Table of Contents

Read all safety instructions in the "Safety Information" section of this manual before doing any procedures.
Follow all warnings, cautions, and notes.

Description

Section Information

All electrical faults in the engine control system can be diagnosed in this section. All components are divided into separate test procedures and contain the following information:

- Diagnostic Trouble Code (DTC) with possible cause
- Circuit diagram
- Component function
- Circuit operation
- Component location
- Diagnostic tool list
- Sensor End Diagnostics (with MasterDiagnostics® software)
- Pin-Point Diagnostics (without MasterDiagnostics® software)
- Harness resistance checks
- Operational voltage check (most components)

Engine Wiring Diagram

EGED 430-1 Engine Wiring Diagram Example

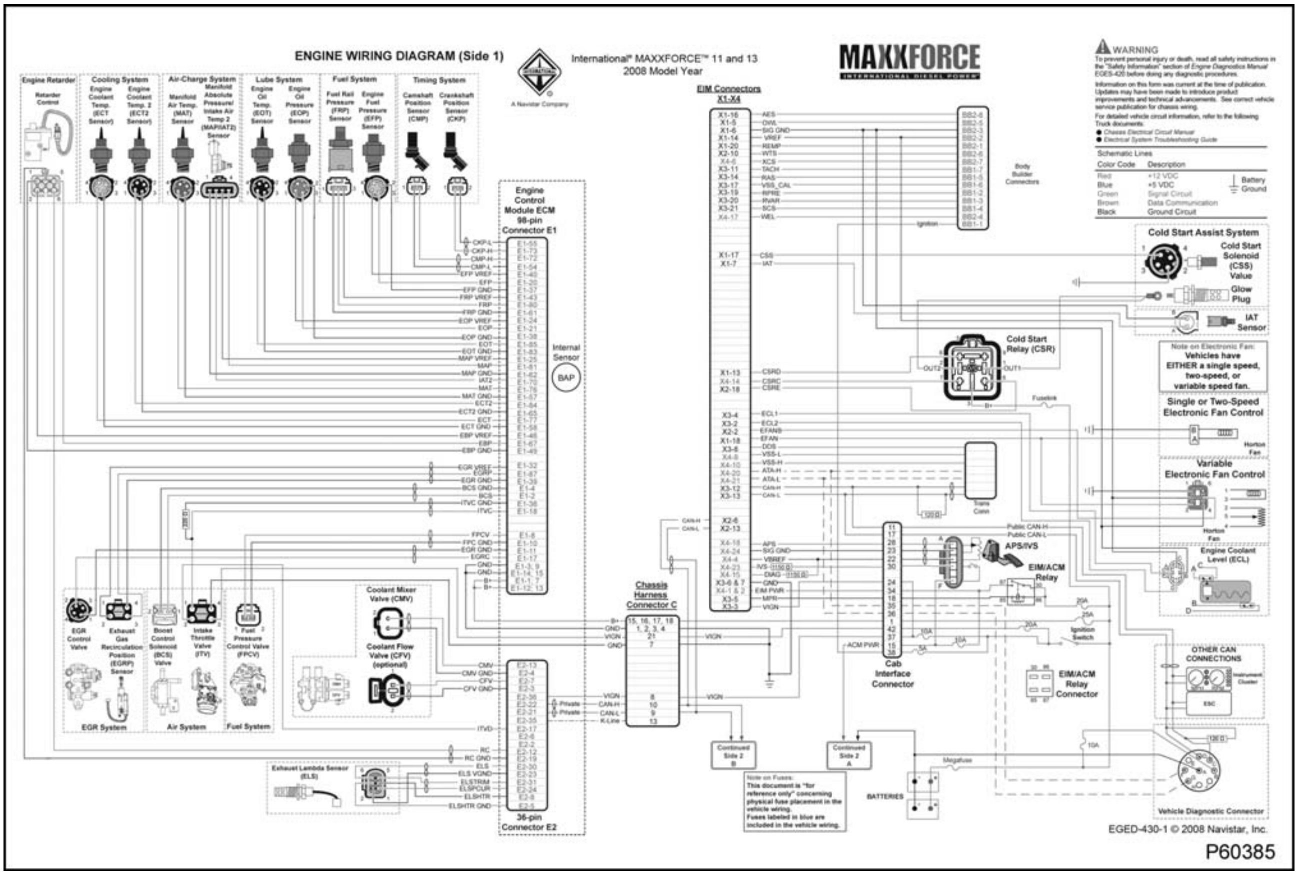

Figure 166 EGED 430-1 (Front Side)

Engine diagnostic forms assist technicians in troubleshooting International® diesel engines. Diagnostic schematics and signal values help technicians find problems to avoid unnecessary repairs.

The Engine Wiring Diagram consists of a circuit diagram for electrical components mounted on the engine side and vehicle side. For a detailed description of vehicle circuits, circuit numbers, or connector and fuse locations, see truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.

Engine Wiring Diagram EGED 430-2 is available in color-coded 11 x 17 inch double side 50 sheet pads. To order technical service literature, contact your International® dealer.

Sensor and Actuator Locations

Engine Mounted Components

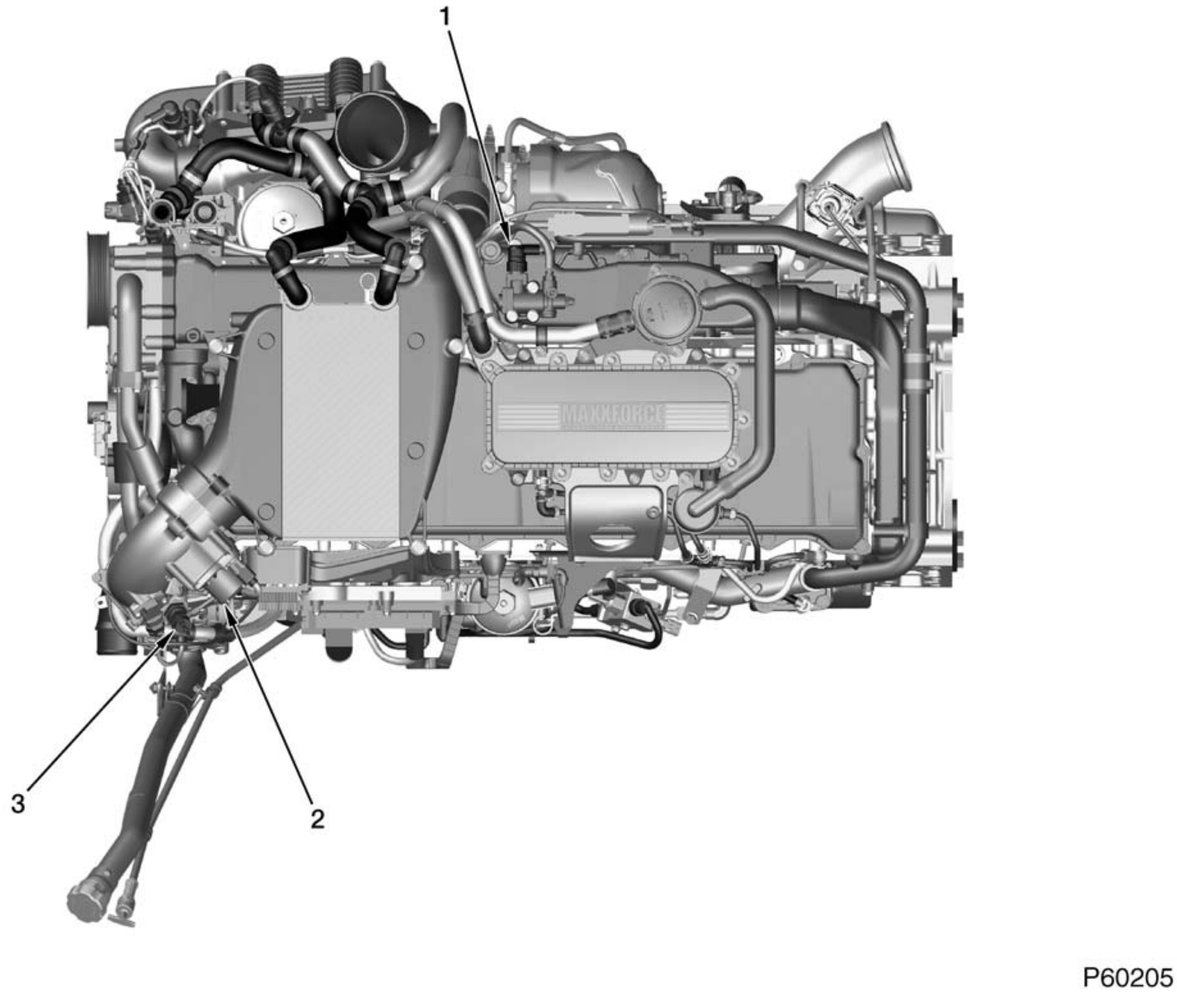

Figure 167 Component location – top

1. Exhaust Gas Recirculation (EGR) control valve
2. Intake Throttle Valve (ITV)
3. Glow plug

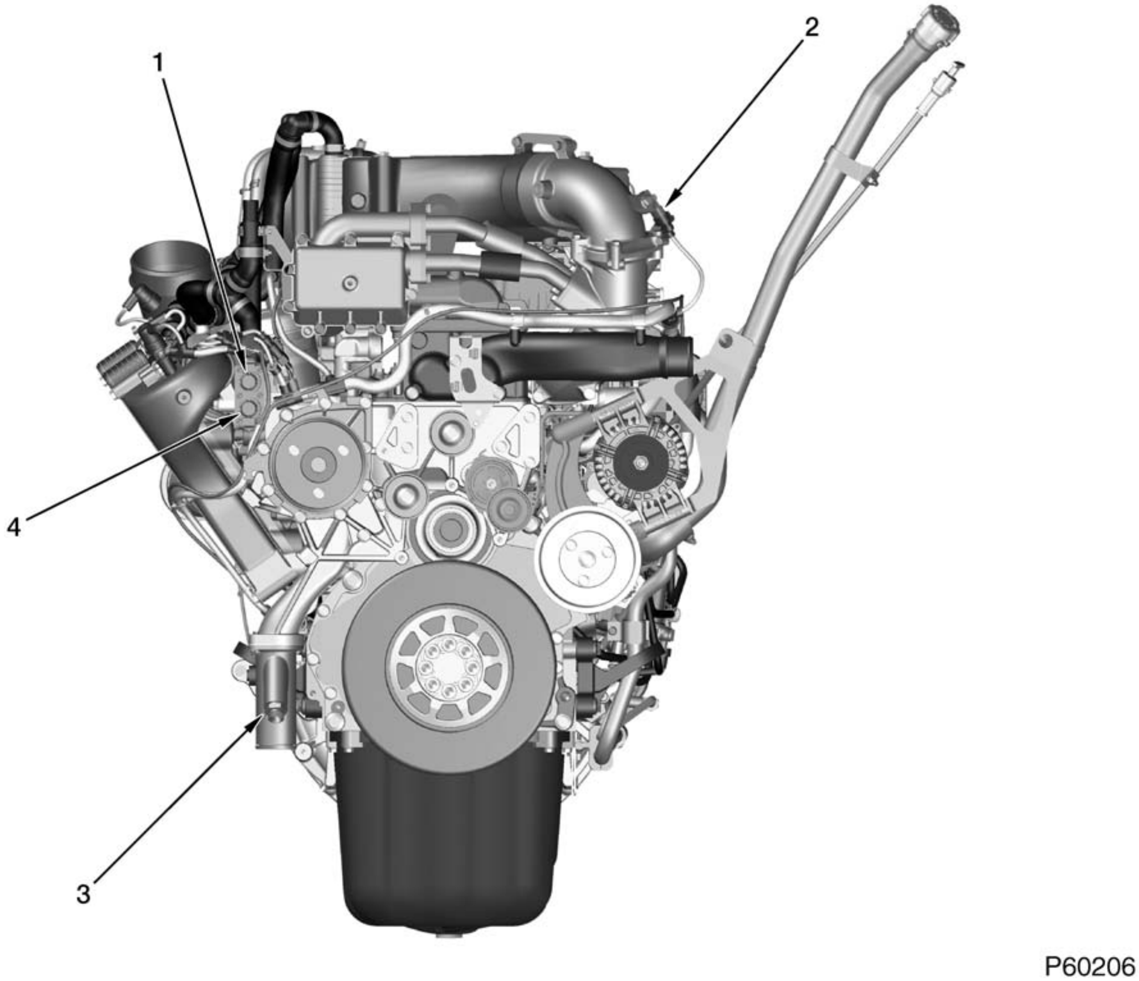

Figure 168 Component location – front

1. Coolant Mixer Valve (CMV)
2. Manifold Absolute Pressure/Intake Air Temperature (MAP/IAT2)
3. Coolant heater (if equipped)
4. Coolant Flow Valve (CFV)

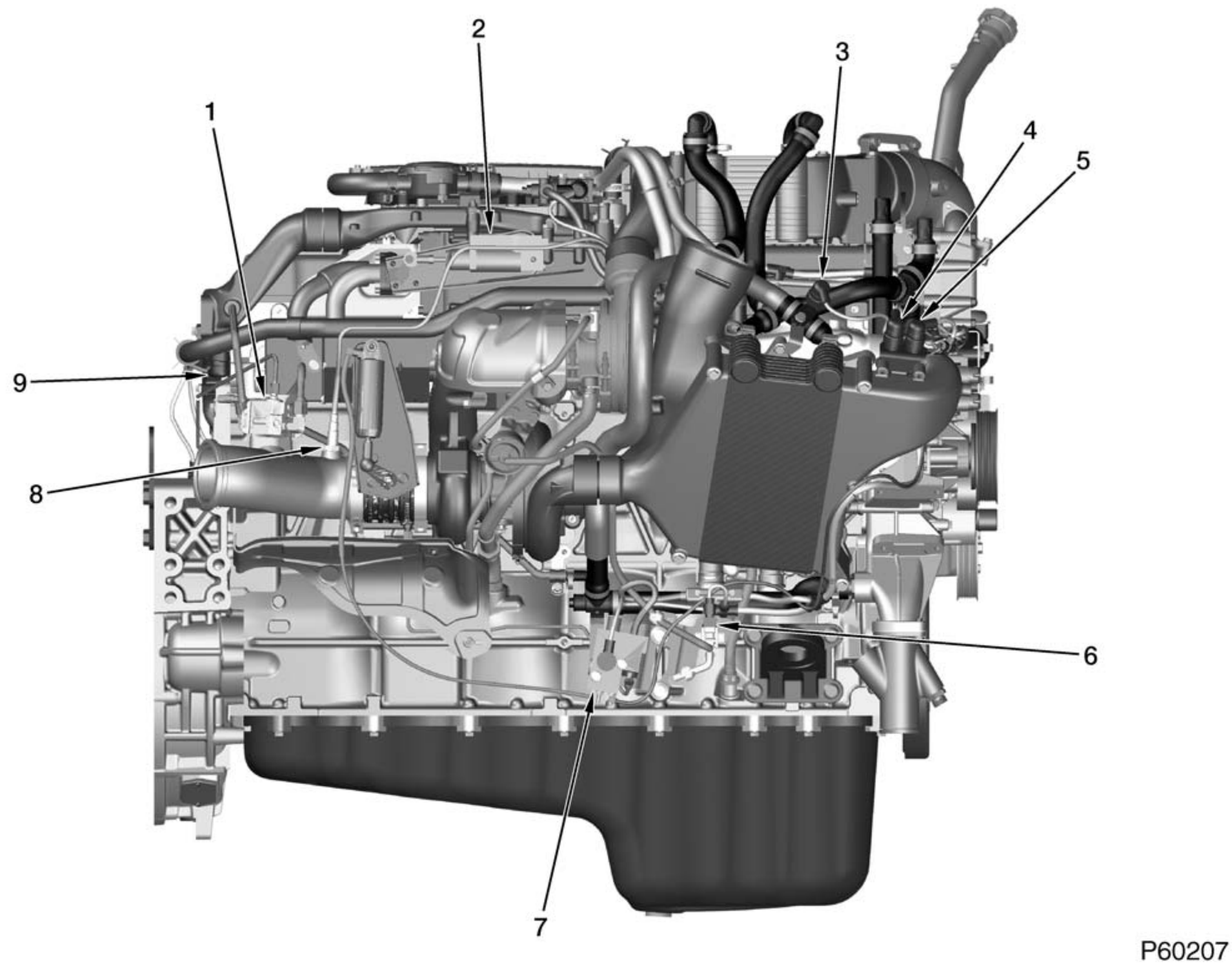

Figure 169 Component location – right

1. Aftertreatment Fuel Injector (AFI)
2. Exhaust Gas Recirculation (EGR) throttle valve with internal Exhaust Gas Recirculation Position (EGRP) sensor
3. Engine Coolant Temperature 2 (ECT2) sensor
4. Engine Oil Temperature (EOT) sensor adapter line
5. Engine Oil Pressure (EOP) sensor adapter line
6. Boost Control Solenoid (BCS) valve
7. Retarder control with internal Engine Back Pressure (EBP) sensor
8. Exhaust Lambda Sensor (ELS)
9. Engine Coolant Temperature (ECT) sensor

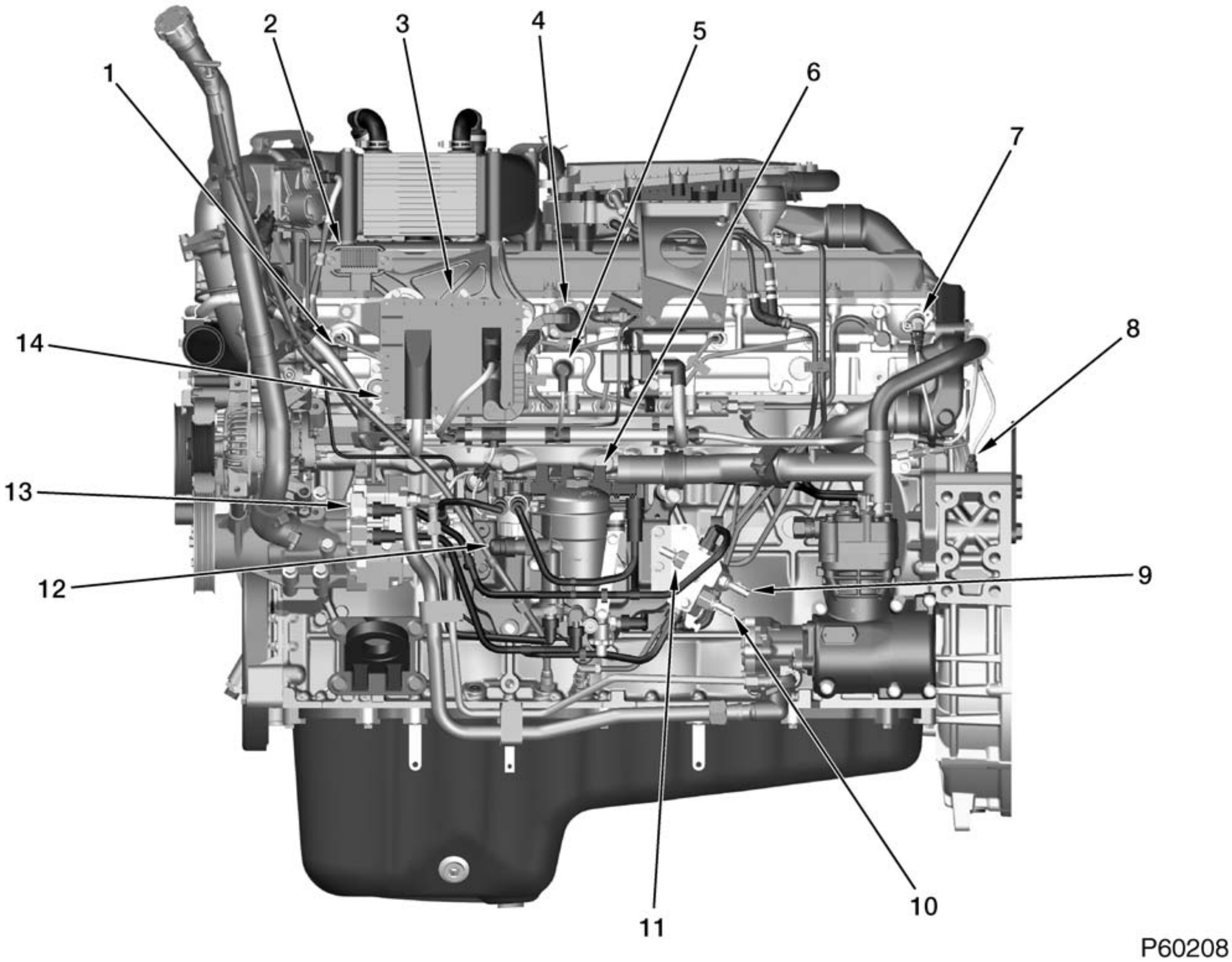

Figure 170 Component location – left

1. Cold Start Solenoid (CSS) valve
2. Cold Start Relay (CSR)
3. Engine Control Module (ECM)
4. Injector harness
5. Manifold Air Temperature (MAT) sensor
6. Engine Interface Module (EIM)
7. Camshaft Position (CMP) sensor
8. Crankshaft Position (CKP) sensor
9. Aftertreatment Fuel Pressure (AFP) sensor
10. Aftertreatment Fuel Supply (AFS) valve
11. Aftertreatment Fuel Drain (AFD) valve
12. Engine Fuel Pressure (EFP) sensor
13. High pressure pump with internal Fuel Pressure Control Valve (FPCV)
14. Fuel Rail Pressure (FRP) sensor

Vehicle Mounted Components

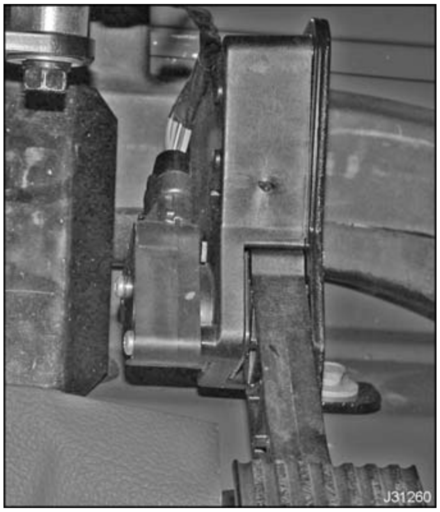

Figure 171 Accelerator Position Sensor/Idle Validation Switch (APS/IVS)

The APS/IVS is mounted on the accelerator pedal.

