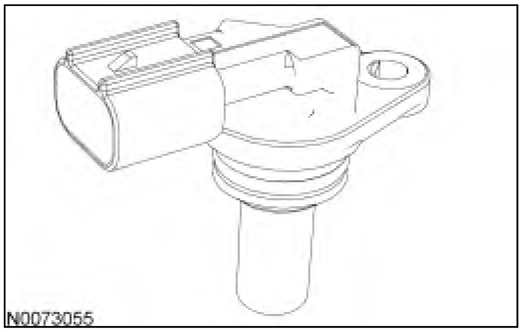


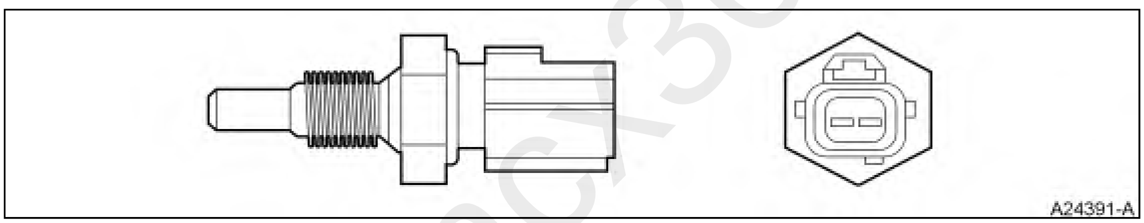
Typical Hall Effect CMP Sensor

Charge Air Cooler (CAC) Coolant Temperature Sensor

The CAC coolant temperature sensor is a thermistor device in which resistance changes with the temperature. The resistance of a thermistor decreases as temperature increases, and the resistance increases as the temperature decreases. The varying resistance affects the voltage drop across the sensor pins and provides electrical signals to the PCM corresponding to temperature.

Thermistor type sensors are considered passive sensors. A passive sensor is connected to a voltage divider network so varying the resistance of the passive sensor causes a variation in total current flow. Voltage that is dropped across a fixed resistor (pull up resistor) in series with the sensor resistor determines the voltage signal at the PCM. This voltage signal is equal to the reference voltage minus the voltage drop across the fixed resistor.

The CAC coolant temperature sensor is installed in the side of the CAC radiator and measures the CAC system coolant temperature. The PCM uses the CAC coolant temperature sensor to determine desired operating condition of the CAC coolant pump.



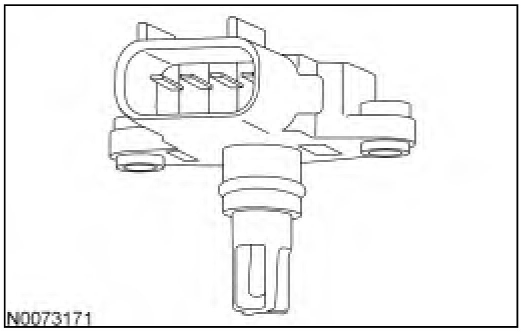
Typical CAC Coolant Temperature Sensor

Charge Air Cooler (CAC) Cooling Fan

The PCM monitors certain parameters (such as manifold pressure, charge air temperature, and engine coolant temperature) to determine CAC cooling fan needs. The CAC cooling fan is relay controlled by the PCM. The PCM controls the CAC cooling fan operation with the CACCF circuit through the CAC cooling fan relay.

Charge Air Cooler Temperature (CACT) Sensor

The CACT sensor is located in the intake air path between the charge air cooler (CAC) and the cylinder head. The CACT sensor measures the air temperature after the CAC. The CACT sensor may be integrated with a turbocharger boost pressure (TCBP) sensor or a manifold absolute pressure and temperature (MAPT) sensor.

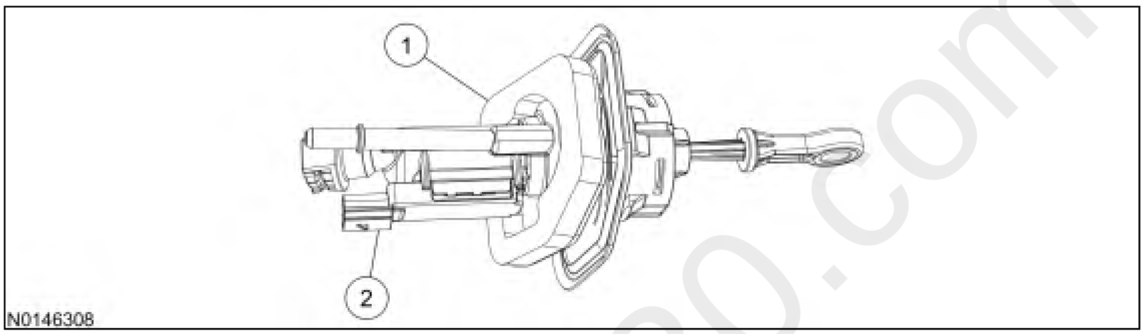


Typical CACT Sensor Integrated With A TCBP Sensor

Clutch Pedal Position (CPP) Sensor

The CPP signal is converted to percent of pedal travel by the PCM. During normal operation, the CPP is used as the indication of the clutch pedal position by the PCM strategy.

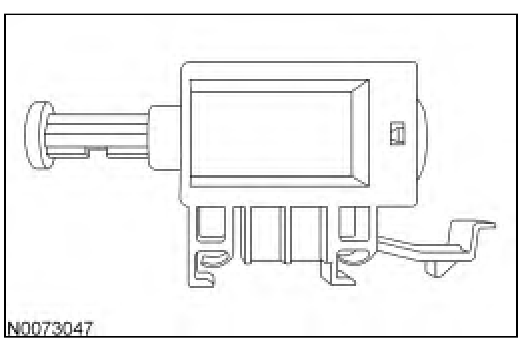
There is 1 reference voltage circuit, 1 signal return circuit, and 1 signal circuit between the PCM and the CPP sensor. The CPP sensor is typically mounted on the clutch master cylinder or pedal assembly.



Item	Number	Description
1	—	Clutch Master Cylinder
2	—	CPP Sensor Assembly

Clutch Pedal Position (CPP) Switch

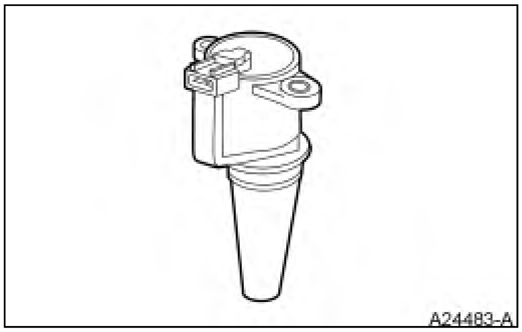
The CPP switch is an input to the PCM indicating the clutch pedal position. The PCM provides a low current voltage on the CPP circuit. When the CPP switch is closed, this voltage is pulled low through the signal return (SIGRTN) circuit. The CPP input to the PCM is used to detect a reduction in engine load. The PCM uses the load information for mass airflow and fuel calculations.



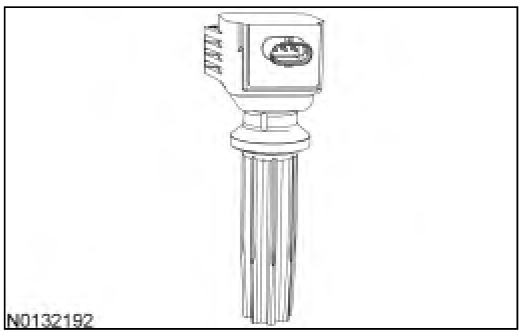
Typical Clutch Pedal Position (CPP) Switch

Coil On Plug (COP)

The COP ignition operates similar to a standard coil pack ignition except each plug has 1 coil per plug. The COP operates in engine crank, engine running and camshaft position failure mode effects management (FMEM) modes. The COP eliminates the need for secondary spark plug wires which improves reliability. Currently there are two types of COP in use today. The first type is a 2 circuit system that consists of the coil and boot that is installed directly on top of the spark plug which is fired by a driver located in the PCM. The second type is a 3 circuit system with the driver integrated in the COP assembly that is triggered when the PCM supplies the signal to fire. This configuration eliminates the need for high current lines from the PCM to the COP. For additional information, refer to Ignition Systems in this section.



Typical Coil On Plug (COP)



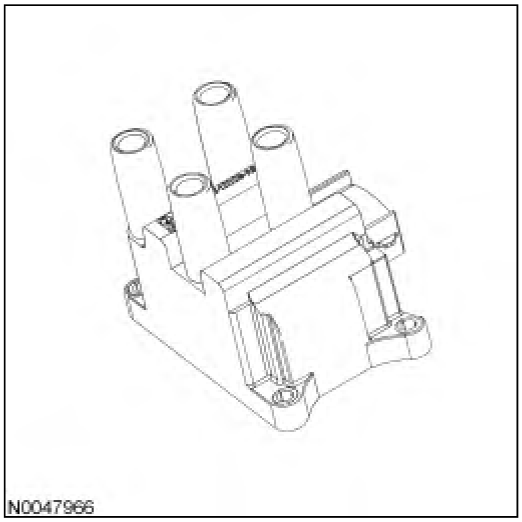
Typical Coil On Plug (COP) With Integrated Driver

Coil Pack

The PCM provides a grounding switch for the coil primary circuit. When the switch is closed, voltage is applied to the coil primary circuit. This creates a magnetic field around the primary coil. The PCM opens the switch, causing the magnetic field to collapse, inducing the high voltage in the secondary coil windings and firing the spark plug. The spark plugs are paired so that as 1 spark plug fires on the compression stroke, the other spark plug fires on the exhaust stroke. The next time the coil is fired the order is reversed. The next pair of spark plugs fire according to the engine firing order.

Two adjacent coil towers share a common coil and are called a matched pair, the matched pairs are 1 and 4 and 2 and 3.

When the coil is fired by the PCM, spark is delivered through the matched pair towers to their respective spark plugs. The spark plugs are fired simultaneously and are paired so that as one fires on the compression stroke, the other spark plug fires on the exhaust stroke. The next time the coil is fired, the situation is reversed. The next pair of spark plugs fire according to the engine firing order.



Typical 4 Tower Coil Pack

Cooling Fan

The PCM monitors certain parameters (such as engine coolant temperature, vehicle speed, A/C ON/OFF status, A/C pressure) to determine engine cooling fan needs.

For Variable Speed Electric Fans:

The PCM controls the fan speed and operation using a duty cycle output on the FCV circuit. The fan controller (located at or integral to the engine cooling fan assembly) receives the FCV command and operates the cooling fan at the speed requested (by varying the power applied to the fan motor).

The fan controller is able to detect certain failure modes within the fan motors. Under certain failure modes, such as a motor that is drawing excessive current, the fan controller shuts the fans off. Fan motor concerns may not set a specific DTC. With the fan motor disconnected from the fan controller, voltage may not be present at the fan controller.

For Relay Controlled Fans:

The PCM controls the fan operation through the fan control LFC (single speed applications), and LFC (low speed), MFC (medium speed), HFC (high speed) for multiple speed applications. Some applications have the xFC circuit wired to 2 separate relays.

For 2 speed fans, although the PCM output circuits are called LFC and HFC, cooling fan speed is controlled by a combination of these outputs.

For 3 speed fans, although the PCM output circuits are called LFC, MFC, and HFC, cooling fan speed is controlled by a combination of these outputs.

Cooling Fan Clutch

The cooling fan clutch is an electrically actuated viscous clutch that consists of 3 main elements:

- a working chamber
- a reservoir chamber
- a cooling fan clutch actuator valve and a fan speed sensor (FSS)

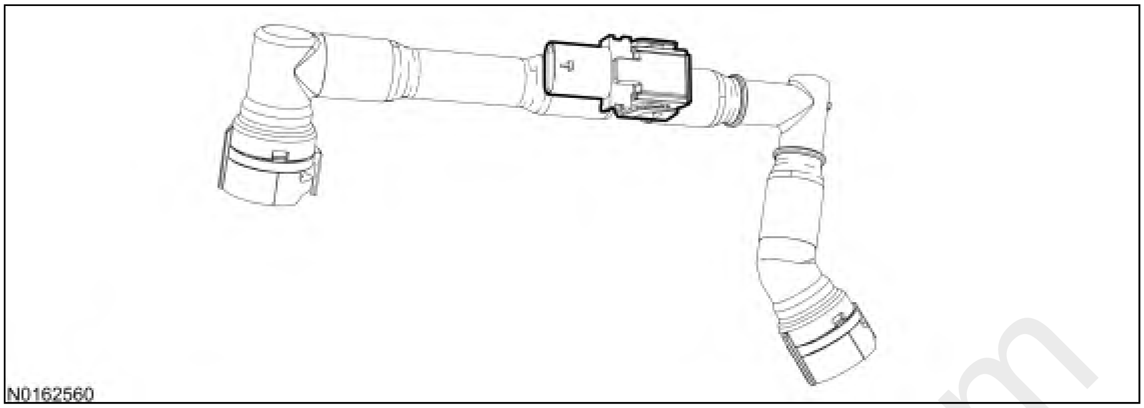
The cooling fan clutch actuator valve controls the fluid flow from the reservoir into the working chamber. Once viscous fluid is in the working chamber, shearing of the fluid results in fan rotation. The cooling fan clutch actuator valve is activated with a pulse width modulated (PWM) output signal from the PCM. By opening and closing the fluid port valve, the PCM can control the cooling fan speed. The cooling fan speed is measured by a Hall effect sensor and monitored by the PCM during closed loop operation.

The PCM optimizes fan speed based on engine coolant temperature, engine oil temperature, transmission fluid temperature, intake air temperature, or air conditioning requirements. When an increased demand for fan speed is requested for vehicle cooling, the PCM monitors the fan speed through the Hall effect sensor. If a fan speed increase is required, the PCM outputs the PWM signal to the fluid port, providing the required fan speed increase.

Crankcase Pressure Sensor

The crankcase pressure sensor measures the vacuum in the positive crankcase ventilation (PCV) system. A change in the PCV system vacuum greater than a calibrated threshold indicates the PCV system is disconnected and will set a DTC. The crankcase pressure sensor is located in the PCV system hose between the intake air system air cleaner and the engine crankcase PCV inlet.

