Module 2
The PGMFI System Overview - Part 2

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2 The PGMFI System Overview - Part 2

2.1 Fuel Control

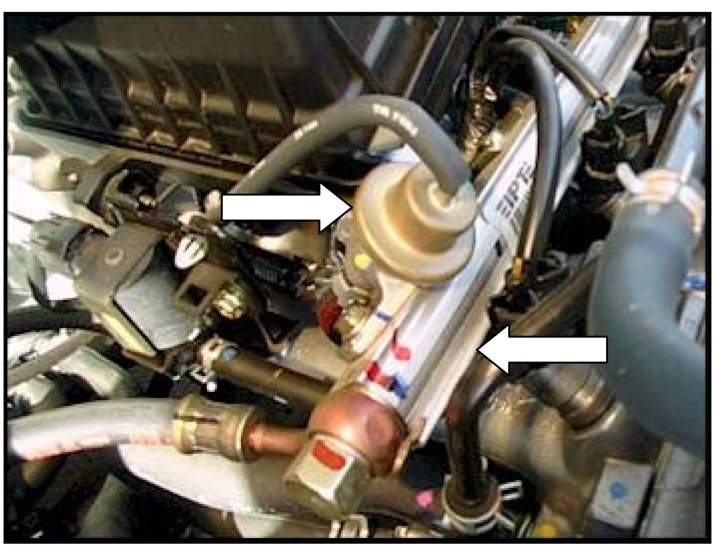
2.1.1 Fuel Delivery System

All Honda PGMFI systems utilize a return type fuel delivery system that provides fuel at approx. 40 PSI to the injectors. The system starts at the fuel pump. The earlier systems had an external mounted pump and the later systems went to an "in-the-tank" pump. On most models with in-the-tank pumps, Honda provides an access hole in the trunk (or hatch area) to access the fuel pump. This allows you to change the pump without dropping the fuel tank on most models. Both of these pumps are rotary style with a built in safety pressure relief valve.

The pump is powered up by a main relay. The main relay works in conjunction with the engine control module (ECM) to control electrical power to the pump under certain conditions. The pump will be powered up for two seconds on initial key on. The pump will not be powered up again unless the car is being cranked or is running. The fuel injection main relay is usually located under the dash on the left side of the car. The fuel pump main relay has been an item that tends to fail at times. When a main relay quits working, it will not power up the fuel pump and the car will not start. These relays tend to fail worse when the temperature inside the car increases. It is also common for a failed fuel pump main relay to set a diagnostic trouble code (DTC) 16.

The fuel is delivered to the engine bay fuel filter (eliminated on many late model Hondas). The fuel filters are steel and the hoses typically attach to the filter using banjo bolts. Typically on one of the banjo bolts is a test port for checking fuel pressure. To check fuel pressure on a Honda you will need a tester with a 6MMx1 tip.

Image 2-1 Fuel Rail and Fuel Pressure Regulator



The fuel leaves the fuel filter and enters the fuel rail (shown at the right arrow in Image 2-1). The fuel rail runs the length of the engine and supplies fuel to all the injectors. A pressure regulator (shown at left arrow in Image 2-1) is mounted onto the rail and holds the fuel in the rail until 40 PSI is reached. When the fuel pressure exceeds 40 PSI the pressure regulator returns the extra fuel back to the tank by the fuel return line. The pressure regulator is also designed to monitor the manifold absolute pressure so it will maintain the same pressure differential between the fuel rail and the manifold under all driving conditions.

