## Powertrain Control Software

### Auto Start Stop

The auto start stop system helps reduce fuel consumption and decrease emissions by automatically shutting down the engine when the vehicle stops and the engine is idling, usually within 1500 ms (1.5 seconds). To initiate the auto start stop operation, the vehicle gear selector must be in DRIVE when the vehicle comes to a stop and the brake pedal must be fully applied. The engine automatically restarts when the brake pedal is released, usually within 200 ms (0.5 seconds), or when a vehicle system requires a restart, for example to recharge the battery or to maintain interior comfort settings.

The auto start stop system is defaulted to an ON state when the engine is started. To switch the auto start stop system OFF, press the auto start stop switch located on the center console. To turn the auto start stop system ON, press the auto start stop switch again. The auto start stop system can only be deactivated during the current ignition cycle.

The instrument panel cluster (IPC) auto start stop indicator illuminates when an auto start stop system inhibit or disable condition is present.

During normal operation the auto start stop system may not stop the engine under the following conditions:

- The A/C, heat or defrost settings are ON
- The rear defroster is ON
- The battery has a low state of charge or is below 5°C (41°F) or above 60°C (140°F)
- The maximum engine off time is exceeded
- The engine operating temperature is less than 60°C (140°F)
- The gear selector is in the PARK, REVERSE, NEUTRAL or SECOND GEAR position
- The steering wheel is turned rapidly or is at a sharp angle
- Initial vehicle speed of greater than 4 km/h (2.5 MPH) and less than 2 seconds has elapsed
- The vehicle is on a steep road grade
- Elevation is above 10,000 feet (3,048 meters) approximately
- The clutch pedal position (CPP) sensor indicates the clutch pedal is fully released

Any of the following conditions may result in an automatic restart of the engine:

- The blower fan speed is increased or the climate control temperature is changed
- An electrical accessory is turned ON or plugged in
- Incorrect brake vacuum
- The auto start stop switch is pressed to disable the system while the engine is stopped

### Brake Over Accelerator

The brake over accelerator feature may not be active during low speed operating conditions. This enables unique drive maneuvers such as trailer tow, boat launch and retrieval or operation in hilly environments where the operator may require the application of both the accelerator pedal and the brake pedal during low speed maneuvering. The brake over accelerator feature will be active at speeds greater than 16 km/h (10 mph).

In the event the accelerator pedal becomes entrapped, such as by an object lodging the pedal, the brake over accelerator feature will reduce engine power when the brake pedal is applied.

Operators that rest a foot on the brake pedal when also applying the accelerator pedal may activate the brake over accelerator feature. The brake activation is detected by the PCM from the electrical brake switch. In addition to brake over accelerator comments, the customer may bring the vehicle in for repair to address concerns such as a hesitation/stumble or a lack/loss of power. In the event of a hesitation/stumble or a lack/loss of power concern, carry out normal vehicle diagnostics for the appropriate symptom code. If the brake over accelerator feature is suspect, the BRKOVR_ACTION, BRKOVRD_POSS and DIST_BRKOVRD PIDs will display a brake over accelerator event occurred.

In the event the brake over accelerator feature is suspected as the cause of the customer concern, explain to the customer the details of the override system as described above. Additionally, make sure the customer is aware that resting a foot on the brake pedal while driving may cause the activation of this feature. This also results in activation of the brake lights on the vehicle while driving. For additional information refer to the Owners Literature.

### Computer Controlled Shutdown

The PCM controls the PCM power relay when the ignition is turned to the ON or START position, by grounding the PCMRC circuit. After the ignition is turned to the OFF, ACC or LOCK position, the PCM stays powered up until the correct engine shutdown occurs.

The ISP-R circuit provides the ignition state input to the PCM. Based on the ISP-R signal the PCM determines when to power down the PCM power relay.

The PCM software monitors the parameters for the controlled systems to make sure that all values have met a threshold for shutdown.