On some vehicles, the CKCP has one digital signal output from the sensor. There is one reference voltage circuit and one signal return circuit for the sensor. For all others, the CKCP has one analog signal output from the sensor. There is one reference voltage circuit and one signal return circuit for the sensor.

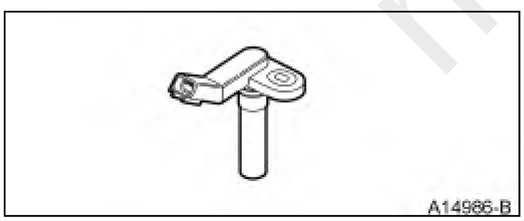


Typical Crankcase Pressure Sensor Integrated With Crankcase Ventilation Tube

Crankshaft Position (CKP) Sensor

The CKP sensor is a magnetic transducer mounted on the engine block adjacent to a pulse wheel located on the crankshaft. By monitoring the crankshaft mounted pulse wheel, the CKP sensor is the primary sensor for ignition information to the PCM. The pulse wheel for some V6 and V8 engines have a total of 35 teeth spaced 10 degrees apart with 1 empty space for a missing tooth. The pulse wheel for some 4 cylinder engines and some V6 engines have a total of 58 teeth spaced 6 degrees apart with 2 empty spaces. The 6.8L 10 cylinder pulse wheel has 39 teeth spaced 9 degrees apart and one 9 degree empty space for a missing tooth. By monitoring the pulse wheel, the CKP sensor signal indicates crankshaft position and speed information to the PCM. By monitoring the missing tooth, the CKP sensor is able to identify piston travel in order to synchronize the ignition system and provide a way of tracking the angular position of the crankshaft relative to a fixed reference for the CKP sensor configuration. The PCM also uses the CKP sensor signal to determine if a misfire has occurred by measuring rapid decelerations between teeth.

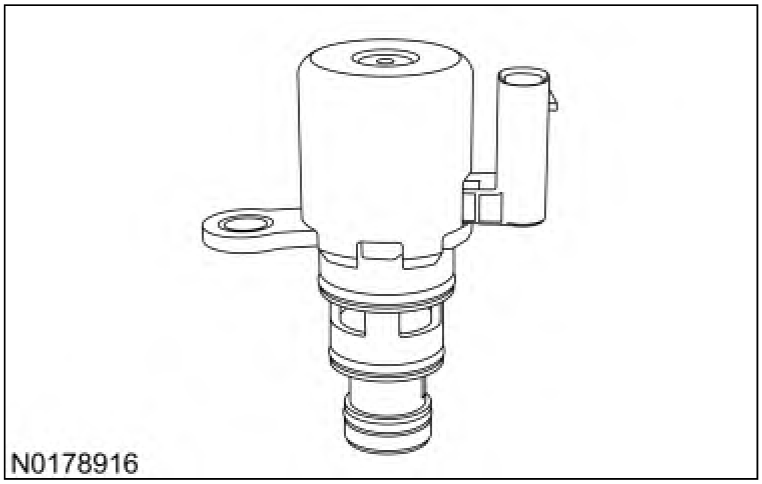
There are 2 types of CKP sensors used. The 2 pin variable reluctance sensor and the 3 pin Hall effect sensor.



Typical CKP Sensor

Cylinder Deactivation Solenoid

The cylinder deactivation solenoid controls the flow of engine oil to the affected intake and exhaust rocker arms effectively activating and deactivating that cylinder when only minimal engine power is required.



Typical Cylinder Deactivation Solenoid

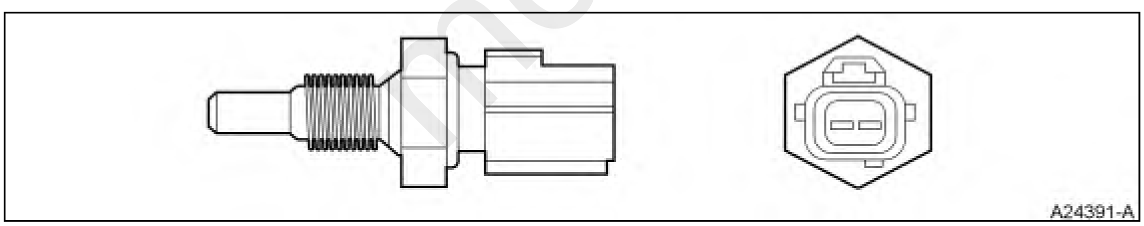
Cylinder Head Temperature (CHT) Sensor

Note: *If the CHT sensor is removed from the cylinder head for any reason it must be replaced with a new sensor.*

The CHT sensor is a thermistor device in which resistance changes with the temperature. The resistance of a thermistor decreases as temperature increases, and the resistance increases as the temperature decreases. The varying resistance affects the voltage drop across the sensor pins and provides electrical signals to the PCM corresponding to temperature.

Thermistor type sensors are considered passive sensors. A passive sensor is connected to a voltage divider network so varying the resistance of the passive sensor causes a variation in total current flow. Voltage that is dropped across a fixed resistor (pull up resistor) in series with the sensor resistor determines the voltage signal at the PCM. This voltage signal is equal to the reference voltage minus the voltage drop across the fixed resistor.

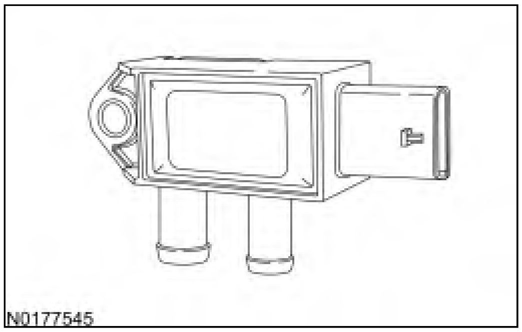
On a typical vehicle, the CHT sensor is located in the cylinder head and the CHT2 sensor is located in the exhaust manifold. The CHT sensor provides complete engine temperature information and is used to infer coolant temperature. If the CHT sensor conveys an overheating condition to the PCM, the PCM initiates a fail safe cooling strategy based on information from the CHT sensor. A cooling system concern, such as low coolant or coolant loss, could cause an overheating condition. As a result, damage to major engine components could occur. Using both the CHT sensor and fail safe cooling strategy, the PCM prevents damage by allowing air cooling of the engine and limp home capability. For additional information, refer to Powertrain Control Software for Fail-Safe Cooling Strategy in this section.



Typical CHT Sensor

Differential Pressure Feedback Exhaust Gas Recirculation (EGR) Sensor

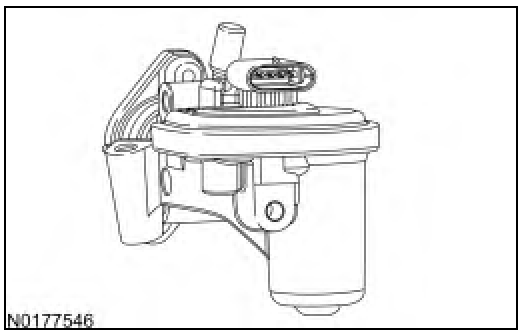
The differential pressure feedback EGR sensor is a piezo resistive type pressure transducer that monitors the differential pressure across a metering orifice located in the orifice tube assembly. The differential pressure feedback EGR sensor receives this signal through 2 hoses referred to as the downstream pressure hose (REF signal) and upstream pressure hose (HI signal). The HI and REF hose connections are marked on the differential pressure feedback EGR sensor housing for identification (note the HI signal uses a larger diameter hose). The differential pressure feedback EGR sensor outputs a voltage proportional to the pressure drop across the metering orifice and supplies it to the PCM as EGR flow rate feedback.



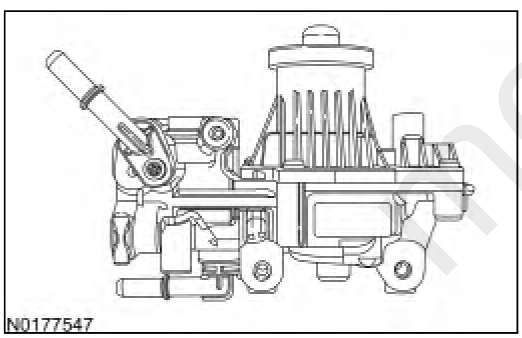
Typical Differential Pressure Feedback EGR Sensor

Electric Exhaust Gas Recirculation (EGR) Valve

Depending on the application, the electric EGR valve is either a water cooled or an air cooled motor and valve assembly. The motor is commanded to move in 52 discrete steps as it acts directly on the EGR valve. The position of the valve determines the rate of EGR flow. The spring works to close the valve against the motor opening force.



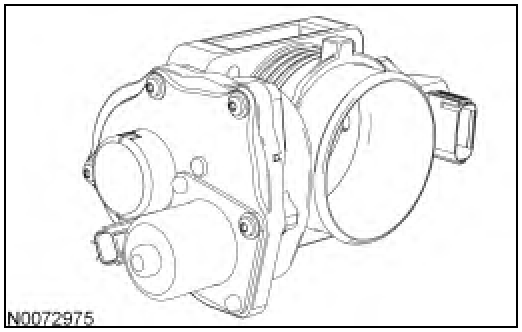
Typical Air Cooled EGR Valve Assembly



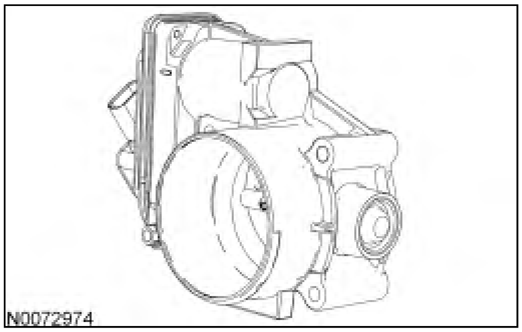
Typical Water Cooled EGR Valve Assembly

Electronic Throttle Body Throttle Actuator Control (TAC)

The electronic throttle body TAC is a DC motor controlled by the PCM. There are 2 designs for the electronic throttle body TAC, parallel and inline. The parallel design has the motor under the bore parallel to the plate shaft. The motor housing is integrated into the main housing. The inline design has a separate motor housing. Both designs use an internal spring to return the throttle plate to a default position. The default position is typically a throttle angle of 7 to 8 degrees from the hard stop angle. The closed throttle plate hard stop prevents the throttle from binding in the bore. This hard stop setting is not adjustable and is set to result in less airflow than the minimum engine airflow required at idle. For additional information, refer to Torque Based Electronic Throttle Control (ETC) in this section.



Typical Inline Electronic Throttle Body TAC Design



Typical Parallel Electronic Throttle Body TAC Design

Electronic Throttle Body Throttle Position Sensor (ETBTPS)

On some vehicles, the ETBTPS has one digital signal output from the sensor. There is one reference voltage circuit (ETCREF) and one signal return circuit (ETCRTN) for the sensor dedicated to the ETBTPS. For additional information, refer to Torque Based Electronic Throttle Control (ETC) in this section.

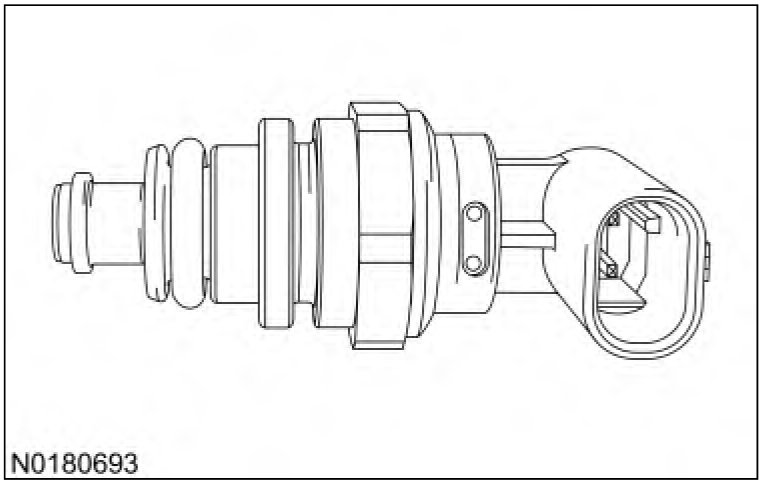
For all others, the ETBTPS has two analog signals output from the sensor. The first ETBTPS signal (TP1) has a negative slope (increasing angle, decreasing voltage) and the second signal (TP2) has a positive slope (increasing angle, increasing voltage). There is one reference voltage circuit (ETCREF) and one signal return circuit (ETCRTN) for the sensor shared with the reference voltage circuits (APPVREF1 and APPVREF2) and signal return circuits (APPRTN1 and APPRTN2) used by the APP sensor. For additional information, refer to Torque Based Electronic Throttle Control (ETC) in this section.

Engine Coolant Temperature (ECT) Sensor

The ECT sensor is a thermistor device in which resistance changes with temperature. The resistance of a thermistor decreases as the temperature increases, and the resistance increases as the temperature decreases. The varying resistance changes the voltage drop across the sensor pins and provides electrical signals to the PCM corresponding to temperature.

Thermistor type sensors are considered passive sensors. A passive sensor is connected to a voltage divider network so varying the resistance of the passive sensor causes a variation in total current flow. Voltage that is dropped across a fixed resistor (pull up resister) in series with the sensor resistor determines the voltage signal at the PCM. This voltage signal is equal to the reference voltage minus the voltage drop across the fixed resistor.

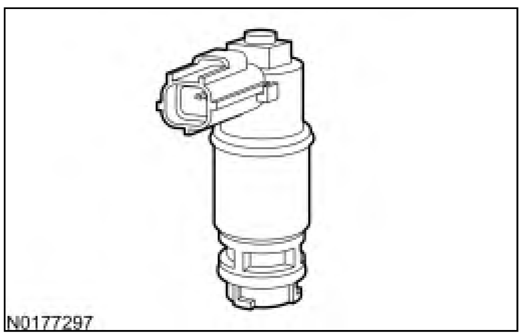
The ECT sensor is located in an engine coolant passage and measures the engine coolant temperature. The PCM uses the engine coolant temperature input for fuel control and for cooling fan control. The ECT sensor can be a threaded or twist lock type.