Diagnostic Procedure Process

Description

The test procedures in this section are written based on the assumption that a Diagnostic Trouble Code (DTC) is set or there is a problem with the component being tested.

Do checks in sequence unless directed otherwise. If a test point is out of specification, the comment area directs you to the possible cause or to another test point. It is not necessary to complete all of the test points, unless additional assistance is needed to pinpoint the fault.

Pin Grip Inspection

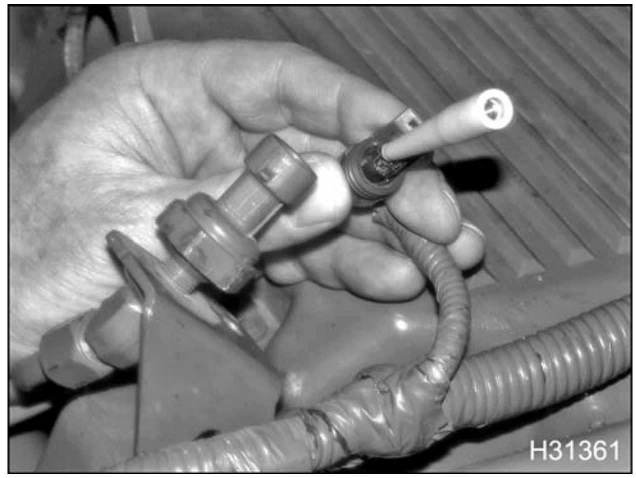

Figure 172 Pin grip check

1. Disconnect the electrical connector from the sensor or actuator.
2. Inspect for corrosion, bent pins, spread pins, or conditions that could cause a loose or intermittent connection.
3. Check the pin grip in the female pin by inserting the correct tool from Terminal Test Adapter Kit.

Diagnostics with Electronic Service Tool (EST)

Sensors can be diagnosed quickly using an EST with MasterDiagnostics® software. The EST monitors sensor signal back to the Engine Control Module (ECM) while testing the sensor's harness connection. Start this procedure with Sensor End Diagnostics (EST with MasterDiagnostics®) (page 198).

Diagnose actuators by running the Actuator Test using an EST with MasterDiagnostics® software. The actuator test commands the actuators to cycle to high and low state while measuring voltage at the actuator's harness connection.

Diagnostics without EST

Sensors can also be diagnosed by only using a Digital Multimeter (DMM). Start this test procedure with Pin-Point Diagnostics (without MasterDiagnostics®) (page 204).

Sensor End Diagnostics (EST with MasterDiagnostics®)

Sensor End Diagnostics (2-Wire)

1. Connect the EST to the vehicle diagnostic connector.
2. Turn the ignition switch to ON. Do not start the engine.
3. Start MasterDiagnostics® software.
4. Open the Continuous Monitor session. This session lists all engine sensors.

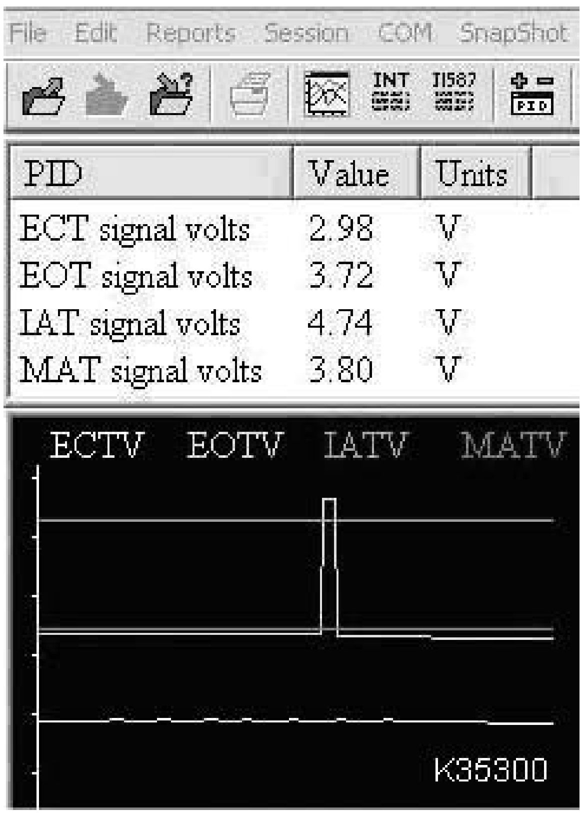

Figure 173 Sensor voltage

5. Monitor the sensor voltage and verify that an active DTC is present.
   - If the code is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected locations.

     If the circuit is interrupted, the signal will spike. Isolate the fault and repair.
   - If the code is active, continue to the next step.
6. Disconnect the sensor. Inspect the connector for corrosion or damaged pins using the Pin Grip Inspection (page 197). Repair as necessary.
7. Connect breakout harness to the engine harness. Leave the sensor disconnected.
8. Monitor the sensor signal voltage with the EST. The voltage should be greater than 4.87 volts with the sensor disconnected, unless the circuit is shorted to ground.

Example

Test Point	Spec	Comments
EST – Monitor EOTV	> 4.78 V	If < 4.78 V, check EOT signal for short to GND. Do Harness Resistance Check.

- If below specification, repair short to ground on the sensor signal circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If within specification, continue to next test point.

9. Short a 3-banana plug harness across the sensor signal circuit and engine ground.
10. Monitor the sensor signal voltage with the EST. The voltage should be 0 volts, unless the sensor signal circuit is open.

Example

Test Point	Spec	Comments
EST – Monitor EOTV Short 3-banana plug harness across 2 and GND	0 V	If > 0.2 V, check EOT signal for OPEN. Do Harness Resistance Check.

- If above specification, repair open in sensor signal circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If within specification, continue to next test point.

11. Short a 3-banana plug harness across the sensor signal circuit and SIG GND circuit.
12. Monitor the sensor signal voltage with the EST. The voltage should be 0 volts, unless the SIG GND circuit is open.

Example

Test Point	Spec	Comments
EST – Monitor EOTV Short 3-banana plug harness across 1 and 2	0 V	If > 0.2 V, check SIG GND for OPEN. Do Harness Resistance Check.

- If above specification, repair open in SIG GND circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If within specification, continue to next test point.

13. Short a 500 ohm resistor harness across the sensor signal circuit and SIG GND circuit.
14. Monitor the sensor signal voltage with the EST. The voltage should be less than 1.0 volt, unless the sensor signal circuit is shorted to voltage.

Example

Test Point	Spec	Comments
EST – Monitor EOTV Short 500 ohm resistor between 1 and 2	< 1.0 V	If > 1.0 V, check EOT signal circuit for short to PWR. Do Harness Resistance Check.

- If above specification, repair the short to voltage in the sensor signal circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If within specification, and both circuits tested okay, continue to the last step.

15. Connect the sensor and clear the DTCs, start the engine, and cycle the accelerator pedal a few times. If the active code remains, the sensor is at fault. Replace the failed sensor.

Example

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.

Sensor End Diagnostics (3-Wire)

1. Connect the EST to the vehicle diagnostic connector.
2. Turn the ignition switch to ON. Do not start engine.
3. Start MasterDiagnostics® software.
4. Run Continuous Monitor session. (This session lists all engine sensors.)

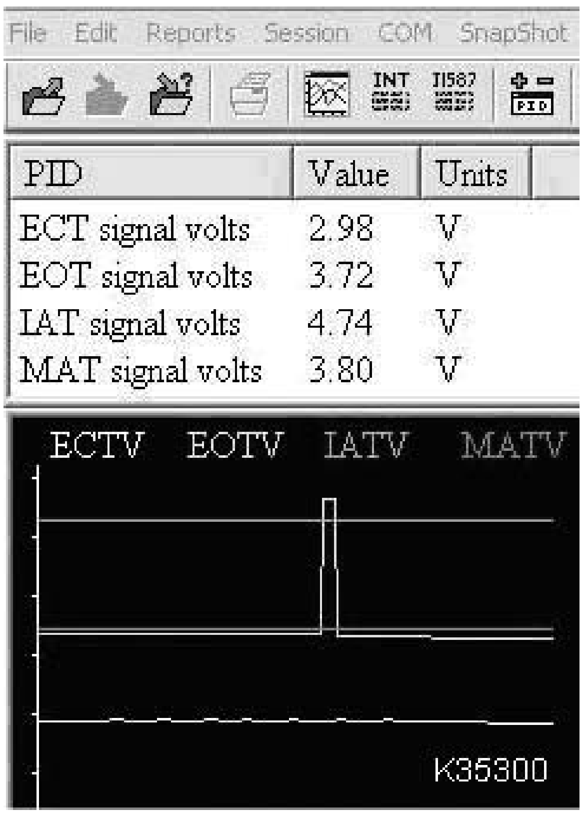

Figure 174 Sensor voltage

5. Monitor the sensor voltage and verify that an active DTC is present.
   - If the code is inactive, monitor the PID while wiggling the connector and all wires at suspected locations.

     If the circuit is interrupted, the signal will spike. Isolate the fault and repair.
   - If the code is active, continue to the next step.
6. Disconnect the sensor. Inspect the connector for corrosion or damaged pins using the Pin Grip Inspection (page 197). Repair as necessary.
7. Connect the breakout harness to the wiring harness. Leave the sensor disconnected.
8. Monitor sensor signal voltage with EST. The voltage should read near 0 volts with the sensor disconnected, unless the sensor signal circuit is shorted to power.

Example

Test Point	Spec	Comments
EST – Monitor MAPV	0 V	If > 0.039 V, check MAP signal for short to PWR

- If above specification, repair short to voltage on sensor signal circuit.
- If within specification, continue to next test point.

9. Use a DMM to measure voltage on the VREF circuit. The voltage should read 5 volts, unless VREF is open or shorted to ground, or a voltage is greater than VREF.

Example

Test Point	Spec	Comments
DMM – Measure volts	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR.
2 to GND		If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check.

- If not within specification, repair open or short in VREF circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If within specification, continue to the next test point.

10. Short 500 ohm resistor across VREF and the sensor signal circuit.
11. Monitor the sensor signal voltage with the EST. The voltage should read 5 volts, unless the sensor signal circuit is open.

Example

Test Point	Spec	Comments
EST – Monitor MAPV Short 500 ohm resistor harness across 2 and 3	5 V	If < 4.5 V, check MAP signal for OPEN. Do Harness Resistance Check.

- If below specification, repair open in sensor signal circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If within specification, continue to the next test point.

12. Use a DMM to measure resistance on the SIG GND circuit to ground. Resistance should read less than 5 ohms, unless the SIG GND is open.

Example

Test Point	Spec	Comments
DMM – Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check.

- If not within specification, repair open in the SIG GND circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If within specification, and all three circuits tested okay, continue to the last step.

13. Connect the sensor and clear the DTCs. If the active code remains, the sensor is at fault. Replace the failed sensor.

Example

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.

Pin-Point Diagnostics (without MasterDiagnostics®)

1. Connect breakout harness to the engine harness. Leave sensor disconnected.
2. Turn the ignition switch to ON. Do not start the engine.
3. Use a DMM to measure voltage on each circuit to engine ground.

Example

Test Point	Spec	Comment
C to GND	5 V	If > 5.5 V, check VREF for short to PWR.
		If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check.

- If the circuit is not within specification, the comment area lists possible causes or directs you to the next test point. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If the circuit is within specification, continue to the next test point.

Actuator Operational Voltage Check

This test allows you to take voltage measurements on actuators commanded high or low.

1. Disconnect the actuator. Inspect the connector for corrosion or damaged pins using the Pin Grip Inspection (page 197). Repair as necessary.
2. Connect the breakout harness between the engine harness and actuator.
3. Connect the EST to the vehicle diagnostic connector.
4. Turn the ignition switch to ON. Do not start the engine.
5. Start MasterDiagnostics® software.
6. Open the Actuator session. This session allows you to monitor the state of all engine actuators.
7. Run the Actuator Test.
8. Use a DMM to measure voltage on each circuit to engine ground.

Example

Test Point	Test	Spec	Comment
B to GND	Actuator State HIGH	B+	If < B+, check actuator control circuit for short to GND.
	Actuator State LOW	7.5 V	If > 7.5 V, check actuator control circuit for OPEN or short to PWR or OPEN across coil.

- If any circuit is not within specification, the comment area lists possible causes or directs you to the next test point.
- If all circuits are within specification, the actuator may not be operating mechanically.

Harness Resistance Check

Complete Sensor End Diagnostics or Pin-Point Diagnostics tests before using this procedure.

Resistance cannot be measured on a circuit if voltage is present. Isolate the circuit from voltage before continuing.

1. Turn the ignition switch to OFF or disconnect the batteries.

   WARNING: To prevent personal injury or death, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

2. Connect breakout box and breakout harness to vehicle or engine harness. Leave ECM and sensor or actuator disconnected.
3. Use a DMM to measure resistance on each circuit from point to point, then to engine ground.

Example

Test Point	Spec	Comment
A-85 to 1	< 5 Ω	If > 5 Ω, check EOT signal circuit for OPEN.
A-85 to GND	> 1 kΩ	If < 1 kΩ, check EOT signal circuit for short to GND.

- If the circuit is not within specification, the comment area lists possible circuit faults.
- If the circuit is within specification, continue to the next test point.

Operational Voltage Check

This test shows what a normal sensor or actuator should read at certain operating conditions. This test is helpful in diagnosing in-range faults or intermittent problems.

1. Connect breakout box or breakout harness between ECM and the component being tested.
2. Turn the ignition switch to ON. Do not start the engine.
3. Open Sensor Compare session or Actuator test session (depending on what is being tested) using the EST with MasterDiagnostics® software.
4. Verify actual sensor or actuator readings are within specification.

Example

Test Point	Condition	DMM	PID
APS	Foot off pedal	0.64 V ± 0.5 V	0%
A to GND or C-48 to GND	Pedal to floor	3.85 V ± 0.5 V	102%
IVS	Foot off pedal	0 V	0 V
D to GND or C-47 to GND	Pedal to floor	B+	B+

Circuit Diagnostics

AFD Valve (Aftertreatment Fuel Drain)

DTC	SPN	FMI	Condition
6902	8307	5	AFD valve circuit fault
6906	8306	14	AFS valve and AFD valve connections reversed

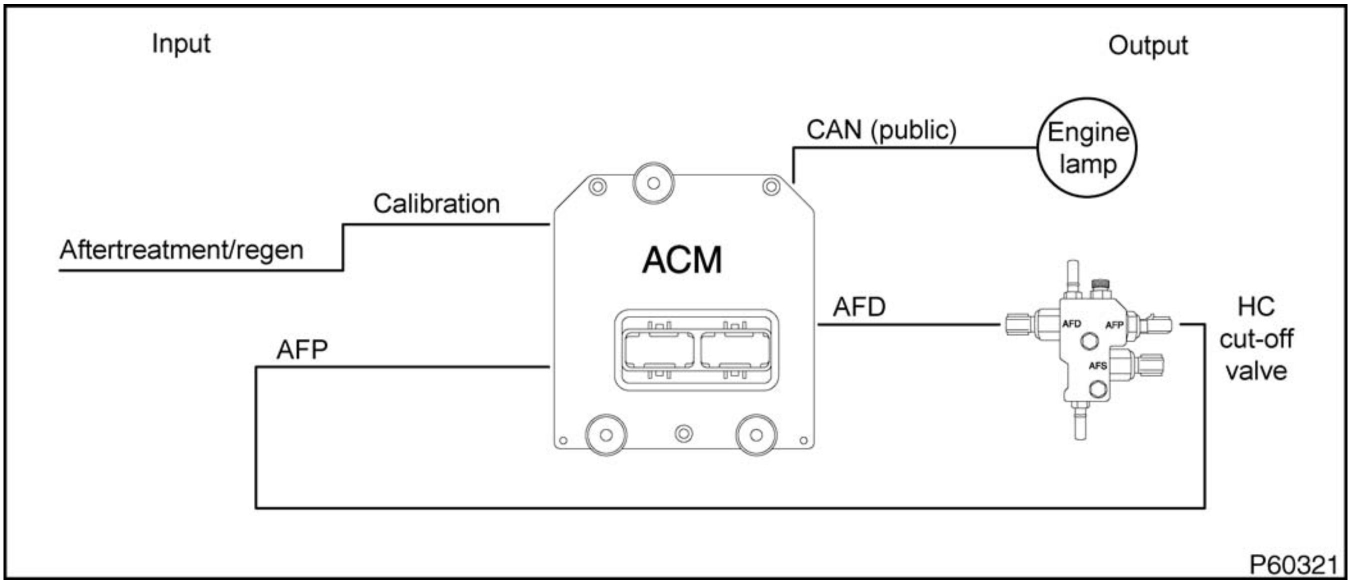

Figure 175 Functional diagram for AFD valve

The functional diagram for the AFD valve includes the following:

- Aftertreatment Control Module (ACM)
- Aftertreatment Fuel Pressure (AFP) sensor
- AFD valve
- Engine lamp (amber)
- CAN (public)
- Hydrocarbon (HC) cut-off valve

Function

The AFD valve is used to relieve the pressure from the aftertreatment fuel system. A fuel overpressure can occur due to fuel thermal expansion inside the Aftertreatment Fuel Injector (AFI) fuel supply line. When the fuel pressure increases, the ACM commands the AFD to open and relieve the fuel pressure into the fuel return line.

Component Location

The AFD valve is integrated into the HC cut-off valve which is located on the right side of the fuel filter.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- Aftertreatment 2-pin Breakout Harness (page 439)
- 180-Pin Breakout Box (page 438)
- Aftertreatment Harness (page 439)
- Terminal Test Adapter Kit (page 446)

AFD Connector End Diagnostics

DTC	Condition	Possible Causes
6902	AFD valve circuit fault	• AFD circuit OPEN or short to GND • AFD circuit short to PWR • ACM PWR circuit OPEN • Failed AFD valve
6906	AFS valve and AFD valve connections reversed	• AFS and AFD connectors reversed

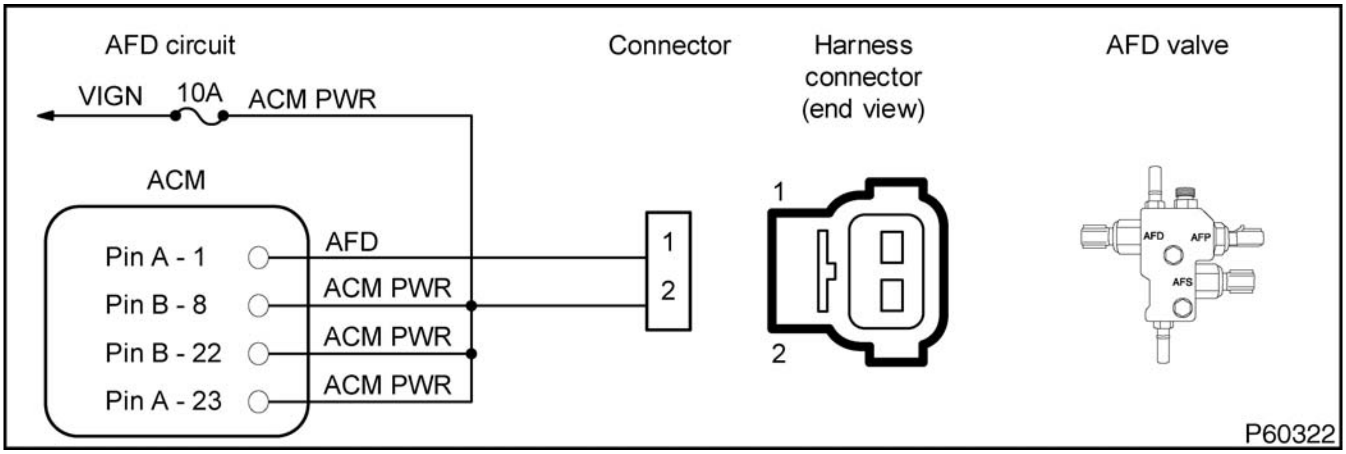

Figure 176 AFD circuit diagram

1. Key ON, engine OFF.
2. Connect the EST with MasterDiagnostics® software.
3. Verify correct engine is selected and launch EST.
4. Open D_Actuator.ssn session.

Connector Voltage Check

Connect breakout harness to engine harness and leave AFD valve disconnected. Turn ignition switch ON. Use DMM to measure voltage after 60 seconds.

Test Point	Spec	Comment
1 to GND	0 V	If > 0 V, check for short to PWR.
2 to GND	B+	If < B+, check for OPEN circuit or blown fuse. Do Harness Resistance Check (page 210).
If measurements are within specifications, do Operational Voltage Check - Actuator Test (page 210).		

Operational Voltage Check - Actuator Test

Connect breakout harness between AFD valve and engine harness. Run Actuator Test. Use DMM to measure voltage. Batteries must be fully charged before performing this test.

