 different EGR flow ratios. This enables PCM to tailor EGR flow to specific engine requirements.

Linear EGR System

The linear EGR valve is designed to accurately supply EGR to engine, independent of intake manifold vacuum. The valve controls EGR flow from exhaust to intake manifold through an orifice with a PCM-controlled pintle. PCM controls pintle position by monitoring the pintle position feedback signal.

Negative Backpressure EGR Valve

This EGR valve uses negative backpressure in the exhaust system to vary amount of EGR flow. The EGR valve also uses a PCM-controlled solenoid to regulate vacuum signal to EGR valve. Vacuum is applied to upper EGR diaphragm through a vacuum hose connected to intake manifold vacuum. Manifold vacuum is also applied to lower EGR diaphragm (through intake port at base of EGR valve). When manifold vacuum in lower chamber is insufficient to overcome spring tension on lower diaphragm, bleed valve will be closed, allowing vacuum in upper chamber to open EGR valve. With engine at idle or under light load, high manifold vacuum applied to lower chamber opens air bleed valve in lower diaphragm. As a result, this bleeds off vacuum in upper chamber, keeping the EGR valve closed.

EVAPORATIVE EMISSION CONTROL

Carbon canister storage is used for evaporative fuel control on all vehicles. The function of evaporative emission control system is to store gasoline fumes from fuel tank in a carbon canister until fumes can be drawn into engine for burning during combustion process.

Evaporative emission system uses 4 basic components:

* Activated carbon canister (may be sealed or open at top or bottom for fresh air intake).
* Tank pressure control valve (mounted internally or externally to fuel tank).
* PCM-controlled canister purge control solenoid (mounted in-line or on canister).
* Canister purge control valve (mounted in-line or on canister).

For specific component application, see appropriate EMISSION APPLICATIONS article. For vacuum hose routing, see appropriate wiring diagram in WIRING DIAGRAMS article.

Carbon Canister

Evaporative fumes from the fuel tank are vented through hoses into a canister containing activated carbon. The activated carbon absorbs and holds fuel vapors when the engine is not operating. When the engine is started and engine speed is greater than idle (purge at idle would cause too rich a mixture), engine vacuum draws fuel vapors from the canister into the engine. Regulation of vapors through this purge line is controlled by a PCM-controlled canister purge control solenoid.

Carbon canisters are either open or closed design. When the engine is started on open canister models, engine vacuum draws outside air into canister either through the top or through a filter in bottom of canister. This helps to purge vapors from the activated carbon.

NOTE: Models without fuel tank pressure control valves may use a special pressure/vacuum relief fuel tank filler cap or other external relief device.

Canister Purge Control Solenoid

Canister purge control solenoid is controlled by the PCM. Current is supplied to solenoid when ignition is on. Solenoid is energized when PCM provides a ground circuit for solenoid. Solenoid may be normally closed or normally open. When solenoid is open, charcoal canister is purged using manifold or ported vacuum. When solenoid is closed, purge vacuum to canister is blocked.

The PCM will allow vacuum to pass through solenoid when engine has been running for more than one minute, engine is at normal operating temperature, vehicle speed is greater than a specified value and throttle is off idle. This solenoid (if used) is located in the purge line between charcoal canister and vacuum purge port, or on top of canister.

Canister Purge Control Valve

Canister purge control valve is a vacuum regulated/purge control valve located in vapor delivery hose between fuel tank and carbon canister, or on top of canister. When engine is not running and tank pressure is less than .7 psi (.49 kg/cmý), internal spring pressure holds valve in the closed position.

This causes fuel tank low-pressure vapors to be vented through a restriction in valve. This restriction will retain most fuel tank vapors in fuel tank. When tank pressure rises and overrides spring tension, fumes are vented to the carbon canister. When engine is running, vacuum is applied to upper port of valve, opening passage between fuel tank and carbon canister, which is purged by engine vacuum.

Tank Pressure Control Valve

Tank pressure control valve is a vacuum regulated/pressure control valve located in fuel tank or in vapor delivery hose between fuel tank and carbon canister. When engine is not running and tank pressure is less than .9 psi (.63 kg/cmý), internal spring pressure holds valve in the closed position.

This causes fuel tank low-pressure vapors to be vented through a restriction inside valve. This restriction will retain most fuel tank vapors in fuel tank. When tank pressure rises and overrides spring tension, fumes are vented to the carbon canister. When engine is running, vacuum is applied to upper port of valve, opening passage between fuel tank and carbon canister, which is purged by engine vacuum.

