Excessive wheel slippage may be caused by sand, gravel, rain, mud, snow, ice, or excessive and sudden increase in RPM while in NEUTRAL or while driving.

**Fail Safe Cooling Strategy**

**Note:** *Not all vehicles with a cylinder head temperature (CHT) sensor have the fail safe cooling strategy.*

The fail safe cooling strategy is only activated by the PCM when an overheating condition has been identified. This strategy provides engine temperature control when the cylinder head temperature exceeds certain limits. The cylinder head temperature is measured by the CHT sensor. For additional information about the CHT sensor, refer to Engine Control Components in this section.

A cooling system failure, such as low coolant or coolant loss, could cause an overheating condition. As a result, damage to major engine components could occur. Along with a CHT sensor, the fail safe cooling strategy is used to prevent damage by allowing air cooling of the engine. This strategy allows the vehicle to be driven safely for a short time with some loss of performance when an overheat condition exists.

Engine temperature is controlled by alternating the number of disabled fuel injectors, allowing all cylinders to cool. When the fuel injectors are disabled, the respective cylinders work as air pumps, and this air is used to cool the cylinders. The more fuel injectors that are disabled, the cooler the engine runs, but the engine has less power.

A wide open throttle (WOT) delay is incorporated if the cylinder head temperature is exceeded during WOT operation. At WOT, the injectors function for a limited amount of time allowing the customer to complete a passing maneuver.

Before injectors are disabled, the fail safe cooling strategy alerts the customer to a cooling system problem by moving the IPC temperature gauge to the H (hot) zone and setting DTC P1285. Depending on the vehicle, other indicators such as an audible chime or warning lamp, can be used to alert the customer of fail safe cooling. If overheating continues, the strategy begins to disable the fuel injectors, DTC P1299 is stored in the PCM memory, and a malfunction indicator lamp (MIL) illuminates. If the overheating condition continues and a critical temperature is reached, all fuel injectors are turned OFF and the engine is disabled.

**Failure Mode Effects Management (FMEM)**

The FMEM is an alternate system strategy in the PCM designed to maintain engine operation if one or more sensor inputs fail.

When a sensor input is determined to be out of limits by the PCM, an alternative strategy is initiated. The PCM substitutes a fixed value for the incorrect input and continues to monitor the suspect sensor input. If the suspect sensor begins to operate within limits, the PCM returns to the normal engine operational strategy.

**Flash Electrically Erasable Programmable Read Only Memory (EEPROM)**

The flash EEPROM is an integrated circuit within the PCM. This integrated circuit contains the software code required by the PCM to control the powertrain. One feature of the EEPROM is that it can be electrically erased and then reprogrammed through the data link connector (DLC) without removing the PCM from the vehicle.

**Flex Fuel**

Flex fuel vehicles are designed to be compatible with any combination of ethanol and gasoline up to 85% ethanol (E85). The percentage of ethanol content in the fuel is inferred by the PCM flex fuel strategy.

The fuel level input (FLI) determines if a refueling event has occurred after an ignition ON or while the engine is running. If a refueling event is detected, the PCM saves the current inferred ethanol value. The PCM flex fuel strategy recognizes a refueling event as gasoline or E85, and enables the flex fuel learn procedure. The flex fuel strategy will infer the correct air to fuel ratio, based on the oxygen sensor input, to maintain stoichiometry after the vehicle refueling event occurs.

The new fuel is calculated to reach the engine after a calibrated amount of fuel has been consumed from the fuel lines and fuel rails. Normal long term fuel trim learning and EVAP purge control are temporarily disabled to allow the new ethanol content to gasoline percentage to be inferred. Ethanol content learning continues until the inference is stabilized within the engine operating conditions.

Typical flex fuel vehicle operation:

- The initial air to fuel ratio and flex fuel percentage is calculated for gasoline after a keep alive memory (KAM) reset. Vehicles that have E85 in the fuel tank after having a KAM reset may result in a hard start when cold, or a cold engine acceleration lack of power, until the PCM flex fuel strategy calculates the correct percentage of ethanol content in the fuel.