Typical ECT Sensor

Evaporative Emission (EVAP) Canister Vent Valve

The EVAP canister vent valve (located in the EVAP canister dust box) is part of the enhanced EVAP system controlled by the PCM. During the EVAP leak check monitor, the EVAP canister vent valve seals the EVAP canister from the atmospheric pressure. This allows the EVAP purge valve to achieve the target vacuum in the fuel tank during the EVAP leak check monitor.



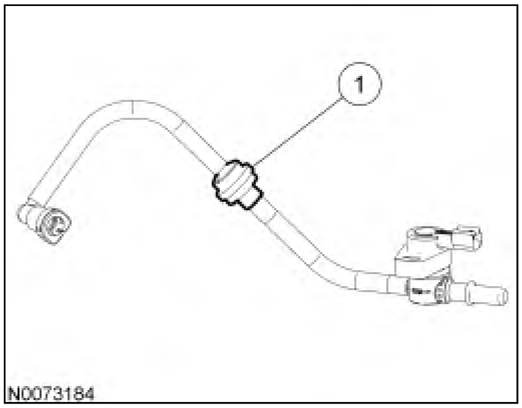
Typical EVAP Canister Vent Valve

Evaporative Emission (EVAP) Check Valve

EVAP Check Valve

The EVAP check valve is used on turbocharged engines to prevent boost pressure from forcing open the EVAP purge valve and entering the EVAP system. The valve is open under normal engine vacuum. The valve closes during boost conditions to prevent the fuel tank from being pressurized and hydrocarbons forced out of the EVAP system into the atmosphere through the EVAP canister vent valve. When the engine is OFF, or at atmospheric pressure, the EVAP check valve is in an indeterminate state. The EVAP check valve is an integral part of the EVAP purge valve assembly.

Typical EVAP Check Valve



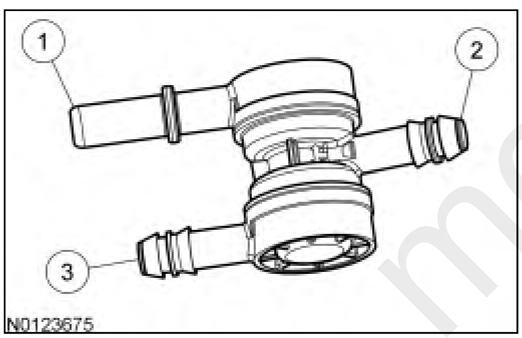
Item	Number	Description
1	—	EVAP Check Valve

EVAP Dual Check Valve

The EVAP dual check valve allows purge flow during boost conditions. Fuel vapors flow through the EVAP dual check valve to the intake air system upstream of the turbocharger before entering the intake manifold. When the engine is OFF, or at atmospheric pressure, the EVAP dual check valve is in an indeterminate state.

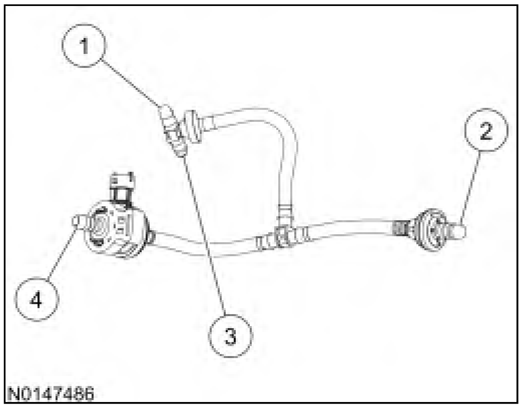
There are 2 types of EVAP dual check valves on turbocharged engines. One type has the check valves integrated in a single housing assembly. The second type has separate check valves connected to a hose assembly with the EVAP ejector integrated with one of the check valves.

Typical EVAP Dual Check Valves



Item	Number	Description
1	—	Purge Flow To The Intake Air Inlet System To The Turbocharger
2	—	Purge Flow From The EVAP Purge Valve
3	—	Purge Flow To The Intake Manifold

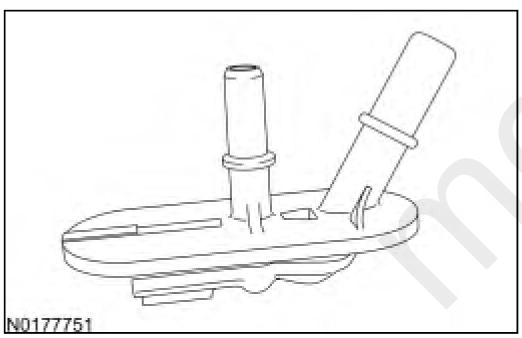
Typical EVAP Dual Check Valve Assembly



Item	Number	Description
1	—	Purge Flow To The Intake Air Inlet System To The Turbocharger From The Check Valve And EVAP Ejector
2	—	Purge Flow To The Intake Manifold
3	—	Turbocharger Boost Pressure From The Charge Air Cooler (CAC)
4	—	Purge Flow From The Fuel Tank

Evaporative Emission (EVAP) Ejector

The EVAP ejector is used on turbocharged engines to create a vacuum in the EVAP purge line from the EVAP purge valve to the intake air system. During boost conditions, boost pressure flows through a venturi inside the EVAP ejector creating a vacuum in the EVAP purge line to the intake air inlet to the turbocharger. When the second EVAP check valve is open, the purge vapor is drawn through the EVAP ejector into the intake air tube, through the turbocharger and charge air cooler, to the intake manifold.

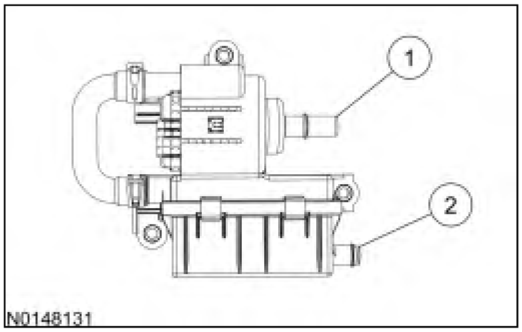


Typical EVAP Ejector

Evaporative Emission (EVAP) Leak Detection Control Module

The EVAP leak detection control module consists of a vacuum pump, a pressure sensor, a 0.02" reference orifice and a switching valve. The vacuum pump is used to apply a vacuum across the reference orifice and to apply a vacuum on the EVAP system for the EVAP leak check monitor. The 0.02" reference orifice is used to obtain a reference check for leak detection every time the EVAP monitor runs. The pressure sensor is used to determine the vacuum level across the reference orifice and for the EVAP leak detection monitor. The EVAP leak detection control module is vented to atmosphere through the switching valve and allows for purging during engine operation and refueling.

Typical EVAP Leak Detection Control Module

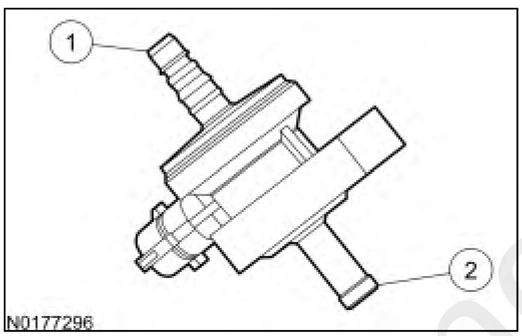


Item	Number	Description
1	—	To EVAP Canister
2	—	To Fresh Air Tube

Evaporative Emission (EVAP) Purge Valve

The EVAP purge valve (located near the engine) is part of the enhanced EVAP system controlled by the PCM. This valve controls the flow of vapors (purging) from the EVAP canister to the intake manifold during various engine operating modes. The EVAP purge valve is a normally closed valve. The PCM outputs a duty cycle between 0% and 100% to control the EVAP purge valve.

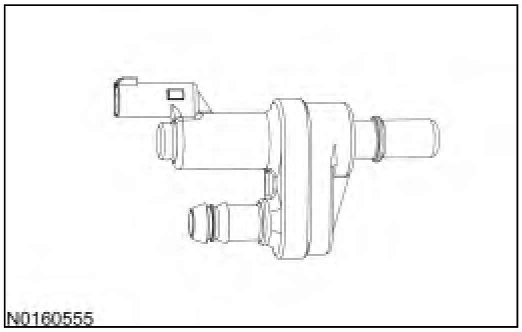
Typical EVAP Purge Valve



Item	Number	Description
1	—	Fuel Vapor To EVAP Canister
2	—	Fuel Vapor To Intake Manifold

Evaporative Emission (EVAP) Vapor Blocking Valve

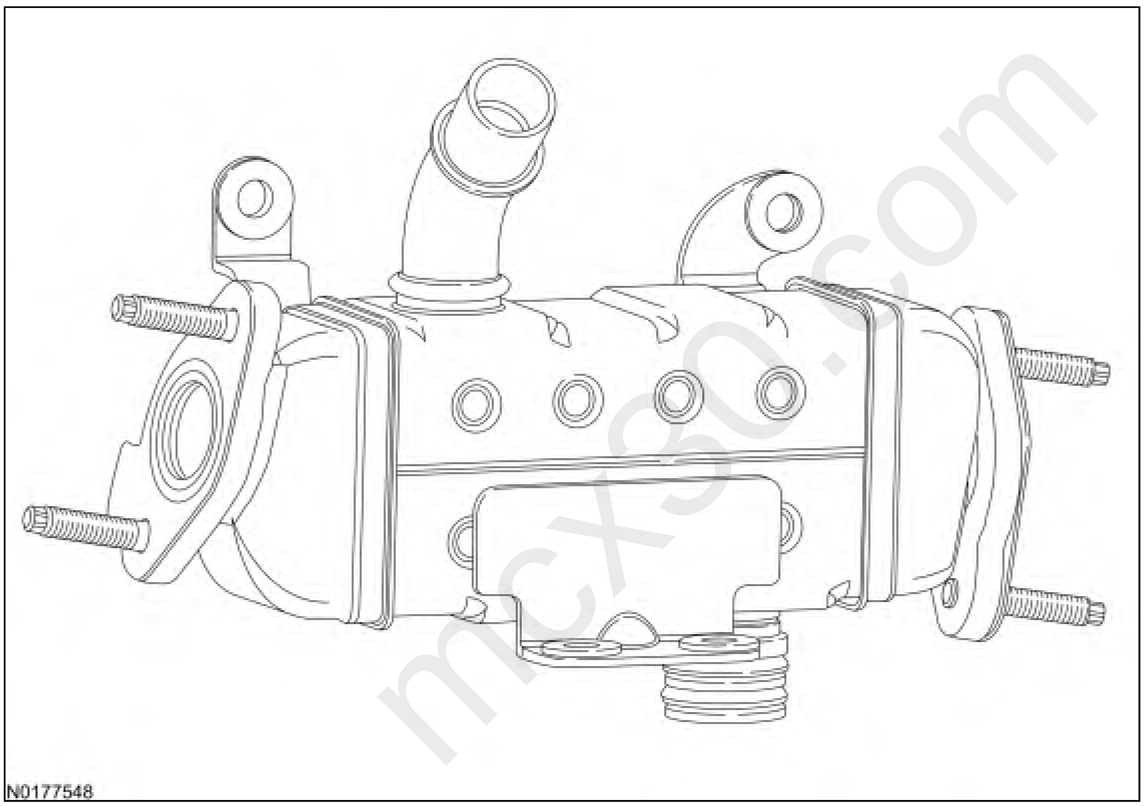
The EVAP vapor blocking valve is a normally open valve, electrically closed by the PCM, to isolate the fuel tank from the rest of the EVAP system. The EVAP vapor blocking valve will automatically open to relieve excess pressure or vacuum, in the fuel tank, if the pressure or vacuum reaches a maximum calibrated value.



Typical EVAP Vapor Blocking Valve

Exhaust Gas Recirculation (EGR) Cooler

The exhaust gases are directed through the EGR cooler to lower the exhaust gas temperature before entering the intake manifold. The EGR cooler uses engine coolant to reduce the exhaust gas temperature.



Typical EGR Cooler

Exhaust Gas Recirculation (EGR) Orifice Tube Assembly

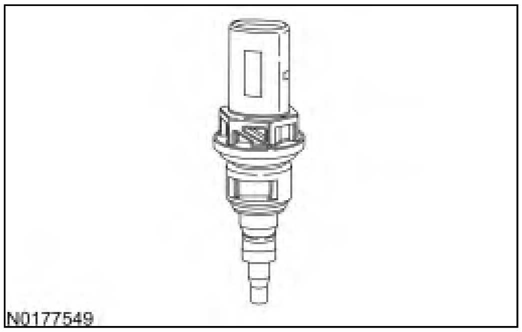
The EGR orifice tube assembly is a section of tubing between the exhaust manifold and the EGR valve. The assembly provides the flow path for the EGR to the intake manifold and also contains the metering orifice and 2 pressure pick up tubes. The internal metering orifice creates a measurable pressure drop as the EGR valve opens and closes. This pressure differential across the orifice is picked up by the differential pressure feedback EGR sensor which provides feedback to the PCM.

Exhaust Gas Recirculation Temperature (EGRT) Sensor

The EGRT bank 1, sensor 2 (EGRT12) is a thermistor device in which resistance changes with temperature. The EGRT 12 sensor is an input to the PCM. The electrical resistance of the sensor increases as the temperature decreases, and the resistance decreases as the temperature increases. The varying resistance changes the voltage drop across the sensor terminals and provides electrical signals to the PCM corresponding to temperature.

The EGRT12 sensor is primarily used for EGR flow caluculation and is also used for EGR cooler diagnostics. The EGRT12 sensor monitors the exhaust gas temperature downstream of the EGR cooler. The EGRT12 sensor is located between the

EGR cooler and the EGR valve on the EGR orifice tube assembly.

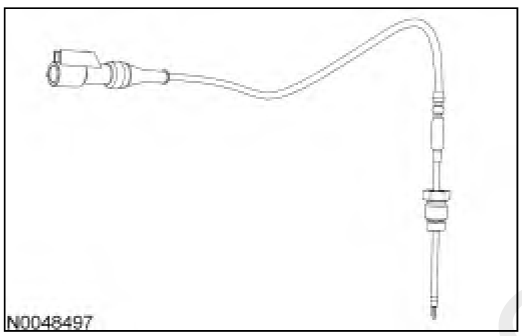


Typical EGRT Sensor

Exhaust Gas Temperature (EGT) Sensor

The EGT sensor is a thermistor sensor. The EGT sensor is an input to the PCM and measures the temperature of the exhaust gas passing through the exhaust system. The electrical resistance of the sensor decreases as the temperature increases, and resistance increases as the temperature decreases. The varying resistance changes the voltage drop across the sensor terminals and provides electrical signals to the PCM corresponding to temperature.

