

# 2002 ENGINE PERFORMANCE

## Theory & Operation

### 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

All engines use the same basic air induction system. Remote air cleaner (with intake air temperature sensor) routes air through Mass Air Flow (MAF) sensor to plenum-mounted throttle body.

### COMPUTERIZED ENGINE CONTROLS

All engines use Sequential Multiport Fuel Injection (SFI) and Distributorless Ignition System (DIS) controlled by Engine Control Module (ECM). Input devices supply ECM with signals which indicate operating conditions of the vehicle. ECM output signals control systems which control vehicle operation to optimize emission control and vehicle performance. On vehicles equipped with automatic transmission/transaxles, ECM also sends outputs to, and receives inputs from, Transmission Control Module (TCM).

### ENGINE CONTROL MODULE

The Engine Control Module (ECM), through various input sensors, monitors cranking signal, intake air amount, intake air temperature, air/fuel ratio, throttle valve opening angle, No. 1 piston compression stroke TDC, engine coolant temperature, engine RPM, vertical chassis movement, A/C operation, detonation, gear status (if automatic transmission/transaxle) and fuel tank pressure. ECM uses this information to control fuel injection timing and duration, ignition timing, idle speed, A/C cutout, fuel pump, purge control system and perform self-diagnostic functions.

ECM includes On Board Diagnostics-II (OBD-II) to monitor efficiency of emissions related components and systems. If an emissions related system malfunctions or deteriorates below preprogrammed performance criteria, OBD-II will illuminate the Malfunction Indicator Light (MIL) and store a Diagnostic Trouble Code (DTC). If a condition exists that may cause catalytic converter damage, MIL will flash continuously.

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

### INPUT DEVICES

The ECM controls various output devices based upon signals received from input devices. These devices include sensors, switches, and circuits (such as an RPM reference signal from the ignition coil). Vehicles are equipped with different combinations of input devices. Not all devices are used on all models. To determine input usage on a specific model, see **WIRING DIAGRAMS** article. Available input signals include the

following:

### **A/C Switch**

When the air conditioner switch is turned on, a signal is sent to the ECM that a request for A/C has been made. A/C switch is located on instrument panel. See **A/C RELAYS** under OUTPUT SIGNALS.

### **Camshaft Position Sensor**

Camshaft Position (CMP) sensor detects the No. 1 piston at TDC of compression stroke . ECM uses input for fuel and ignition control. On Optima (2.7L), CMP sensor is located at rear of right cylinder head. On Sedona, CMP sensor is located on front of left cylinder head, under timing belt cover, near camshaft pulley. On all other models, CMP sensor is at rear of cylinder head.

### **Chassis Acceleration Sensor (Spectra & Sportage)**

Chassis Acceleration (CA) sensor detects vertical chassis movement on rough terrain. ECM uses signal for engine misfire detection determination. On Spectra, CA sensor is located at right side of engine compartment near shock tower. On Sportage, CA sensor is located at lower right engine compartment below starter.

### **Crankshaft Position Sensor**

Crankshaft Position (CKP) sensor detects engine crankshaft angle position. ECM uses input to determine engine speed, misfire detection, and for fuel and ignition control. On Optima (2.7L), Rio and Spectra, CKP sensor is located in transaxle bellhousing. On Optima (2.4L) and Sedona, CKP sensor is located under timing belt cover, near crankshaft pulley. On Sportage, CKP sensor is located on left side of transmission bellhousing.

### **Engine Coolant Temperature Sensor**

Engine Coolant Temperature (ECT) sensor is a thermistor whose resistance decreases as engine coolant temperature increases. ECM uses ECT sensor information for controlling fuel enrichment when engine is cold. On Optima (2.4L), Rio, Spectra and Sportage, ECT sensor is located near thermostat housing. On Optima (2.7L) and Sedona, ECT sensor is located on coolant crossover passage, at rear of cylinder heads.

### **Fuel Tank Pressure Sensor**

Fuel Tank Pressure (FTP) sensor is a pressure-sensitive variable resistor. FTP sensor measures fuel tank pressure changes, monitoring fuel tank for leaks. FTP sensor is used to close the evaporative system, and observes tank pressure respectively with canister close valve. FTP sensor is located on fuel tank.