- A cold start with alcohol blended fuel may be more difficult than with gasoline, due to the lower volatility of alcohol blended fuel.
- Ethanol requires more fuel flow than gasoline, and flex fuel vehicles require a higher flow injector.
- Vehicles with flex fuel capability have the fuel type identified on the fuel filler pipe.

**Fuel Level Input (FLI)**

The FLI is a communications network message. Most vehicle applications use a potentiometer type FLI sensor connected to a float in the fuel pump (FP) assembly to determine fuel level.

**Fuel Trim**

**Short Term Fuel Trim**

If the oxygen sensors are warmed up and the PCM determines the engine can operate near the 14.7 to 1 (9 to 1 E100) stoichiometric air to fuel ratio, the PCM enters closed loop fuel control mode. Since an oxygen sensor can only indicate rich or lean, the fuel control strategy continuously adjusts the desired air to fuel ratio between rich and lean causing the oxygen sensor to switch around the stoichiometric point. If the time between rich and lean switches is the same, then the system is actually operating at stoichiometric. The desired air to fuel control parameter is called short term fuel trim (SHRTFT1 and SHRTFT2) where stoichiometric is represented by 0%. Richer (more fuel) is represented by a positive number and leaner (less fuel) is represented by a negative number. Normal operating range for short term fuel trim is between -25% and 25%. Some calibrations have time between switches and short term fuel trim excursions that are not equal. These unequal excursions run the system slightly lean or rich of stoichiometric. This practice is referred to as using bias. For example, the fuel system can be biased slightly rich during closed loop fuel to help reduce nitrogen oxides ($NO_X$).

Values for SHRTFT1 and SHRTFT2 may change significantly on a scan tool as the engine is operated at different RPM and load points. This is because SHRTFT1 and SHRTFT2 react to fuel delivery variability that changes as a function of engine RPM and load. Short term fuel trim values are not retained after the engine is turned OFF.

**Long Term Fuel Trim**

While the engine is operating in closed loop fuel control, the short term fuel trim corrections are learned by the PCM as long term fuel trim (LONGFT1 and LONGFT2) corrections. These corrections are stored in the keep alive memory (KAM) fuel trim tables. Fuel trim tables are based on engine speed and load and by bank for engines with 2 heated oxygen sensors (HO2S) forward of the catalyst. Learning the corrections in KAM improves both open loop and closed loop air fuel ratio control. Advantages include:

- Short term fuel trim does not have to generate new corrections each time the engine goes into closed loop.
- Long term fuel trim corrections can be used while in open loop and closed loop modes.

Long term fuel trim is represented as a percentage, similar to the short term fuel trim, however it is not a single parameter. A separate long term fuel trim value is used for each RPM and load point of engine operation. Long term fuel trim corrections may change depending on the operating conditions of the engine (RPM and load), ambient air temperature, and fuel quality (% alcohol, oxygenates). When viewing the LONGFT1 and LONGFT2 PIDs, the values may change a great deal as the engine is operated at different RPM and load points. The LONGFT1 and LONGFT2 PID display the long term fuel trim correction currently being used at that RPM and load point.

**High Speed Controller Area Network (CAN)**

The CAN is a serial communication language protocol used to transfer signal messages between electronic modules or nodes. Two or more signals can be sent over one CAN circuit allowing 2 or more electronic modules or nodes to communicate with each other. This communication or multiplexing network operates at 500 kB/sec (kilobytes per second) and allows the electronic modules to share their information messages.

Included in these messages is diagnostic data that is output over the CAN + and CAN - lines to the DLC. The PCM connection to the DLC is typically done with a 2 wire, twisted pair cable used for the network interconnection. The diagnostic data such as self-test or PIDs can be accessed with a scan tool. For additional information on scan tool equipment, refer to Section 2, Diagnostic Methods.

**Idle Air Trim**

Idle air trim is designed to adjust the idle air control calibration to correct for wear and aging of components. When the engine conditions meet the learning requirement, the strategy monitors the engine and determines the values required for ideal idle calibration. The idle air trim values are stored in a table for reference. This table is used by the PCM as a correction factor when controlling the idle speed. The table is stored in the KAM and retains the learned values even after the engine is shut OFF. A DTC is set if the idle air trim has reached its learning limits.