Test Point	Spec	Comment
DMM - Measure volts across pin 1 and GND		
Normal state	B+	If < B+, check for OPEN circuit. Do Harness Resistance Check (page 210).
Actuator state LOW	< 2 V	If > 2 V, check for OPEN AFD circuit.
Actuator state HIGH	> 9 V	If < 9 V, check AFD circuit for short to GND, or failed AFD.
If measurements are within specifications, do Actuator Resistance Check (page 210).		

Actuator Resistance Check

Turn ignition switch OFF. Connect breakout harness to AFD valve and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to 2	1 Ω to 8 Ω	If not within specification, replace the HC cut-off valve.
If measurements are within specifications, do Harness Resistance Check (page 210).		

Harness Resistance Check

Turn ignition switch OFF. Connect breakout box and breakout harness to engine harness and leave AFD valve and ACM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1k Ω, check for short circuit.
1 to A-1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1 kΩ	If < 1k Ω, check for short circuit.
2 to fuse	< 5 Ω	If > 5 Ω, check for OPEN circuit.

Actuator Test

The actuator test allows a technician to test the actuators by measuring voltage changes and visually monitoring actuator movement.

This test first runs through the Engine Control Module (ECM) actuators, then the Aftertreatment Control Module (ACM) actuators, and finishes with the Engine Interface Module (EIM) actuators.

ECM Actuators

During the ECM portion of the actuator test, all ECM actuators are commanded to LOW state, 8% to 15% duty cycle. Then one by one, each actuator is commanded to HIGH state, 80% to 100% duty cycle. This test will not cycle the Fuel Pressure Control Valve (FPCV) or the Exhaust Lambda Sensor (ELS) heater.

ACM Actuators

During the ACM portion of the actuator test, all ACM actuators remain at 0% duty cycle. Then one by one, each actuator is cycled on. The Aftertreatment Fuel Supply (AFS) valve and Aftertreatment Fuel Drain (AFD) valve are commanded to 100%, then drop to 66%. The Aftertreatment Fuel Injector (AFI) is commanded to a low duty cycle measured in seconds from 0 (off) to 0.1 (on).

EIM Actuators

During the EIM portion of the actuator test, the actuators cycle simultaneously. Fan Control Status is 1 (on), then cycles to 0 (off). The Cold Start Relay (CSR) and Cold Start Solenoid (CSS) is 0 (off), then cycles to 1 (on).

NOTE: When the Actuator Test is running, the sensor monitoring Parameter Identifiers (PIDs) are turned off.

This test cycles the following actuators:

- ECM actuators:
  - Intake Throttle Valve (ITV)
  - Boost Control Solenoid (BCS) valve
  - Exhaust Gas Recirculation (EGR) control valve
  - Coolant Mixer Valve (CMV)
  - Coolant Flow Valve (CFV)
- EIM actuators:
  - Cold Start Relay (CSR)
  - Cold Start Solenoid (CSS) valve
  - Electronic Fan Control (EFAN)
- ACM actuators:
  - Aftertreatment Fuel Drain (AFD) valve
  - Aftertreatment Fuel Supply (AFS) valve
  - Aftertreatment Fuel Injector (AFI)

AFI (Aftertreatment Fuel Injector)

DTC	SPN	FMI	Condition
6900	8305	12	AFI circuit fault

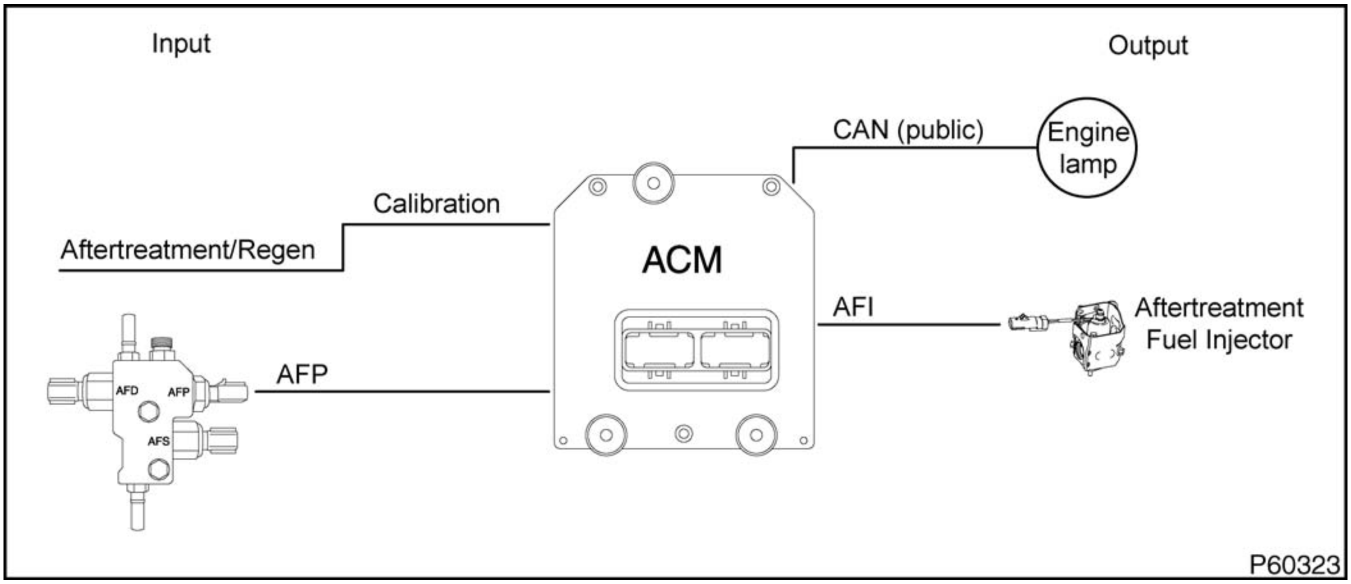

Figure 177 Functional diagram for AFI

The functional diagram for the AFI includes the following:

- Aftertreatment Control Module (ACM)
- Aftertreatment Fuel Pressure (AFP) sensor
- Aftertreatment/Regen calibration
- AFI
- CAN (public)
- Engine lamp (amber)
- Hydrocarbon (HC) cut-off valve

Function

Pressurized fuel is supplied to the AFI from the HC cut-off valve through the fuel filter housing assembly. When the conditions required for regeneration are met, the ACM sends voltage to the AFI to open and inject fuel into the turbo exhaust pipe.

Component Location

The AFI is located on the right side of the engine and is installed on the turbo exhaust pipe after the Exhaust Lambda Sensor (ELS).

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- Aftertreatment 2-pin Breakout Harness (page 439)
- 180-Pin Breakout Box (page 438)
- Aftertreatment Harness (page 439)
- Terminal Test Adapter Kit (page 446)

AFI Connector End Diagnostics

DTC	Condition	Possible Causes
6900	AFI circuit fault	• AFI circuit fault • Failed AFI

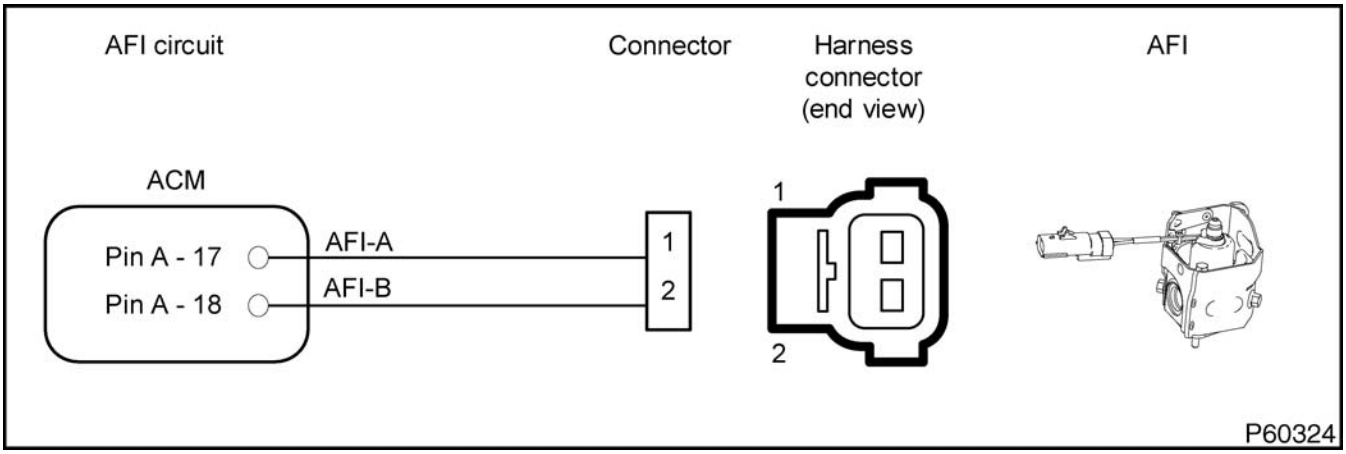

Figure 178 AFI circuit diagram

1. Key ON, engine OFF.
2. Connect the EST with MasterDiagnostics® software.
3. Verify correct engine is selected and launch EST.
4. Open D_Actuator.ssn session.

Connector Voltage Check

Connect breakout harness to engine harness and leave AFI disconnected. Turn ignition switch ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	B+	If < B+, check for OPEN circuit or short to GND. Do Harness Resistance Check (page 214).
2 to GND	B+	If < B+, check for OPEN circuit or short to GND. Do Harness Resistance Check (page 214).
If measurements are within specifications, do Operational Voltage Check - Actuator Test (page 214).		

Operational Voltage Check - Actuator Test

Connect breakout harness between AFI and engine harness. Run Actuator Test. Use DMM to measure voltage. Batteries must be fully charged before performing this test.

Test Point	Spec	Comment
DMM - Measure volts across pin 1 and GND		
Normal state	B+	If < B+, check for OPEN circuit. Do Harness Resistance Check (page 214).
Actuator state LOW	8 V +/- 1 V	If > 2 V, check for OPEN AFI circuit.
Actuator state HIGH	> 10 V	If < 10 V, check AFI circuit for short to GND, or failed AFI.
If measurements are within specifications, do Actuator Resistance Check (page 214).		

Actuator Resistance Check

Turn ignition switch OFF. Connect breakout harness to AFI and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to 2	< 2 Ω	If not within specification, replace the AFI.
If measurements are within specifications, do Harness Resistance Check (page 214).		

Harness Resistance Check

Turn ignition switch OFF. Connect breakout box and breakout harness to engine harness and leave AFI and ACM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1k Ω, check for short to GND.
1 to A-17	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1 kΩ	If < 1k Ω, check for short to GND.
2 to A-18	< 5 Ω	If > 5 Ω, check for OPEN circuit.

Actuator Test

The actuator test allows a technician to test the actuators by measuring voltage changes and visually monitoring actuator movement.

This test first runs through the Engine Control Module (ECM) actuators, then the Aftertreatment Control Module (ACM) actuators, and finishes with the Engine Interface Module (EIM) actuators.

ECM Actuators

During the ECM portion of the actuator test, all ECM actuators are commanded to LOW state, 8% to 15% duty cycle. Then one by one, each actuator is commanded to HIGH state, 80% to 100% duty cycle. This test will not cycle the Fuel Pressure Control Valve (FPCV) or the Exhaust Lambda Sensor (ELS) heater.

ACM Actuators

During the ACM portion of the actuator test, all ACM actuators remain at 0% duty cycle. Then one by one, each actuator is cycled on. The Aftertreatment Fuel Supply (AFS) valve and Aftertreatment Fuel Drain (AFD) valve are commanded to 100%, then drop to 66%. The Aftertreatment Fuel Injector (AFI) is commanded to a low duty cycle measured in seconds from 0 (off) to 0.1 (on).

EIM Actuators

During the EIM portion of the actuator test, the actuators cycle simultaneously. Fan Control Status is 1 (on), then cycles to 0 (off). The Cold Start Relay (CSR) and Cold Start Solenoid (CSS) is 0 (off), then cycles to 1 (on).

NOTE: When the Actuator Test is running, the sensor monitoring Parameter Identifiers (PIDs) are turned off.

This test cycles the following actuators:

- ECM actuators:
  - Intake Throttle Valve (ITV)
  - Boost Control Solenoid (BCS) valve
  - Exhaust Gas Recirculation (EGR) control valve
  - Coolant Mixer Valve (CMV)
  - Coolant Flow Valve (CFV)
- EIM actuators:
  - Cold Start Relay (CSR)
  - Cold Start Solenoid (CSS) valve
  - Electronic Fan Control (EFAN)
- ACM actuators:
  - Aftertreatment Fuel Drain (AFD) valve
  - Aftertreatment Fuel Supply (AFS) valve
  - Aftertreatment Fuel Injector (AFI)

AFP Sensor (Aftertreatment Fuel Pressure)

DTC	SPN	FMI	Condition
5558	7314	4	AFP VREF out-of-range
5560	7310	4	AFP signal out-of-range LOW
5561	7310	3	AFP signal out-of-range HIGH

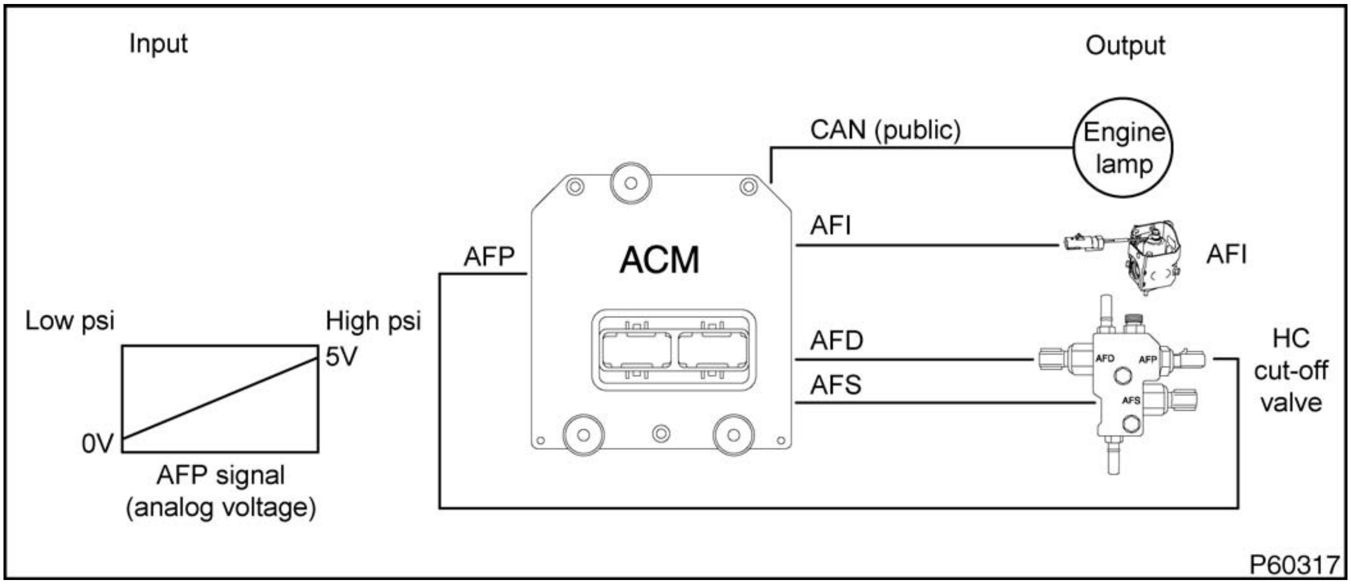

Figure 179 Functional diagram for the AFP sensor

The functional diagram for the AFP sensor includes the following:

- Aftertreatment Control Module (ACM)
- Aftertreatment Fuel Drain (AFD) valve
- Aftertreatment Fuel Supply (AFS) valve
- Aftertreatment Fuel Injector (AFI)
- AFP sensor
- CAN (public)
- Engine lamp (amber)
- Hydrocarbon (HC) cut-off valve

Function

The AFP sensor monitors the fuel pressure in the aftertreatment fuel system and provides a feedback signal to the ACM.

Sensor Location

The AFP sensor is integrated into the Hydrocarbon (HC) cut-off valve which is located on the right side of the fuel filter.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 3-Banana Plug Harness (page 437)
- 500 Ohm Resistor Harness (page 439)
- 180-Pin Breakout Box (page 438)
- Aftertreatment Harness (page 439)
- Aftertreatment Fuel Pressure Breakout Harness (page 440)
- Terminal Test Adapter Kit (page 446)

AFP Sensor End Diagnostics

DTC	Condition	Possible Causes
5558	AFP VREF out-of-range	• AFP VREF circuit shorted or OPEN
5560	AFP signal out-of-range LOW	• AFP signal circuit OPEN or short to GND • Failed AFP sensor
5561	AFP signal out-of-range HIGH	• AFP signal circuit short to PWR • Failed AFP sensor

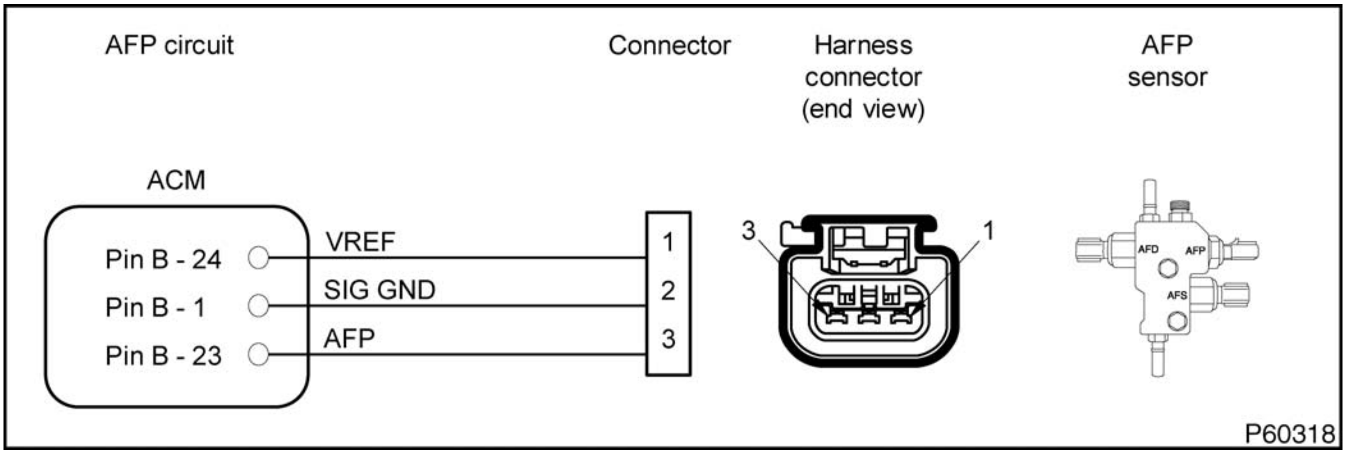

Figure 180 AFP circuit diagram

1. Using the EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at the suspected location. If the circuit is interrupted, the PID spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor. Inspect connectors for damaged pins, corrosion, or loose pins using the Pin Grip Inspection (page 197). Repair if necessary.
4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect breakout harness. Leave sensor disconnected. Turn the ignition switch to ON. Use EST to monitor PIDs and DMM to measure voltage.

Test Point	Spec	Comment
EST – Monitor AFPv	0 V	If > 0.25 V, check AFP signal circuit for short to PWR
DMM — Measure volts 1 to GND	5.0 V +/- 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Checks (page 220).
EST – Monitor AFPv Short across breakout harness pins 1 and 3	5 V	If < 4.5 V, check AFP signal circuit for OPEN. Do Harness Resistance Checks (page 220).
DMM — Measure voltage 1 to 2	5 v +/- 0.5 V	If < 4.5 V, check SIG GND for OPEN. Do Harness Resistance Checks (page 220).

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace HC cut-off valve.

AFP Pin-Point Diagnostics

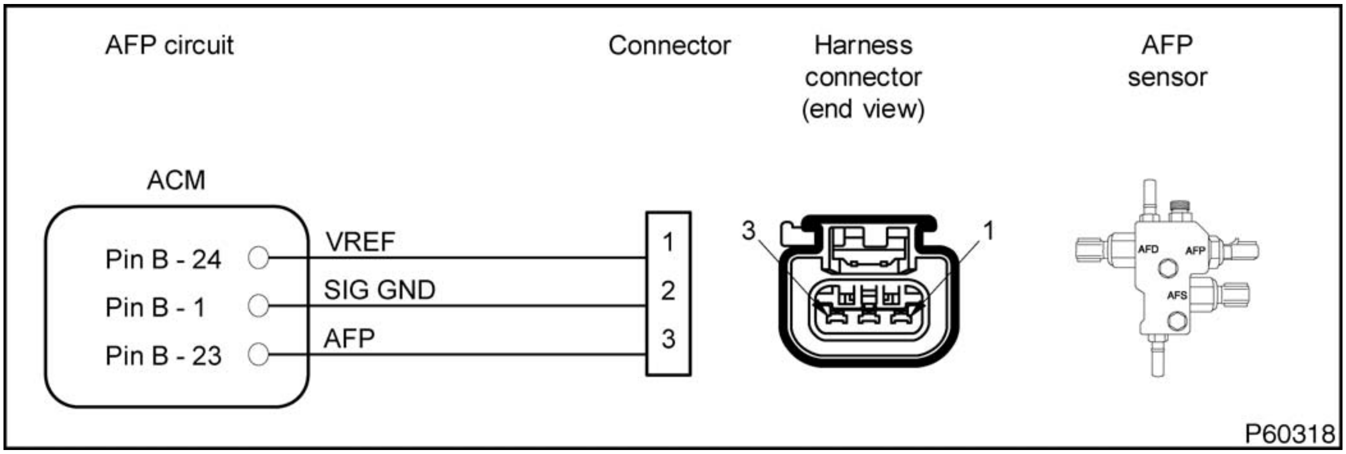

Figure 181 AFP circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	5 V	If > 5.5 V, check VREF for short to PWR.
		If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Checks (page 220).
2 to GND	0 V	If > 0.25 V, check SIG GND circuit for short to PWR.
3 to GND	0 V	If > 0.25 V, check AFP for short to PWR

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
2 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Do Harness Resistance Checks (page 220).
3 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave ACM and AFP sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to B-24	< 5 Ω	If > 5 Ω, check VREF signal circuit for OPEN.
2 to B-1	< 5 Ω	If > 5 Ω, check SIG RTN circuit for OPEN.
3 to B-23	< 5 Ω	If > 5 Ω, check AFP circuit for OPEN.