### **Heated Oxygen Sensors**

The front Heated Oxygen (HO2S) sensor determines whether the air fuel mixture is too rich or too lean. It generates a voltage signal depending on oxygen content in exhaust gases. ECM uses inputs from front HO2S for calculating fuel mixture correction to fuel injector pulse width. Front HO2S is located before warm-up catalytic converter. ECM uses input from rear HO2S to monitor effectiveness of Three Way Catalytic (TWC) converter. Rear HO2S is located downstream from TWC converter.

## **Intake Air Temperature Sensor**

Intake Air Temperature (IAT) sensor is a thermistor whose resistance decreases as intake air temperature increases. ECM uses IAT sensor to control fuel delivery. When air temperature is cold, ECM enriches fuel mixture by increasing injector pulse width. ECM will decrease injector pulse width when air temperature is warm. On Optima (2.7L) and Rio, IAT sensor is located in intake plenum. On Optima (2.4L), IAT sensor is a component of Mass Air Flow (MAF) sensor located on air intake hose near air cleaner housing. On Spectra and Sportage, IAT sensor is located in air cleaner housing.

## **Knock Sensor**

Knock Sensor (KS) is mounted on engine block. KS detects detonation in cylinders and vibration from the engine. KS is a piezo electric element that converts vibration into a voltage signal which is then sent to ECM. ECM will retard timing based on this signal. Optima (2.7L) is equipped with two KS, one located on each side of engine block. On Optima (2.4L), KS is located on left side of engine block. On Rio, KS is located on right side of engine block. On Sedona, KS is located on center of engine block, under intake manifold. On Spectra, KS is located behind intake manifold support bracket on engine block. On Sportage, KS is located on right side of engine block, above oil filter.

## **Mass Air Flow Sensor**

Mass Air Flow (MAF) is hot film type sensor. MAF sensor measures amount of air entering the engine. This measurement of airflow is a reflection of engine load (throttle opening). Main input used in fuel injector duration calculation. MAF sensor is located on air intake hose near air cleaner housing.

## **Manifold Absolute Pressure Sensor (Optima 2.4L & Sedona)**

Manifold Absolute Pressure (MAP) sensor converts intake manifold pressure into a voltage signal. On Optima 2.4L, ECM uses MAP sensor signal to verify operation of Exhaust Gas Recirculation (EGR) system. On all models, MAP sensor is located on intake plenum.

## **Power Steering Pressure Switch**

Power Steering Pressure (PSP) switch closes in response to an increase in power steering fluid pressure (load condition). With the switch closed, a monitored voltage circuit supplied by the ECM is pulled low to vehicle ground through switch. The ECM then sends a signal to the Intake Air Control (IAC) valve to adjust idle speed to compensate for increased engine load. PSP switch is located on power steering pump.

## **Throttle Position Sensor**

Throttle Position (TP) sensor resistance increases linearly as throttle is opened. Sends a voltage signal to ECM (throttle angle signal). ECM uses this signal to calculate fuel injection duration. TP sensor is located on plenum-mounted throttle body.

## **Transaxle/Transmission Range Switch (A/T)**

Signals shift lever position to ECM. Transaxle/Transmission Range (TR) switch input is used by ECM for idle speed control and load/no load determination. On all models except Sportage, TR switch is located on left top

side of transaxle. On Sportage 2WD, TR switch is located on right side of transmission. On Sportage 4WD, TR switch is located on left side of transfer case.

### **Vehicle Speed Sensor**

Vehicle Speed Sensor (VSS) is built-in speedometer gear assembly. Uses a reed switch to sense speedometer gear revolutions from the transaxle/transmission. VSS converts transaxle/transmission gear revolutions into pulse signals which are sent to the ECM. On all models except Sportage, VSS sensor is located on rear of transaxle housing. On Sportage 2WD, VSS is located on right side of transmission. On Sportage 4WD, VSS is located on left rear side of transfer case.

## **OUTPUT SIGNALS**

Vehicles are equipped with different combinations of output devices. Not all devices are used on all models. To determine output usage on a specific model, see **WIRING DIAGRAMS** article. The ECM processes information from input sensors and sends appropriate voltage control signals to the following engine controls:

### **A/C Relays**

When the air conditioner switch is turned on, a signal is sent to the ECM. The ECM then adjusts the Idle Air Control (IAC) valve to maintain optimum idle speed. Appropriate voltage control signals are sent to various relays. Then allowing the A/C compressor clutch to engage. See appropriate **AIR CONDITIONING & HEATER SYSTEMS** article.