Whenever an idle air control component is replaced, or a repair affecting idle is carried out, it is recommended the KAM be reset. This is necessary so the idle strategy does not use the previously learned idle air trim values.

To reset the KAM, refer to Section 2, Resetting The Keep Alive Memory (KAM). It is important to note that erasing DTCs with a scan tool does not reset the idle air trim table.

Once the KAM has been reset, the engine must idle for 15 minutes (actual time varies between strategies) to learn new idle air trim values. Idle quality improves as the strategy adapts. Adaptation occurs in 4 separate modes as shown in the following table.

**Idle Air Trim Learning Modes**

| Transmission Range | Air Conditioning Mode |
|---|---|
| NEUTRAL | A/C ON |
| NEUTRAL | A/C OFF |
| DRIVE | A/C ON |
| DRIVE | A/C OFF |

**International Standards Organization (ISO) 14229 Diagnostic Trouble Code (DTC) Descriptions**

The ISO 14229 is a global, diagnostic communication standard. The ISO 14229 is a set of standard diagnostic messages that can be used to diagnose any vehicle module in use and at the assembly plant. The ISO 14229 is similar to the Society of Automotive Engineers (SAE) J2190 diagnostic communication standard that was used by all Original Equipment Manufacturers (OEMs) for previous communication protocols.

The ISO 14229 changes the way PIDs, DTCs, and output state control (OSC) is processed internally in the PCM and in the scan tool software. Most of the changes are to make data transfer between electronic modules more efficient, and the amount and type of information that is available for each DTC. This information may be helpful in diagnosing driveability concerns.

**Historical Diagnostic Trouble Codes (DTCs)**

Historical DTCs use bit 5 (the DTC test failed at least once since last code clear) to indicate that a DTC is no longer confirmed or pending, but has failed at least once since the last time the DTCs were cleared. The bit 5 is designed to eventually age out and clear in 80 drive cycles (255 in the future). The scan tool does not allow a technician to retrieve historical DTCs unless there are no active DTCs present. This information, in conjunction with manufacturer freeze frame and snapshot data, may be useful in diagnosing a noticeable fault that did not progress to MIL status, or an extended amount of time has occurred before diagnosis, and the confirmed DTC has cleared.

**DTC Structure**

Like all digital signals, DTCs are sent to the scan tool as a series of 1s and 0s. Each DTC is made up of 2 data bytes, each consisting of 8 bits that can be set to 1 or 0. In order to display the DTCs in the conventional format, the data is decoded by the scan tool to display each set of 4 bits as a hexadecimal number (0 to F). For example, P0420 Catalyst System Efficiency Below Threshold (Bank 1).

| DTC Byte 1 | | DTC Byte 2 | |
|---|---|---|---|
| 0000 | 0100 | 0010 | 0000 |
| P0 | 4 | 2 | 0 |

The table below shows how to decode the bits into hex digits.

| Binary Bit Pattern | Hex Digit | Binary Bit Pattern | Hex Digit |
|---|---|---|---|
| 0000 | 0 | 1000 | 8 |
| 0001 | 1 | 1001 | 9 |
| 0010 | 2 | 1010 | A |
| 0011 | 3 | 1011 | B |
| 0100 | 4 | 1100 | C |
| 0101 | 5 | 1101 | D |
| 0110 | 6 | 1110 | E |
| 0111 | 7 | 1111 | F |

The first 4 bits of a DTC do not convert directly into hex digits. The conversion into different types of DTCs (P, B, C and U) is defined by SAE J2012. This standard contains DTC definitions and formats.

| Binary Bit Pattern | SAE DTC Type | Binary Bit Pattern | SAE DTC Type |
|---|---|---|---|
| 0000 | P0 | 1000 | B0 |
| 0001 | P1 | 1001 | B1 |
| 0010 | P2 | 1010 | B2 |
| 0011 | P3 | 1011 | B3 |
| 0100 | C0 | 1100 | U0 |
| 0101 | C1 | 1101 | U1 |
| 0110 | C2 | 1110 | U2 |
| 0111 | C3 | 1111 | U3 |