The PCM uses the input from the EGT sensor to monitor the particulate filter temperature. The EGT sensors are located in the exhaust system downstream of the particulate filter.

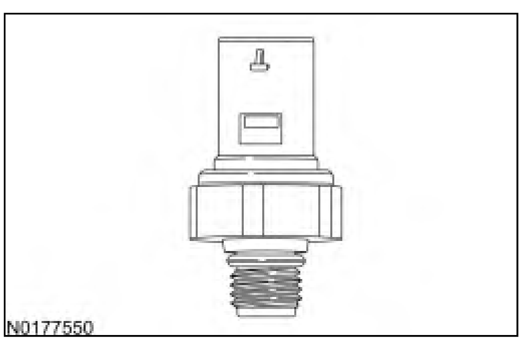


Typical EGT Sensor

Exhaust Pressure (EP) Sensor

The EP sensor measures the exhaust pressure downstream of the EGR cooler. The EP sensor signal is used primarily for EGR cooler effectiveness.

The EP sensor is located between the EGR cooler and the EGR valve on the EGR orifice tube assembly.



Typical EP Sensor

Fan Speed Sensor (FSS)

The FSS is a Hall effect sensor that measures the cooling fan clutch speed by generating a waveform with a frequency proportional to the fan speed. If the cooling fan clutch is moving at a relatively low speed, the sensor produces a signal with a low frequency. As the cooling fan clutch speed increases, the sensor generates a signal with a higher frequency. The PCM uses the frequency signal generated by the FSS as a feedback for closed loop control of the cooling fan clutch. For additional information on the cooling fan clutch, refer to Cooling Fan Clutch in this section.

Fuel Injection Pump

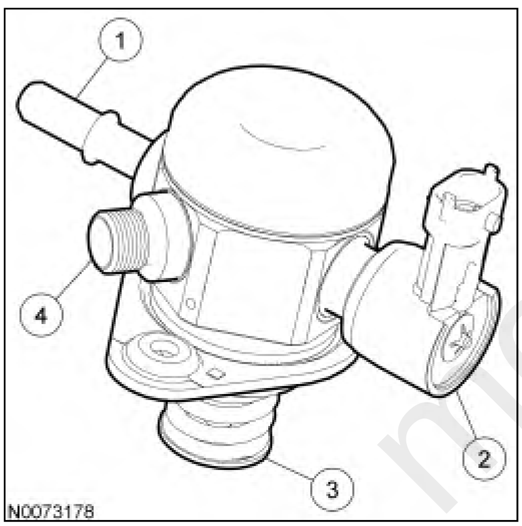
NOTICE: Do not apply battery positive (B+) voltage directly to the fuel volume regulator solenoid electrical connector pins. Internal damage to the solenoid may occur in a matter of seconds.

The engine driven fuel injection pump increases fuel rail pressure to the desired level to support fuel injection requirements. Unlike conventional port fuel injection systems, with direct injection the desired fuel rail pressure ranges widely over operating conditions. The pump receives fuel from the fuel pump (FP) assembly, increases the fuel pressure from approximately 448 kPa (65 psi) to a variable pressure up to 20 MPa (2900 psi), and delivers it to the fuel rails. The fuel injection pump is driven by a dedicated intake camshaft lobe and is located on top of the engine.

The fuel volume regulator is a solenoid valve permanently mounted to the pump assembly. The PCM commands the fuel volume regulator to meter in a specified fuel volume with each pump stroke. The PCM regulates the fuel volume entering the rail to achieve the desired fuel rail pressure.

The fuel volume regulator control is synchronous to the cam position on which the pump is mounted. The fuel volume regulator control takes into account that camshaft phasing varies during engine operation for purposes of valve control.

Fuel Injection Pump



Item	Number	Description
1	—	Low Pressure Fuel Inlet
2	—	Fuel Volume Regulator Solenoid
3	—	Pump Piston Follower
4	—	High Pressure Fuel Outlet

Fuel Injectors

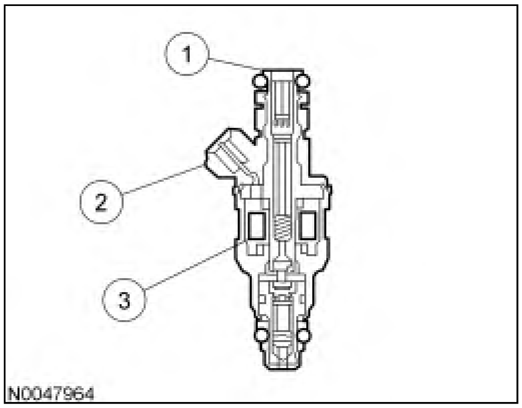
NOTICE: Do not apply battery positive (B+) voltage directly to the fuel injector electrical connector pins. Internal damage to the solenoid may occur in a matter of seconds.

The fuel injector is a solenoid operated valve that meters fuel flow to the engine. The fuel injector opens and closes a constant number of times per crankshaft revolution. The amount of fuel is controlled by the length of time the fuel injector is held open.

The fuel injector is normally closed and is operated by a 12 volt source from either the PCM power relay or fuel pump relay. The ground signal is controlled by the PCM.

The fuel injector is a deposit resistant injector (DRI) type and does not have to be cleaned. Install a new fuel injector if the flow is checked and found to be out of specification.

Typical Fuel Injector



Item	Number	Description
1	—	Fuel Filter Screen
2	—	Connector
3	—	Solenoid Coil

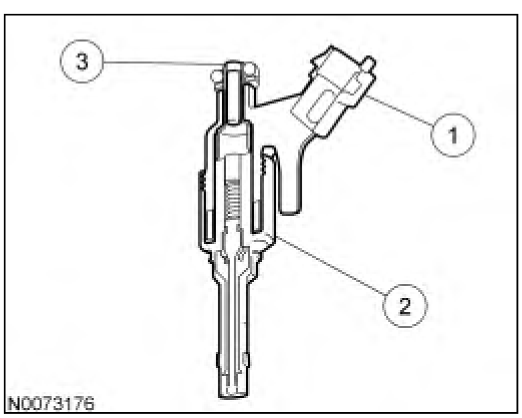
Fuel Injectors — Direct Injection

The gasoline direct fuel injection fuel injector delivers fuel directly into the cylinder under high pressure. Each injector is controlled by 2 circuits from the PCM.

A boosted voltage supply, up to 65 volts, is generated in the PCM and used to initially open the injector. The injector driver controls three transistor switches that apply the boost voltage to open the injector and then modulates the current to hold the injector open. If boost voltage is unavailable, the correct injector opening current may not be generated in the time required.

The PCM contains a smart driver that monitors and compares high side and low side injector currents to diagnose numerous concerns. Each fuel injector high side circuit is paired inside the PCM with another fuel injector high side circuit. All injector concerns are reported with a single DTC per injector.

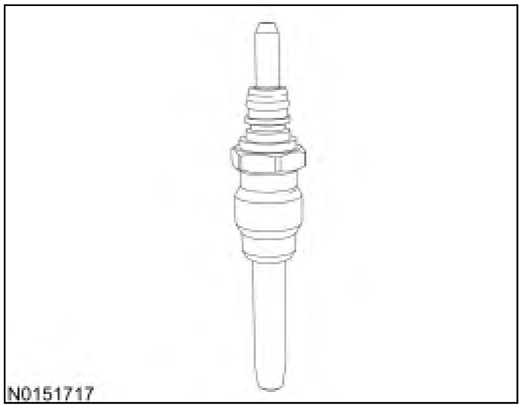
Typical Direct Fuel Injection Fuel Injector



Item	Number	Description
1	—	Connector
2	—	Solenoid Coil
3	—	Fuel Filter Screen

Fuel Injector Heater

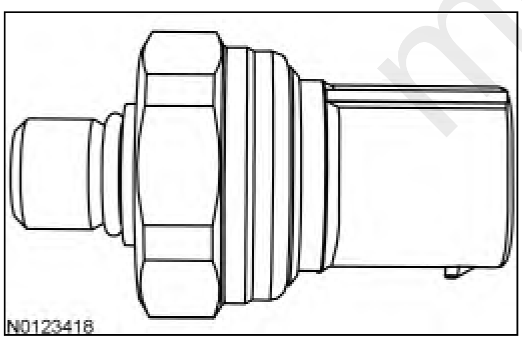
The fuel injector heater provides a heat source at the fuel rail during combustion to improve cold engine starting and operation. The fuel injector heater is made of a resistive material that heats up when electricity flows through it. The fuel injector heater is controlled by the fuel injector heater control module. The PCM may activate the fuel injector heater control module and the fuel injector heaters any time the engine is running during cold ambient temperatures. For additional information, refer to Cold Start System in this section.



Typical Fuel Injector Heater

Fuel Pressure Sensor

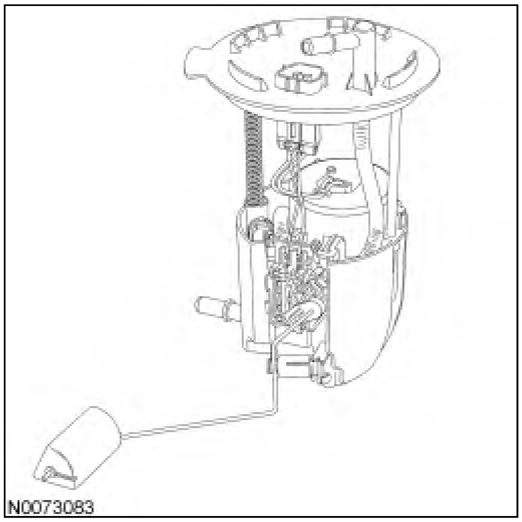
The fuel pressure sensor (located in the fuel line either near the fuel tank or near the engine) provides a pressure feedback signal for the low pressure fuel system to the PCM. The PCM uses the FLP signal to determine correct operation of the low pressure fuel system.



Typical Fuel Pressure Sensor

Fuel Pump (FP) Assembly

The FP assembly contains the fuel pump and sender assembly. The fuel pump is located inside the FP assembly reservoir and supplies fuel through the FP assembly manifold to the engine and FP assembly jet pump. The jet pump continuously refills the reservoir with fuel, and a check valve located in the manifold outlet maintains system pressure when the fuel pump is not energized. A flapper valve located in the bottom of the reservoir allows fuel to enter the reservoir and prime the fuel pump during the initial fill.



Typical Mechanical Returnless FP Assembly

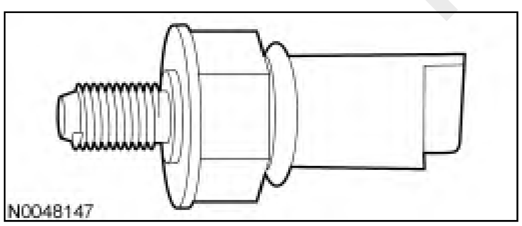
Fuel Pump (FP) Assembly And Reservoir

The FP assembly is mounted inside the fuel tank in a reservoir. The pump has a discharge check valve that maintains the system pressure after the ignition has been turned OFF to minimize starting concerns. The reservoir prevents fuel flow interruptions during extreme vehicle maneuvers with low tank fill levels.

Fuel Rail Pressure (FRP) Sensor

The FRP sensor is a diaphragm strain gauge device. The FRP sensor measures the pressure difference between the fuel rail and atmospheric pressure. The FRP sensor nominal output varies between 0.5 and 4.5 volts, with 0.5 volts corresponding to 0 MPa (0 psi) gauge and 4.5 volts corresponding to 26 MPa (3771 psi) gauge. The sensor can read vacuum and may lower the output voltage to slightly below 0.5 volts. This condition is normal and is usually the case after several hours of cold soak before the vehicle dome light is turned ON. The FP assembly is energized at the same time the dome light is commanded ON. A disabled or malfunctioning dome light does not affect the FP assembly control.

The FRP sensor is located on the fuel rail and provides a feedback signal to indicate the fuel rail pressure to the PCM. The PCM uses the FRP signal to command the correct injector timing and pulse width for correct fuel delivery at all speed and load conditions. The FRP sensor, along with the fuel volume regulator (part of the fuel injection pump), form a closed loop fuel pressure control system. An electrically faulted FRP sensor results in the deactivation of the fuel injection pump. Fuel pressure to injectors is then provided only by the FP assembly. When the fuel injection pump is de-energized and the injectors are active, the fuel rail pressure is approximately 70 kPa (10 psi) lower than FP assembly pressure due to the pressure drop across the fuel injection pump. Thus, if the FP assembly pressure is 448 kPa (65 psi), then the fuel rail pressure would be approximately 379 kPa (55 psi) if the injectors are active.



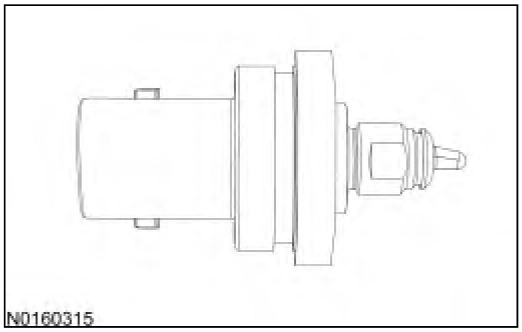
Typical Fuel Rail Pressure (FRP) Sensor

Fuel Rail Pressure Temperature (FRPT) Sensor

The temperature component of the FRPT sensor is a thermistor device in which resistance changes with temperature. The electrical resistance of a thermistor decreases as the temperature increases, and resistance increases as the temperature decreases. The varying resistance affects the voltage drop across the sensor terminals and provides electrical voltage signals to the PCM corresponding to temperature.

The pressure component of the FRPT sensor provides a signal to the PCM indicating fuel rail pressure. The PCM supplies a 5 volt reference (VREF) signal, as well as supplying 5 volts on the FRP circuit. As pressure increases, the sensor signal voltage decreases.

The FRPT sensor measures the pressure and temperature of the fuel in the fuel rail and sends these signals to the PCM. The PCM uses the fuel pressure and temperature sensor inputs to command the correct fuel pump speed. The relationship between the fuel pressure and the fuel temperature is also used to determine the possible presence of fuel vapor in the fuel rail. The FRPT sensor is located at the top of the left fuel rail.