### **Canister Close Valve**

Canister Close Valve (CCV) closes air inlet to Evaporative Emissions (EVAP) canister when ignition is turned off. CCV is opened and closed by ECM to test EVAP system for leaks. CCV is located near EVAP canister. See **FUEL EVAPORATION SYSTEM** under EMISSION SYSTEMS.

### **Exhaust Gas Recirculation Control Solenoid Valve**

Control Solenoid Valve (CSV) is actuated by ECM to allow engine vacuum to reach Exhaust Gas Recirculation (EGR) valve, allowing exhaust gases to enter into intake manifold. CSV is located near dynamic chamber (plenum). See **EXHAUST GAS RECIRCULATION CONTROL** under EMISSION SYSTEMS.

### **Electronic Gas Injection Main Relay**

Electronic Gas Injection (EGI) main relay is normally open and controlled by ECM. Supplies battery voltage to electrical devices. On Optima, main relay is located on right side of dash center console. On all others models, relay is located on relay/fuse box in engine compartment. See **SYSTEM & COMPONENT TESTING** article.

### **Fuel Injectors**

Fuel is supplied to engine through electronically pulsed injectors. ECM controls amount of fuel by controlling duration of fuel injector pulse. See **SYSTEM & COMPONENT TESTING** article.

## **Fuel Pump Relay**

Normally open and controlled by ECM. Fuel pump relay supplies battery voltage to fuel pump. On Optima, fuel pump relay is located right side of dash center console. On all others models, fuel pump relay is located on main relay/fuse box in engine compartment. See **SYSTEM & COMPONENT TESTING** article.

## **Ignition Control Module**

Integrated into ECM, controls operation of ignition coils. The ECM controls ignition timing, based on signals from various engine sensors.

## **Leak Detection Pump (Spectra)**

To test EVAP system for leaks, ECM command Leak Detection Pump (LDP) valve to open and close. LDP valve is now heated and can completely eliminate the humidity factor when in test mode. LDP can be identified by a 4 pin connector terminal. LDP is located rear of vehicle near EVAP canister and fuel tank. See **FUEL EVAPORATION SYSTEM** under EMISSION SYSTEMS.

## **Malfunction Indicator Light**

Malfunction Indicator Light (MIL) also called CHECK ENGINE light. Warns of problem in emission system. See **SELF-DIAGNOSTIC SYSTEM** article.

## **Purge Solenoid Valve**

Purge Solenoid Valve (PSV) is actuated by ECM and allows fuel vapors to be purged from EVAP canister into intake manifold. PSV is located near dynamic chamber (plenum). See **FUEL EVAPORATION SYSTEM** under EMISSION SYSTEMS.

# **FUEL SYSTEM**

## **FUEL DELIVERY - RETURNLESS SYSTEM (SPECTRA)**

Extra fuel is returned to fuel tank after passing through fuel filter located under car. Conventional system returns fuel after passing through fuel rail and pressure regulator. Eliminating fuel return from engine lowers fuel and fuel tank temperatures reducing evaporative emissions.

## **Fuel Delivery Module**

Fuel delivery module consists of electric fuel pump, pressure regulator, fuel filter and fuel sender unit. Fuel delivery module is located in fuel tank.

## **Fuel Pressure Regulator**

Fuel pressure regulator is pre-set. Modulates system pressure at return line to fuel pump. Fuel pressure regulator is located in fuel delivery module in fuel tank.

## **Fuel Pump**

Fuel Pump is an electric pump controlled by ECM through fuel pump relay. One-way check valve maintains pressure when fuel pump is off. Fuel pump is located in fuel delivery module in fuel tank.

## **FUEL DELIVERY - CONVENTIONAL SYSTEM**

Fuel is pumped from fuel tank mounted fuel pump through fuel rail to fuel injectors. Variable pressure regulator is mounted on fuel rail to control injector fuel pressure to about 40.5 psi (290 kPa) above manifold absolute pressure. Excess fuel is returned from fuel rail to fuel tank. System minimizes vapor lock by keeping fuel moving through fuel rail.