ISO 14229 sends 2 additional bytes of information with each DTC, a failure type byte and a status byte.

| DTC Byte 1 | | DTC Byte 2 | | Failure Type Byte | | Status Byte | |
|---|---|---|---|---|---|---|---|
| 0000 | 0100 | 0010 | 0000 | 0000 | 0000 | 1111 | 0101 |
| P0 | 4 | 2 | 0 | 0 | 0 | F | 9 |

All ISO 14229 DTCs are 4 bytes long instead of 3 or 2 bytes long. Additionally, the status byte for ISO 14229 DTCs is defined differently than the status byte for previous applications with 3 byte DTCs.

**Failure Type Byte**

The failure type byte is designed to describe the specific failure associated with the basic DTC. For example, a failure type byte of 1C means circuit voltage out of range, 73 means actuator stuck closed. When combined with a basic component DTC, it allows one basic DTC to describe many types of failures.

| DTC Byte 1 | | DTC Byte 2 | | Failure Type Byte | | Status Byte | |
|---|---|---|---|---|---|---|---|
| 0000 | 0001 | 0001 | 0000 | 0001 | 1100 | 1010 | 1111 |
| P0 | 1 | 1 | 0 | 1 | C | A | F |

For example, P0110:1C-AF means intake air temperature (IAT) sensor circuit voltage out of range. The base DTC, P0110, means IAT sensor circuit, while the failure type byte 1C means circuit voltage out of range. This DTC structure was designed to allow manufacturers to more precisely identify different kinds of faults without always having to define new DTC numbers.

The PCM does not use failure type bytes and always sends a failure type byte of 00 (no sub type information). This is because OBD II regulations require manufacturers to use 2 byte DTCs for generic scan tool communications. Additionally, the OBD II regulations require the 2 byte DTCs to be very specific, so there is no additional information that the failure type byte could provide.

A list of failure type bytes is defined by SAE J2012 but is not described here because the PCM does not use the failure type byte.

**Status Byte**

The status byte is designed to provide additional information about the DTC, such as when the DTC failed, when the DTC was last evaluated, and if any warning indication has been requested. Each of the 8 bits in the status byte has a precise meaning that is defined in ISO 14229.

The protocol is that bit 7 is the most significant and left most bit, while bit 0 is the least significant and right most bit.

| Most Significant Bits | | | | Least Significant Bits | | | |
|---|---|---|---|---|---|---|---|
| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |



**DTC Status Bit Definitions**

Refer to the following status bit descriptions:

Bit 7

- 0 - The ECU is not requesting warning indicator to be active
- 1 - The ECU is requesting warning indicator to be active

Bit 6

- 0 - The DTC test completed this monitoring cycle
- 1 - The DTC test has not completed this monitoring cycle

Bit 5

- 0 - The DTC test has not failed since last code clear
- 1 - The DTC test failed at least once since last code clear

Bit 4

- 0 - The DTC test completed since the last code clear
- 1 - The DTC test has not completed since the last code clear

Bit 3

- 0 - The DTC is not confirmed at the time of the request
- 1 - The DTC is confirmed at the time of the request

Bit 2

- 0 - The DTC test completed and was not failed on the current or previous monitoring cycle
- 1 - The DTC test failed on the current or previous monitoring cycle

Bit 1

- 0 - The DTC test has not failed on the current monitoring cycle
- 1 - The DTC test failed on the current monitoring cycle

Bit 0

- 0 - The DTC is not failed at the time of request
- 1 - The DTC is failed at the time of request

For DTCs that illuminate the MIL, a confirmed DTC means the PCM has stored a DTC and has illuminated the MIL. If the fault has corrected itself, the MIL may no longer be illuminated but the DTC still shows a confirmed status for 40 warm up cycles at which time the DTC is erased.

For DTCs that do not illuminate the MIL, a confirmed DTC means the PCM has stored a DTC. If the fault has corrected itself, the DTC still shows a confirmed status for 40 warm up cycles at which time the DTC is erased.