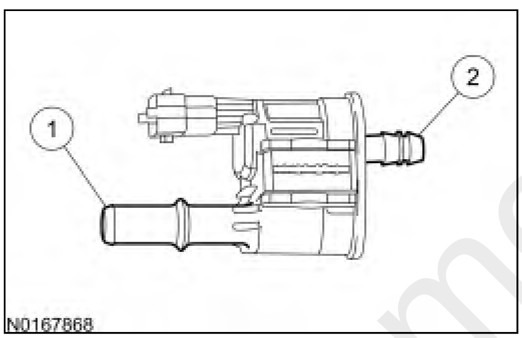


Typical FRPT Sensor

Fuel Tank Isolation Valve (FTIV)

The FTIV is a PCM controlled solenoid that isolates the fuel tank from the rest of the EVAP system. The FTIV is a normally closed valve blocking the flow of vapors from the fuel tank to the EVAP canister. This prevents the canister from becoming saturated causing hydrocarbons (HC) to be released into the atmosphere in a situation where the engine does not run during a drive cycle. The FTIV will automatically open to relieve excess vacuum if the fuel tank vacuum reaches a maximum mechanical relief threshold value.

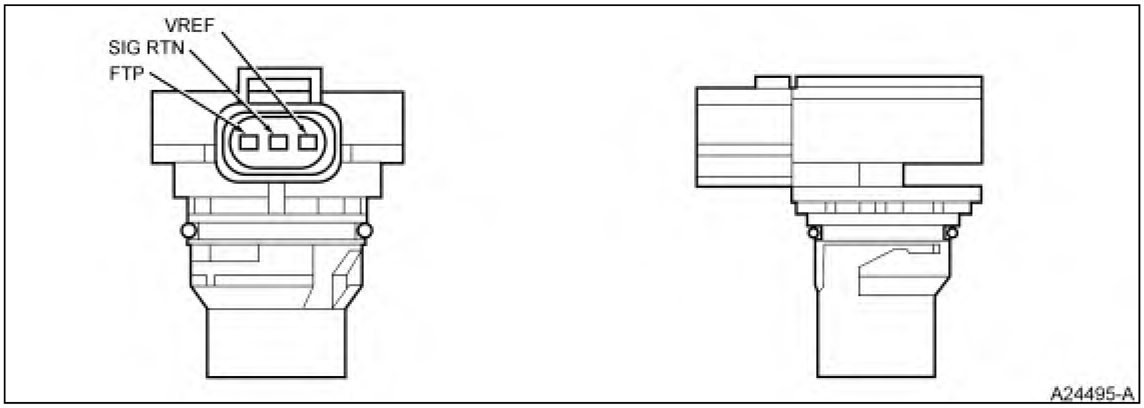
Typical Fuel Tank Isolation Valve (FTIV)



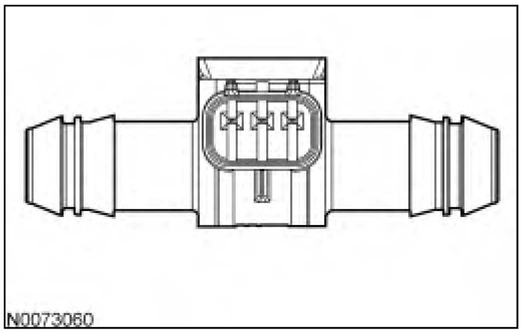
Item	Number	Description
1	—	To Fuel Tank
2	—	To EVAP Canister

Fuel Tank Pressure (FTP) Sensor

The in tank FTP sensor or the inline FTP sensor measures the fuel tank pressure.



Typical In Tank FTP Sensor

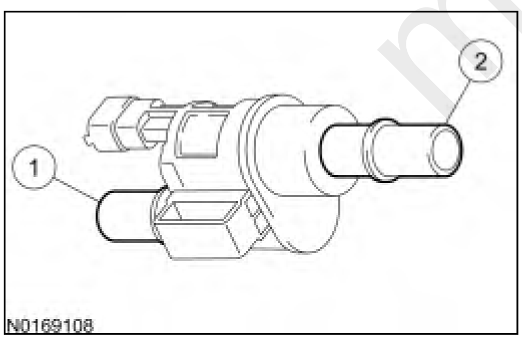


Typical Inline FTP Sensor

Fuel Vapor Vent Valve (FVVV)

The FVVV is a PCM controlled solenoid that isolates the fuel tank from the rest of the EVAP system. The PCM opens the FVVV during refueling to allow the flow of vapors from the fuel tank to the EVAP canister. The FVVV will automatically open to relieve excess pressure if the fuel tank pressure reaches a maximum mechanical relief threshold value.

Typical Fuel Vapor Vent Valve (FVVV)



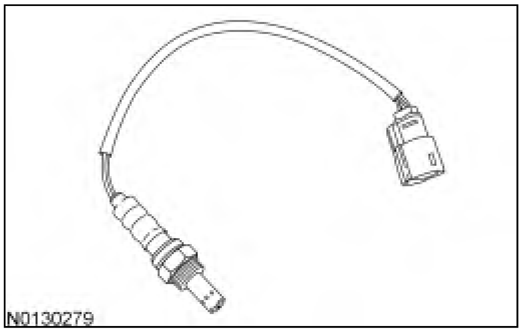
Item	Number	Description
1	—	To Fuel Tank
2	—	To EVAP Canister

Heated Oxygen Sensor (HO2S)

The HO2S detects the presence of oxygen in the exhaust and produces a variable voltage according to the amount of oxygen detected. A high concentration of oxygen (lean air to fuel ratio) in the exhaust produces a voltage signal less than 0.4 volt. A low concentration of oxygen (rich air to fuel ratio) produces a voltage signal greater than 0.6 volt. The HO2S provides feedback to the PCM indicating air to fuel ratio in order to achieve a near stoichiometric air to fuel ratio of 14.7 to 1 (9 to 1 E100) during closed loop engine operation.

When the oxygen sensor is cold, disconnected or on initial start up, the voltage may read between 1.5 to 1.7 volts. The oxygen sensor voltage will decrease to the normal operating range of 0.0 to 1.1 volts during warm, stabilized engine running conditions.

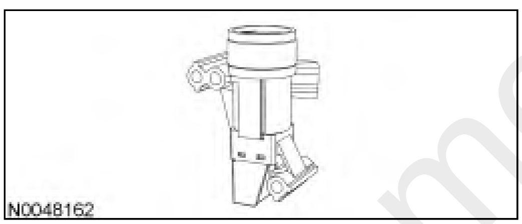
The HO2S heater is embedded with the sensing element. The heating element heats the sensor to a temperature of 800°C (1,472°F). At approximately 300°C (572°F) the engine enters closed loop operation. The VPWR circuit supplies voltage to the heater. The PCM turns the heater ON by providing the ground when the correct conditions occur. The heater allows the engine to enter closed loop operation sooner. The use of this heater requires the HO2S heater control to be duty cycled, to prevent damage to the heater.



Typical HO2S

Inertia Fuel Shutoff (IFS) Switch

The IFS switch is used in conjunction with the electric fuel pump. The IFS switch shuts off the fuel pump if a collision occurs. It consists of an inverted pendulum mass that is retained in a conical cone through a set of linear springs. When a sharp impact occurs, the pendulum shifts out of the conical cone, opens the circuit and shuts off the electric fuel pump. Once the switch is open, it must be manually reset before restarting the vehicle.



Typical IFS Switch

Intake Air Temperature (IAT) Sensor

The IAT sensor is a thermistor device in which resistance changes with temperature. The resistance of a thermistor decreases as the temperature increases, and the resistance increases as the temperature decreases. The varying resistance affects the voltage drop across the sensor pins and provides electrical signals to the PCM corresponding to temperature.

Thermistor type sensors are considered passive sensors. A passive sensor is connected to a voltage divider network so that varying the resistance of the passive sensor causes a variation in total current flow. Voltage that is dropped across a fixed resistor in a series with the sensor resistor determines the voltage signal at the PCM. This voltage signal is equal to the reference voltage minus the voltage drop across the fixed resistor.

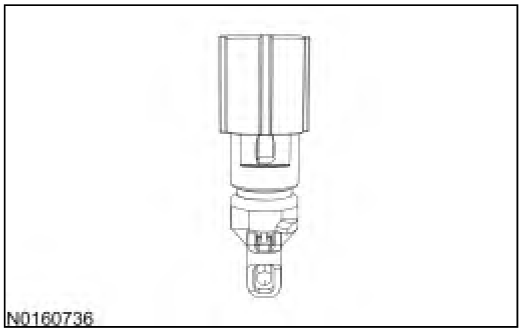
The IAT sensor provides air temperature information to the PCM. The PCM uses the air temperature information as a correction factor in the calculation of fuel, spark, and airflow.

The IAT sensor provides a quicker temperature change response time than the ECT or CHT sensor.

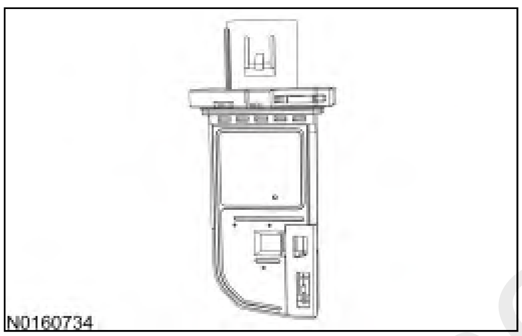
Currently there are 2 types of IAT sensors used, a stand alone and an integrated type. Both types function the same, however the integrated type is incorporated into the mass airflow (MAF) sensor, the manifold absolute pressure and temperature (MAPT) sensor, or the turbocharger intake pressure and temperature (TCIPT) sensor instead of being a stand alone sensor.

The IAT2 sensor is typically located near the intake manifold and is used to measure the intake manifold temperature. The PCM uses this information to determine the air charge and provide input for various engine control functions. The IAT2 sensor may be integrated with the manifold absolute pressure (MAP) sensor.

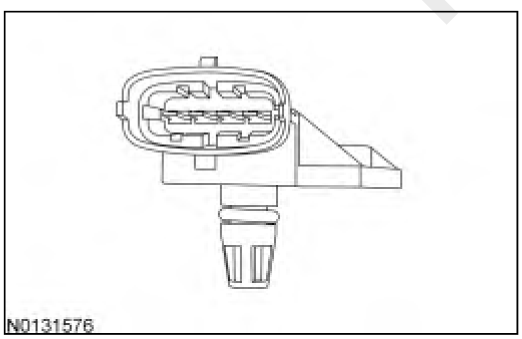
The Ford GT uses 2 integrated MAF/IAT sensors, a bank 1 and a bank 2 sensor. The bank 1 sensor is used for most diagnostics and engine control functions. Each sensor provides data to the PCM that is used for diagnostics related to the dual intake air system configuration. The sensors are located on opposite sides of the vehicle in the duct next to the air filter.



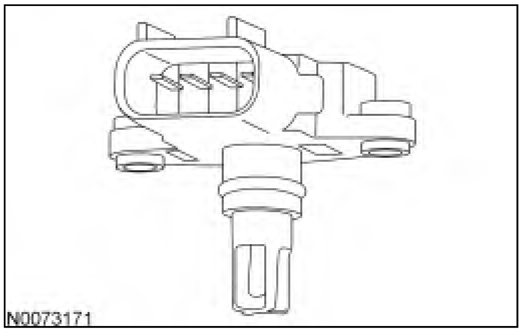
Typical Stand Alone IAT Sensor



Typical IAT Sensor Integrated With A MAF Sensor



Typical IAT Sensor Integrated With A MAPT Sensor



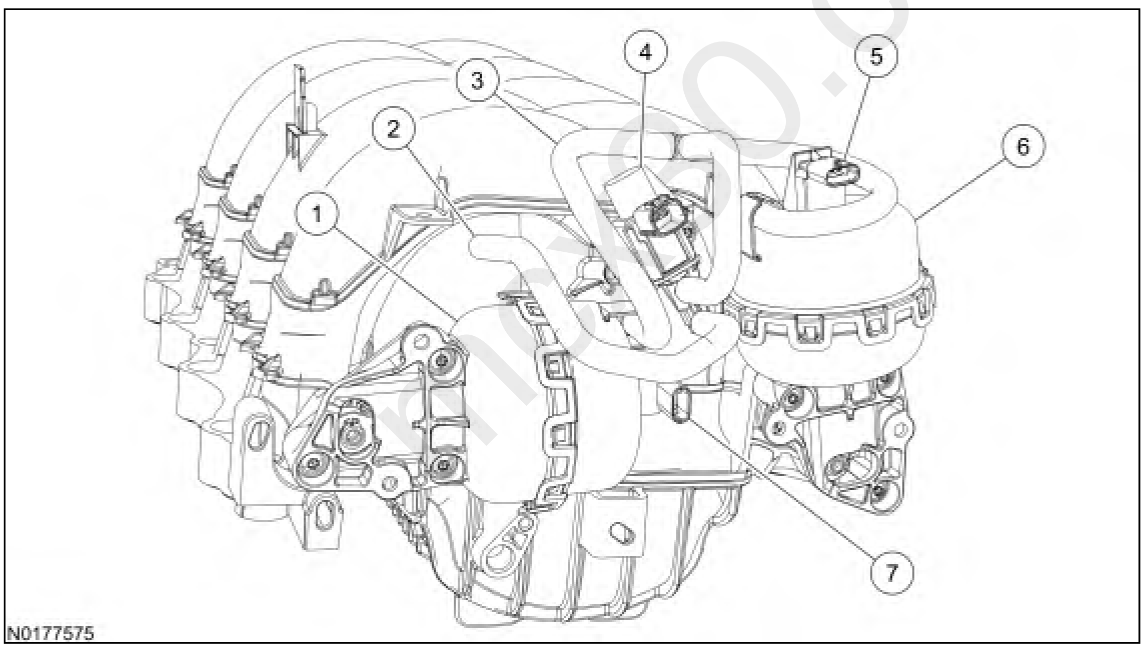
Typical IAT2 Sensor Integrated With A MAP Sensor

Intake Manifold Runner Control (IMRC)

WARNING: Substantial opening and closing torque is applied by this system. To prevent injury, be careful to keep fingers away from lever mechanisms when actuated. Failure to follow these instructions may result in personal injury.