AFP Circuit Operation

The AFP sensor is a pressure sensor that is supplied with 5 volts at Pin 1 from ACM Pin B-24. The sensor is grounded at Pin 2 from ACM Pin B-1 and returns a variable voltage signal from Pin 3 to ACM Pin B-23.

AFS Valve (Aftertreatment Fuel Supply)

DTC	SPN	FMI	Condition
6901	8306	5	AFS Valve circuit fault
6906	8306	14	AFS valve and AFD valve connections reversed

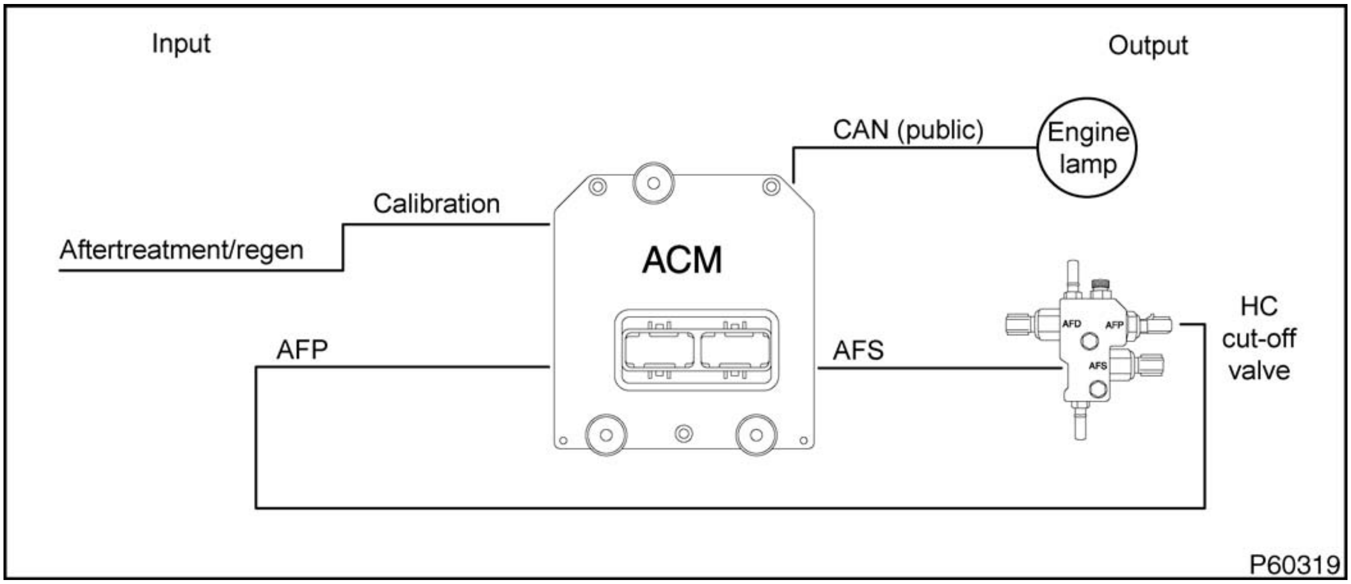

Figure 182 Functional diagram for AFS valve

The functional diagram for the AFS valve includes the following:

- Aftertreatment Control Module (ACM)
- Aftertreatment Fuel Pressure (AFP) Sensor
- Aftertreatment/Regen calibration
- AFS valve
- CAN (public)
- Engine lamp (amber)
- Hydrocarbon (HC) cut-off valve

Function

The AFS valve controls the fuel supply to the AFI when regeneration is required. The AFS valve is controlled by the ACM.

Component Location

The AFS valve is integrated into the HC cut-off valve which is located on the right side of the fuel filter.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- Aftertreatment 2-pin Breakout Harness (page 439)
- 180-Pin Breakout Box (page 438)
- Aftertreatment Harness (page 439)
- Terminal Test Adapter Kit (page 446)

AFS Valve Connector End Diagnostics

DTC	Condition	Possible Causes
6901	AFS Valve circuit fault	• AFS signal circuit fault • Failed AFS valve
6906	AFS valve and AFD valve connections reversed	• AFS and AFD connectors reversed

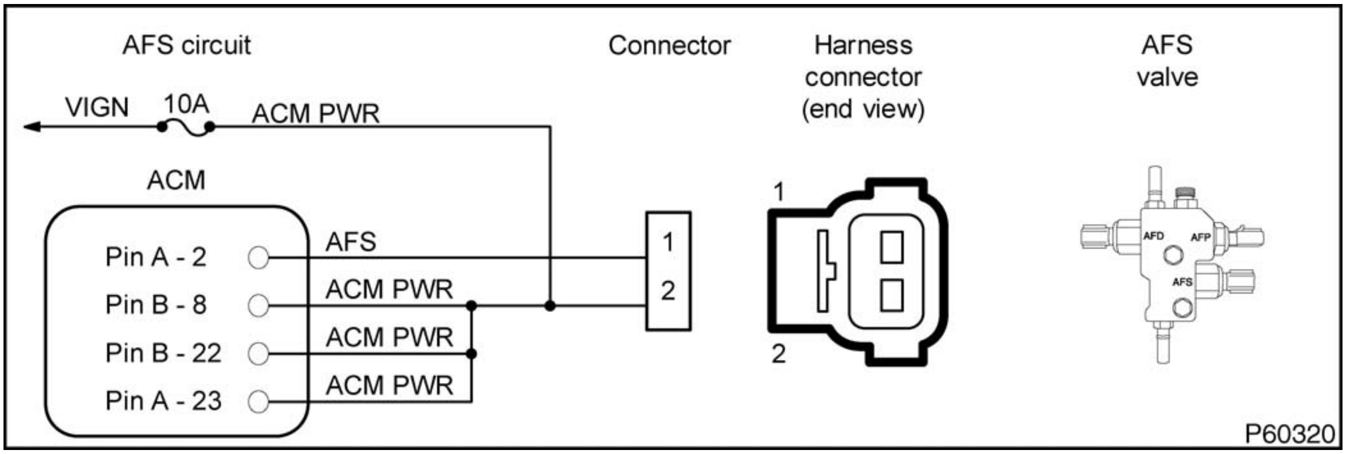

Figure 183 AFS circuit diagram

1. Key ON, engine OFF.
2. Connect the EST with MasterDiagnostics® software.
3. Verify correct engine is selected and launch EST.
4. Open D_Actuator.ssn session.

Connector Voltage Check

Connect breakout harness to engine harness and leave AFS valve disconnected. Turn ignition switch ON. Use DMM to measure voltage after 60 seconds.

Test Point	Spec	Comment
1 to GND	0 V	If > 0 V, check for short to PWR.
2 to GND	B+	If < B+, check for OPEN circuit or blown fuse. Do Harness Resistance Check (page 223)
If measurements are within specifications, do Operational Voltage Check - Actuator Test (page 223).		

Operational Voltage Check - Actuator Test

Connect breakout harness between AFS valve and engine harness. Run Actuator Test. Use DMM to measure voltage. Batteries must be fully charged before performing this test.

Test Point	Spec	Comment
DMM - Measure volts across pin 1 and GND		
Normal state	B+	If < B+, check for OPEN circuit. Do Harness Resistance Check (page 223).
Actuator state LOW	< 2 V	If > 2 V, check for OPEN AFS circuit.
Actuator state HIGH	> 9 V	If < 9 V, check AFS circuit for short to GND, or failed AFS valve.
If measurements are within specifications, do Actuator Resistance Check (page 223).		

Actuator Resistance Check

Turn ignition switch OFF. Connect breakout harness to AFS valve and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to 2	1 Ω to 8 Ω	If not within specification, replace the HC cut-off valve.
If measurements are within specifications, do Harness Resistance Check (page 223).		

Harness Resistance Check

Turn ignition switch OFF. Connect breakout box and breakout harness to engine harness and leave AFS valve and ACM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1k Ω, check for short to GND.
1 to A-2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1 kΩ	If < 1k Ω, check for short to GND.
2 to fuse	< 5 Ω	If > 5 Ω, check for OPEN circuit.

Actuator Test

The actuator test allows a technician to test the actuators by measuring voltage changes and visually monitoring actuator movement.

This test first runs through the Engine Control Module (ECM) actuators, then the Aftertreatment Control Module (ACM) actuators, and finishes with the Engine Interface Module (EIM) actuators.

ECM Actuators

During the ECM portion of the actuator test, all ECM actuators are commanded to LOW state, 8% to 15% duty cycle. Then one by one, each actuator is commanded to HIGH state, 80% to 100% duty cycle. This test will not cycle the Fuel Pressure Control Valve (FPCV) or the Exhaust Lambda Sensor (ELS) heater.

ACM Actuators

During the ACM portion of the actuator test, all ACM actuators remain at 0% duty cycle. Then one by one, each actuator is cycled on. The Aftertreatment Fuel

Supply (AFS) valve and Aftertreatment Fuel Drain (AFD) valve are commanded to 100%, then drop to 66%. The Aftertreatment Fuel Injector (AFI) is commanded to a low duty cycle measured in seconds from 0 (off) to 0.1 (on).

EIM Actuators

During the EIM portion of the actuator test, the actuators cycle simultaneously. Fan Control Status is 1 (on), then cycles to 0 (off). The Cold Start Relay (CSR) and Cold Start Solenoid (CSS) is 0 (off), then cycles to 1 (on).

NOTE: When the Actuator Test is running, the sensor monitoring Parameter Identifiers (PIDs) are turned off.

This test cycles the following actuators:

- ECM actuators:
  - Intake Throttle Valve (ITV)
  - Boost Control Solenoid (BCS) valve
  - Exhaust Gas Recirculation (EGR) control valve
  - Coolant Mixer Valve (CMV)
  - Coolant Flow Valve (CFV)
- EIM actuators:
  - Cold Start Relay (CSR)
  - Cold Start Solenoid (CSS) valve
  - Electronic Fan Control (EFAN)
- ACM actuators:
  - Aftertreatment Fuel Drain (AFD) valve
  - Aftertreatment Fuel Supply (AFS) valve
  - Aftertreatment Fuel Injector (AFI)

AFT System (Aftertreatment)

DTC	SPN	FMI	Condition
2687	8302	1	DPF low flow resistance
2698	3251	0	DPF high restriction
2773	8303	10	DOC unable to reach regen temp
2774	8303	1	DOC efficiency – AFI low flow
3787	8326	2	DPF cleanliness test – soot level too high
5559	7310	2	AFP sensor failed ambient pressure test
6814	3242	7	EGT2 Temp above maximum severe
6817	3245	7	EGT3 Temp above maximum severe
6905	8306	7	Aftertreatment fuel leak: fuel line, AFD, or AFI
6910	8307	12	AFD valve fail to open
6912	8308	7	AFP above normal with AFS closed
6913	7310	7	AFP above normal with AFD open
6914	7310	1	AFP below normal during DPF regen

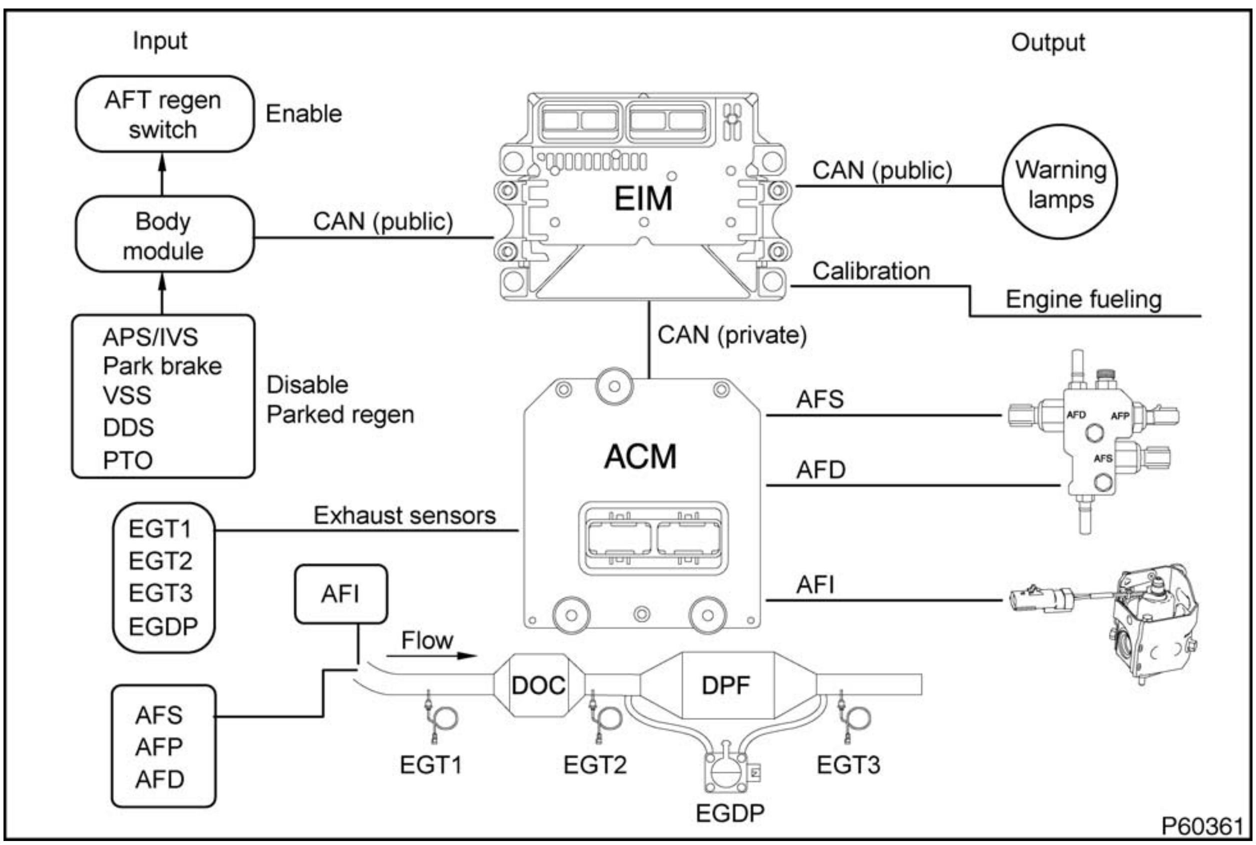

Figure 184 Functional diagram for AFT System

The functional diagram for the AFT System includes the following:

- Aftertreatment Fuel Drain (AFD) valve
- Aftertreatment Fuel Injector (AFI)
- Aftertreatment Fuel Pressure (AFP) sensor
- Aftertreatment Fuel Supply (AFS) valve
- Engine Control Module (ECM)
- Diesel Oxidation Catalyst (DOC)
- Diesel Particulate Filter (DPF)
- Exhaust Gas Temperature 1 (EGT1) sensor
- Exhaust Gas Temperature 2 (EGT2) sensor
- Exhaust Gas Temperature 3 (EGT3) sensor
- Exhaust Gas Differential Pressure (EGDP) sensor
- Warning lamps
- AFT regen switch
- Accelerator Position Sensor (APS)/Idle Validation Switch (IVS)
- Vehicle Speed Sensor (VSS)
- Driveline Disconnect Switch (DDS)
- Power Takeoff (PTO)

Function

The AFT System is designed to decrease the exhaust particulate emissions leaving the tailpipe. The DPF captures particulate matter (soot) and ash from the exhaust. Eventually soot and ash exceeds DPF capacity and must be removed. Soot build-up is removed by heating the filter until the soot turns into carbon dioxide gas. This is the DPF regeneration process. Ash build-up is periodically removed from the filter by a special cleaning machine.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)

AFT System Diagnostics

DTC	Condition	Possible Causes
2687	DPF low flow resistance	• Exhaust leak before DPF • Leaking or reversed EGDP sensor hoses • Failed DPF (open flow) • Biased EGDP sensor or circuit
2698	DPF high restriction	• DPF needs to regenerate
2773	DOC unable to reach regen temp	• Failed DOC
2774	DOC efficiency – AFI low flow	• AFI injection fault
3787	DPF cleanliness test – soot level too high	• DPF soot load too high • DPF service required
5559	AFP sensor failed ambient pressure test	• Biased circuit or AFP sensor • Open AFS valve • Closed AFD sensor
6814	EGT2 temp above maximum severe	• EGT2 above 800 °C (1472 °F) for 10 seconds • Over-fueling • Plugged DPF or exhaust system • Biased EGT2 sensor or circuit
6817	EGT3 temp above maximum severe	• EGT3 above 800 °C (1472 °F) for 10 seconds • Over-fueling • Plugged DPF or exhaust system • Biased EGT3 sensor or circuit
6905	Aftertreatment fuel leak: fuel line, AFD, or AFI	• Leaking fuel line • AFS valve fault • AFD valve fault • Biased AFP sensor or circuit
6910	AFD valve fail to open	• AFD valve or circuit fault
6912	AFP above normal with AFS closed	• AFS valve or circuit fault • Biased AFP sensor or circuit

6913	AFP above normal with AFD open	• AFD valve or circuit fault • Biased AFP sensor or circuit
6914	AFP below normal during DPF regen	• Fuel pressure below 296 kPa (43 psi) for 5 seconds during regen • AFD valve or circuit fault • AFS valve or circuit fault • Biased AFP sensor or circuit

Alert Levels of DPF Soot Loading

There are four indication levels that the DPF is accumulating a level of soot and needs to be cleaned, each with an increasing urgency for action.

Levels	Conditions	Action
Regeneration lamp on solid	Exhaust regeneration required	Drive on highway at highway speeds so the system can go into active regeneration. OR Start a parked regeneration to prevent loss of power.
Regeneration lamp flashing	DPF is full	Pull vehicle safely off of the road and start a parked regeneration to prevent loss of power.
Regeneration lamp flashing Warn Engine lamp on solid Audio alarm beeps 5 times every minute	DPF is full engine performance is limited	Pull vehicle safely off of the road and start a parked regeneration to prevent engine stopping.
Regeneration lamp flashing Engine STOP lamp on solid Audio alarm beeps continuously	DPF is overfull engine may shutdown soon	Pull vehicle safely off of the road, turn on flashers, place warning devices and STOP ENGINE, DO NOT USE parked regeneration. Call for service.
When the High Exhaust System Temperature lamp is illuminated, the exhaust temperature is above 400 °C (750 °F) and a regeneration could be in process.		

DTC 2687 – DPF low flow resistance

DTC 2687 is set when the measured DPF differential pressure is less than a minimum value for a certain exhaust flow rate.

Pin-Point AFT System Fault

1. Inspect exhaust and EGDP sensor for damage. Check for leaks in exhaust or EGDP sensor hose. Check that EGDP sensor hoses are not reversed.
2. Check for active EGDP sensor DTCs. See EGDP Sensor (Exhaust Gas Differential Pressure) (page 320) in this section of the manual.
3. Check for high exhaust back pressure due to a plugged DOC. See “Appendix A: Performance Specifications” in this manual for maximum EBP.
4. Check for damaged DPF. Remove and inspect for cracks that could allow exhaust gas to bypass the filter.

DTC 2698 – DPF high restriction

DTC 2698 is set when the measured DPF differential pressure exceeds a maximum value for a certain exhaust flow rate.

Pin-Point AFT System Fault

1. Check for active DTCs that could prevent AFT system regeneration.
2. Do a Parked Regeneration. See Manual Parked Regeneration (page 233) in this section.
3. If unable to do a parked regeneration, use the EST and run the Aftertreatment (AFT) Cleanliness Test (page 172) in the “Performance Diagnostics” section of this manual.

DTC 2773 – DOC unable to reach regen temp

DTC 2773 is set when the EGT2 sensor is not heating up during a fuel injected regen. EGT3 is heating up indicating that fuel is not igniting until it reaches the DPF.

Pin-Point AFT System Fault

1. Check for active DTCs that could prevent AFT system regeneration.
2. Check all Exhaust Gas Temperature sensors for in-range biased signal. See “Appendix A: Performance Specifications” in this manual.
3. Check for engine performance problems.
4. Test Aftertreatment (AFT) System for faults. Run the Aftertreatment Fuel Injector (AFI) Flow Test (page 173) in the “Performance Diagnostics” section of this manual.
5. Check for damaged DOC. Remove and inspect for damage.

DTC 2774 – DOC efficiency - AFI low flow

DTC 2774 is set when the EGT2 and EGT3 sensors are not warming up during a fuel injected regen.

Pin-Point AFT System Fault

1. Check for active DTCs that could prevent AFT system regeneration.
2. Check all Exhaust Gas Temperature sensors for in-range biased signal. See “Appendix A: Performance Specifications” in this manual.
3. Check for engine performance problems.
4. Test Aftertreatment (AFT) System for faults. Run the Aftertreatment Fuel Injector (AFI) Flow Test (page 173) in the “Performance Diagnostics” section of this manual.

DTC 3787 – DPF cleanliness test - soot level too high

DTC 3787 is set when the DPF soot level has reached its set limit.

Pin-Point AFT System Fault

1. Remove and service the DPF.

DTC 5559 – AFP sensor failed ambient pressure test

DTC 5559 is set when the AFP signal is not changing with the system in operation.