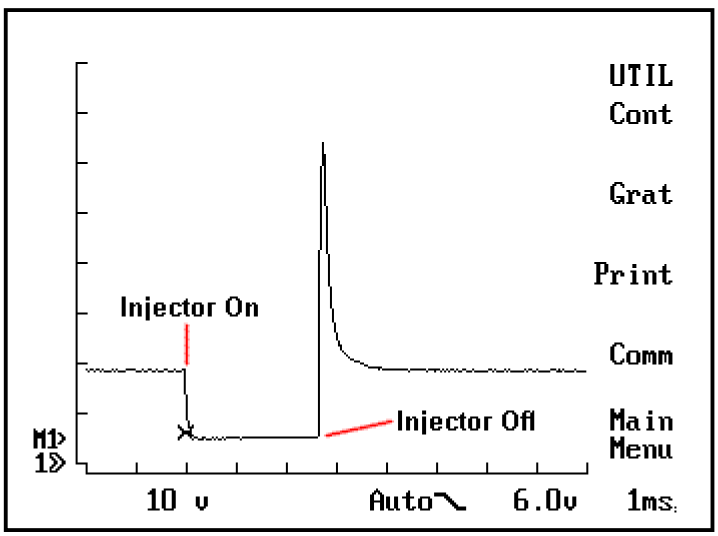
The fuel pressure is maintained in the fuel rail when the vehicle is cut off. A check valve in the pump, the closed pintle of the fuel injector, and the pressure regulator accomplish this.

For More Information About	Go To
The Fuel Delivery System	**Chapter 8**

2.1.2 Fuel Injector Information

The fuel injectors receive power from the main relay and the ECM opens the pintle by supplying a ground to complete the circuit. The injector circuit is a saturation type circuit, meaning the resistance of the circuit controls the injector current.

Screen Capture 2-1 Typical Fuel Injector Waveform



All Honda injector circuits have about 10-13 ohms resistance. The earlier systems had low resistance injectors and had an external dropping resistors. The later systems have the dropping resistor integral with the injector and do not use an external dropping resistor.

Screen Capture 2-1 shows a voltage waveform from a Honda fuel injector. The car was an 89 Accord with original injectors in it. The voltage reading is taken from the ground wire, the wire from the injector to the ECM. The injector is "fired" when the ECM provides a circuit ground. This occurs when the voltage is pulled to ground. The injector pintle will stay open until the ground is released and the voltage goes back up.

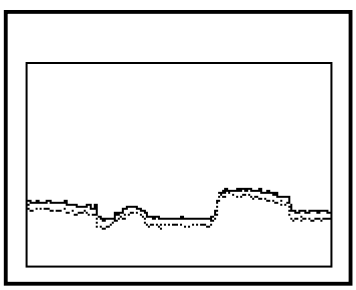
The injector pulse width (PW) on this car is running just over 2.5ms. You read the PW from the time grids across the bottom of the screen. The tester is set up so that each grid block is equal to 1ms. You calculate the amount of time the injector was turned on by counting the grids.

The ECM controls the amount of fuel that is delivered to the engine by precisely controlling the amount of time the fuel injector is held open on each intake stroke. This is commonly referred to as the injector PW. The fuel available behind the pintle is maintained at a steady 40 PSI: therefore, the amount of time the injector pintle is held open gives an accurate indication of the amount of fuel that was injected. Injector PW is measured in milli seconds (ms), which is one thousandth of a second.

On Honda's multi-port injection (MPI) systems the injectors are fired sequentially, and in synchronous mode, meaning each injector only fires once per each cylinder's intake stroke. Some Asian fuel injection systems will fire an injector multiple times in the same cycle (asynchronous mode) during periods of high fuel demand. When this happens just monitoring PW will not reflect the true amount of fuel delivered to the engine. Since a Honda does not fire its injectors in an asynchronous mode the injector PW gives an accurate indication of the fuel delivered to the engine.

The PGMFI system used on all Hondas is a Speed-Density type and uses engine RPM and the Manifold Absolute Pressure (MAP) Sensor input voltage to determine the initial base PW. All the other inputs "fine tune" the PW within their specific window of authority. No other input in the PGMFI system has the authority that the MAP Sensor has. The MAP sensor can drive the PW from the normal idle PW of 2.5ms to as high as 15ms under a heavy load!