**Controller Area Network (CAN)**

The CAN is based on society of automotive engineers (SAE) J2284, international standard organization (ISO)-11898, and is a serial communication language protocol used to transfer messages (signals) between electronic control 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 500k/sec (kilobytes per second) and allows the electronic modules to share their information messages.

Included in these messages is diagnostic data sent over the CAN+ and CAN- lines to the data link connector (DLC). The PCM connection to the DLC is done with a twisted pair cable used for network interconnection. The diagnostic data such as self-test or parameter identification (PID) can be accessed with a scan tool. Information on scan tool equipment is described in Section 2, Scan Tool Setup and Functionality.

**Controller Area Network 2 (CAN2)**

The increased number of modules on the vehicle dictate a more efficient method of communication. Multiplexing is the process of communicating several messages over the same signal path. This process allows multiple modules to communicate with each other through the signal path (CAN2+ and CAN2-). The glow plug control module (GPCM) and nitrogen oxides (NOx) modules communicate with the PCM using CAN2 communications, to determine the priority in which the signals are sent. Refer to the Controller Area Network (CAN) in this section for additional information.

**Cold Idle Kicker**

The cold idle kicker strategy provides an increase in idle speed during cold engine warm up. The PCM uses the engine coolant temperature (ECT) sensor and transmission position as primary inputs, and in certain conditions the PCM uses the ambient air temperature input to adjust the cold idle RPM up to a maximum of 1,200 RPM (Transit) or 1,175 RPM (all others).

**Diesel Engine Power Monitor**

The diesel engine power monitor strategy resides in the PCM. The function of the diesel engine power monitor is to check the engine operation for unwanted fuel injections without a driver demand. During the diesel engine power monitor the PCM checks the commanded fuel injections and engine speed.

**Diesel 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.*

Diesel particulates in the exhaust are trapped by the diesel particulate filter. Regeneration is the process by which the exhaust gas temperatures are increased, the higher exhaust temperatures burn off the particulates in the filter. The frequency and length of regeneration events fluctuate while both factors are determined by the vehicle drive cycle, ambient temperature, vehicle loading and the vehicle operator driving style. Under normal driving conditions, regeneration frequency varies from 143 to 805 km (89 to 500 miles) between each occurrence. The duration of a normal regeneration event varies between 10 and 30 minutes (Transit) or 10 and 40 minutes (all others). The first regeneration on a new vehicle may not require 143 km (89 miles), it may occur at any time. The duration of a regeneration event may be reduced if a constant speed above 48 km/h (30 mph) is maintained. Driving at lower speeds and stop and go conditions may result in longer duration times for a regeneration event to successfully complete.

During normal vehicle operation the PCM estimates the amount of particulates that accumulate in the diesel 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
- distance traveled since the last diesel particulate filter regeneration
- engine coolant temperature

- engine speed
- exhaust gas temperature bank 1, sensor 1 (EGT11)
- exhaust gas temperature bank 1, sensor 2 (EGT12)
- exhaust gas temperature bank 1, sensor 3 (EGT13)
- exhaust gas temperature bank 1, sensor 4 (EGT14) (if equipped)
- fuel level
- fuel temperature
- intake air temperature
- turbocharger condition

Diesel particulate filter regeneration may be initiated by the PCM, manually using a scan tool, or through operator commanded regeneration (if equipped). For additional information on operator commanded regeneration, refer to Section 2,Scan Tool Setup and Functionality.

When the appropriate conditions are met, the PCM initiates a diesel 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 and as long as the transmission remains in gear. The regeneration process is interrupted if the transmission is shifted into the PARK or NEUTRAL position. If the regeneration process is not complete when the vehicle entered the PARK or NEUTRAL position, the regeneration process may continue during the next drive cycle.