Pin-Point AFT System Fault

1. Check for biased AFP sensor or circuit.
2. Check for active AFD or AFS DTCs. See AFD Valve (Aftertreatment Fuel Drain) (page 208) and AFS (Aftertreatment Fuel Supply) Valve (page 221) in this section.
3. Run Aftertreatment (AFT) System Leak Test (page 174) and Aftertreatment Fuel Supply (AFS) Valve Leak Test (page 176) while monitoring AFP PID in the “Performance Diagnostics” section of this manual.

DTC 6814 – EGT2 temp above maximum severe

DTC 6814 is set when the DOC outlet temperature exceeds the safe maximum temperature for more than 10 seconds.

Pin-Point AFT System Fault

1. Check engine performance and verify engine is not over-fueling.
2. Check for damaged DPF. Remove and inspect for blockage.
3. Check for active EGT2 sensor DTCs. See EGT2 Sensor (Exhaust Gas Temperature 2) (page 341) in this section.
4. Check for active EGR control valve faults or DTCs. See EGR Control Valve (Exhaust Gas Recirculation) (page 325) in this section.
5. Check for active ITV faults or DTCs. See ITV (Intake Throttle Valve) Actuator (page 408) in this section.

6. Test Aftertreatment (AFT) System for faults. Run the Aftertreatment Fuel Injector (AFI) Flow Test (page 173) in the “Performance Diagnostics” section of this manual.

DTC 6817 – EGT3 temp above maximum severe

DTC 6817 is set when the DPF outlet temperature exceeds the safe maximum temperature for more than 10 seconds.

Pin-Point AFT System Fault

1. Check engine performance and verify engine is not over-fueling.
2. Check for other active DTCs that would cause an over-fueling issue.
3. Check EGT3 sensor for a biased signal. See EGT3 Sensor (Exhaust Gas Temperature 3) (page 345) in this section.
4. Test Aftertreatment (AFT) System for faults. Run the Aftertreatment Fuel Injector (AFI) Flow Test (page 173) in the “Performance Diagnostics” section of this manual.

DTC 6905 – Aftertreatment fuel leak: fuel line, AFD, or AFI

DTC 6905 is set when the AFS is opened yet the pressure in the aftertreatment fuel system does not build up as expected.

Pin-Point AFT System Fault

1. Check for biased AFP sensor or circuit.
2. Check for active AFD or AFS DTCs. See AFD Valve (Aftertreatment Fuel Drain) (page 208) and AFS Valve (Aftertreatment Fuel Supply) (page 221) in this section.
3. Run Aftertreatment (AFT) System Leak Test (page 174) and Aftertreatment Fuel Supply (AFS) Valve Leak Test (page 176) while monitoring AFP PID in the “Performance Diagnostics” section of this manual.

DTC 6910 – AFD valve fail to open

DTC 6910 is set when the ACM detects that the driver output for the AFD valve is opened or shorted.

Pin-Point AFT System Fault

1. Check for biased AFP sensor or circuit.
2. Check for active AFD or AFS DTCs. See AFD Valve (Aftertreatment Fuel Drain) (page 208) and AFS Valve (Aftertreatment Fuel Supply) (page 221) in this section.
3. Run Aftertreatment (AFT) System Leak Test (page 174) and Aftertreatment Fuel Supply (AFS) Valve Leak Test (page 176) while monitoring AFP PID in the “Performance Diagnostics” section of this manual.

DTC 6912 – AFP above normal with AFS closed

DTC 6912 is set when the ACM fails its internal system leak test (which happens once per key-cycle or on demand from the service tool), or if the pressure in the system rises when the AFS is not being commanded open.

Pin-Point AFT System Fault

1. Check for biased AFP sensor or circuit.
2. Check for active AFD or AFS DTCs. See AFD Valve (Aftertreatment Fuel Drain) (page 208) and AFS Valve (Aftertreatment Fuel Supply) (page 221) in this section.
3. Run Aftertreatment (AFT) System Leak Test (page 174) and Aftertreatment Fuel Supply (AFS) Valve Leak Test (page 176) while monitoring AFP PID in the “Performance Diagnostics” section of this manual.

DTC 6913 – AFP above normal with AFD open

DTC 6913 is set when the AFP signal is above normal with the AFD valve open.

Pin-Point AFT System Fault

1. Check for biased AFP sensor or circuit.
2. Check for active AFD DTCs. See AFD Valve (Aftertreatment Fuel Drain) (page 208) in this section.
3. Run Aftertreatment (AFT) System Leak Test (page 174) while monitoring AFP PID in the “Performance Diagnostics” section of this manual.

DTC 6914 – AFP below normal during DPF regen

DTC 6914 is set when the AFP signal is below 234 kPa (34 psi) during a fuel injected regen.

Pin-Point AFT System Fault

1. Check for biased AFP sensor or circuit.
2. Check for active AFD or AFS DTCs. See AFD Valve (Aftertreatment Fuel Drain) (page 208) and AFS Valve (Aftertreatment Fuel Supply) (page 221) in this section.
3. Run Aftertreatment (AFT) System Leak Test (page 174) and Aftertreatment Fuel Supply (AFS) Valve Leak Test (page 176) while monitoring AFP PID in the “Performance Diagnostics” section of this manual.

AFT System Operation

When driving at high speeds or with heavy loads, the exhaust temperature is hot enough to convert the soot to ash.

When driving at lower speeds or lighter loads, the exhaust temperature is typically not hot enough to convert the soot to ash. In these situations, the engine control system increases the exhaust temperature and the particulate matter can be converted to ash.

Automatic regeneration occurs when driving. The operator is not required to do anything to start regeneration.

Automatic regeneration is not possible during frequent stops or low operating speeds. If a regeneration is required in these conditions, a manual parked regeneration must be done.

Active Rolling Regeneration

When the Engine Control Module (ECM) determines the DPF needs to be regenerated, the aftertreatment lamp illuminates. The ECM controls the engine operation to increase exhaust temperature. This enables the DPF to convert accumulated particulate matter to ash.

The following entry conditions are required for active rolling regeneration:

- No disabling DTCs 1741, 1742, or 2674
- ECT above 75 °C (170 °F)
- PTO not active; Standby mode OK
- Inhibit regeneration switch not active
- EGT1 below 500 °C (932 °F)
- EGT2 below 650 °C (1202 °F)
- EGT3 below 750 °C (1382 °F)

Manual Parked Regeneration

Manual parked regeneration occurs when the operator requests the control system to do a stationary regeneration. Exhaust temperature is increased and particulate matter is converted to ash.

The following entry conditions are required for manual parked regeneration:

- DPF lamp ON, signaling need to regenerate
- No disabling DTCs 1114, 1115, 1141, 1142, 1311, 1312, 1741, 1742, or 2674
- ECT above 75 °C (170 °F)
- ECT above 65 °C (150 °F)
- Engine running
- Vehicle speed below 2 mph (3 km/h)
- Parking brake must be set
- Brake pedal not pressed
- Accelerator pedal not pressed
- PTO not active
- Driveline disengaged
- AFT regen switch in OFF position
- EGT2 and EGT3 below 500 °C (932 °F)

Manual Parked Regeneration Procedure

WARNING: To prevent personal injury or death, make certain vehicle is safely off roadway and away from people, flammable materials or structures, as the regeneration process creates elevated exhaust temperatures that can cause a fire.

To start parked regeneration (cleaning) of exhaust DPF, do the following steps:

1. Park the vehicle safely off the road and away from flammable materials and vapors.
2. Before starting parked regeneration (using AFT regen switch), the following conditions must be in place:
   - Parking brake must be set
   - Transmission must be in neutral or park
   - Engine coolant temperature must be a minimum of 71 °C (160 °F)
   - Accelerator, foot brake, or clutch pedal (if equipped) must not be pressed
3. Press the AFT regen switch to the ON position to initiate the regeneration cycle.

   The engine speed automatically ramps up to a preset rpm. The AFT regen switch indicator illuminates when the cycle has started. If the indicator is blinking, verify all conditions in Step 2 are met. If the AFT regen switch continues blinking, press the switch again.

   The regeneration cycle lasts approximately 20 minutes.
4. When the regeneration cycle is complete, the AFT regen switch turns off. The engine rpm returns to normal idle and all exhaust filter indicators turn off. The vehicle is now ready for normal driving operation.

Diesel Oxidation Catalyst (DOC)

The DOC converts fuel to heat for DPF regeneration.

Diesel Particulate Filter (DPF)

The DPF filters and stores particulate matter (soot) and ash (non-combustibles) from leaving the tailpipe.

Regeneration

Regeneration is the process of converting particulate matter trapped in the DPF to ash.

Passive Rolling Regeneration

Passive rolling regeneration occurs when the engine provides sufficient temperature through the exhaust gases to convert the particulate matter to ash.

AFT Cleanliness Test (EST enabled)

The on-board cleanliness test forces the system into a manual regeneration and measures DPF ash/soot levels before and after the test. This test is required to reset the DPF monitors after a DPF has been serviced or replaced.

AFT Regen Switch

The AFT regen switch enables the operator to request a stationary regeneration for the DPF.

Inhibit Regeneration Switch (optional)

The inhibit regeneration switch enables the operator to cancel and prevent a DPF regeneration.

DPF Soot Loading Percentage

ECM calculation of the soot level in DPF.

DPF Ash Loading Percentage

ECM calculation of the ash level in DPF.

DPF Status Lamp

The DPF status lamp provides information on need to regenerate the DPF. Several levels of status are available. The lamp changes states from OFF, to solid ON to flashing. The lamp is used in combination with the check engine and stop engine lamps.

High Exhaust System Temperature Indicator (HEST)

The HEST alerts the operator when the exhaust temperature is elevated above 400 °C (750 °F). This may or may not be due to DPF regeneration.

AMS (Air Management System)

DTC	SPN	FMI	Condition
1166	105	0	MAT temperature above maximum
2351	7129	1	EBP below desired level
2352	7129	0	EBP above desired level
2357	7129	7	Retarder control valve unable to achieve desired EBP
6258	102	7	Boost below desired

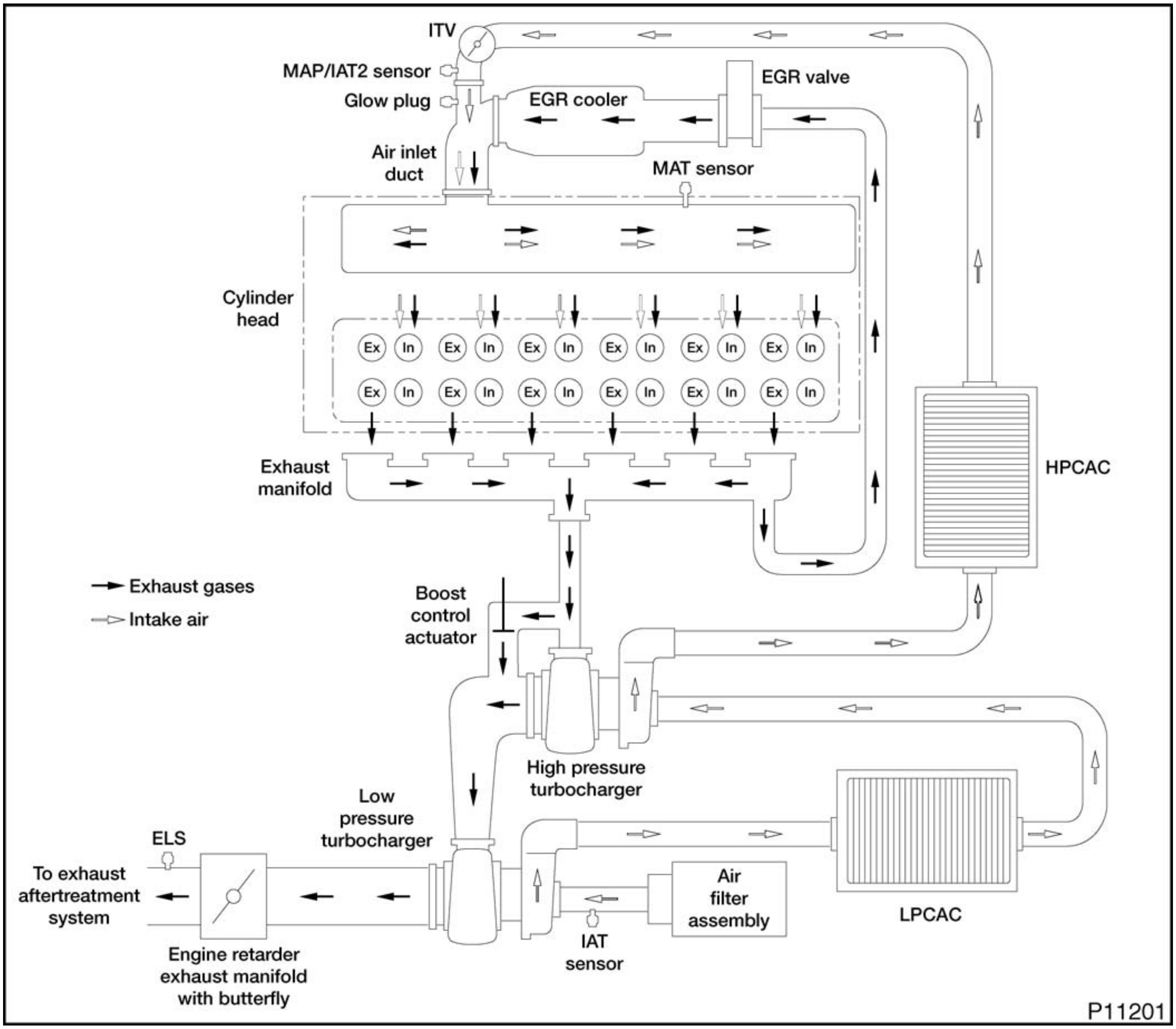

Figure 185 Functional diagram for AMS

The functional diagram for AMS includes the following:

- Air filter assembly
- Low pressure turbocharger
- Low Pressure Charge Air Cooler (LPCAC)
- High pressure turbocharger
- High Pressure Charge Air Cooler (HPCAC)
- Intake Throttle Valve (ITV)
- Air inlet duct
- Cold start assist
- Exhaust and intake valves
- Exhaust Gas Recirculation (EGR) system
- Exhaust system
- Engine retarder exhaust manifold with butterfly
- Diesel Oxidation Catalyst (DOC) – aftertreatment
- Diesel Particulate Filter (DPF) – aftertreatment

Function

The AMS monitors intake air temperature and pressure relative to the BAP, which is internal to the ECM. The ECM interprets the inputs from the various sensors and correspondingly adjusts the fuel injection, the EGR, the BCS, and the ITV for maximum performance and fuel economy under the current conditions.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)

AMS System Diagnostics

DTC	Condition	Possible Causes
1166	MAT temperature above maximum	• Biased MAT sensor or circuit • EGR system or circuit fault • ITV or circuit fault
2351	EBP below desired level	• Exhaust leakage • Failed turbochargers • Biased EBP circuit • Retarder control failure
2352	EBP above desired level	• Exhaust restriction • Plugged DPF • Biased EBP circuit • Retarder control failure
2357	Retarder control valve unable to achieve desired EBP	• Exhaust leak • Failed DPF • Failed turbocharger • Retarder control failure • Low engine performance
6258	Boost below desired	• Engine performance issue • Engine mechanical failure • Low fuel pressure • Failed turbochargers • EGR stuck open • Biased MAP/IAT2 sensor or circuit • ITV or circuit fault

DTC 1166 - MAT temperature above maximum

DTC 1166 is set when the MAT temperature rises above 80 °C (176 °F) at normal operation, or 90 °C (194 °F) with the retarder control activated.

Pin-point AMS System Fault

1. Check for biased MAT sensor or circuit. See Sensor Compare (page 160) in the “Performance Diagnostics” section of this manual.
2. Check for active EGR control valve faults or DTCs. See EGR Control Valve (Exhaust Gas Recirculation) (page 325) in this section.

DTC 1166 - MAT temperature above maximum (cont.)

3. Check for active ITV faults or DTCs. See ITV (Intake Throttle Valve) Actuator (page 408) in this section.

DTC 2351 - EBP below desired level

DTC 2351 is set when the ECM has determined that the exhaust back pressure is lower than normal.

Pin-point AMS System Fault

1. Inspect exhaust system for leakage.
2. Check for EBP circuit fault and for biased EBP sensor or circuit. See Sensor Compare (page 160) in the “Performance Diagnostics” section of this manual.
3. Check for active retarder control faults or DTCs. See Retarder Control (page 423) in this section.

DTC 2352 - EBP above desired level

DTC 2352 is set when the ECM has determined that the exhaust back pressure is higher than normal.

Pin-point AMS System Fault

1. Inspect exhaust system for any restrictions or DPF restriction. See Exhaust System in the “Performance Diagnostics” section of this manual. Do a Parked Regeneration. See Manual Parked Regeneration (page 233) in this section.
2. Check for EBP circuit fault and for biased EBP sensor or circuit. See Sensor Compare (page 160) in the “Performance Diagnostics” section of this manual.
3. Check for active retarder control faults or DTCs. See Retarder Control (page 423) in this section.

DTC 2357 - Retarder control valve unable to achieve desired EBP

DTC 2357 is set when the ECM has determined that the exhaust back pressure is below normal.

Pin-point AMS System Fault

1. Inspect exhaust system for any leaks.
2. Inspect DPF and DOC for any leaks
3. Inspect the turbochargers and Charge Air Coolers (CACs) for damage. See Charge Air Cooler (CAC) System (page 154) in the “Performance Diagnostics” section of this manual.
4. Check for engine performance issues. See the “Performance Diagnostics” section of this manual section.
5. Check for active retarder control faults or DTCs. See Retarder Control (page 423) in this section.

DTC 6258 - Boost below desired

DTC 6258 is set when the boost pressure is not within a certain range of the boost pressure set point (inability to meet the boost pressure set point).

Pin-point AMS System Fault

1. Check for engine performance issues. See the “Performance Diagnostics” section of this manual.
2. Inspect the turbochargers and Charge Air Coolers (CACs) for damage. See Charge Air Cooler (CAC) System (page 154) in the “Performance Diagnostics” section of this manual.
3. Check for low fuel pressure. See Low Pressure Fuel System (page 137) in the “Hard Start and No Start Diagnostics” section of this manual.
4. Inspect turbochargers for damage.
5. Check for active EGR control valve faults or DTCs. See EGR Control Valve (Exhaust Gas Recirculation) (page 325) in this section.
6. Check for active MAP/IAT2 sensor faults or DTCs. See MAP/IAT2 Sensor (Manifold Absolute Pressure/Intake Air Temperature 2) (page 414) in this section.
7. Check for active ITV faults or DTCs. See ITV (Intake Throttle Valve) Actuator (page 408) in this section.

APS/IVS (Accelerator Position Sensor/Idle Validation Switch)

DTC	SPN	FMI	Condition
1129	91	0	APS VREF out-of-range HIGH
1130	91	1	APS VREF out-of-range LOW
1131	91	4	APS signal out-of-range LOW
1132	91	3	APS signal out-of-range HIGH
1133	91	2	APS in-range fault
1134	91	7	APS and IVS disagree
1135	558	11	IVS signal fault

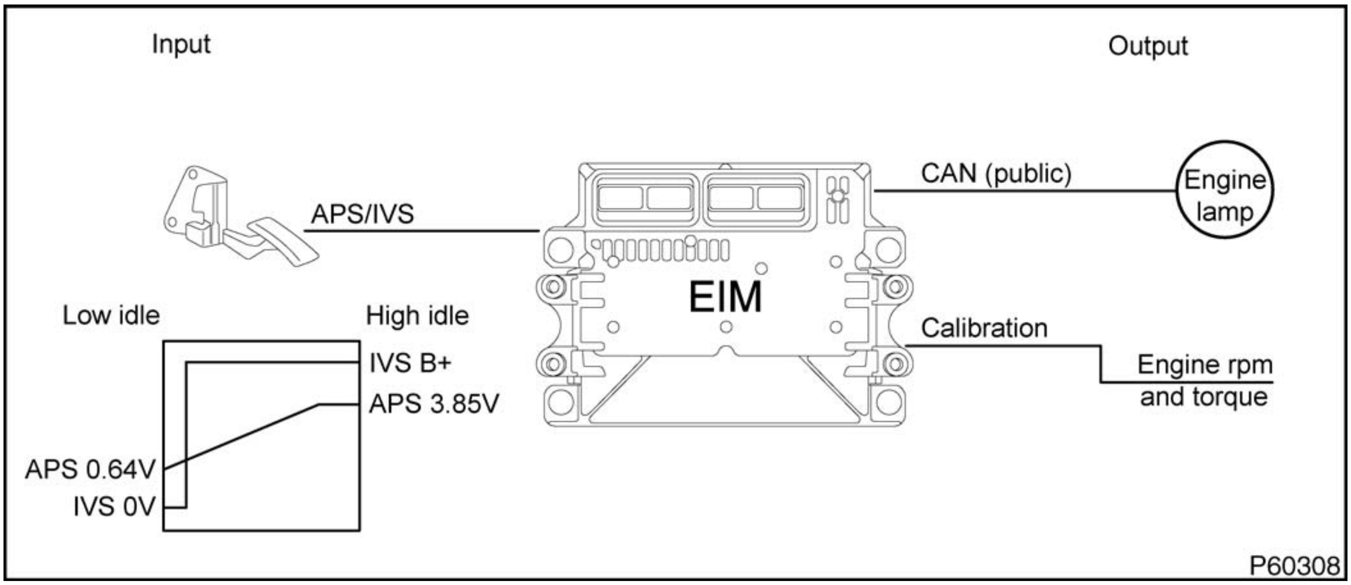

Figure 186 Functional diagram for the APS/IVS

The functional diagram for the APS/IVS includes the following:

- APS/IVS
- Engine Interface Module (EIM)
- Engine lamp (amber)
- Engine rpm and torque calibration

Function

The APS/IVS sensor is controlled by the operator. The ECM uses this sensor to control engine acceleration based off of the operator’s demand for power.