POSITIVE CRANKCASE VENTILATION

Except 2.4L & 3.0L

The Positive Crankcase Ventilation (PCV) system is used to provide more effective elimination of crankcase vapors. Fresh air from the air filter housing or throttle body is supplied to the crankcase where it is mixed with blow-by gases and passed through a PCV valve into the intake manifold or supercharger inlet (3.8L VIN 1). This mixture is then passed into the combustion chamber and burned.

The PCV valve provides primary control in this system by metering the flow of the blow-by vapors, according to manifold vacuum. When manifold vacuum is high (at idle), the PCV restricts the flow to maintain a smooth idle condition.

Under conditions in which abnormal amounts of blow-by gases are produced (such as worn cylinders or rings), the system is designed to allow the excess gases to flow back through crankcase vent hose into the intake or throttle body to be consumed during normal combustion.

2.4L

Unlike conventional crankcase ventilation systems, the 2.4L PCV system does not have a fresh air inlet to the crankcase. All blow-by gases are drawn from the crankcase through an oil/air separator. Flow is regulated by an orifice in the manifold intake nipple. Oil suspended in the blow-by gases is trapped in the separator and returned to the crankcase. Blow-by gases are then drawn into air cleaner outlet resonator by normal engine vacuum and burned in the combustion process.

3.0L

The 3.0L PCV system does not have a fresh air intake. Control of engine blow-by gases is through the PCV housing which meters the flow at a rate dependent upon manifold vacuum. To maintain idle quality, the PCV housing restricts flow when manifold vacuum is high. If abnormal operating conditions arise, the system is designed to allow excessive amounts of blow-by gases to backflow through the crankcase vent tube into the engine air intake system where it can be consumed by normal combustion.

SELF-DIAGNOSTIC SYSTEM

DESCRIPTION

The PCM is equipped with a self-diagnostic system which detects system failures or abnormalities. When a malfunction occurs, PCM will illuminate the Malfunction Indicator Light (MIL) located on instrument cluster. When a malfunction is detected and MIL is turned on, a corresponding Diagnostic Trouble Code (DTC) will be stored in PCM memory. Malfunctions are designated as either "emission related" or "non-emission related", and are divided into 4 code types to identify type of fault. The 4 code types are defined as follows:

* Type "A" - Emission related faults that illuminate MIL at first occurrence of a fail condition.
* Type "B" - Emission related faults that illuminate MIL if a fault occurs in 2 consecutive ignition cycles.
* Type "C" - Non-emission related faults that illuminate MIL only when fault is present. MIL will turn off 3 seconds after engine start if fault is no longer present, but a record of fault will remain stored in memory.
* Type "D" - Non-emission related faults which do not illuminate MIL.

Emission related DTCs (type "A" or "B") cause MIL to illuminate and remain on until the malfunction is repaired. On models using digital display on dash to indicate codes, codes may be accompanied by a "current" or "history" indication for intermittent and hard failures. If MIL illuminates and remains on during vehicle operation, cause of malfunction must be determined using affected Diagnostic Trouble Code (DTC) located in appropriate SELF-DIAGNOSTICS article. If a sensor fails, PCM will use a substitute value in its calculations to continue engine operation. In this condition, vehicle is functional but loss of good driveability is likely.

Non-emission related DTCs (type "C") cause MIL to flicker or glow and go out about 10 seconds after the intermittent fault goes away. The corresponding diagnostic trouble code, however, will be retained in PCM memory. On models using a digital display on dash to indicate codes, codes may be accompanied by a "current" or "history" indication for intermittent and hard failures. If related fault does not reoccur within 50 engine restarts, related diagnostic trouble code will be erased from PCM memory. Intermittent failures may be caused by sensor, connector or wiring related problems. See appropriate TROUBLE SHOOTING - NO CODES article.

MALFUNCTION INDICATOR LIGHT

As a bulb and system check, the Malfunction Indicator Light (MIL will illuminate when ignition switch is turned to ON position and engine is not running. When engine is started, MIL should go out. If MIL does not go out, a malfunction has been detected in the computerized engine control system or MIL circuit is faulty. MIL may be used on some models to display stored diagnostic trouble codes. To access codes, see appropriate SELF-DIAGNOSTICS article.

SERIAL DATA

PCM is equipped with a serial data line. Serial data is a stream of electrical impulses which can be interpreted by special testers or other control modules. On some models, serial data and codes must be accessed using a scan tool connected to the Data Link Connector (DLC). Update intervals and information contained within the data stream vary with model application.

On some models, serial data may be accessed using the Driver Information Center (DIC) and Climate Control Panel (CCP). On these models, serial data may be shared with A/C controller, supplemental restraint controller, anti-lock brake controller and even cruise control unit.