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 vehicle is driven at speeds greater than 7 km/h (4 mph) and the engine coolant temperature is above 40°C (140°F) (F–Series Super Duty) or 70°C (158°F) (all others)
- regeneration does not initiate if the power take off (PTO) or stationary elevated idle control are active (if equipped)
- 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
- air induction or flutter sound on deceleration and engine shut down may be noticed
- exhaust gas temperatures are elevated
- the throttle body is active during the regeneration process

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

- DPF PID to determine diesel particulate filter bank 1 inlet pressure.
- DPF_REGN_AVGD PID to determine the average distance between regeneration events.
- DPF_REGN_AVGT PID to determine the average time between regeneration events.
- DPF_V PID to determine the diesel particulate filter pressure sensor voltage.
    - CLOGGED: DTCs P246C and P2463 may set. The DRIVE TO CLEAN EXHAUST FILTER message will be displayed. This may be caused by repeated regeneration interruptions due to shifting into the PARK or NEUTRAL position or extended stationary operation. The scan tool manual regeneration test may not function.
    - OVERLOADED: DTCs P246C and P2463 may set. The DRIVE TO CLEAN EXHAUST FILTER message will be displayed. Automatic vehicle regeneration is disabled when DTC P246C is set. A manual regeneration can be commanded using the scan tool. The vehicle can be driven at steady state speeds when the engine coolant temperature is greater than 70°C (158°F) to enable regeneration, only if DTC P246C is not set.
    - LOADED: DTC P2463 may set. 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 40°C (140°F) (F–Series Super Duty) or 70°C (158°F) (all others) 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. GO to Pinpoint Test RB to continue diagnosis.

**Engine Brake**

The engine brake is enabled by pressing the engine brake switch. When the engine brake is enabled the engine brake indicator will be turned on. The engine brake indicator will blink if the engine brake is disabled due to engine operating conditions or a system fault is detected. When the engine brake is enabled the PCM controls the turbocharger actuator to move the VGT vanes to create higher exhaust back pressure during decel events. If the engine brake switch is enabled, the engine brake will automatically engage anytime the accelerator pedal is released and the engine RPM is greater than a calibrated threshold. Pressing the accelerator pedal will disengage the engine brake and return the VGT vanes to the normal position.

**Engine RPM And Vehicle Speed Limiter**

The PCM limits the engine RPM by cutting off fuel whenever the engine RPM limit is detected. The purpose of the engine RPM limiter is to prevent damage to the powertrain. The RPM limit for the F-150 is 4,600 RPM. The RPM limit for the F-650 / F-750 and F-Series Super Duty is 3,800 RPM. The RPM limit for the Transit is 4,500 RPM.

The vehicle speed limit for the:

- F-150 pickup is 169 km/h (106 mph).
- F-250 and F-350 pickup is 153 km/h (95 mph).
- F-450 pickup is 140 km/h (87 mph).
- F-350, F-450 and F-550 narrow frame vehicle is 130 km/h (81 mph).
- F-650 / F-750 is 120 km/h (75 mph).
- Transit is 156 km/h (97 mph).

**Engine Shutdown Timer**

Vehicles equipped with the engine shutdown timer have an instrument panel cluster message and an audible alert that notifies the driver 30 seconds prior to engine shutdown. When the engine shutdown occurs, the PCM broadcasts a shutdown message to all the vehicle modules. One minute after the engine shutdown occurs, the body control module (BCM) (F-650 / F-750) or the circuit deactivation ignition module (CDIM) (all others) electrically changes the ignition state to OFF and the vehicle goes into the normal delay accessory mode.

Engine shutdown occurs under the following conditions:

- Vehicle speed below 1.6 km/h (1 mph)
- Engine coolant temperature is greater than 15°C (60°F)
- Transmission in the PARK or NEUTRAL position
- Engine shutdown occurs in 5 minutes with the parking brake applied
- Engine shutdown occurs in 15 minutes without the parking brake applied
- The engine shutdown time may be increased in regeneration mode or scan tool mode (60 minutes maximum)
- Brake or accelerator pedal application in the 30 second window resets the engine shutdown timer
- Power take off (PTO) or auxiliary idle control system not active

**Failure Mode Effects Management (FMEM)**

The FMEM system is an alternative strategy in the PCM designed to maintain vehicle operation if there is a concern with one or more critical sensor inputs. When a sensor input is perceived to be out of limits by the PCM, an alternative strategy is initiated. The PCM substitutes a fixed value and continues to monitor the incorrect sensor input. If the suspect sensor operates within limits, the PCM returns to the normal engine running strategy. FMEM operation results in continuous memory DTCs during normal engine operation and when carrying out the key on engine running (KOER) self-test mode.