Screen Capture 2-2



Screen Capture 2-2 shows the tremendous influence the MAP Sensor has on PW. This information was captured from a 1996 Honda Civic that was being driven on a typical open road. The MAP Sensor input voltage (solid line) is feeding load information back to the ECM. The PW (dotted line) is changing to match the MAP input voltage almost identically.

The typical PW of a fully warmed idling Honda is from 2.4 - 3.1 ms. The PW can go as high as 15ms or higher under heavy load conditions. When the ECM sees a start signal and a cold engine coolant temperature (ECT) sensor input the PW can be increased as high as 60ms or more. The injectors are also turned off during deceleration.

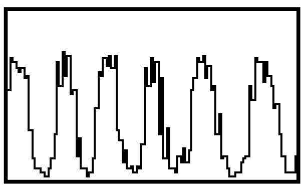
To determine the correct PW over a wide range of engine operation, the ECM utilizes several key inputs, such as: RPM, MAP Sensor, throttle position (TP) Sensor, ECT Sensor, intake air temperature (IAT) Sensor, Oxygen (O2) Sensor and Start Signal.

2.1.3 Open Loop / Closed Loop Operation

When a Honda is initially started, it is running in open loop (OL). OL operation means the ECM is not monitoring the oxygen sensor and is determining the correct PW strictly from the other inputs, internal ECM parameters, and long term fuel trim LT FT corrections.

When a specific strategy is met, the ECM will monitor the O2 sensor and adjust the PW to try to maintain a stoichiometric ratio. Honda O2 sensors are standard zirconium sensors and will register around .1 volt when the mixture is lean and around .9 when the mixture is rich. When the O2 sensor is maintaining .5 volt the ECM is producing the optimum A/F ratio, which is often referred to as the stoichiometric ratio. The ECM modifies the injector PW in an attempt to keep the O2 sensor voltage at .5.

Screen Capture 2-3



When in closed loop (CL), the O2 sensor voltage will modulate between a high and low voltage several times a second. Screen Capture 2-3 shows the O2 sensor voltage of a Honda running in CL operation. This modulation is a result of the ECM constantly trimming the PW in an attempt to maintain .5 on the O2 sensor.

Earlier Honda PGMFI systems had rather elaborate CL strategies. All systems required the car to be above 100 degrees F, and to run a minimum amount of time. Some Honda models with unheated O2 sensors even required that the throttle be "snapped" to initiate CL operation.

The later PGMFI systems added O2 sensor heaters and the system goes into CL quickly and tends to stay there. A heated O2 sensor is easy to identify since it has four wires instead of one or two.

Certain Civic models use a very special O2 sensor called a Lean Air Fuel (LAF) sensor. This sensor has 5 wires and can be controlled by the ECM to run the engine on A/F ratios as lean as 23:1.

For More Information About	Go To
Open/Closed Loop Theory	**Chapter 9**
Open/Closed Loop Case Studies	**Chapter 10**

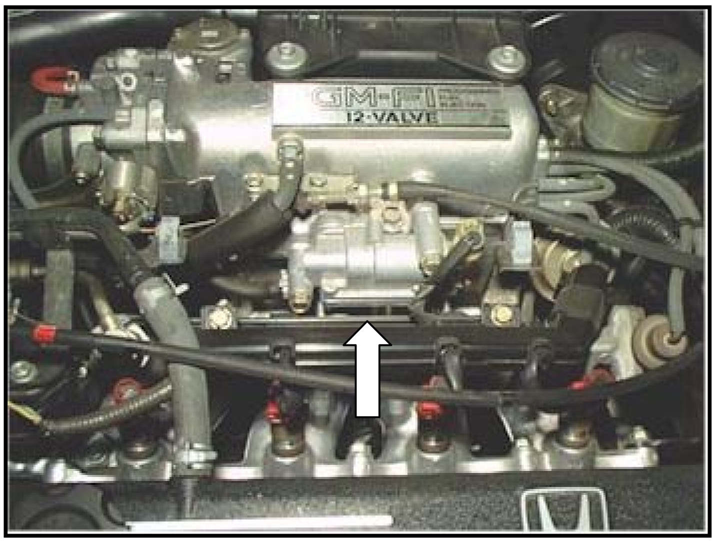
2.2 Idle Control

2.2.1 Basic Curb Idle Speed Control

Since the Honda PGMFI system is a Speed-Density type system, idle can easily be controlled by simply controlling the air that bypasses the throttle plate. The idle control system is one of the PGMFI sub systems that has seen a lot of change since the first PGMFI systems on the 1985 models.