Sensor Location

The APS/IVS sensor is installed in the cab on the accelerator pedal.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 3-Banana Plug Harness (page 437)
- 96-Pin Breakout Box – DLC II (page 438)
- APS/IVS Sensor Breakout Harness (page 440)
- Terminal Test Adapter Kit (page 446)

APS/IVS Sensor End Diagnostics

DTC	Condition	Possible Causes
1129	APS VREF out-of-range HIGH	• VREF circuit shorted to PWR • Failed sensor
1130	APS VREF out-of-range LOW	• VREF circuit OPEN or shorted to GND • Failed sensor
1131	APS signal out-of-range LOW	• APS signal OPEN or shorted to GND • Failed sensor
1132	APS signal out-of-range HIGH	• APS signal shorted to VREF or PWR • SIG RTN circuit OPEN • Failed sensor
1133	APS in-range fault	• Circuit fault • Failed sensor
1134	APS and IVS disagree	• Circuit fault • Failed sensor
1135	IVS signal fault	• IVS circuit OPEN or shorted to GND • IVS circuit shorted to PWR • Failed sensor

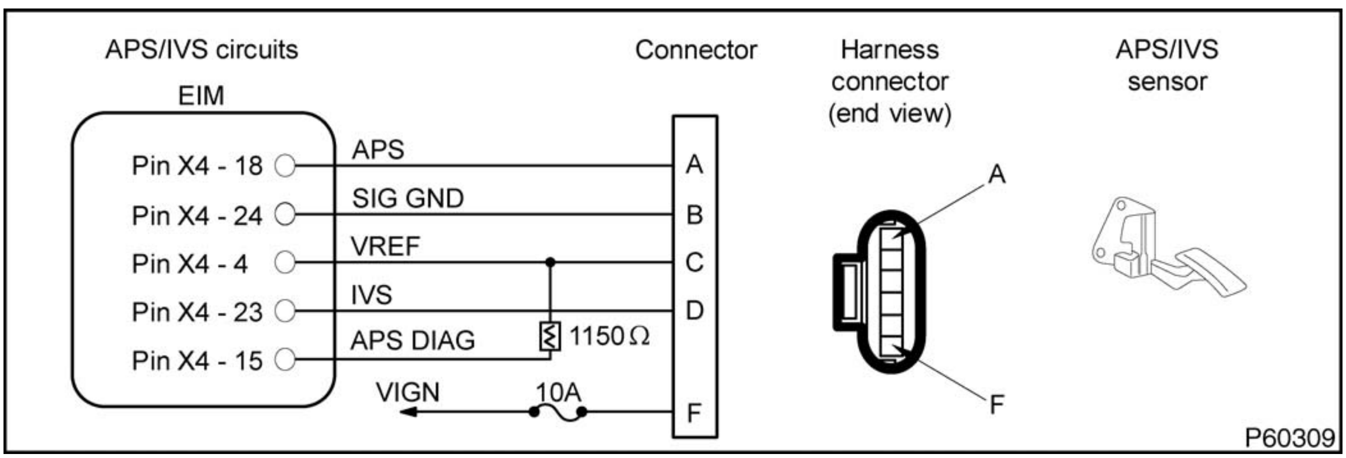

Figure 187 APS/IVS circuit diagram

1. Using the EST, open the D_ContinuousMonitor.ssn.

2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor. Inspect connectors for damaged pins, corrosion, or loose pins using the Pin Grip Inspection (page 197). Repair if necessary.
4. Connect Breakout Harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect breakout harness. Leave sensor disconnected. Turn the ignition switch to ON. Use EST to verify correct DTC becomes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comment
EST – Check DTC	DTC 1131	If DTC 1132 is active, check APS signal for short to PWR.
DMM – Measure volts C to GND	5 V +/– 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Checks (page 246).
EST – Check DTC Short across breakout harness pins A and C	DTC 1132	If DTC 1131 is active, check APS signal for OPEN. Do Harness Resistance Checks (page 246).
DMM – Measure resistance B to GND	< 5Ω	If > 5Ω, check SIG GND for OPEN. Do Harness Resistance Checks (page 246).
DMM – Measure voltage D to GND	0 V	If > 0.25 V, check IVS circuit for short to PWR.
DMM – Measure voltage F to GND	B+	If < B+, check for OPEN circuit or blown fuse.

If checks are within specification, connect sensor, clear DTCs, and cycle the accelerator pedal a few times. If active code returns, replace APS/IVS sensor.

APS/IVS Pin-Point Diagnostics

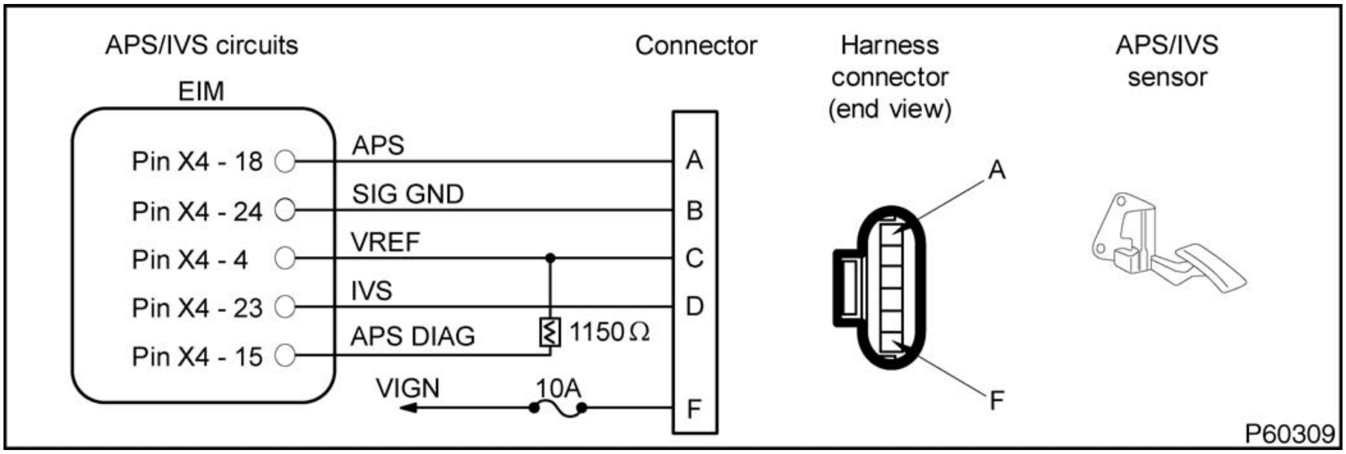

Figure 188 APS/IVS circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
A to GND	0 V	If > 0.25 V, check for short to PWR.
B to GND	0 V	If > 0.25 V, check for short to PWR.
C to GND	5 V	If > 5.5 V, check VREF for short to PWR.
		If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Checks (page 246).
D to GND	0 V	If > 0.25 V, check for short to PWR.
F to GND	B+	If < B+, check for OPEN or blown fuse.

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
A to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
B to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D to GND	500 Ω to 600 Ω	If < 500 Ω, check for short to GND.
F to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave Engine Interface Module (EIM) and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
A to X4-18	< 5 Ω	If > 5 Ω, check APS signal circuit for OPEN.
B to X4-24	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
C to X4-4	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
D to X4-23	< 5 Ω	If > 5 Ω, check IVS signal circuit for OPEN.
F to Fuse	< 5 Ω	If > 5 Ω, check PWR circuit for OPEN.
X4-4 to X4-15	1 - 1.5 kΩ	If not within specification, replace resistor.

Operational Voltage Check

Connect breakout box or breakout harness between EIM and sensor. Turn ignition switch ON. Use DMM to measure voltage and EST to read PID.

Test Point	Condition	DMM	PID
APS	Foot off pedal	0.64 V ± 0.5 V	0%
A to GND or X4-18 to GND	Pedal to floor	3.85 V ± 0.5 V	100%
IVS	Foot off pedal	0 V	Low idle
D to GND or X4-23 to GND	Pedal to floor	B+	Off idle

APS/IVS Circuit Operation

The APS/IVS is integrated into one component and mounted on the pedal. The APS/IVS switch can be replaced without replacing the complete assembly.

The EIM determines accelerator pedal position by processing input signals from the APS and the IVS.

APS

The APS is a potentiometer sensor that is supplied with a 5 V reference voltage at Pin C from EIM Pin X4-4 and is grounded at Pin B from EIM Pin X4-24. The sensor returns a variable voltage signal from Pin A to EIM Pin X4-18.

IVS

The IVS is an ON/OFF switch that is supplied B+ on Pin F from the PWR fuse. The switch sends an ON or OFF idle voltage signal from Pin D to EIM Pin X4-23.

APS Auto-Calibration

The EIM auto-calibrates the APS signal every time the ignition key is turned on. The EIM learns the lowest and highest pedal positions allowing for maximum pedal sensitivity. When the key is turned off, this information is lost until the next key cycle where the process is repeated. No accelerator pedal adjustment is needed with this feature.

Fault Detection / Management

When the key is on, the EIM continuously monitors the APS/IVS circuits for expected voltages. It also compares the APS and IVS signals for conflict. If a conflict occurs, the EIM sets a DTC.

Any malfunction of the APS/IVS sensor circuit illuminates the amber engine lamp. If the EIM detects an APS signal out of range HIGH or LOW, the engine ignores the APS signal and operates at low idle. If a disagreement in the state of IVS and APS is detected by the EIM and the EIM determines that it is an IVS fault, the EIM only allows a maximum of 50% APS to be commanded. If the EIM cannot discern if it is an APS or IVS fault, the engine is allowed to operate at low idle only.

Diagnostic Trouble Codes (DTCs)

NOTE: If multiple APS/IVS DTCs are present, verify that the APS/IVS part number is correct for the specific vehicle model.

NOTE: If elevated low idle rpm is experienced after replacing the pedal assembly or APS/IVS sensor, and there are no DTCs present, check pedal assembly or APS/IVS sensor part numbers for correctness.

ATA Datalink (American Trucking Association)

DTC	SPN	FMI	Condition
None			No communication with TCM

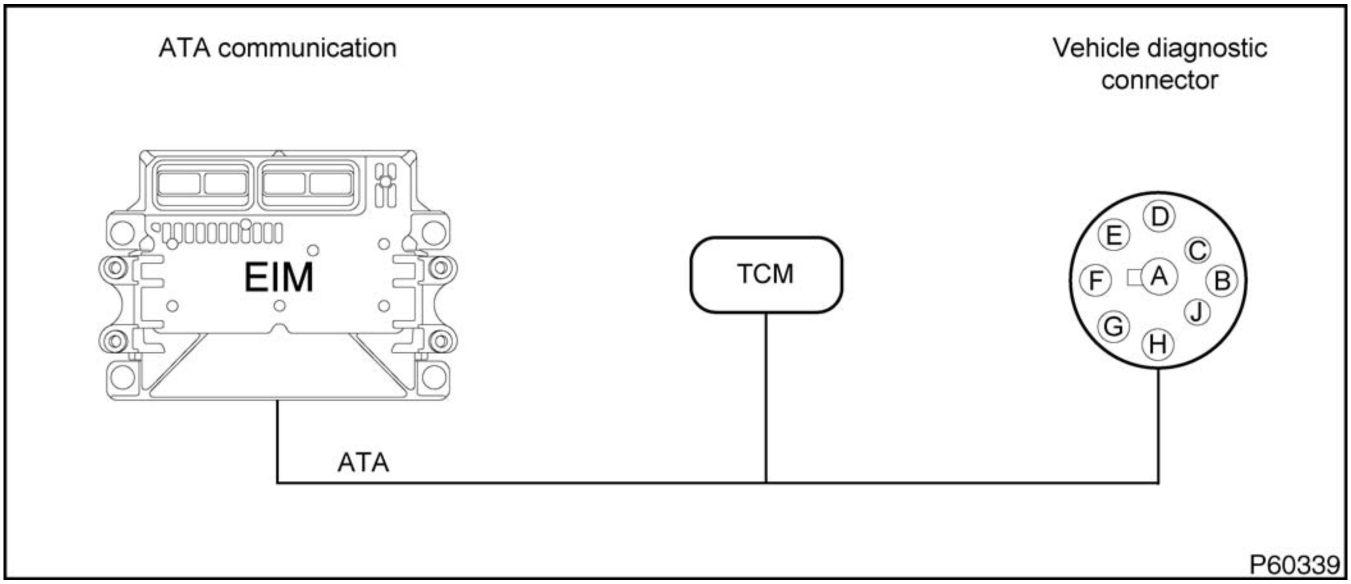

Figure 189 Functional diagram for ATA

The functional diagram for ATA includes the following:

- Engine Interface Module (EIM)
- Transmission Control Module (TCM)
- Vehicle diagnostic connector

Function

The ATA datalink provides communication between the EIM and an ATA compatible TCM. The EST tool can access this datalink at the vehicle diagnostic connector.

Location

The ATA circuits are connected to the EIM, TCM and vehicle diagnostic connector. The vehicle diagnostic connector is located under the dash on the driver's side.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- Terminal Test Adapter Kit (page 446)
- 96-Pin Breakout Box – DLC II (page 438)

ATA Pin-Point Diagnostics

DTC	Condition	Possible Causes
None	No communication with EST	• B+ circuit OPEN or shorted to GND • GND circuit OPEN • ATA circuits OPEN or shorted to PWR or GND

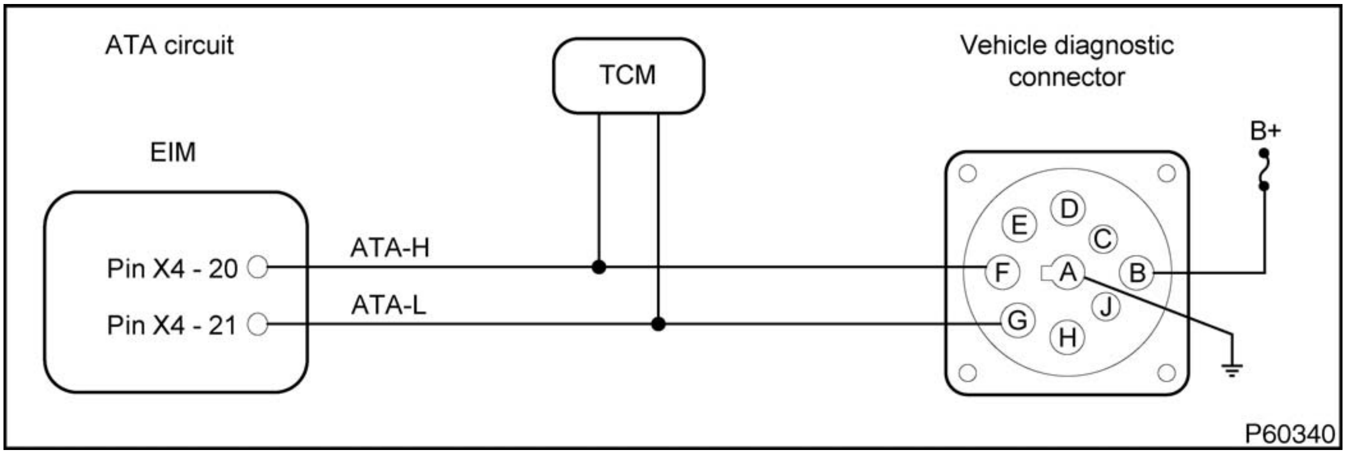

Figure 190 ATA circuit diagram

Connector Voltage Check - EST

Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
B to GND	B+	If < B+, check B+ circuit to vehicle diagnostic connector for OPEN or short to GND, or blown fuse.
B to A	B+	If < B+, check GND circuit to vehicle diagnostic connector for OPEN.
F to GND	1 V to 4 V	The sum of F to GND and G to GND should equal 4 V to 5 V.
G to GND	1 V to 4 V	The sum of G to GND and F to GND should equal 4 V to 5 V.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box. Leave EIM disconnected.

Test Point	Spec	Comment
F to X4-20	< 5 Ω	If > 5 Ω, check ATA-H for OPEN in circuit
F to GND	> 1 kΩ	If < 1 kΩ, check ATA-H for short to GND
G to X4-21	< 5 Ω	If > 5 Ω, check ATA-L for OPEN in circuit

Harness Resistance Check (cont.)

G to GND	> 1 kΩ	If < 1 kΩ, check ATA-L for short to GND
A to GND	< 5 Ω	If > 5 Ω, check GND for OPEN in circuit

ATA Operation

Vehicle Diagnostic Connector

The fuse protected B+ signal is supplied to the vehicle diagnostic connector through Pin B, and ground is through Pin A. American Trucking Association High (ATA-H) signal runs from EIM Pin X4-20 and vehicle diagnostic connector Pin F. American Trucking Association Low (ATA-L) signal runs from EIM Pin X4-21 and vehicle diagnostic connector Pin G.

Engine Gauge Cluster (EGC)

There are two types of EGC modules; one uses CAN communication and the other uses ATA communication. The following information is sent through data communication:

- Engine lamp (red)
- Engine lamp (amber)
- Coolant level lamp
- Wait to start lamp
- Water in fuel lamp
- Speedometer
- Tachometer
- Odometer / hourmeter
- Change oil message
- Oil pressure gauge
- Engine oil temperature gauge
- Engine coolant temperature gauge

Fault Detection / Management

There are no engine Diagnostic Trouble Codes (DTCs) for ATA communication faults. See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.

Repair Information

The ATA circuits use a twisted wire pair. All repairs must maintain one complete twist per inch along the entire length of the circuit. This circuit is polarized, one positive and one negative. Reversing the polarity of this circuit disrupts communication.

BCS (Boost Control Solenoid) Valve

DTC	SPN	FMI	Condition
1256	7312	5	Boost Control Solenoid open circuit
1257	7312	11	Boost Control Solenoid short circuit

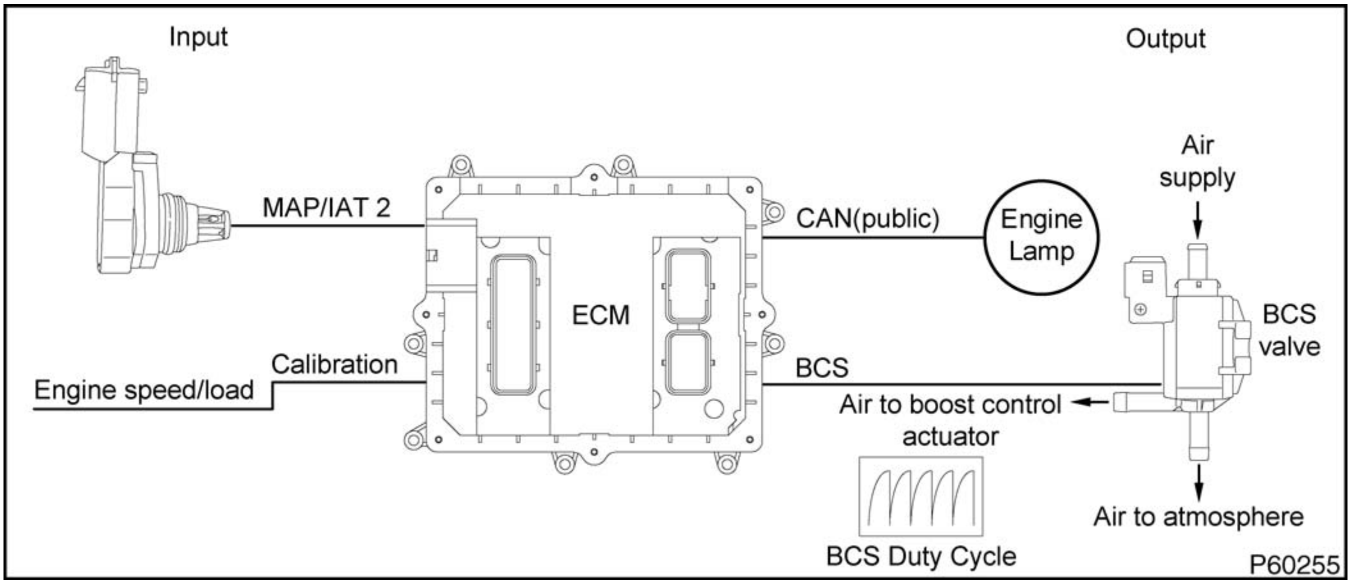

Figure 191 Functional diagram for boost control actuator

The functional diagram for the boost control actuator includes the following:

- BCS valve
- Engine lamp (amber)
- Engine Control Module (ECM)
- Engine speed/load calibration
- Manifold Absolute Pressure/Intake Air Temperature 2 (MAP/IAT2) sensor

Function

The BCS valve changes the boost control actuator linear position by controlling the air supply flow.