## **Fuel Pump**

Fuel Pump is an electric pump controlled by ECM through fuel pump relay. Control valve in fuel pump retains fuel pressure when pump is not running. Fuel pump is located in fuel tank as part of fuel pump assembly.

## **Fuel Pressure Regulator**

Fuel pressure regulator is a sealed unit, divided into 2 chambers (fuel and spring chambers) by a diaphragm. The fuel chamber receives fuel through fuel rail. Spring chamber is connected to intake manifold vacuum. The balance between calibrated spring pressure seating diaphragm against return pipe and vacuum pulling diaphragm away from return pipe, maintains injector fuel pressure at 40.5 psi (290 kPa) more than manifold absolute pressure. Fuel pressure regulator is located on end of fuel rail.

## **IDLE SPEED**

### **Idle Air Control Valve**

Idle Air Control (IAC) valve is an electromechanical valve controlled by ECM. Is mounted on intake manifold plenum and allows air to by-pass the throttle plate. The amount of air allowed to by-pass the throttle plate is controlled by a duty signal determined by ECM. IAC valve is located (except Sportage) on plenum-mounted throttle body, On Sportage, IAC valve is located near air intake tube. See **SYSTEM & COMPONENT TESTING** article.

## **IGNITION SYSTEMS**

### **DISTRIBUTORLESS IGNITION SYSTEM**

Distributorless Ignition (DIS) system consists of a Crankshaft Position (CKP) sensor, Camshaft Position (CMP) sensor, 2 ignition coils for 4-cylinder engines and 3 ignition coils for V6 engines. On Optima (2.7L), Rio, Spectra and Sportage, CKP sensor is located on transaxle/transmission bellhousing. On Optima (2.4L) and Sedona, CKP sensor is located under timing belt cover, near crankshaft pulley. On Optima (2.7L), CMP sensor is located in rear of right cylinder head. On Sedona, CMP sensor is located under left side timing cover, near camshaft pulley. On all other models, CMP sensor is located on rear of cylinder head. On 4-cylinder engines, ignition coils are located directly on top of No. 2 and No. 4 spark plugs. On Optima 2.7L, ignition coil pack is mounted on rear of right cylinder head. On Sedona, ignition coils are located directly on top of No. 2, 4 and 6

spark plugs. Each ignition coil is connected to companion cylinder spark plug by plug wire. System uses waste spark method. Each ignition coil fires 2 spark plugs simultaneously. Sensors signal ECM which cylinder is ready to fire. The ECM then triggers appropriate ignition coil.

## **EMISSION SYSTEMS**

CO, HC and NO<sub>x</sub> emissions are controlled by Exhaust Gas Recirculation (EGR) control system, Positive Crankcase Ventilation (PCV) system, Evaporative Emissions (EVAP) control system and catalytic converters.

### **EXHAUST GAS RECIRCULATION CONTROL**

#### **Optima 2.4L**

ECM controls Exhaust Gas Recirculation (EGR) operation by activating EGR control solenoid valve according to engine load. When engine is cold, ECM signals EGR control solenoid valve to deactivate EGR. ECM verifies EGR operation by monitoring the Manifold Absolute Pressure (MAP) sensor signal for a change in pressure when EGR is requested. EGR flow will result in a change in the MAP sensor signal. If signal does not change as expected, ECM will recognize this as an EGR malfunction, and will store a trouble code and turn on the Malfunction Indicator Light (MIL). See appropriate SELF-DIAGNOSTICS article.

### **FUEL EVAPORATION SYSTEM**

**NOTE:**        **Not all components listed are used on every vehicle. To determine component usage on a specific model, see VACUUM DIAGRAMS article.**

Fuel evaporation system prevents escape of raw fuel vapor to atmosphere. System components include fuel tank, EVAP canister, Canister Close Valve (CCV), Leak Detection Pump (LDP with Heater), Purge Solenoid Valve (PSV), Fuel Tank Pressure Sensor (FTPS), rollover valve, On-board Refueling Vapor Recovery (ORVR) valve, catch tank, check valve, vapor separator, leak detection pump (Spectra), fuel filler cap and Engine Control Module (ECM). ECM controls operation of PSV and CCV. PSV controls when fuel vapors are allowed to be drawn from EVAP canister into intake manifold so that they may be burned. CCV controls EVAP canister's vent to atmosphere.