The early idle control systems were primitive by today's standards. The curb idle was set by an air by-pass screw in the throttle body. This screw controlled how much air bypassed the throttle blade. Except for the fast idle valve the only other feature was a vacuum diaphragm that opened the throttle to offset of air conditioning compressor load.

Image 2-2 Idle Air Control Components

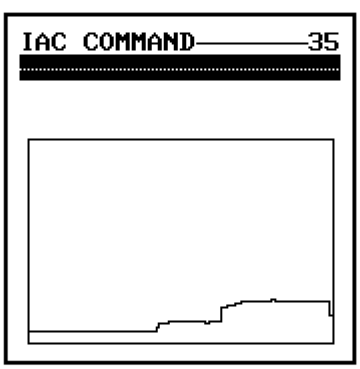


The idle control systems of these earlier models had the characteristics of a carburetor. The ECM had no control over the idle other than the air conditioning vacuum diaphragm. To help make the idle more stable, the ECM would typically widen the PW slightly and increase ignition timing when any type of load event occurred.

In 1988, Honda added an Idle Air Control (IAC) valve to the PGMFI system (shown in Image 2-2). By adding the IAC valve the ECM now had full control over the idle. The IAC valve is an electrically activated valve that could control the amount of air that bypassed the throttle blade. Now the ECM could increase the idle to offset the load from any event that occurred.

The IAC valve is supplied battery voltage on one side of its winding and the ECM controls the ground on the other side. The ECM controls the current in the IAC valve winding by duty cycling the time the IAC valve is grounded. The amount of current that flows through the IAC valve windings control how far open the valve is held open.

Screen Capture 2-4



Screen Capture 2-4 shows the IAC valve current as loads are created. Turning on the rear window defogger made the first "hump" and turning on the air conditioning created the second one.

The ECM uses the IAC valve to compensate for the slightest of loads. The ECM monitors the idle and will compensate for any load that attempts to pull the idle down. The disadvantage with this approach is that the idle must start dropping before the ECM can offset the drop by increasing the IAC valve current. If the ECM strictly relied on RPM drop to make an idle air correction, the idle would tend to “bobble” with every load event.

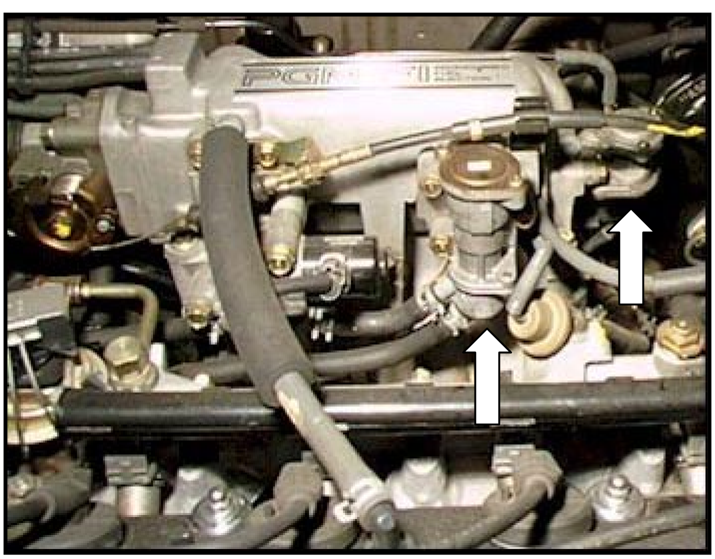
The ECM monitors most components that could have a significant effect on the base idle. It can then begin making a correction before the idle has a chance to drop. Some of the inputs that are used by the ECM to anticipate a load are, Electronic Load Detector (ELD), Power Steering Pressure (PSP) Switch, air conditioning switch, automatic transmission gear selector, etc.