The IMRC is a vacuum actuated system with a PCM controlled electric solenoid and manifold mounted vacuum actuators for bank 1 and bank 2. The IMRC solenoid controls each vacuum actuator to activate a shutter device attached to the actuator shaft. There is an intake manifold runner control sensor for each bank to provide the shutter position to the PCM.

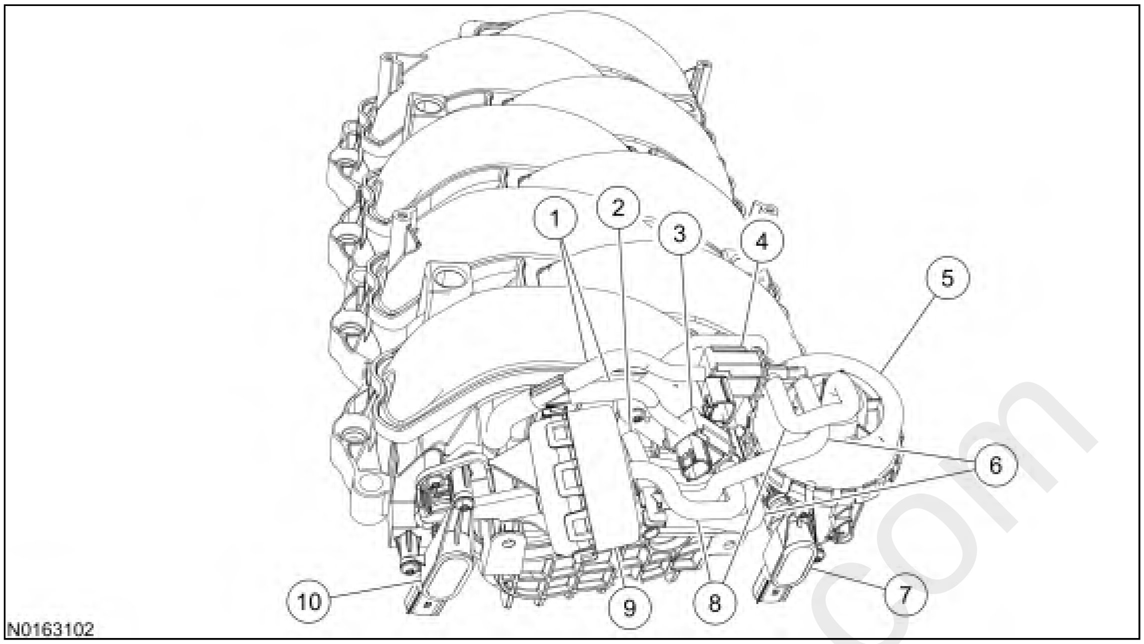
The IMRC shutters are in the closed position below 3,000 RPM to create air flow turbulence for better charge mixing in the cylinder. The IMRC shutters are in the open position above 3,000 RPM to reduce air flow restriction.



Typical IMRC With 1 Control Solenoid

Intake Air System	Component
1	Vacuum Actuator Bank 2
2	Manifold Vacuum Supply Line
3	Vacuum Lines From IMRC Solenoid To Vacuum Actuators
4	Intake Manifold Runner Control Bank 1 (IMRC1) Solenoid
5	Intake Manifold Runner Control Bank 1 (IMRC1) Sensor

Intake Air System	Component
6	Vacuum Actuator Bank 1
7	Intake Manifold Runner Control Bank 2 (IMRC2) Sensor



Typical IMRC With 2 Control Solenoids

Intake Air System	Component
1	Vent Lines To The Intake Air Tube
2	Manifold Vacuum Supply Port
3	Intake Manifold Runner Control Bank 2 (IMRC2) Solenoid
4	Intake Manifold Runner Control Bank 1 (IMRC1) Solenoid
5	Vacuum Actuator Bank 1
6	Manifold Vacuum Supply Lines
7	Intake Manifold Runner Control Bank 1 (IMRC1) Sensor
8	Vacuum Lines From IMRC Solenoid To Vacuum Actuator
9	Vacuum Actuator Bank 2
10	Intake Manifold Runner Control Bank 2 (IMRC2) Sensor

Intake Manifold Tuning Valve (IMTV)

WARNING: Substantial opening and closing torque is applied by this system. To prevent injury, be careful to keep fingers away from lever mechanisms when actuated. Failure to follow these instructions may result in personal injury.

The IMTV is a motorized actuated unit mounted directly to the intake manifold. The IMTV actuator controls a shutter device attached to the actuator shaft. There is no monitor input to the PCM with this system to indicate shutter position.

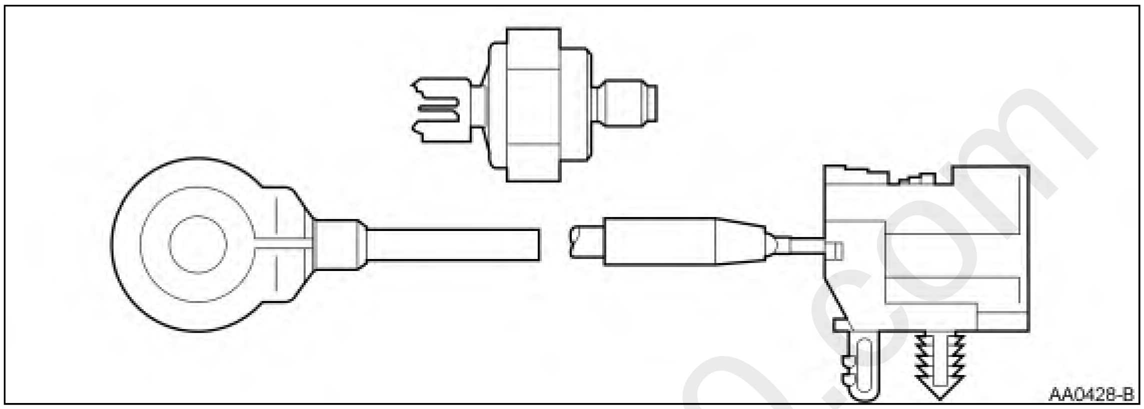
The motorized IMTV unit is not energized below a calibrated RPM. The shutter is in the closed position to prevent airflow blend from occurring in the intake manifold. The motorized unit is energized above a calibrated RPM. The motorized unit is commanded ON by the PCM initially at a 100 percent duty cycle to move the shutter to the open position, and then falling to approximately 50 percent to continue to hold the shutter open.

Knock Sensor (KS)

The KS is a tuned accelerometer on the engine which converts engine vibration to an electrical signal. The PCM uses this signal to determine the presence of engine knock and to retard spark timing.

Typical locations for the KS:

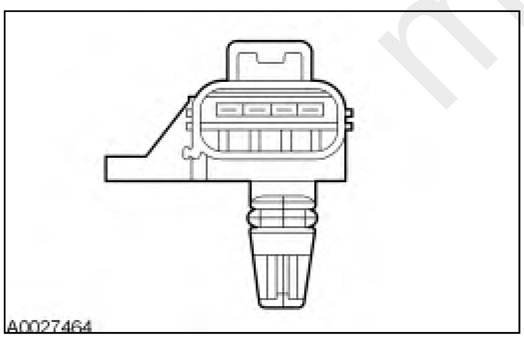
- KS11 - bank 1, sensor 1 (near cylinder 1/2)
- KS12 - bank 1, sensor 2 (near cylinder 3/4)
- KS21 - bank 2, sensor 1 (near cylinder 4/5 on a V engine)
- KS22 - bank 2, sensor 2 (near cylinder 6/8 on a V engine)



Typical Types Of Knock Sensor (KS)

Manifold Absolute Pressure (MAP) Sensor

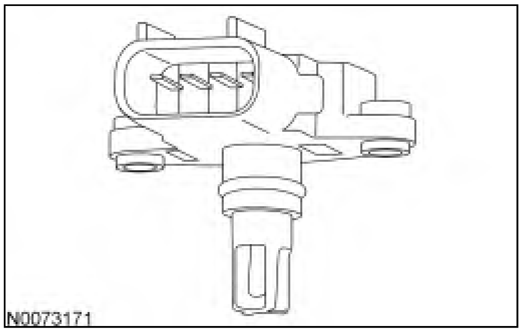
The MAP sensor is located on the intake manifold and measures the intake manifold pressure. The PCM uses this information to determine the air charge and to provide the input for various engine control functions. The MAP sensor may be integrated with an intake air temperature (IAT) sensor.



Typical MAP Sensor

Manifold Absolute Pressure Temperature (MAPT) Sensor

The MAPT sensor is located on the intake manifold and may be integrated with an intake air temperature (IAT) sensor or a charge air cooler temperature (CACT) sensor.



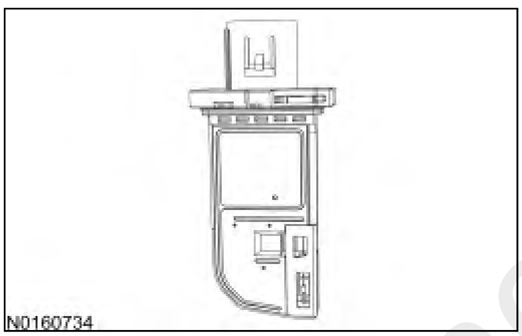
Typical MAPT Sensor

Mass Airflow (MAF) Sensor

The MAF sensor uses a hot wire sensing element to measure the amount of air entering the engine. Air passing over the hot wire causes it to cool. This hot wire is maintained at 200°C (392°F) above the ambient temperature as measured by a constant cold wire. The current required to maintain the temperature of the hot wire is proportional to the mass airflow. The MAF sensor then outputs a signal to the PCM proportional to the intake air mass. The PCM calculates the required fuel injector pulse width in order to provide the desired air to fuel ratio. This input is also used in determining transmission electronic pressure control (EPC), shift, and torque converter clutch (TCC) scheduling.

The MAF sensor is located near the air cleaner assembly. Most MAF sensors have an integrated IAT sensor.

The Ford GT uses 2 integrated MAF/IAT sensors, a bank 1 and a bank 2 sensor. Each sensor provides data to the PCM that is used for diagnostics related to the dual intake air system configuration. The sensors are located on opposite sides of the vehicle in the duct next to the air filter.



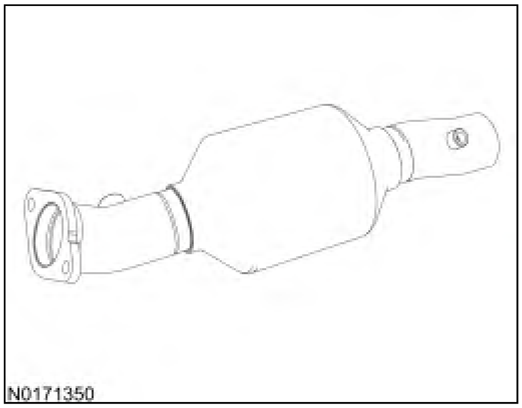
Typical MAF Sensor

Output Shaft Speed (OSS) Sensor

The OSS sensor provides the PCM with the source of vehicle speed. The sensor may be physically located in different places on the vehicle, depending upon the specific application. The design of each speed sensor is unique and depends on which powertrain control feature uses the information that is generated.

Particulate Filter

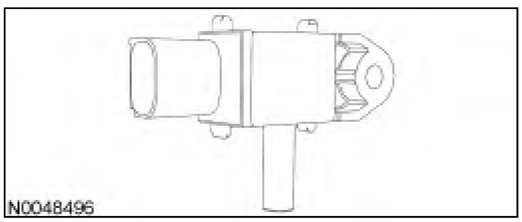
The particulate filter collects the soot and ash particles that are present in the exhaust gas. The particulate filter assembly typically consists of active precious metals deposited on a substrate filter. The exhaust gas is forced to flow through the walls of the porous substrate and exit through the adjoining channels. The particulates that are larger than the pore size of the walls are trapped for regeneration. During normal operation, particulate filter temperatures may be greater than 550°C (1,022°F). These conditions provide an opportunity for passive regeneration. During deceleration conditions, the vehicle will enter deceleration fuel shutoff and provide additional oxygen at temperatures that are sufficient to burn soot, allowing the particulate filter to regenerate passively. The precious metal washcoat promotes the regeneration of the trapped particulates through the heat generating reaction and catalyzes the untreated exhaust gas. The substrate filter is held in the metal shell by a ceramic fiber support system. The support system makes up the size differences that occur due to thermal expansion and maintains a uniform holding force on the substrate filter.



Typical Particulate Filter

Particulate Filter Pressure Sensor

The particulate filter pressure sensor is an input to the PCM and measures the pressure before the particulate filter. The sensor is a gauge type sensor. The particulate filter pressure sensor is referenced to atmospheric pressure and is located at the exhaust system upstream of the particulate filter. At ignition ON, engine OFF the particulate filter pressure sensor pressure value reads 0 kPa (0 psi). The range of the sensor is 0-80 kPa (0-11.6 psi). The PCM calculates soot load based on the particulate filter pressure and initiates regeneration conditions when the soot load reaches a threshold.



Typical Particulate Filter Pressure Sensor

Power Take Off (PTO) Switch And Circuits

The PTO circuit is used by the PCM to disable some of the OBD monitors during PTO operation. The PTO switch is normally open. When the PTO unit is activated, the PTO switch is closed and battery voltage is supplied to the PTO input circuit. This indicates to the PCM that an additional load is being applied to the engine. The PTO indicator lamp illuminates when the PTO system is functioning correctly and flashes when the PTO system is damaged.

When the PTO unit is activated, the PCM disables some OBD monitors which may not function reliably during PTO operation. Without the PTO circuit information to the PCM, false DTCs may be set during PTO operation. Prior to an inspection/maintenance (I/M) test, operate the vehicle with the PTO disengaged long enough to successfully complete the OBD monitors.

PTO Circuits Description

The 3 PTO input circuits are PTO mode, PTO engage, and PTO RPM.

The PTO engage circuit is used when the operator is requesting the PCM to check the needed inputs required to initiate the PTO engagement.