To determine if a test has completed and passed, such as after a repair, information can be combined from 2 bits as follows:

If bit 6 is 0 (the DTC test completed this monitoring cycle), and bit 1 is 0 (the DTC test has not failed on the current monitoring cycle), then the DTC has been evaluated at least once this drive cycle and was a pass.

If bit 6 is 0 (the DTC test completed this monitoring cycle) and bit 0 is 0 (the DTC test is not failed at the time of request), then the most recent test result for that DTC was a pass.

The status byte bits can be decoded as a 2 digit hexadecimal number, and displayed as the last 2 digits of the DTC, for example for DTC P0110:1C-AF, AF represents the status byte info.



| **Status Byte** | | | | | | | |
|---|---|---|---|---|---|---|---|
| A equals 1010 | | | | F equals 1111 | | | |
| Bit 7 equals 1 | Bit 6 equals 0 | Bit 5 equals 1 | Bit 4 equals 0 | Bit 3 equals 1 | Bit 2 equals 1 | Bit 1 equals 1 | Bit 0 equals 1 |

**Multiplexing**

The increased number of modules on the vehicle necessitates a more efficient method of communication. Multiplexing is a method of sending 2 or more signals simultaneously over a single circuit. In an automotive application, multiplexing is used to allow 2 or more electronic modules to communicate simultaneously over a single media. Typically this media is a twisted pair of wires. The information or messages that can be communicated on these wires consists of commands, status or data. The advantage of using multiplexing is to reduce the weight of the vehicle by reducing the number of redundant components and electrical wiring.

**Multiplexing Implementation**

Currently Ford Motor Company uses CAN communication language protocol to communicate with the PCM.

For additional information about the module communications network, refer to the Workshop Manual Section 418-00, Module Communications Network for Description and Operation.

**Particulate Filter Regeneration**

**Note:** *Regeneration may occur during normal operation. During regeneration, diagnostic procedures may display biased values. If a regeneration occurs during diagnostic procedures, allow the process to complete before continuing diagnostics. Regeneration can be disabled during diagnosis using a scan tool.*

Particulates in the exhaust are trapped by the particulate filter. Regeneration is the process by which the exhaust gas temperatures are increased and the higher exhaust temperatures burn off the particulates in the filter. Under normal driving conditions, regeneration is an ongoing passive process. When necessary, the PCM may initiate regeneration by creating a lean condition along with retarding the spark advance, raising the exhaust temperature to regeneration conditions.

During normal vehicle operation, the PCM estimates the amount of particulates that accumulate in the particulate filter. The estimated amount of particulates is based on a number of different vehicle operating conditions, including vehicle speed, engine run time, and load. Additionally the PCM monitors the following:

- battery voltage
- engine coolant temperature
- engine speed
- exhaust gas temperature (EGT) sensors
- fuel level
- fuel temperature
- intake air temperature
- turbocharger condition

Particulate filter regeneration may be initiated by the PCM or manually initiated using a scan tool.

When the appropriate conditions are met, the PCM initiates a particulate filter regeneration. Regeneration is carried out when the PCM calculates the particulate level in the filter has reached a level that requires cleaning.

The regeneration process initiates while the vehicle is driven and may continue for up to 5 minutes after the vehicle is stationary.

The PCM may continue to initiate the regeneration process until the regeneration process completes. After the regeneration process is completed the filter is sufficiently cleaned and continues to trap exhaust particulate matter.

The following conditions are considered normal while the vehicle is in regeneration. No repairs are necessary if they are present:

- regeneration does not initiate until the engine coolant temperature is above 70°C (158°F)
- white smoke from the tail pipe during cold ambient temperatures
- engine responsiveness may be slightly different
- exhaust smell may be noticed during the initiation
- engine pitch may be different
- intake air system sound on deceleration and engine shut down may be noticed
- exhaust gas temperatures are elevated

To help determine the condition of the particulate filter and recent regeneration events, access and monitor the following parameters:

- DPF PIDs to determine particulate filter inlet pressure.
- DPF_V PID to determine the particulate filter pressure sensor voltage.
  - CLOGGED: The DRIVE TO CLEAN EXHAUST FILTER message will be displayed. The scan tool manual regeneration test may not function.
  - OVERLOADED: The DRIVE TO CLEAN EXHAUST FILTER message will be displayed. The vehicle can be driven at steady state speeds when the engine coolant temperature is greater than 70°C (158°F) to enable regeneration.
  - LOADED: The DRIVE TO CLEAN EXHAUST FILTER message may be displayed. The scan tool manual regeneration test may function normally. The vehicle can be driven at steady state speeds when the engine coolant temperature is greater than 70°C (158°F) to enable regeneration.
  - PART LOAD: The particulate filter is partially soot loaded, regeneration is not required at this time. The scan tool manual regeneration test may not function when the filter is in this state. Due to a lack of filter loading, the PCM may not initiate a regeneration event.
  - CLEAN: The particulate filter is clean. The scan tool manual regeneration test does not function when the filter is in this state due to a lack of filter loading. The PCM does not initiate a regeneration event.
  - SYSTEM LEAK: The particulate filter may be missing or an exhaust leak may be present. Verify there are no exhaust system leaks, and inspect the particulate filter substrate for damage.

**Permanent Diagnostic Trouble Code (DTC)**

The software stores a permanent DTC in non volatile random access memory (NVRAM) whenever a DTC is set and the MIL has been illuminated. Permanent DTCs can only be cleared by the module strategy itself. After a permanent DTC is stored, 3 consecutive test passed monitoring cycles must complete before the permanent DTC can be erased. At that time, both the permanent DTC is erased and the MIL is extinguished. The PCM clears permanent DTCs after one monitoring cycle if a request to clear DTCs is sent by the scan tool, and the test subsequently runs and passes (test must continue to pass for the entire driving cycle for continuous monitors) and a Permanent DTC Driving Cycle has been completed. A Permanent DTC Driving Cycle requires a total of 10 minutes of engine run time, consisting of 5 minutes of vehicle operation above 40 km/h (25 MPH) and 30 continuous seconds of vehicle operation at idle. After clearing DTCs, running the OBD Drive Cycle ensures that all monitors complete, the Permanent DTC Driving Cycle completes, inspection/maintenance (I/M) readiness codes are set to a ready status and any permanent DTCs are erased. A permanent DTC cannot be erased by clearing the KAM. The intended use of the permanent DTC is to prevent vehicles from passing an in use inspection simply by disconnecting the battery or clearing the DTCs with a scan tool prior to the inspection. The presence of permanent DTCs at an inspection without the MIL illuminated is an indication that a correct repair was not verified by the on board monitoring system.

**Vehicle Speed Limiter**

The PCM disables some or all of the fuel injectors whenever a vehicle over speed condition is detected. The purpose of the vehicle speed limiter is to prevent damage to the powertrain. Once the driver reduces the excessive vehicle speed, the engine returns to the normal operating mode. No repair is required. However, the technician should clear the DTCs and inform the customer of the reason for the DTC.

Either excessive wheel slippage caused by sand, gravel, rain, mud, snow, ice or excessive RPM increase in neutral may cause the vehicle speed limiter to activate even though the vehicle has not exceeded the maximum speed limit.

**Powertrain Control Module - Vehicle Speed Output (PCM-VSO)**

The PCM-VSO speed signal subsystem generates vehicle speed information for distribution to modules and subsystems that require vehicle speed data. This subsystem senses the transmission output shaft speed with a sensor. The data is processed by the PCM and distributed as a message on the vehicle communication network.