ECM's On Board Diagnostics-II (OBD-II) runs monitors for large and small EVAP system leaks when vehicle is idling at a stop. ECM uses FTPS output to determine EVAP system pressure and pressure changes. At beginning of monitor, PSV is closed and CCV or LDP is commanded closed by ECM to measure compensation gradient. Compensation gradient is the increase in fuel tank pressure due to evaporation of fuel in fuel tank. After predetermined amount of time passes, CCV is opened and PSV is turned on. When PSV reaches 100 percent duty cycle, CCV is closed. If vacuum buildup, minus compensation gradient, is less than programmed threshold, gross leak is diagnosed. After maximum vacuum buildup, PSV is turned off (closed). If vacuum in fuel tank, minus compensation gradient, decreases to less than programmed threshold, small leak is diagnosed. CCV is opened and monitor is complete. If either gross leak, or small leak, is detected for 2 driving cycles, ECM assumes there is defect in evaporative emissions system and illuminates MIL. For EVAP codes or DTC P1446, P1447 and P1448, see appropriate SELF-DIAGNOSTICS article.

#### **Purge Solenoid Valve**

Purge Solenoid Valve (PSV) is a normally closed valve. PSV is duty cycle-controlled by ECM. PSV is located in vapor line between EVAP canister and intake manifold. When commanded open by ECM, fuel vapors collected in EVAP canister are allowed to be drawn into (purged) intake system.

### **Fuel Tank Pressure Sensor**

Measures pressure and vacuum levels in fuel tank. ECM can check Purge Solenoid (PSV) valve operation and for leaks in EVAP system. By monitoring Fuel Tank Pressure (FTP) sensor data during different operating cycles, FTP sensor is located on top of fuel pump assembly.

## **POSITIVE CRANKCASE VENTILATION**

The Positive Crankcase Ventilation (PCV) system uses intake manifold vacuum to eliminate crankcase pressure and recycle blow-by gasses. Manifold vacuum draws gases from crankcase, through PCV hose, into combustion chamber. The PCV valve is positioned in hose through which crankcase gases flow on their way to combustion chamber.

By opening and closing in direct relation to engine vacuum, the PCV valve meters crankcase gas flow to combustion chamber. During periods of high manifold vacuum, such as at idle and deceleration, PCV valve is almost completely closed, limiting flow of gases. During cruise speeds, PCV valve permits greatest flow of gases.

Under conditions in which excessively high amounts of crankcase pressure is produced (such as heavy load), system allows excess gases to flow back through crankcase vent hose and into intake tract. See **SYSTEM & COMPONENT TESTING** article.

## **SELF-DIAGNOSTIC SYSTEM**

ECM is equipped with On Board Diagnostics-II (OBD-II) system which monitors emission related components and systems for malfunction or deterioration. When OBD-II determines there is an emissions related problem, the Malfunction Indicator Light (MIL) is illuminated and ECM stores a Diagnostic Trouble Code (DTC).

ECM programming includes advanced diagnostic test modes 6, 7 and 22. Mode 6 allows access to catalyst and evaporative systems test results which are not continuously monitored by ECM. Mode 7 allows off-board testing of emission related devices that are continuously monitored by ECM. Mode 7 also enables verification of repair in only one drive cycle and without having to duplicate particular operating conditions. Mode 22 allows accessing PIDs (inputs and outputs). For further information, see appropriate SELF-DIAGNOSTICS article.

## **MALFUNCTION INDICATOR LIGHT**

**NOTE:**        **Loose fuel cap will cause Malfunction Indicator Light (MIL) to illuminate.**

Also called CHECK ENGINE light, MIL comes on when ignition is turned on. MIL remains on for several seconds after engine has started, then goes out. If ECM detects emission related component or systems deterioration or failure, MIL will illuminate and Diagnostic Trouble Code (DTC) is stored in memory. MIL will



stay on until DTC is erased with scan tool or battery is disconnected for at least 20 seconds. If detected failure may cause catalytic converter damage, MIL will continuously flash on and off. See appropriate SELF-DIAGNOSTICS article.