**Flash Electronically 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 flash EEPROM is that it can be electronically erased and then reprogrammed without removing the PCM from the vehicle. The reprogramming is carried out through the DLC.

**Fuel Balancing And Control**

Fuel balancing and control is an algorithm designed to reduce differences in injected fuel quantity from cylinder to cylinder. The increase in crankshaft speed due to individual cylinder combustion events is measured. The amount of fuel injected to each cylinder is then adjusted up or down to minimize the difference in increase in crankshaft speed from cylinder to cylinder. For Transit, fuel balancing and control operates in closed loop control in an engine speed range of 800 to 1,150 RPM. For all others, fuel balancing and control operates in closed loop control in an engine speed range of 500 to 2800 RPM and a commanded injection quantity of 3.5 to 75 mg per stroke.

**Fuel Level Input**

Fuel level information is sent from the instrument panel cluster to the PCM on the controller area network (CAN) communication link.

**Fuel Mass Observer**

The fuel mass observer is an algorithm used to detect deviations in performance of all fuel injectors from nominal. The oxygen percentage as measured by the nitrogen oxides bank 1, sensor 2 (NOx12) is compared to a modeled oxygen percentage based upon the current fuel, boost, and EGR settings. The deviation between the measured and modeled oxygen percentage is expressed in terms of the error in fueling required to explain the deviation. This calculated error in fueling is then divided by the current requested fueling level to generate a ratio of percentage error in fueling. This fueling ratio is then filtered over time. If the filtered error in fueling ratio exceeds minimum or maximum limits, then a DTC is set.

**Fuel Trim**

The fuel control system uses fuel trim tables to compensate for the variability that occurs in fuel system components due to normal wear and aging. Fuel trim tables are based on fuel mass.

**Instrument Panel Cluster (IPC) Message Center Functionality**

The message center, located in the IPC, displays specific exhaust filter messages when a diesel particulate filter regeneration is required, during the regeneration process, and when the regeneration is complete.

Refer to the Owners Literature for additional information on the IPC messages.

**Minimum Fuel Mass Adaption**

Minimum Fuel Mass Adaption is an algorithm used to detect deviations in individual fuel injector performance from nominal. In a deceleration fuel shut off condition, fuel rail pressure is set to a calibrated pressure and small injections are made from a single fuel injector. The measured acceleration in crankshaft speed is compared to the expected acceleration for the target fuel quantity. From this information, a correction to fuel injection quantity for the specific injector is determined. This information is used to adjust all pilot injections on that fuel injector for correct fuel delivery. If the absolute amount of correction exceeds minimum or maximum limits, a DTC sets.

**Multiplexing**

Multiplexing is the process of communicating several messages over the same signal path. This process allows multiple modules to communicate with each other through the signal path controller area network (CAN). Modules communicate with the PCM using CAN communications, to determine the priority in which the signals are sent. For additional information, refer to Controller Area Network (CAN) in this section.

**Zero Fuel Calibration**

Zero fuel calibration is an algorithm used to detect deviations in individual fuel injector performance from nominal. In an overrun decel fuel shut off condition, fuel rail pressure is set to 30,000 kPa (4,351 psi) and small injections are made from a single fuel injector. The observed acceleration in crankshaft speed is detected and a regression line generated to predict the fueling required to achieve the expected acceleration. If the calculated fueling required to generate the expected acceleration in crankshaft speed falls outside the allowable control limits for the system, an addition routine is called to very precisely learn the adjustment to fuel injector energizing time required to achieve expected acceleration. This information is then used to adjust all injections on that fuel injector for a correct fuel delivery. If the absolute energizing time observed for the test injection to yield the expected acceleration exceeds minimum or maximum limits, a DTC sets.