2.2.2 Fast Idle Controls

When a Honda is started cold the idle must be increased until the engine warms up. A fast idle valve accomplishes this. The fast idle valve is a mechanical valve that has been on all PGMFI systems. The valve is open when cold and will gradually close as the car warms up. When the valve is open it allows air to by-pass the throttle blade. An expanding wax pellet that is heated up by the engine’s coolant closes the valve. When the engine has reached a certain temperature, the fast idle valve will be completely closed and the idle will be under the control of the IAC valve.

The fast idle valve, being an all-mechanical device, does tend to give some problems. The most common problem is that the expanding wax pellet gets "lazy" and the valve will not completely close. If the valve does not completely close down, the IAC valve will not be able to control the idle speed with this additional air entering the intake. If this happens the car idle will sometimes go up and down and seem to be out of control.

Image 2-3 Fast Idle Valve & Air Shot Valve



If a fast idle valve is not closing down when the engine is fully warmed the valve should be replaced. You can confirm that the fast idle valve is closing completely by removing the lid (held in place by two screws) and checking for airflow. No air should be flowing through the hole in the center of the valve. A fast idle valve is shown at the left arrow in Image 2-3.

2.2.3 Other Miscellaneous Air Controls

When a Honda is initially started up, it will run better right after start up if additional air is added to the intake manifold. The ECM accomplishes this either by a mechanical valve or electronically.

The mechanical style uses a starting air valve (shown in Image 2-3 at the right arrow), which is normally open and allows air to enter the intake manifold. While the engine is cranking this valve is open and adding air. Once the engine has started the rising intake manifold vacuum will close the valve down and no more air will be added to the manifold.

Some models do not use a mechanical valve but do dump additional air into the manifold by activating an air dump solenoid. The ECM activates a solenoid (usually located in an emission box), which adds air to the intake during starting.

For More Information About	Go To
The Idle Control Sub-System	**Chapter 22**

2.3 Ignition Controls

2.3.1 General Overview

The earlier PGMFI systems utilized distributors with traditional mechanical and vacuum advances. This was not optimum since the ECM had no control over the ignition timing. In 1988 the Civic and Prelude went to electronic distributors, and Accord went full electronic in 1990. The electronic distributors gave the ECM full control over the ignition timing. The information in this manual will cover the full electronic distributors

Image 2-4 Typical Honda Distributor

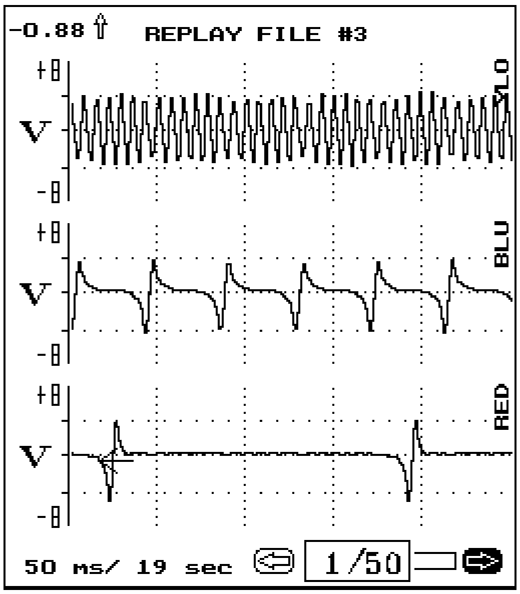
Setting the timing on an ECM controlled distributor requires jumping a service check connector to disable any ECM added advance. After jumping the service check connector, the timing can be checked by using a standard timing light.

Image 2-4 shows a typical Honda electronic controlled distributor with an internal coil. All Honda distributors are similar with the ECM input sensors located in the base and the igniter unit located in the upper part of the distributor.