THROTTLE ACTUATOR CONTROL SYSTEM

THROTTLE CONTROL

Some models use a Throttle Actuator Control (TAC) system to calculate and control the position of throttle plate electronically. This eliminates the need for a mechanical cable attachment from accelerator pedal to throttle body. The TAC system consists of an Accelerator Pedal Position (APP) sensor, throttle body/actuator assembly, Throttle Actuator Control (TAC) module and Powertrain Control Module (PCM). Cruise control functions are also performed by the TAC system.

The throttle actuator is an electric motor attached to throttle body and responds to command signals received from the TAC module. As vehicle operator moves accelerator pedal, a signal is sent to TAC module. A command is then sent to throttle actuator to adjust throttle plate accordingly. The PCM communicates with TAC module to compare values of Throttle Position (TP) sensor, APP sensor and other various engine sensors. A diagnostic trouble code will set if actual throttle angle measured by TP sensor does not match sensor values sent by the APP sensor.

MISCELLANEOUS CONTROLS

NOTE: Although not considered true engine performance-related systems, some controlled devices may affect driveability if they malfunction.

A/C COMPRESSOR CLUTCH

On many models, PCM regulates operation of A/C compressor clutch through a PCM-controlled A/C compressor clutch relay. This allows the PCM to disengage the A/C compressor when compressor load on engine may cause driveability problems (i.e., during hot restart, idle, low speed steering maneuvers and wide open throttle operation), or if A/C refrigerant pressure drops or rises beyond normal operating levels.

Refrigerant pressure sensing may be accomplished by monitoring high and low pressure switches or a pressure sensor which will register either high or low pressure levels. Power steering load is monitored through a power steering pressure switch. Hot restart is monitored through the coolant temperature sensor. For component application and related wiring, see appropriate A/C COMPRESSOR CLUTCH CONTROLS article in AIR CONDITIONING & HEATING.

A/C Pressure Sensor

Some models are equipped with an A/C pressure sensor which is used to inform PCM of A/C system pressure levels. Low pressure signal will cause A/C compressor to disengage to prevent system damage. High pressure levels cause PCM to engage high speed cooling fans while A/C compressor clutch is engaged. Extremely high pressure levels will cause PCM to disengage A/C compressor clutch to prevent system damage.

A/C Pressure Switches

A/C high and low pressure switches may be used in the PCM-monitored A/C request circuit. Switches are normally closed, completing the circuit between ignition and PCM. PCM will engage or disengage A/C compressor clutch relay based upon status of this circuit. When system refrigerant pressure increases beyond a certain point, high side switch will open, causing A/C request circuit voltage to drop.

If system refrigerant level decreases, causing refrigerant pressure to drop below normal, low side pressure switch will open, causing A/C request circuit voltage to drop. Switches may be used as normal clutch cycling devices or as safety devices which prevent compressor damage in the event of excessively high or low refrigerant pressure.

ELECTRIC COOLING FAN

On many models, PCM regulates operation of electric cooling fan through a PCM-controlled cooling fan relay which controls the ground circuit or power circuit for the cooling fan. This allows PCM to operate cooling fan based upon engine coolant temperature. Most systems will engage electric cooling fan whenever A/C clutch is engaged, regardless of engine temperature. A malfunction of the cooling fan will cause engine overheating and possible detonation.

Some models use more than one cooling fan. The second fan may function as an auxiliary cooling device when A/C is engaged or (on models using A/C high and low pressure switches) during periods of engine overheating, or high A/C refrigerant pressures.

For component application and related wiring, see appropriate ELECTRIC COOLING FANS article in ENGINE COOLING.

ELECTRONIC VARIABLE ORIFICE ACTUATOR (SATURN)

The Electronic Variable Orifice (EVO) actuator is a linear solenoid mounted in power steering pump. PCM controls both power supply and ground path for the solenoid using a Pulse Width Modulated (PWM) signal. During periods of low speed turns (as determined by VSS input), EVO actuator is commanded to open more, allowing pump to provide an increased fluid flow for increased steering assist. During high-speed, straight-line steering, EVO actuator is commanded to restrict flow of steering fluid to steering gear. Unused steering fluid is returned to reservoir by way of a by-pass.

HOT LIGHT OR COOLANT TEMPERATURE LIGHT

When engine coolant temperature sensor input indicates temperature exceeds specified range, PCM will turn on the TEMP or HOT light by providing a ground for the light circuit. As a bulb check, PCM also supplies a ground to turn on light when ignition is first turned on.

TRANSMISSION

Torque Converter Clutch (Non-Electronic Transmission)

The purpose of the transmission/transaxle converter clutch feature is to eliminate power loss of torque converter stage when vehicle is in a cruise condition. This allows convenience of automatic transmission/transaxle and fuel economy of a manual transmission.