The key features of the PCM-VSO system are to:

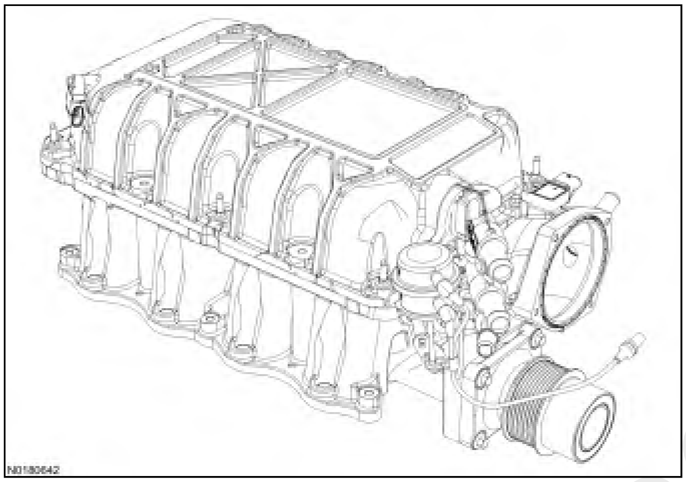
- infer vehicle movement from a speed sensor.
- convert transmission output shaft rotational information to vehicle speed information.
- compensate for tire size and axle ratio with a programmed calibration variable.
- distribute vehicle speed information as a multiplexed message.

The signal from a non-contact shaft sensor, such as an output shaft speed (OSS) sensor or vehicle speed sensor (VSS), mounted on the transmission is sensed directly by the PCM. The PCM converts the OSS or VSS information to 8,000 pulses per mile, based on a tire and axle ratio conversion factor. This conversion factor is programmed into the PCM at the time the vehicle is assembled and can be reprogrammed in the field for changes in the tire size and axle ratio. The PCM transmits the computed vehicle speed and distance traveled information to all vehicle speed signal users on the vehicle.

## Supercharger And Charge Air Cooler (CAC) Systems

### Supercharger Assembly

The supercharger assembly is a positive displacement pump. The supercharger supplies an additional volume of intake air to the engine by increasing air pressure and density in the intake manifold. The supercharger assembly incorporates a bypass system to reduce air handling losses when boost is not required, resulting in better fuel economy. The supercharger increases torque across the entire engine operating range. The supercharger can provide additional airflow at any engine speed.