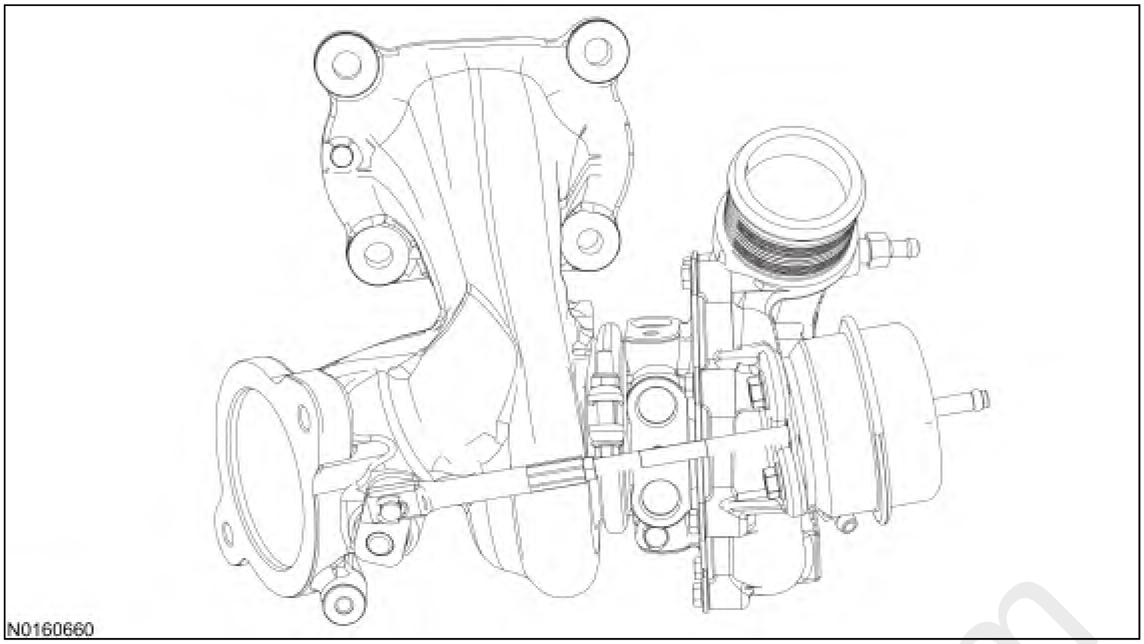
The PTO RPM circuit is used when the operator is requesting additional engine RPM for PTO operation.

Turbocharger

The turbocharger assembly is an exhaust driven centrifugal compressor. Expanding exhaust gases drive the turbine shaft assembly to speeds over 100,000 RPM. The turbocharger increases the power output of an engine by increasing the mass of air entering the engine.

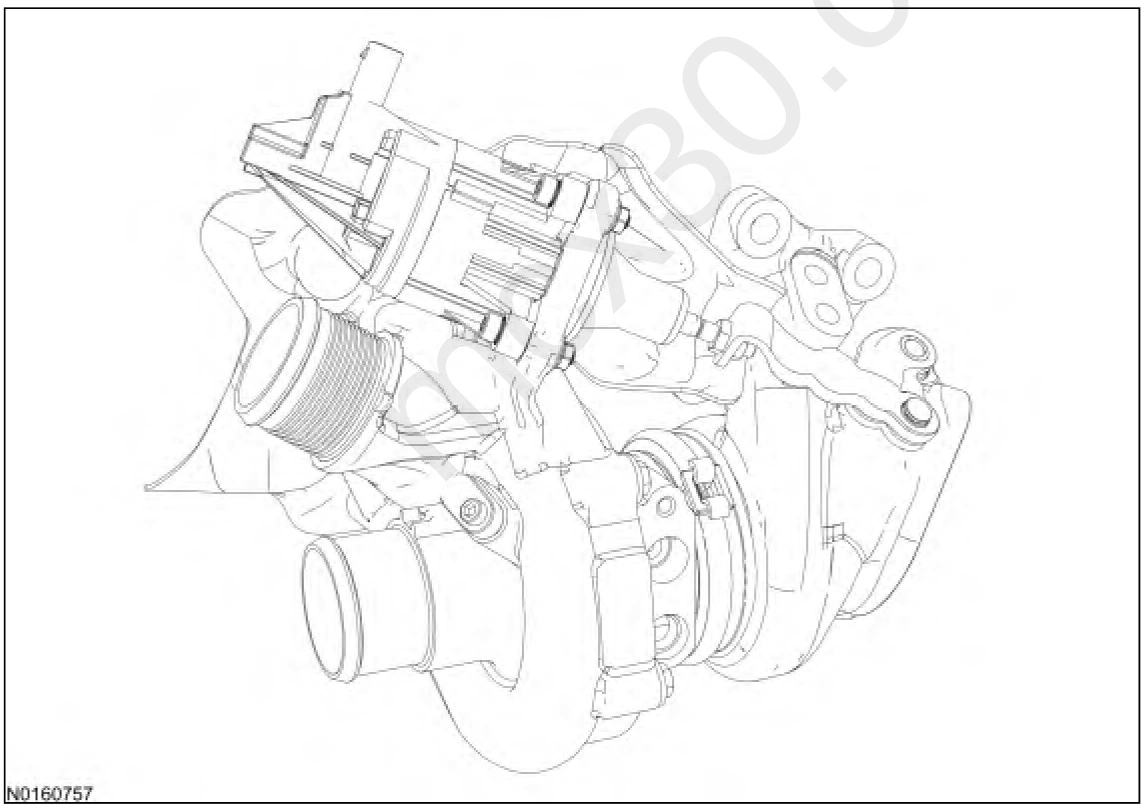
Three types of turbocharger are currently being used.

The first type of turbocharger has an integrated wastegate and a remote bypass valve.



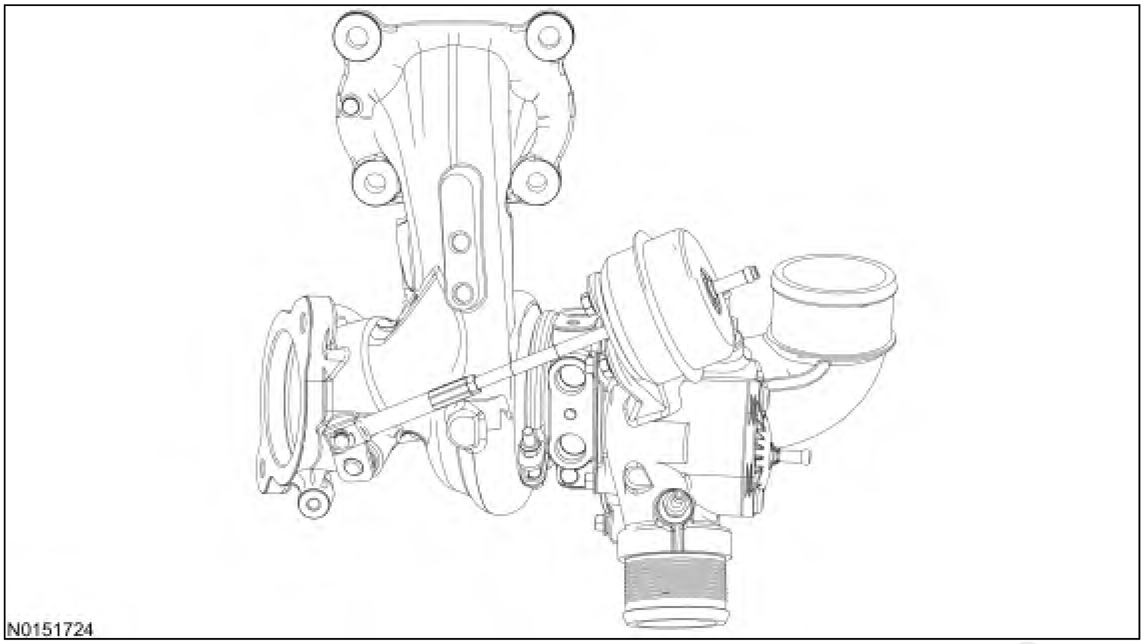
Typical Turbocharger With Integrated Wastegate And Remote Bypass Valve

The second type of turbocharger has an integrated wastegate, an electric wastegate motor and a remote bypass valve.



Typical Turbocharger With Integrated Electric Wastegate Motor And Remote Bypass Valve

The third type of turbocharger has an integrated wastegate and an integrated bypass valve in the turbocharger housing.

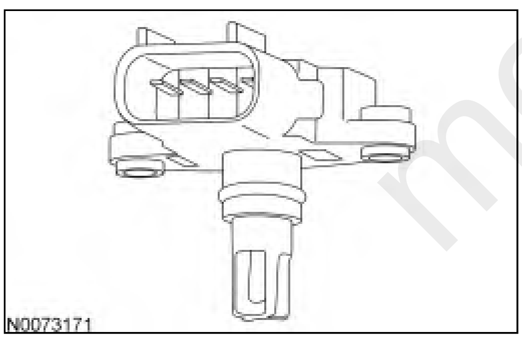


Typical Turbocharger With Integrated Wastegate And Integrated Bypass Valve

Turbocharger Boost Pressure (TCBP) Sensor

The TCBP sensor is located in the intake air tube between the turbocharger and the charge air cooler (CAC). The TCBP sensor measures the throttle inlet pressure. The PCM uses the information from the TCBP sensor to refine the estimate of the airflow rate through the throttle and to determine the desired boost pressure. The TCBP sensor may be integrated with a charge air cooler temperature (CACT) sensor.

On some vehicles, the TCBP sensor or TCBP/CACT sensor has one digital signal output from the sensor. There is one reference voltage circuit and one signal return circuit for the sensor. For all others, the TCBP has one analog signal output from the sensor. The TCBP/CACT has two analog signal outputs from the sensor. There is one reference voltage circuit and one signal return circuit for the sensor.



Typical TCBP Sensor Integrated With A CACT Sensor

Turbocharger Bypass Valve

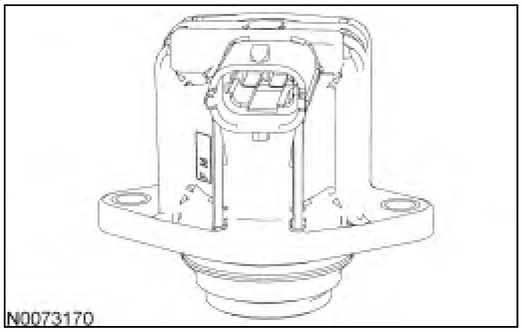
The turbocharger bypass valve prevents back flow through the turbocharger when the throttle is rapidly closed to avoid undesirable noise. The high pressure downstream of the turbocharger is vented back to the intake air upstream when the turbocharger bypass valve is open reducing pressure in the system.

There are three types of turbocharger bypass valves currently in use.

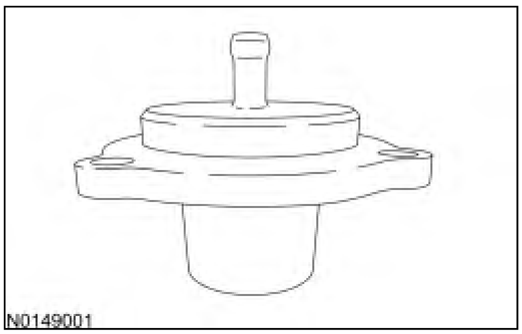
The first type of turbocharger bypass valve is solenoid controlled and located between the turbocharger intake and the turbocharger boost pressure output to the charge air cooler (CAC).

The second type of turbocharger bypass valve is solenoid controlled and is integrated in the turbocharger housing. The operation of the turbocharger bypass valves that are solenoid controlled is similar.

The third type of turbocharger bypass valve is an electropneumatically controlled system, integrated in the turbocharger housing, that consists of a pneumatically controlled turbocharger bypass, a vacuum source from the vacuum pump, a control solenoid for vacuum and pressure, and the tubing.



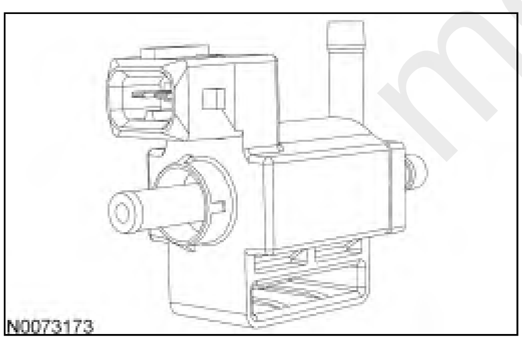
Typical Turbocharger Bypass Valve (Integrated Solenoid)



Typical Turbocharger Bypass Valve (Pneumatic Control)

Turbocharger Bypass Valve Solenoid

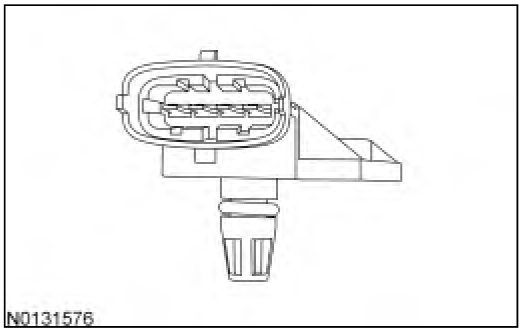
The turbocharger bypass valve solenoid is pulse width modulated (PWM) by the PCM to control the pneumatically actuated turbocharger bypass valve. The turbocharger bypass valve solenoid supplies or vents vacuum to the pneumatically controlled turbocharger bypass valve to open or close the turbocharger bypass valve.



Typical Turbocharger Bypass Valve Solenoid (Remote Solenoid)

Turbocharger Intake Pressure And Temperature (TCIPT) Sensor

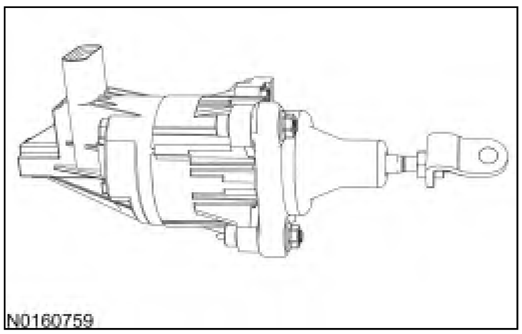
The TCIPT sensor is located in the intake air tube between the air filter assembly and the turbocharger. The TCIPT sensor measures the turbocharger intake pressure and temperature. The PCM uses the information from the TCIPT sensor to determine if the airflow to the turbocharger is being restricted by a clogged air filter or other debris. An intake air temperature (IAT) sensor is integrated with the TCIPT sensor.