The main differences among Honda ignition systems are the location of the ignition coil. Most coils were located internal of the distributor, but some models do use an external mounted coil.

2.3.2 The Ignition Process

Screen Capture 2-5 CYL, CKP, TDC



The process necessary to create a spark "starts" in the distributor base. If the system is a DPI system there will be two distributor input signals, a crankshaft position sensor (CKP) and a top dead center (TDC) sensor. If the system is a MPI system it will also include a cylinder (CYL) sensor input.

Screen Capture 2-5 shows a MPI Honda with all three sensors. This waveform was taken from a Honda with a new genuine Honda distributor.

- The CKP waveform is on top
- The TDC waveform is in the middle
- The CYL waveform is at the bottom

Note that some of the later model Hondas are moving some of these sensors out of the distributor and using crankshaft fired sensor.

The ECM uses these distributor inputs along with other inputs to calculate the optimum time to spark the sparkplug. To fire the sparkplug the ECM simply grounds a wire that runs from the igniter unit (mounted inside the distributor) to the ECM.

When the ECM supplied ground triggers the igniter, the igniter interrupts the ignition coil current. This causes the ignition coil to produce high-tension voltage that sparks the sparkplug.

Over the years several different components of Honda's ignition system have developed failure patterns. Some of the more common failures associated with the Honda ignition systems are:

- Distributor igniter failures (More common in the late 1980s)
- Distributor rotor button failures
- Distributor base bearing failures

- Engine oil leaking into the distributor
- Distributor input signal failures (CKP/TDC/CYL Sensors)
- Ignition coil failures (Mainly on internal coils)

For More Information About	Go To
The Ignition System	**Chapter 15**

2.4 Summary of Major Components

Inputs		Description
AC Signal		The signal received by the ECM when the dashboard AC button is activated. The ECM then turns on the AC compressor clutch relay if certain conditions have been met.
A/T Gear Position		The signal that indicates to the ECM which position the gear selector is in. This information helps the ECM to anticipate a load so it can make an idle, fuel and timing adjustment to stabilize the idle.
BARO Sensor	BARO	This sensor monitors barometric pressure so the ECM can compensate for the difference in air pressure. This is a typical 5-volt reference input. Note that the BARO and MAP sensor should read the same with key on / engine off KOEO.
Crankshaft Position	CKP	Sends a high-density 4volt AC type signal to the ECM. This input is used for injector timing and misfire monitoring on OBD-II cars
Cylinder Position	CYL	This sensor produces a 4volt AC type signal each time the number one cylinder fires
Electric Load Detector	ELD	Senses the electrical system for electrical loads. The ECM uses this information to anticipate a load that would effect idle and to switch the alternator between 12.5 volt and 14.5 volt modes.
EGR Lift		The EGR lift sensor reports the EGR valve position. The primary use of this input is to confirm the EGR valve is open to the amount the ECM expects it to be. The sensor is a standard 5-volt reference sensor. The typical input range is from 1.2 volts (closed) - 4 volts (fully opened).
Engine Coolant Temp	ECT	This is a thermistor input and it monitors the temperature of the engine coolant. A typical ECT sensor voltage on a fully warmed engine is approx. .6 Volt. Note that the ECT and IAT sensor use the same type thermistor and therefore should read the same if the engine coolant and ambient are at the same temperature, such as a cold engine. Note that the ECT and IAT