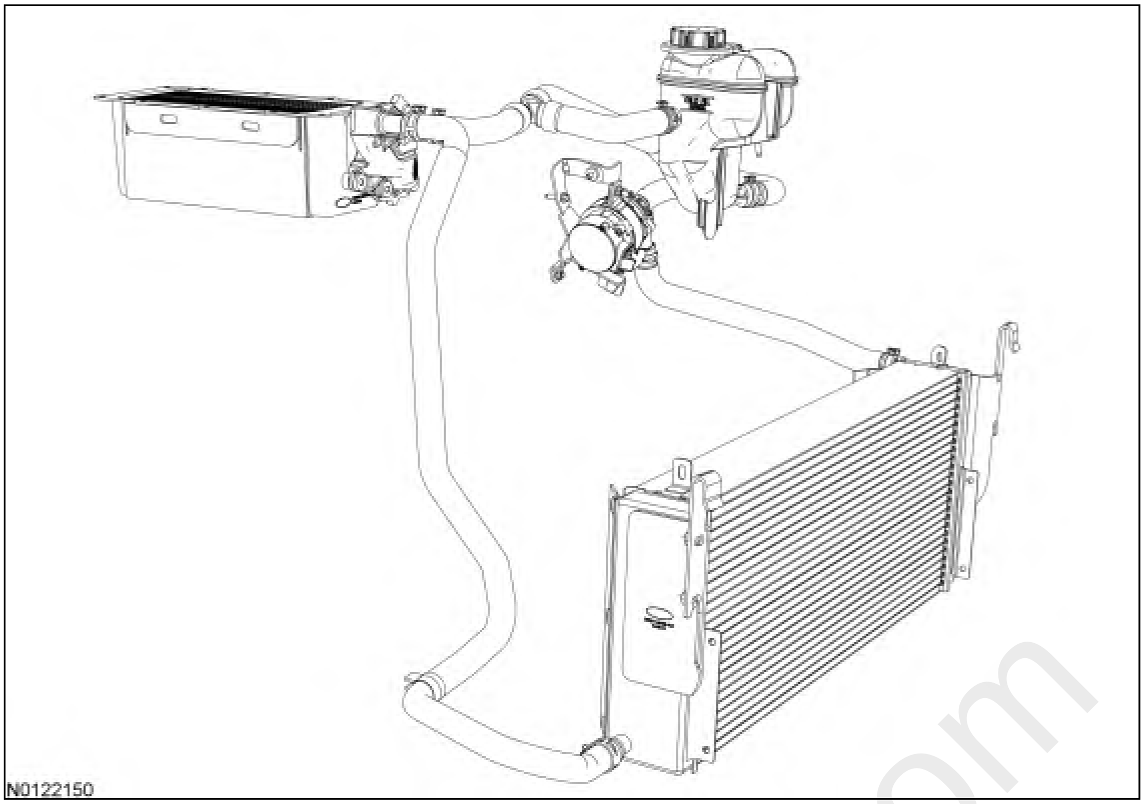

*Supercharger Assembly*

### Supercharger Bypass System

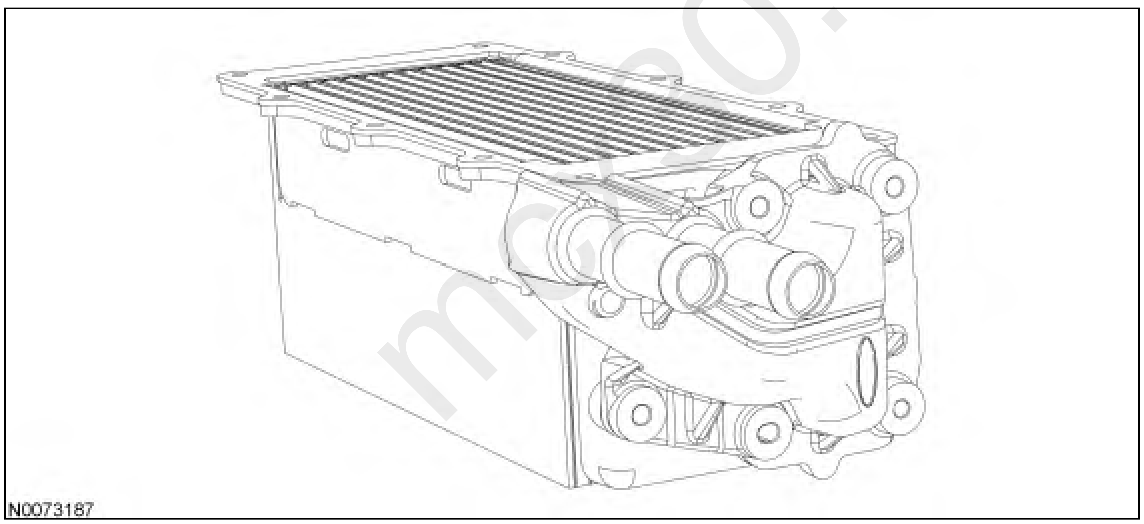
The supercharger bypass system allows the high pressure air at the outlet of the supercharger to vent back into the inlet of the supercharger, equalizing the pressure. This eliminates boost when it is not required. The system uses a vacuum bypass actuator, which controls the bypass valve in the supercharger. The system normally operates with engine vacuum applied to the bypass actuator. The actuator will open and bypass the supercharger boost during high vacuum engine conditions. As the throttle is opened and engine vacuum decreases, the actuator closes to allow the supercharger to pressurize the air in the manifold.

### Charge Air Cooler (CAC) System

The CAC system cools the intake air temperature which has been heated by the supercharger. The removal of heat from the pressurized air going into the CAC increases the air density which improves combustion efficiency, engine horsepower, and torque. The system contains the CAC located in the intake manifold, the CAC radiator, the CAC coolant reservoir, the CAC pump, and the tubing to connect these components. The CAC is positioned after the supercharger directly in the flow of the intake air. As the heated air flows through the CAC, heat is transferred to the coolant which is circulated to the CAC radiator to be cooled by the airflow through the grille. The CAC pump is controlled by PCM. The PCM maintains a desirable intake air temperature by monitoring an intake air temp 2 (IAT2) sensor in the upper intake manifold.




*Typical CAC System — Air To Liquid Cooled*




*Typical CAC*