Component Location

The BCS valve is mounted on a bracket on the lower right side of the engine, near the front.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- Boost Control Solenoid Breakout Harness (page 440)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)

BCS Valve Connector End Diagnostics

DTC	Condition	Possible Causes
1256	Boost Control Solenoid open circuit	• BCS OPEN circuit • BCS valve failure
1257	Boost Control Solenoid short circuit	• BCS short circuit • Failed BCS valve

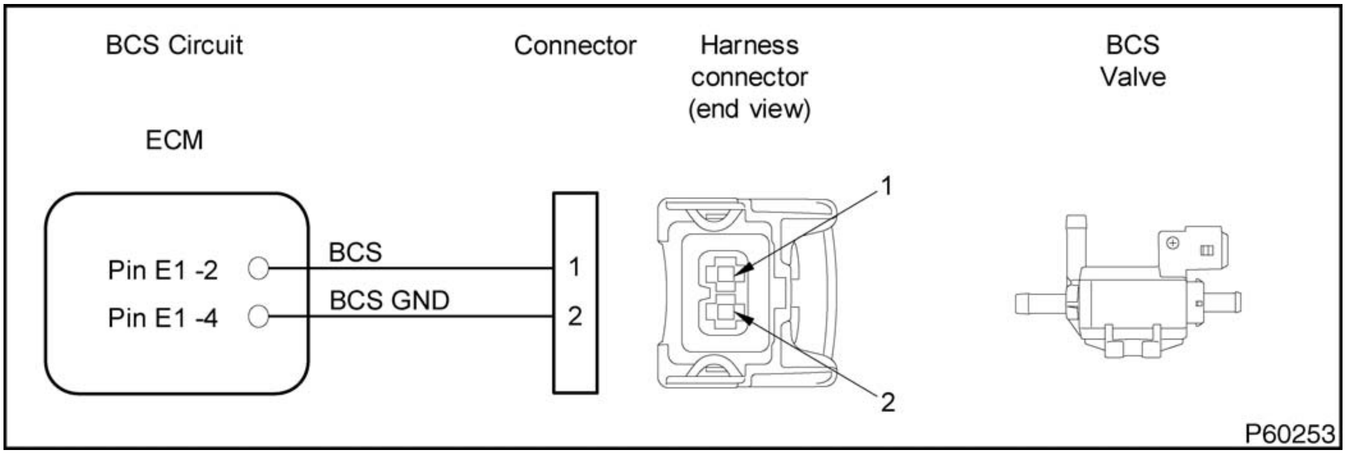

Figure 192 BCS valve circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

NOTE: Air tanks must be above 620 kPa (90 psi) before running this test.

1. Key ON, engine OFF.
2. Connect the EST with MasterDiagnostics® software.
3. Verify correct engine is selected and launch EST.
4. Open D_Actuator.ssn session.
5. Run Actuator Test.
6. Visually monitor boost control actuator linkage movement.
   - If linkage moves through its full travel, the system is working correctly.
   - If linkage does not move through full travel, check for a mechanical problem such as sticking linkage, low actuator supply pressure, plugged or open air supply hose.
   - If the linkage does not move at all, do Connector Voltage Checks (page 253).

Connector Voltage Check

Connect breakout harness to engine harness and leave BCS valve disconnected. Turn ignition switch ON. Use DMM to measure voltage.

Test Point	Spec	Comment
2 to Battery Positive	B+	If < B+, check for OPEN BCS GND circuit.
1 to 2	6 V to 9 V	If 0 V, check for OPEN or short to GND.
		If < 6 V, check for poor connection, corroded circuits.
		If > 9 V, check for short to PWR
If measurements are within specifications, do Operational Voltage Check - Actuator Test (page 253).		

Operational Voltage Check - Actuator Test

Connect breakout harness between BCS valve and engine harness. Run Actuator Test. Use DMM to measure voltage. Batteries must be fully charged before performing this test.

Test Point	Spec	Comment
DMM - Measure Volts across pins 1 and GND		
Normal state	< 1 V	If > 1 V, check for short to PWR.
Actuator state LOW	1 V +/- 0.5 V	If > 1.5 V, check for OPEN circuit or BCS valve.
Actuator state HIGH	> 9 V	If < 9 V, check for OPEN circuit or short to GND
If measurements are within specifications, do Actuator Resistance Check (page 253).		

Actuator Resistance Check

Turn ignition switch OFF. Connect breakout harness to BCS valve and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to 2	21 Ω to 24 Ω	If not within specification, replace the BCS valve.
If measurements are within specifications, do Harness Resistance Check (page 254).		

Harness Resistance Check

Turn ignition switch OFF. Connect ECM breakout box and breakout harness to engine harness, leave BCS valve and ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1k Ω, check for short circuit.
1 to E1-2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1 kΩ	If < 1k Ω, check for short circuit.
2 to E1-4	< 5 Ω	If > 5 Ω, check for OPEN circuit.

If voltage and resistance checks are within specifications, and there are no mechanical faults, such as low boost control actuator supply psi, damaged air supply hoses, failed actuator valve or sticky linkage, and the boost control actuator does not actuate, replace BCS valve.

BCS Valve Operation

The BCS valve controls the boost control actuator position by regulating the compressed air based on a Pulse Width Modulated (PWM) signal received from the ECM.

With no PWM signal, the BCS valve is open and air is supplied to the boost control actuator maintaining it in the open position. When an increase in the charge air pressure is required, the ECM supplies PWM voltage to close the BCS valve. The limit values of the PWM signal are between 0% (fully opened BCS valve), to 100% (closed BCS valve). When the BCS valve closes, it interrupts the air supply to the boost control actuator and at the same time it relieves the air pressure from the boost control actuator by opening the vent to the atmosphere. The boost control actuator then closes, resulting in increased charge air pressure.

Actuator Test

The actuator test allows a technician to test the actuators by measuring voltage changes and visually monitoring actuator movement.

This test first runs through the Engine Control Module (ECM) actuators, then the Aftertreatment Control Module (ACM) actuators, and finishes with the Engine Interface Module (EIM) actuators.

ECM Actuators

During the ECM portion of the actuator test, all ECM actuators are commanded to LOW state, 8% to 15% duty cycle. Then one by one, each actuator is commanded to HIGH state, 80% to 100% duty cycle. This test will not cycle the Fuel Pressure Control Valve (FPCV) or the Exhaust Lambda Sensor (ELS) heater.

ACM Actuators

During the ACM portion of the actuator test, all ACM actuators remain at 0% duty cycle. Then one by one, each actuator is cycled on. The Aftertreatment Fuel Supply (AFS) valve and Aftertreatment Fuel Drain (AFD) valve are commanded to 100%, then drop to 66%. The Aftertreatment Fuel Injector (AFI) is commanded to a low duty cycle measured in seconds from 0 (off) to 0.1 (on).

EIM Actuators

During the EIM portion of the actuator test, the actuators cycle simultaneously. Fan Control Status is 1 (on), then cycles to 0 (off). The Cold Start Relay (CSR) and Cold Start Solenoid (CSS) is 0 (off), then cycles to 1 (on).

NOTE: When the Actuator Test is running, the sensor monitoring Parameter Identifiers (PIDs) are turned off.

This test cycles the following actuators:

- ECM actuators:
  - Intake Throttle Valve (ITV)
  - Boost Control Solenoid (BCS) valve
  - Exhaust Gas Recirculation (EGR) control valve
  - Coolant Mixer Valve (CMV)
  - Coolant Flow Valve (CFV)
- EIM actuators:
  - Cold Start Relay (CSR)
  - Cold Start Solenoid (CSS) valve
  - Electronic Fan Control (EFAN)
- ACM actuators:
  - Aftertreatment Fuel Drain (AFD) valve
  - Aftertreatment Fuel Supply (AFS) valve
  - Aftertreatment Fuel Injector (AFI)

CAN Communications (Controller Area Network) (Public)

DTC	SPN	FMI	Condition
None			No communication with EST

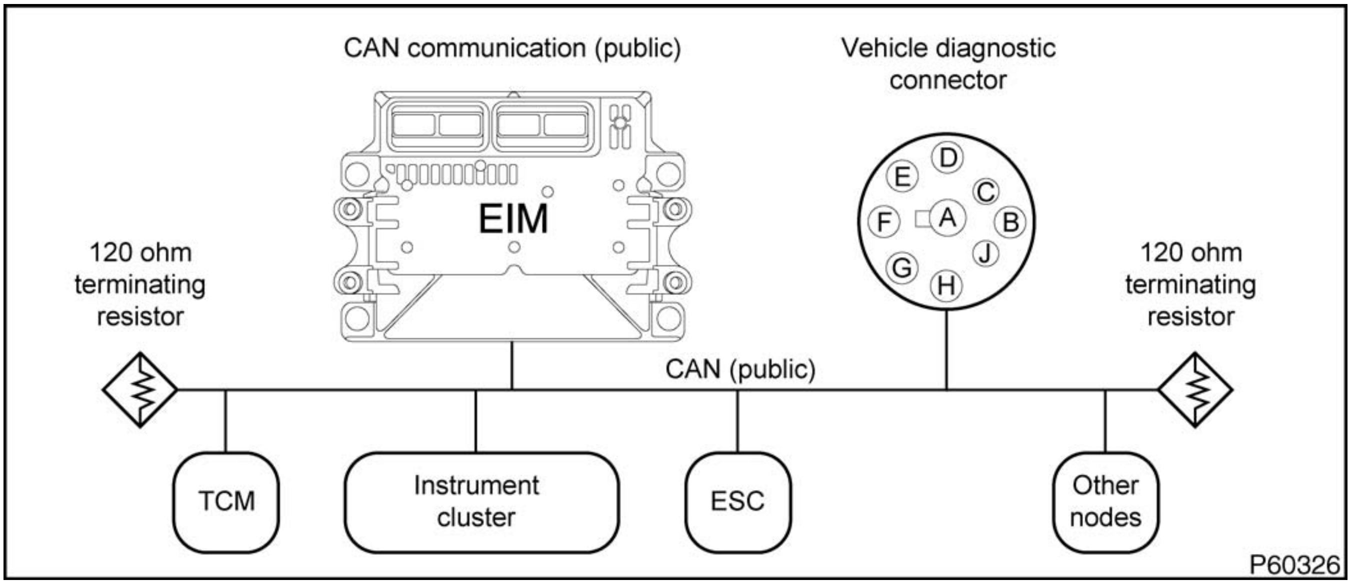

Figure 193 Functional diagram for the CAN (public)

The functional diagram for the CAN (public) includes the following:

- 120 ohm terminating resistors
- Vehicle diagnostic connector
- Electronic System Control (ESC) body controller
- Engine Interface Module (EIM)
- Instrument cluster
- Other nodes
- Transmission Control Module (TCM)

Function

The public CAN network provides a communication link between all connecting modules. The EST uses this network system to communicate with the EIM.

Location

The public CAN circuits run throughout the vehicle harness. The vehicle diagnostic connector is located under the dash on the driver's side.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 96-Pin Breakout Box – DLC II (page 438)
- Terminal Test Adapter Kit (page 446)

CAN (Public) Pin-Point Diagnostics

DTC	Condition	Possible Causes
None	No communication with EST	• CAN-H or CAN-L circuits OPEN or shorted to PWR or GND • B+ OPEN or shorted to GND • GND circuit OPEN

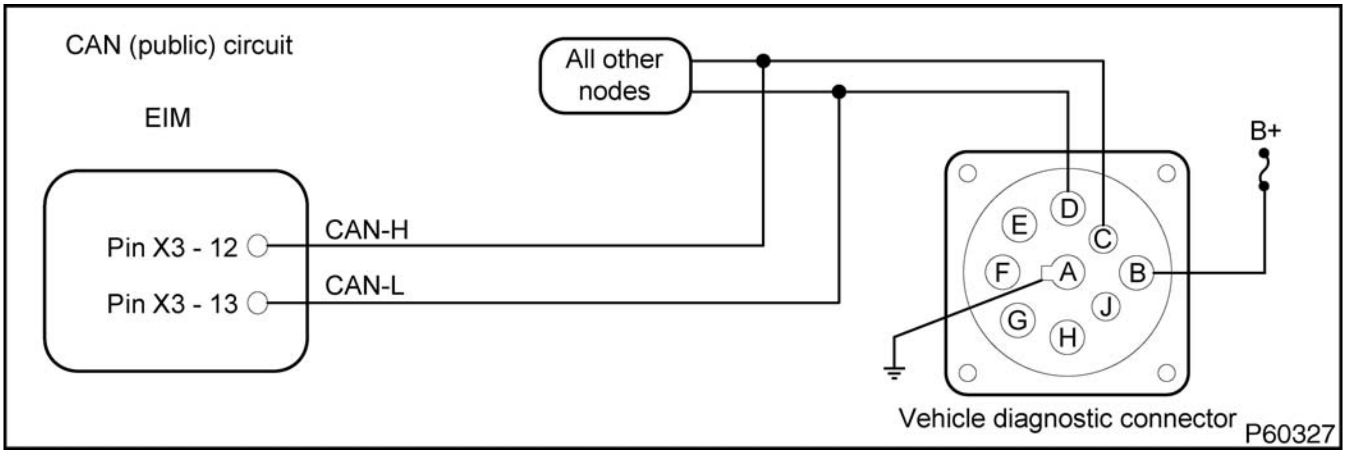

Figure 194 CAN (public) communication circuit diagram

Connector Voltage Check

Turn ignition switch to ON. Use DMM to measure voltage at the vehicle diagnostic connector.

Test Point	Spec	Comment
B to GND	B+	If < B+, check B+ circuit to vehicle diagnostic connector for OPEN or short to GND, or blown fuse.
B to A	B+	If < B+, check GND circuit to vehicle diagnostic connector for OPEN.
C to GND	1 V to 4 V	The sum of C to GND and D to GND should be < 0.2 V.
D to GND	1 V to 4 V	The sum of D to GND and C to GND should be <0.2 V.

EST Communication Check

Turn ignition switch to ON. Connect EST to vehicle diagnostic connector. If the EST is unable to communicate with the EIM, disconnect each module connected to the CAN (public) individually until communication can be established.

NOTE:

- If communication to EIM is established, check CAN (public) circuits to disconnected node for correct wiring. See truck *Electrical System Troubleshooting Guide*.
- If communication to EIM is not established, go to next test point.

Test Point	Comment
Disconnect TCM	See note.
Disconnect ESC	See note.
Disconnect instrument cluster	See note.
Disconnect other nodes	See note.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box. Leave EIM disconnected.

Test Point	Spec	Comment
C to X3-12	< 5 Ω	If > 5 Ω, check CAN-H for OPEN in circuit.
C to GND	> 1 kΩ	If < 1 kΩ, check CAN-H for short to GND.
D to X3-13	< 5 Ω	If > 5 Ω, check CAN-L for OPEN in circuit.
D to GND	> 1 kΩ	If < 1 kΩ, check CAN-L for short to GND.
A to GND	< 5 Ω	If > 5 Ω, check GND for OPEN in circuit.

CAN (Public) Circuit Operation

CAN is a J1939 serial bus system, also known as the Drivetrain Datalink. The public CAN network provides a communication link between all connecting modules, sending and receiving messages.

The EST with MasterDiagnostics® software communicates with the EIM through the vehicle diagnostic connector. The EST, through the public CAN network, is able to retrieve Diagnostic Trouble Codes (DTCs), run diagnostic tests, and view Parameter Identifiers (PIDs) from all inputs and outputs of the Aftertreatment Control Module (ACM), Engine Control Module (ECM), and Engine Interface Module (EIM).

CAN public supports the following functions:

- Transmission of engine parameter data
- Transmission and clearing of DTCs
- Diagnostics and troubleshooting
- Programming performance parameter values
- Programming engine and vehicle features
- Programming calibrations and strategies in the ACM, ECM and EIM.

Public CAN versus Private CAN

The public CAN network is set up to communicate with many different modules. The network branches off into many different locations with each path ending in a module connection or a 120 ohm terminating resistor. The termination resistors are used to reduce reflections.

The private CAN system is set up to only communicate between the ACM, ECM and EIM.

Vehicle Diagnostic Connector

The vehicle diagnostic connector provides an interface for the EST. The EST communicates with the joining modules through the CAN network for diagnostics and module programming. The vehicle diagnostic connector is supplied with fused B+ at Pin B and GND at Pin A. Public CAN-H runs between EIM Pin X3-12 and vehicle diagnostic connector Pin C. Public CAN-L runs between Pin X3-13 and vehicle diagnostic connector Pin D.

Instrument Cluster

The following information is sent through data communication:

- Engine lamp (red)
- Engine lamp (amber)
- Coolant level lamp
- Wait to start lamp
- Water in fuel lamp
- Speedometer
- Tachometer
- Odometer/hourmeter
- Change oil message
- Oil pressure gauge
- Engine oil temperature gauge
- Engine coolant temperature gauge

Repair Information

The public CAN circuits use a twisted wire pair. All repairs must maintain one complete twist per inch along the entire length of the circuit. This circuit is polarized, one positive and one negative. Reversing the polarity of this circuit disrupts communications.

CAN Communications (Controller Area Network) (Private)

DTC	SPN	FMI	Condition
6314	8342	7	ECM CAN message not received from EIM
6315	8309	2	ACM CAN message not received ECM
6316	8311	2	ACM CAN message not received EIM
6317	8316	2	EIM CAN message not received ACM
6318	8342	14	EIM CAN message not received ECM
None			Engine crank, no start condition

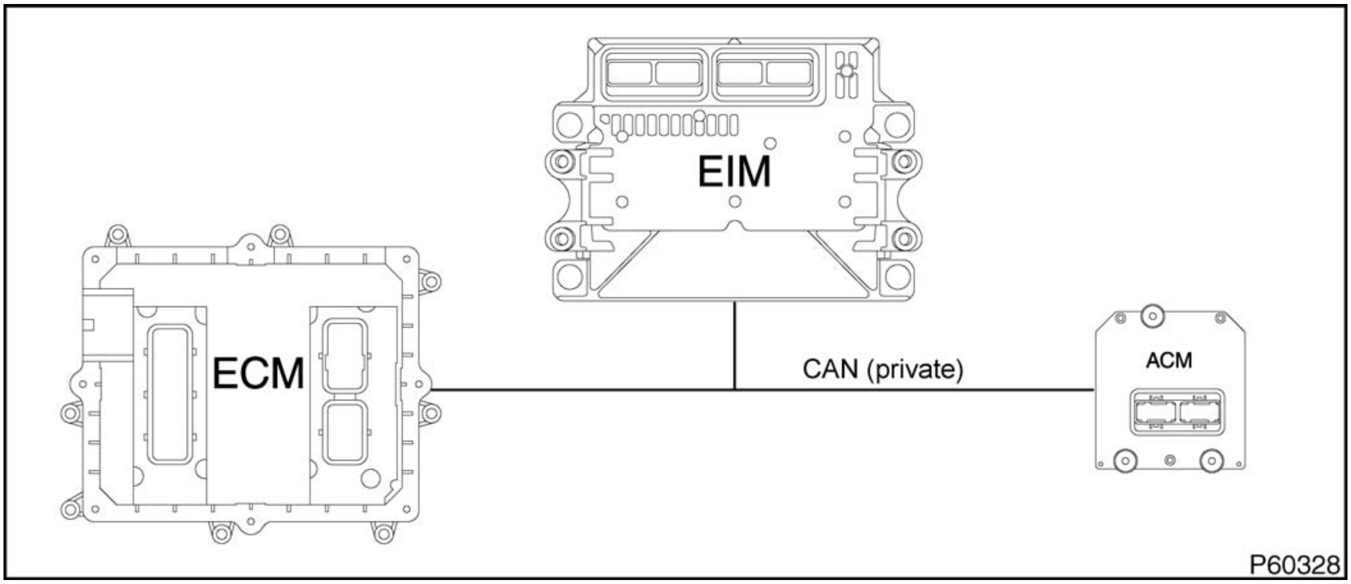

Figure 195 Functional diagram for the CAN (private)

The functional diagram for the CAN (private) includes the following:

- Aftertreatment Control Module (ACM)
- Engine Control Module (ECM)
- Engine Interface Module (EIM)
- CAN (private)

Function

The private CAN network provides a communication link between the ACM, ECM and EIM. Some of the information communicated through private CAN include Diagnostic Trouble Codes (DTCs) and parameter identifier (PID) information.

Location

The private CAN circuits run throughout the vehicle harness and are connected to ACM, ECM and EIM.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- Terminal Test Adapter Kit (page 446)
- 180-Pin Breakout Box (page 438)
- Aftertreatment Harness (page 439)
- E1-Engine Harness (page 443)

- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- 96-Pin Breakout Box – DLC II (page 438)

CAN (Private) Pin-Point Diagnostics

DTC	Condition	Possible Causes
6314	ECM CAN message not received from EIM	• CAN-H or CAN-L circuits OPEN or shorted to PWR or GND • EIM power circuit fault • Failed EIM
6315	ACM CAN message not received from ECM	• CAN-H or CAN-L circuits OPEN or shorted to PWR or GND • ECM power circuit fault • Failed ECM
6316	ACM CAN message not received from EIM	• CAN-H or CAN-L circuits OPEN or shorted to PWR or GND • EIM power circuit fault • Failed EIM
6317	EIM CAN message not received from ACM	• CAN-H or CAN-L circuits OPEN or shorted to PWR or GND • ACM power circuit fault • Failed ACM
6318	EIM CAN message not received from ECM	• CAN-H or CAN-L circuits OPEN or shorted to PWR or GND • ECM power circuit fault • Failed ECM

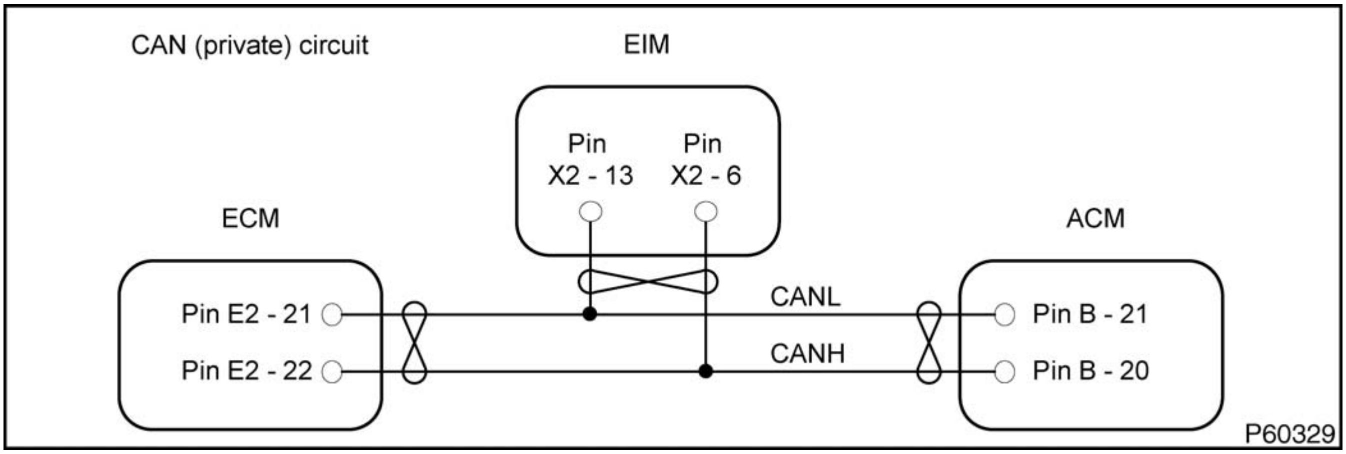

Figure 196 CAN communication circuit diagram

CAN (private) Communication Check

Turn ignition switch to ON. Connect EST to vehicle diagnostic connector. Open continuous monitor session and monitor EIM, ECM and ACM PIDs.