Typical TCIPT Sensor

Turbocharger Wastegate Motor

The turbocharger wastegate motor is attached to the turbocharger and allows the PCM to control the turbocharger wastegate position. The turbocharger wastegate motor controls the turbocharger wastegate linkage position to control the boost pressure limit. During driving conditions, the PCM controls the turbocharger wastegate motor position with positive and negative voltage circuits, to change the position of the turbocharger wastegate to increase or decrease the boost pressure to the desired value. The PCM monitors the turbocharger wastegate position sensor signal for feedback on the wastegate motor performance, and to detect a stuck wastegate. The turbocharger wastegate position sensor is integral to the turbocharger wastegate motor.



Typical Turbocharger Wastegate Motor

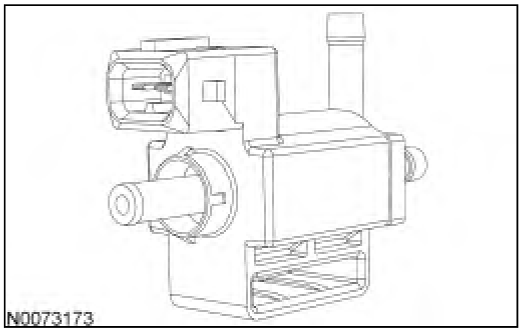
Turbocharger Wastegate Regulating Valve Solenoid

The turbocharger wastegate regulating valve solenoid allows the PCM to control the turbocharger wastegate position. The turbocharger wastegate regulating valve solenoid controls the pressure or vacuum supplied to the pneumatically actuated wastegate diaphragm in order to control the boost pressure limit. When the compressor outlet pressure increases, a pneumatically powered actuator opens the turbocharger wastegate and limits the compressor outlet pressure. The turbocharger wastegate regulating valve solenoid supplies pressure or vacuum to the pneumatically actuated wastegate canister diaphragm, which regulates the boost pressure to the desired value.

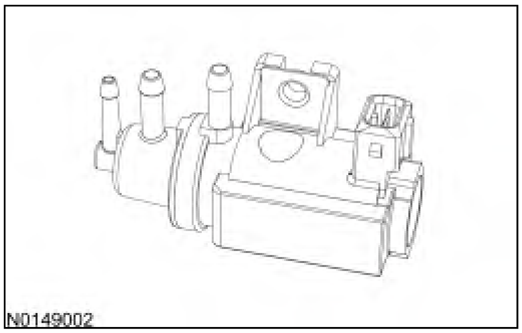
For the pressure actuated turbocharger wastegate, the turbocharger wastegate regulating valve solenoid controls the pressure applied to the turbocharger wastegate actuator. The amount of pressure vented from the pneumatic turbocharger wastegate actuator allows the PCM to control boost pressure. To generate maximum boost pressure, the PCM controls the turbocharger wastegate regulating valve solenoid to completely vent the pressure being applied to the turbocharger wastegate actuator. If a concern is present, the spring pressure in the pneumatic turbocharger wastegate actuator defaults the turbocharger wastegate to a fully closed position.

For the normally closed vacuum actuated turbocharger wastegate, the turbocharger wastegate regulating valve solenoid controls vacuum applied to the turbocharger wastegate actuator. The amount of vacuum applied to the turbocharger wastegate actuator allows the PCM to control the boost pressure. To generate maximum boost pressure, the PCM controls the turbocharger wastegate regulating valve solenoid to vent vacuum from the turbocharger wastegate actuator. Boost pressure levels are controlled by regulating vacuum to the wastegate actuator. The spring pressure in the turbocharger wastegate actuator defaults the turbocharger wastegate to a fully closed position.

For the normally open vacuum actuated turbocharger wastegate, the turbocharger wastegate regulating valve solenoid controls vacuum applied to the turbocharger wastegate actuator. The amount of vacuum applied to the turbocharger wastegate actuator allows the PCM to control the boost pressure. To generate maximum boost pressure, the PCM controls the turbocharger wastegate regulating valve solenoid to apply full vacuum to the turbocharger wastegate actuator. Boost pressure levels are controlled by regulating vacuum to the wastegate actuator. The spring pressure in the turbocharger wastegate actuator defaults the turbocharger wastegate to a fully open position.



Typical Turbocharger Wastegate Regulating Valve Solenoid (Pressure Actuated Wastegate)



Typical Turbocharger Wastegate Regulating Valve Solenoid (Vacuum Actuated Wastegate)

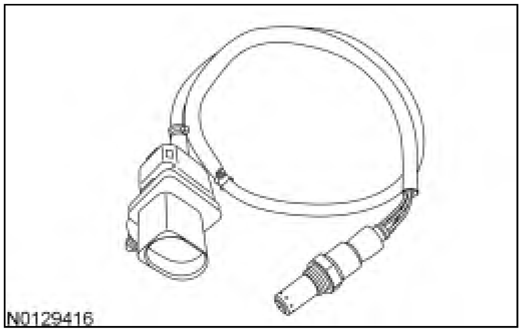
Universal Heated Oxygen Sensor (HO2S)

The universal HO2S, sometimes referred to as a wideband oxygen sensor, uses the typical HO2S combined with a current controller in the PCM to infer an air to fuel ratio relative to the stoichiometric air to fuel ratio. This is accomplished by balancing the amount of oxygen ions pumped in or out of a measurement chamber within the sensor. The typical HO2S within the universal HO2S detects the oxygen content of the exhaust gas in the measurement chamber. The oxygen content inside the measurement chamber is maintained at the stoichiometric air to fuel ratio by pumping oxygen ions in and out of the measurement chamber. As the exhaust gasses get richer or leaner, the amount of oxygen that must be pumped in or out to maintain a stoichiometric air to fuel ratio in the measurement chamber varies in proportion to the air to fuel ratio. The amount of current required to pump the oxygen ions in or out of the measurement chamber is used to measure the air to fuel ratio. The measured air to fuel ratio is actually the output from the current controller in the PCM and not a signal that comes directly from the sensor.

The universal HO2S also uses a self contained reference chamber to make sure an oxygen differential is always present. The oxygen for the reference chamber is supplied by pumping small amounts of oxygen ions from the measurement chamber into the reference chamber. The universal HO2S does not need access to outside air.

Part to part variance is compensated for by placing a resistor in the connector. This resistor trims the current measured by the current controller in the PCM.

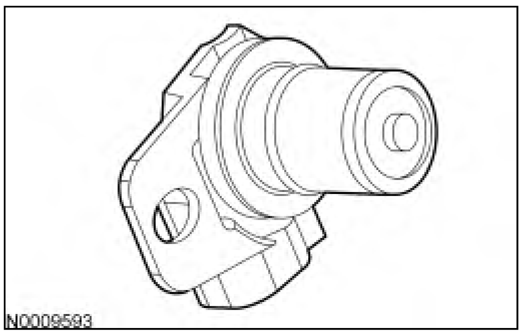
The universal HO2S heater is embedded with the sensing element allowing the engine to enter closed loop operation sooner. The heating element heats the sensor to a temperature of 780°C to 830°C (1,436°F to 1,526°F). The VPWR circuit supplies voltage to the heater. The PCM controls the heater ON and OFF by providing the ground to maintain the sensor at the correct temperature for maximum accuracy.



Typical Universal HO2S

Vehicle Speed Sensor (VSS)

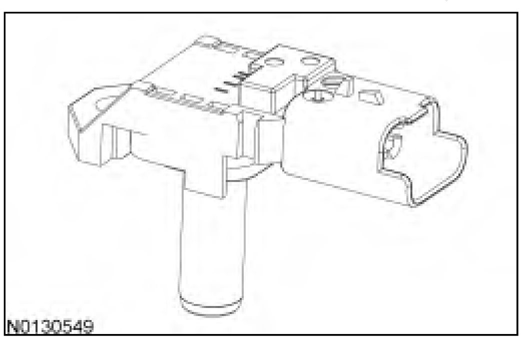
The VSS is a variable reluctance or Hall effect sensor that generates a waveform with a frequency that is proportional to the speed of the vehicle. If the vehicle is moving at a relatively low speed, the sensor produces a signal with a low frequency. As the vehicle velocity increases, the sensor generates a signal with a higher frequency. The PCM uses the frequency signal generated by the VSS (and other inputs) to control such parameters as fuel injection, ignition control, transmission shift scheduling, and TCC scheduling.



Typical VSS

Wastegate Vacuum Sensor

The wastegate vacuum sensor is an absolute pressure sensor that provides the PCM an analog voltage output that is proportional to the applied vacuum. The wastegate vacuum sensor is located near the turbocharger and the turbocharger wastegate regulating valve solenoid. The wastegate vacuum sensor measures the vacuum supplied by the turbocharger wastegate regulating valve solenoid to the wastegate actuator. The PCM uses the information from the wastegate vacuum sensor to determine the amount of vacuum being applied to the wastegate actuator.



Typical Wastegate Vacuum Sensor

Engine Off Timer Monitor

The engine off time is obtained from the powertrain control module (PCM) or the body control module (BCM). If the engine off time is obtained from the BCM, the PCM expects to receive a message with the engine off time from the BCM shortly after engine start up. If the message is not available on the controller area network (CAN) or a battery disconnect has occurred, a communication DTC sets.

There are two parts to this test.

The first part determines if the timer is incrementing during engine OFF. The PCM determines the timer is incrementing during engine OFF by comparing the engine coolant temperature value prior to shut down, to the engine coolant temperature value at ignition ON to determine if an engine OFF soak has occurred. For an engine OFF soak to occur, the engine coolant temperature value must be greater than 71°C (160 °F) while the engine is running. The timer starts at ignition OFF and the engine coolant temperature value must decrease by greater than 17°C (30 °F) before the next ignition ON signal. If the engine off timer indicates a value less than 30 seconds, a DTC sets.

The second part checks the accuracy of the engine off timer. The PCM determines the accuracy of the engine off timer by comparing time in the BCM with the time in the PCM. The timer in the BCM is allowed to count up for 5 minutes and compared to a different clock in the PCM. If the two timers differ by more than 15 seconds, a DTC sets.

Evaporative Emission (EVAP) Leak Check Monitor

The EVAP leak check monitor is an on board strategy designed to detect a leak from an opening equal to or greater than 0.5 mm (0.020 inch) in the enhanced EVAP system. The correct function of the individual components of the enhanced EVAP system, as well as its ability to flow fuel vapor to the engine, is also examined. The EVAP leak check monitor relies on the individual components of the enhanced EVAP system to either allow a natural vacuum to occur in the fuel tank or apply engine vacuum to the fuel tank and then seal the entire enhanced EVAP system from the atmosphere. The fuel tank pressure is then monitored to determine the total vacuum lost (bleed up) for a calibrated period of time. Inputs from the engine coolant temperature (ECT) sensor or cylinder head temperature (CHT) sensor (if equipped), intake air temperature (IAT) sensor, mass airflow (MAF) sensor (if equipped), vehicle speed, fuel level input (FLI) and fuel tank pressure (FTP) sensor, are required to enable the EVAP leak check monitor.

During the EVAP leak check monitor repair verification drive cycle, clearing the continuous diagnostic trouble codes (DTCs) and resetting the emission monitors information in the PCM, bypasses the minimum soak time required to complete the monitor. The EVAP leak check monitor does not run if the ignition is turned OFF after clearing the continuous DTCs and resetting the emission monitors information in the PCM. The EVAP leak check monitor does not initiate until the heated oxygen sensor (HO2S) monitor is complete.

If the vapor generation is high on some vehicle enhanced EVAP systems, where the monitor does not pass, the result is treated as a no test. Therefore, the test is complete for the day.

Some vehicle applications have an engine OFF natural vacuum (EONV) check as part of the EVAP leak check monitor.

Engine On EVAP Leak Check Monitor

The engine on EVAP leak check monitor is executed by the individual components of the enhanced EVAP system as follows:

1. The EVAP purge valve controls the flow of vacuum from the engine and creates a target vacuum on the fuel tank.
2. The EVAP canister vent valve seals the EVAP system from the atmosphere. It is closed by the PCM (100% duty cycle) to allow the EVAP purge valve to achieve the target vacuum on the fuel tank.
3. The FTP sensor is used by the engine on EVAP leak check monitor to determine if the target vacuum necessary to carry out the leak check on the fuel tank is reached. Some vehicle applications with the engine on EVAP leak check monitor use a remote inline FTP sensor. Once the target vacuum on the fuel tank is achieved, the change in fuel tank vacuum over a calibrated period of time determines if a leak exists.
4. If the initial target vacuum cannot be reached, DTC P0455 (gross leak detected) sets. The engine on EVAP leak check monitor aborts and does not continue with the leak check portion of the test.

   For some vehicle applications, if the initial target vacuum cannot be reached after a refueling event and the purge vapor flow is excessive, DTC P0457 (fuel cap off) sets.

   If the initial target vacuum is exceeded, a system flow concern exists and DTC P1450 (unable to bleed up fuel tank vacuum) is set. The engine on EVAP leak check monitor aborts and does not continue with the leak check portion of the test.

   If the vacuum increase is quicker than expected, a blocked fuel vapor tube is suspected and if confirmed after an intrusive test, DTC P144A sets.

   If the target vacuum is achieved on the fuel tank, the change in the fuel tank vacuum (bleed up) is calculated for a calibrated period of time. The calculated change in fuel tank vacuum is compared to a calibrated threshold for a leak from an opening of 1.0 mm (0.040 inch) in the enhanced EVAP system. If the calculated bleed up is less than the calibrated threshold, the enhanced EVAP system passes. If the calibrated bleed up exceeds the calibrated threshold, the test aborts. The test can be repeated up to 3 times.

   If the bleed up threshold is still being exceeded after 3 tests, a vapor generation test is carried out before DTC P0442 (small leak detected) sets. This is accomplished by returning the enhanced EVAP system to atmospheric pressure by closing the EVAP purge valve and opening the EVAP canister vent valve. Once the FTP sensor observes the fuel tank is at atmospheric pressure, the EVAP canister vent valve closes and seals the enhanced EVAP system.

   The fuel tank pressure build up over a calibrated period of time is compared to a calibrated threshold for pressure build up due to vapor generation.