		sensor use the same type thermistor and therefore should read the same if the engine coolant and ambient are at the same temperature, such as a cold engine.
Intake Air Temp	IAT	This is a thermistor input and it monitors the temperature of the intake air. The thermistor in the IAT has the same temp/resistance profile as the ECT. Both should read the same when at the same temperature, such as a cold engine.
Manifold Pressure	MAP	Senses the absolute pressure of the intake manifold. The input voltage is an indicator of load to the ECM. This input has the most authority of all the inputs. A normal MAP Sensor input voltage is 1 volt or less on a fully warmed idling engine with all accessories turned off. This voltage is critical. If the voltage gets up much over 1 volt at idle, the car will typically run rich.
Oxygen Sensor	O2S	The O2 Sensor senses the exhaust oxygen content. When the PGMFI goes into CL operation, the ECM uses this input to trim the injector PW. The voltage will go from .1 (lean) to .9 (rich). The voltage can switch 3-5 times a second and it may be difficult to monitor this voltage accurately with a digital volt-ohm meter (DVOM). A digital storage oscilloscope (DSO) works nice on checking this input.
Heated Oxygen Sensor	HO2S	Same as an O2, but with a heater. The heater helps the O2 sensor reach operating temperature faster. The heater will also keep the sensor from cooling off in long periods of idle and falling out of CL. A HO2S has 4 wires instead of 1 or 2.
Power Steering Pressure Switch	PSP	Senses high power steering pressure. This is used to anticipate a load that would affect idle speed. When the power steering pressure gets above a set amount (usually at full steering wheel lock) the ECM compensates for the load by opening the IAC valve more and increasing the PW slightly.
Start Signal		While cranking, the ignition switch sends a "start" signal to the ECM. The ECM will add extra fuel on start-ups. The colder the ECT sensor indicates, the richer the A/F mixture. It is not uncommon to see a PW exceed 100ms on an extremely cold start.
Throttle Position	TP	Monitors the position of the throttle and how fast the throttle is opening or closing. The ECM uses this information to make adjustments to the A/F ratio during periods of closed throttle, wide-open throttle, and

		rapid throttle openings. Also the ECM cuts off the injectors on deceleration, based on the TP position and vehicle speed. This sensor is a standard 5-volt reference and the input is typically .45 volt (closed) and 4.5 Volts (wide open).
Top Dead Center	TDC	This sensor sends a 4volt AC type signal to the ECM each time a cylinder fires.
VTEC Pressure		This switch is used to indicate to the ECM that the VTEC was activated. It senses the presence of oil pressure in the VTEC oil galley.
Vehicle Speed	VSS	This sensor is located on the outside of the transmission and inputs a 0-12volt square wave signal that increases its frequency as the vehicle speed increases. The vehicle speed is included in many of the strategies. This input was added in 1988.
Outputs		**Descriptions**
AC Compressor Relay		The ECM energizes the AC compressor relay after the AC switch has been activated and various conditions have been met.
Alternator Mode		The ECM switches the alternator between a 12.5volt mode and a 14.5volt mode, based on information from the ELD Sensor.
Condenser Fan Relay		The ECM controls the operation of the AC condenser fans by energizing the condenser fan relay.
Idle Air Control Valve	IAC	The ECM finely controls the idle speed by controlling the current that flows through the IAC valve.
EGR Solenoid Valve		The EGR Solenoid Valve controls the EGR valve. When the EGR strategy has been met, the ECM grounds the EGR Solenoid Valve winding. After the ECM grounds this solenoid, vacuum is applied to the EGR valve.
Fuel Injectors		The ECM takes numerous inputs into account and opens the pintle of the fuel injector for just the right amount of time and at the right time, to deliver the correct amount of fuel.
Main Relay		The fuel injection main relay provides power to the electric fuel pump and the injectors. The ECM controls the main relay. The relay is turned on for two seconds and then will turn off unless the car is cranking or running.
Malfunction Indicator Light	MIL	The Malfunction Indicator Light (MIL) is activated directly by the ECM.
Oxygen Sensor Heater		Immediately upon the car starting, the ECM provides current to the oxygen sensor heaters. The current is

		monitored and if the heaters fail the ECM will store a diagnostic trouble code (DTC) and illuminate the MIL.
Radiator Fan Relay		The ECM controls the radiator fan operation by energizing the radiator fan relay.
VTEC Solenoid Valve		The ECM grounds the solenoid of this valve when the VTEC system is to be activated. The ECM looks for the VTEC pressure input to confirm the VTEC was properly activated.