Fused battery ignition is supplied to TCC solenoid through a brake switch. On some models, gear hydraulic apply switches (located within the transmission) may also be in series with solenoid power or ground circuit. For wiring reference, see appropriate wiring diagram in WIRING DIAGRAMS article.

Converter clutch will engage when vehicle is moving faster than a precalibrated speed, engine is at normal operating temperature, throttle position sensor output is not changing (indicating a steady vehicle speed), transmission 3rd gear switch is closed (if equipped), and brake switch is closed.

When vehicle speed is great enough (about 20-45 MPH as indicated by the vehicle speed sensor), PCM energizes TCC solenoid mounted in transmission. This allows torque converter to directly connect engine to the transmission. When operating conditions indicate transmission should operate as normal, TCC solenoid is de-energized.

This allows transmission to return to normal automatic operation. Since power for the TCC solenoid is delivered through the brake switch, transmission will also return to normal automatic operation when brake pedal is depressed. To check TCC system, perform functional check of TCC system. See MISCELLANEOUS CONTROLS in appropriate SYSTEM & COMPONENT TESTING article.

Torque Converter Clutch (Electronic Transmission)

The torque converter clutch functions similarly to the non-electronic type except instead of a single internal TCC solenoid, 2 solenoids are used. A standard TCC solenoid is used in conjunction with a Pulse Width Modulated (PWM) solenoid that regulates hydraulic pressure to make locking and unlocking of the TCC smoother.

Electronic Transmission

On vehicles equipped with electronic transmission, transmission is controlled by the Powertrain Control Module (PCM). PCM controls other vehicle functions as well as the transmission. The PCM monitors a number of engine/vehicle functions and uses the data to control shift solenoid "A", shift solenoid "B", TCC and, on some models, transaxle pressure control solenoid to regulate TCC engagement, upshift pattern, downshift pattern and line pressure (shift quality).

* Shift Solenoid "A" - Shift solenoid "A" is attached to valve body and is a normally open exhaust valve. PCM activates solenoid by grounding it through an internal quad-driver. Solenoid "A" is on in 1st and 4th gears but off in 2nd and 3rd gears. When on, solenoid redirects fluid to act on the shift valves.
* Shift Solenoid "B" - Shift solenoid "B" is attached to valve body and is a normally open exhaust valve. PCM activates solenoid by grounding it through an internal quad-driver. Solenoid "B" is on in 3rd and 4th gears but off in 1st and 2nd gears. When on, solenoid redirects fluid to act on the shift valves.
* Transaxle Pressure Control Solenoid - Transaxle pressure control solenoid is attached to the valve body and controls line pressure by moving a pressure regulator valve against spring pressure. Transaxle pressure control solenoid takes the place of the force motor used on past model transmissions. PCM varies line pressure based upon engine load. Engine load is calculated from various inputs, especially the TP sensor. Line pressure is actually varied by changing the amperage applied to transaxle pressure control solenoid from zero (high pressure) to 1.1 amps (low pressure). The transaxle pressure control solenoid is periodically pulsed to prevent pressure regulator valve from sticking due to fluid contamination.

Shift Light (Except Corvette)

The shift light is used on M/T models. Light indicates the best transmission shift point for maximum fuel economy based on engine speed and load. Power for light is supplied through the GAUGES fuse. Light illuminates when PCM supplies a ground circuit for bulb. For wiring reference, see appropriate wiring diagram in WIRING DIAGRAMS article.

1-To-4 Light (Corvette)

The 1-to-4 light is used on M/T models. Light indicates when driver should shift transmission from 1st gear to 4th gear for maximum fuel economy. Power for light is supplied through the CLUSTER fuse. Light illuminates when PCM supplies a ground circuit for bulb. For wiring reference, see appropriate wiring diagram in WIRING DIAGRAMS article.

NOTE: 2nd and 3rd gear blockout relay may also be referred to as a computer aided gear select solenoid or skip shift solenoid.

2nd & 3rd Gear Block-Out Relay (Camaro, Corvette & Firebird)

Power for the 2nd and 3rd gear block-out relay winding is supplied by the ENG1 or ENG SEN fuse. When PCM determines driver should shift transmission from 1st gear to 4th gear for maximum fuel economy, PCM will provide a ground for the 2nd and 3rd gear block-out relay. When relay is energized, voltage supplied by the BACK-UP fuse will pass through relay and energize the 2nd and 3rd gear block-out solenoid mounted in the transmission. When 2nd and 3rd gear blockout solenoid is energized, transmission is locked out from shifting from 1st gear into any gear other than 4th. For wiring reference, see appropriate wiring diagram in WIRING DIAGRAMS article.

END OF ARTICLE