- If the EIM PIDs are reading correctly but both ECM and ACM are reading N/A or Error, do Harness Resistance Check (page 262).
- If EIM PIDs are reading correctly but only the ECM or ACM are reading N/A or Error, verify PWR, GND and CAN circuits to that module.

Harness Resistance Check

Turn ignition switch to OFF. Disconnect EIM, ECM and ACM. Connect breakout box. Leave EIM, ECM and ACM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
X2-6 to E2-22	< 5 Ω	If > 5 Ω, check CAN-H for OPEN in circuit.
X2-6 to B-20	< 5 Ω	If > 5 Ω, check CAN-H for OPEN in circuit.
X2-6 to GND	> 1 kΩ	If < 1 kΩ, check CAN-H for short to GND.
X2-13 to E2-21	< 5 Ω	If > 5 Ω, check CAN-L for OPEN in circuit.
X2-13 to B-21	< 5 Ω	If > 5 Ω, check CAN-L for OPEN in circuit.
X2-13 to GND	> 1 kΩ	If < 1 kΩ, check CAN-L for short to GND.

CAN (Private) Circuit Operation

The EIM communicates with the ECM and ACM through CAN (private) circuits. CAN-H circuit connects EIM pin X2–6 with ECM pin E2–22 and ACM pin B–20, and CAN-L circuit connects EIM pin X2–13 with ECM pin E2–21 and ACM pin B–21. Some of the information communicated through private CAN include DTCs and PID information.

Public CAN versus Private CAN

The public CAN network is set up to communicate with many different modules. The network branches off into many different locations with each path ending in a module connection or a 120 ohm terminating resistor. The termination resistors are used to reduce reflections.

The private CAN system is set up to only communicate between the EIM, ECM and ACM.

Repair Information

The private CAN circuits use a twisted wire pair. All repairs must maintain one complete twist per inch along the entire length of the circuit. This circuit is polarized, one positive and one negative. Reversing the polarity of this circuit disrupts communications.

CFV (Coolant Flow Valve)

DTC	SPN	FMI	Condition
1260	7321	5	Coolant Flow Valve open circuit
1261	7321	11	Coolant Flow valve short circuit

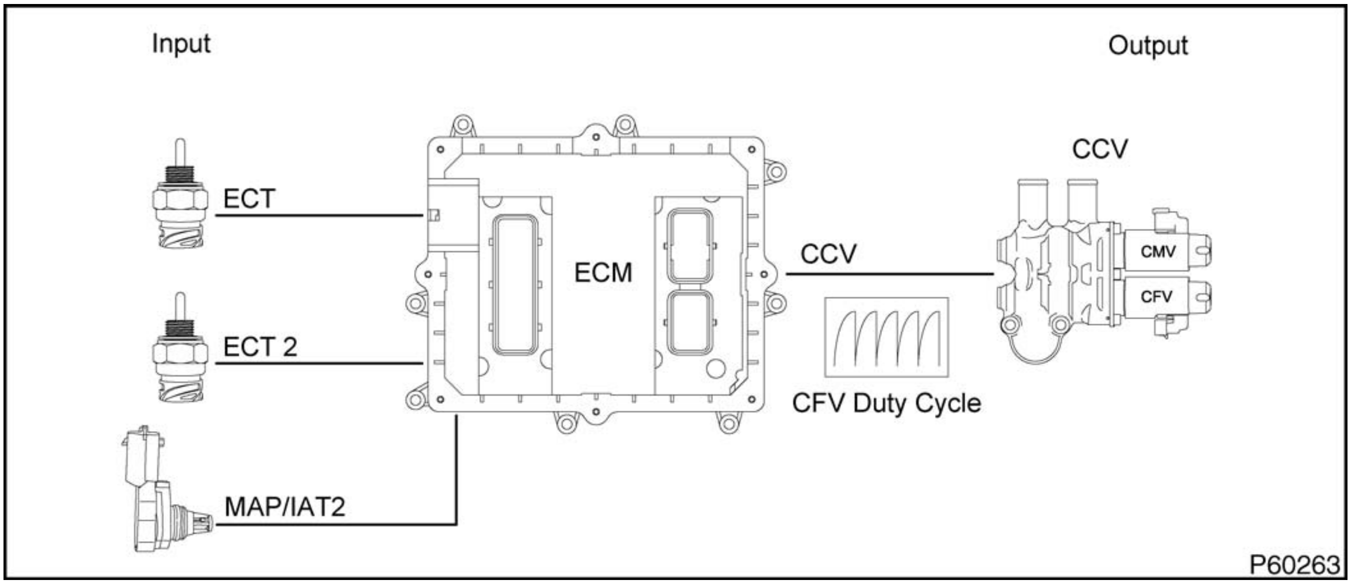

Figure 197 Functional diagram for CFV

The functional diagram for the CFV includes the following:

- CFV
- Engine Control Module (ECM)
- Engine Coolant Temperature (ECT) sensor
- ECT2 sensor
- Manifold Absolute Pressure/Intake Air Temperature 2 (MAP/IAT2) sensor

Function

The Coolant Mixer Valve (CMV) and CFV are located in the Coolant Control Valve (CCV). These valves are controlled by the ECM to regulate the flow, and mix coolant going through the Change Air Coolers (CAC).

CFV controls the rate of coolant flow through the CACs and the CMV regulates the temperature of the coolant, by directing the coolant either through the low temperature radiator or through an internal bypass.

Component Location

The CMV and CFV are part of the CCV, which is located on the right side of the front cover. They are serviced as an assembly.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- Coolant Flow Valve Breakout Harness (page 441)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- Terminal Test Adapter Kit (page 446)

CFV Connector End Diagnostics

DTC	Condition	Possible Causes
1260	Coolant Flow Valve open circuit	• CFV circuits OPEN • Failed CFV
1261	Coolant Flow Valve short circuit	• CFV circuits shorted • Failed CFV

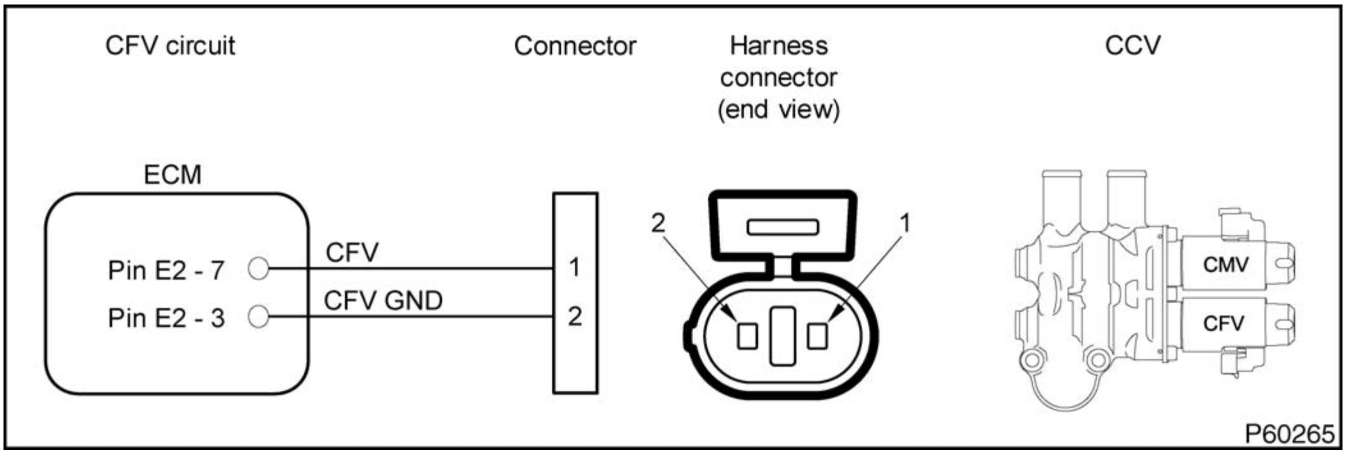

Figure 198 CFV circuit diagram

1. Key ON, engine OFF.
2. Connect the EST with MasterDiagnostics® software.
3. Verify correct engine is selected and launch EST.
4. Open D_Actuator.ssn session.

Connector Voltage Check

Connect breakout harness to engine harness and leave CFV disconnected. Turn ignition switch ON. Use DMM to measure voltage after 60 seconds.

Test Point	Spec	Comment
2 to battery positive	B+	If < B+, check for OPEN CFV GND circuit.
1 to 2	6 V to 9 V	If 0 V, check for OPEN or short to GND. If < 6 V, check for poor connection, corroded circuits. If > 9 V, check for short to PWR
If measurements are within specifications, do Operational Voltage Check - Actuator Test (page 266).		

Operational Voltage Check - Actuator Test

Connect breakout harness between CFV and engine harness. Run Actuator Test. Use DMM to measure voltage. Batteries must be fully charged before performing this test.

Test Point	Spec	Comment
DMM - Measure Volts across pin A and GND		
Normal state	< 1 V	If > 1 V, check for short to PWR.
Actuator state LOW	1 V +/- 0.5 V	If > 1.5 V, check for OPEN circuit or CFV.
Actuator state HIGH	> 9 V	If < 9 V, check for OPEN circuit or short to GND
If measurements are within specifications, do Actuator Resistance Check (page 266).		

Actuator Resistance Check

Turn ignition switch OFF. Connect breakout harness to CFV and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to 2	4 Ω to 8 Ω	If not within specification, replace the CCV.
If measurements are within specifications, do Harness Resistance Check (page 266).		

Harness Resistance Check

Turn ignition switch OFF. Connect ECM breakout box and breakout harness to engine harness and leave CFV and ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1k Ω, check for short circuit.
1 to E2-7	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1 kΩ	If < 1k Ω, check for OPEN circuit.
2 to E2-3	< 5 Ω	If > 5 Ω, check for OPEN circuit.
If voltage and resistance checks are within specifications, the CFV is working correctly. See Coolant System (page 92) in the “Engine Symptoms Diagnostics” section in this manual, to diagnose a mechanical fault.		

Actuator Test

The actuator test allows a technician to test the actuators by measuring voltage changes and visually monitoring actuator movement.

This test first runs through the Engine Control Module (ECM) actuators, then the Aftertreatment Control Module (ACM) actuators, and finishes with the Engine Interface Module (EIM) actuators.

ECM Actuators

During the ECM portion of the actuator test, all ECM actuators are commanded to LOW state, 8% to 15% duty cycle. Then one by one, each actuator is commanded to HIGH state, 80% to 100% duty cycle. This test will not cycle the Fuel Pressure Control Valve (FPCV) or the Exhaust Lambda Sensor (ELS) heater.

ACM Actuators

During the ACM portion of the actuator test, all ACM actuators remain at 0% duty cycle. Then one by one, each actuator is cycled on. The Aftertreatment Fuel Supply (AFS) valve and Aftertreatment Fuel Drain (AFD) valve are commanded to 100%, then drop to 66%. The Aftertreatment Fuel Injector (AFI) is commanded to a low duty cycle measured in seconds from 0 (off) to 0.1 (on).

EIM Actuators

During the EIM portion of the actuator test, the actuators cycle simultaneously. Fan Control Status is 1 (on), then cycles to 0 (off). The Cold Start Relay (CSR) and Cold Start Solenoid (CSS) is 0 (off), then cycles to 1 (on).

NOTE: When the Actuator Test is running, the sensor monitoring Parameter Identifiers (PIDs) are turned off.

This test cycles the following actuators:

- ECM actuators:
  - Intake Throttle Valve (ITV)
  - Boost Control Solenoid (BCS) valve
  - Exhaust Gas Recirculation (EGR) control valve
  - Coolant Mixer Valve (CMV)
  - Coolant Flow Valve (CFV)
- EIM actuators:
  - Cold Start Relay (CSR)
  - Cold Start Solenoid (CSS) valve
  - Electronic Fan Control (EFAN)
- ACM actuators:
  - Aftertreatment Fuel Drain (AFD) valve
  - Aftertreatment Fuel Supply (AFS) valve
  - Aftertreatment Fuel Injector (AFI)

CKP Sensor (Crankshaft Position)

DTC	SPN	FMI	Condition
1614	8064	3	CKP signal out-of-range HIGH
1615	8064	4	CKP signal out-of-range LOW
4553	8064	5	CKP - no signal, open circuit
4554	8064	7	CKP missing gap detection error
4555	8064	8	CKP excessive pulses
4556	8064	14	CKP circuits reversed

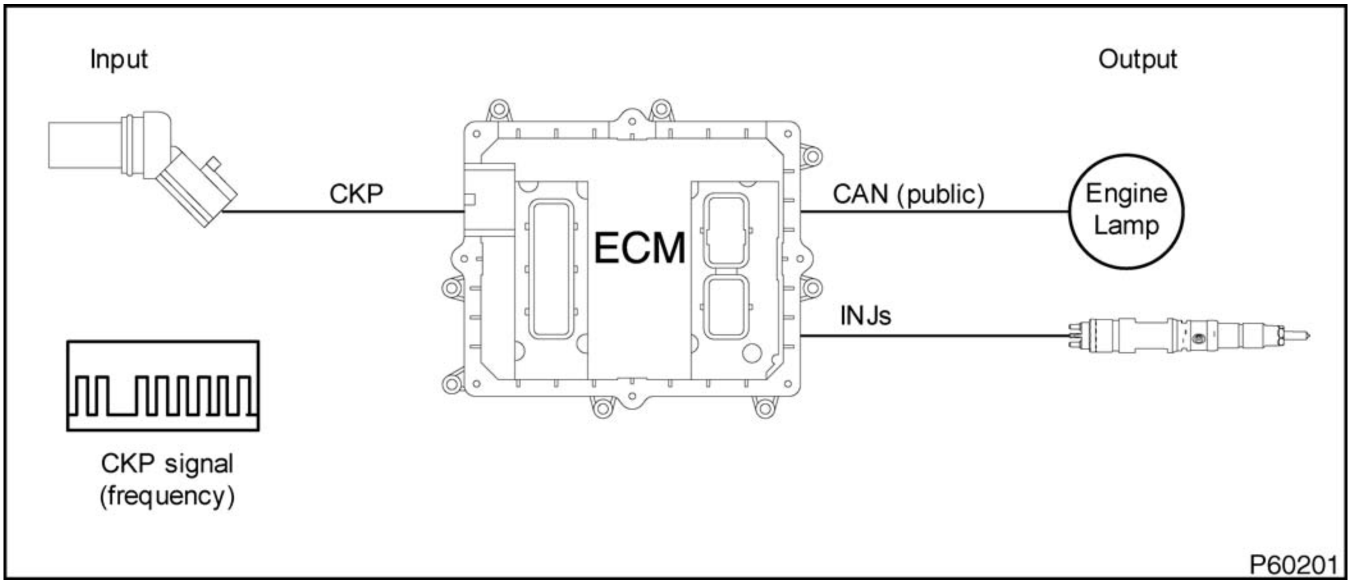

Figure 199 Functional diagram for the CKP sensor

The functional diagram for the CKP sensor includes the following:

- CKP sensor
- Engine Control Module (ECM)
- Fuel injector (INJ)
- Engine lamp (amber)

Function

The CKP sensor provides the ECM with a crankshaft speed and position signal. The ECM uses this signal to calculate engine speed, fuel timing, fuel quantity and duration of fuel injection.

Component Location

The CKP sensor is installed in the top left side of the flywheel housing.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- Terminal Test Adapter Kit (page 446)

- CMP, CKP and FPCV Breakout Harness (page 442)

CKP Sensor Pin-Point Diagnostics

DTC	Condition	Possible Causes
1614	CKP Signal out-of-range HIGH	• CKP-H signal OPEN or shorted to GND or PWR • CKP-L signal OPEN • Failed sensor
1615	CKP Signal out-of-range LOW	• CKP-H signal OPEN or shorted to GND or PWR • CKP-L signal OPEN • Failed sensor
4553	CKP - No signal, open circuit	• Circuit fault • Failed sensor
4554	CKP missing gap detection error	• Circuit fault • Failed sensor
4555	CKP excessive pulses	• CKP-H signal OPEN or shorted to GND or PWR • CKP-L signal OPEN • Failed sensor
4556	CKP circuits reversed	• Circuits reversed • Failed sensor

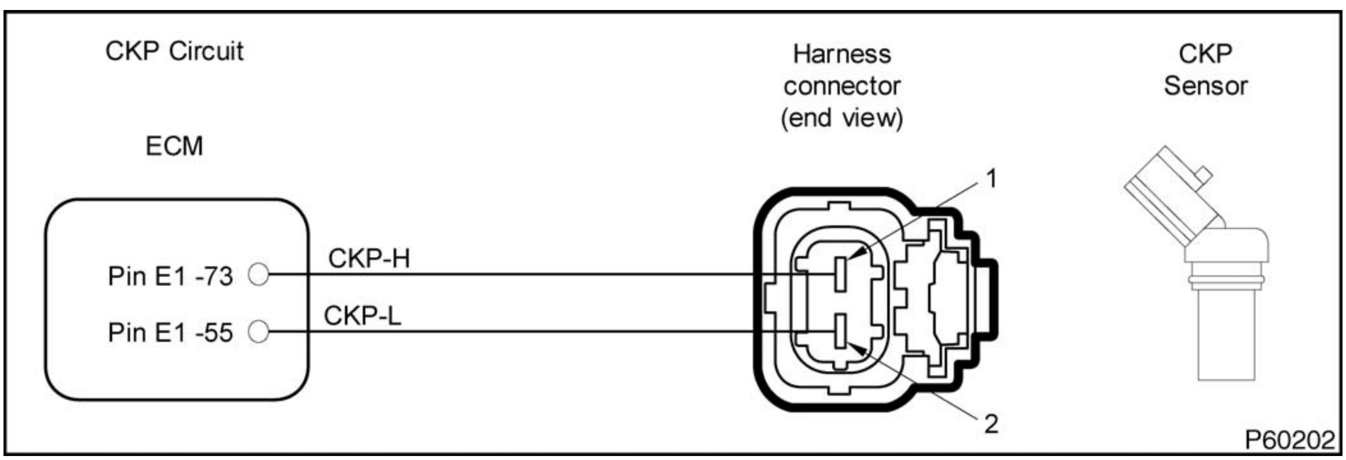

Figure 200 CKP sensor circuit diagram

Sensor Resistance Check

Turn the ignition switch to OFF. Connect breakout harness to CKP sensor and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to 2	774 Ω to 946 Ω	If measurement is within specification, do Harness Resistance Checks (page 270).
If measurement is not within specification, replace CKP sensor.		

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and leave ECM and CKP sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E1-55 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E1-55 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E1-73 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E1-73 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E1-73 to E1-55	> 1 kΩ	If < 1 kΩ, check for CKP-H short to CKP-L.
If measurements are within specification, do Operational Checks (page 270).		

Operational Checks

Connect breakout harness between CKP sensor and engine harness. Use DMM set to AC Volts-Hz.

Test Point	Condition	DMM	Engine Speed
E1-55 to E1-73	Engine crank	100 Hz to 250 Hz	100 rpm to 250 rpm
	Low idle	630 Hz to 730 Hz	600 rpm to 700 rpm
	High idle	2230 Hz	2180 rpm

CKP Sensor Circuit Operation

The CKP sensor contains a permanent magnet that creates a magnetic field. The signal is created when the timing disk rotates and breaks the magnetic field created by the sensor. The ECM pins for the CKP sensor are CKP-L E1-55 and CKP-H E1-73.

As the crankshaft turns, the CKP sensor detects a 60 hole timing disk on the flywheel. Holes 59 and 60 are missing so the ECM calculates and identifies the position of the crankshaft based on the signal gap.

The CKP sensor produces pulses for each hole edge that passes it. Crankshaft speed is derived from the frequency of the CKP sensor signal. The crankshaft position is determined by synchronizing the SYNC tooth with the SYNC gap signals from the target disk. From the CKP signal frequency, the ECM can calculate engine rpm.

By comparing the CKP signal with the Camshaft Position (CMP) signal, the ECM calculates engine rpm and timing. Diagnostic information on the CKP input signal is obtained by performing accuracy checks on frequency and duty cycle with software strategies.

CMP Sensor (Camshaft Position)

DTC	SPN	FMI	Condition
1607	8021	5	CMP - No signal
1608	8021	7	CMP sensor angle based phase system error- disagreement
1609	8021	8	CMP sensor time based phase system disagreement
1610	8021	14	CMP circuits reversed
1611	8021	3	CMP signal out-of-range HIGH
1612	8021	4	CMP signal out-of-range LOW

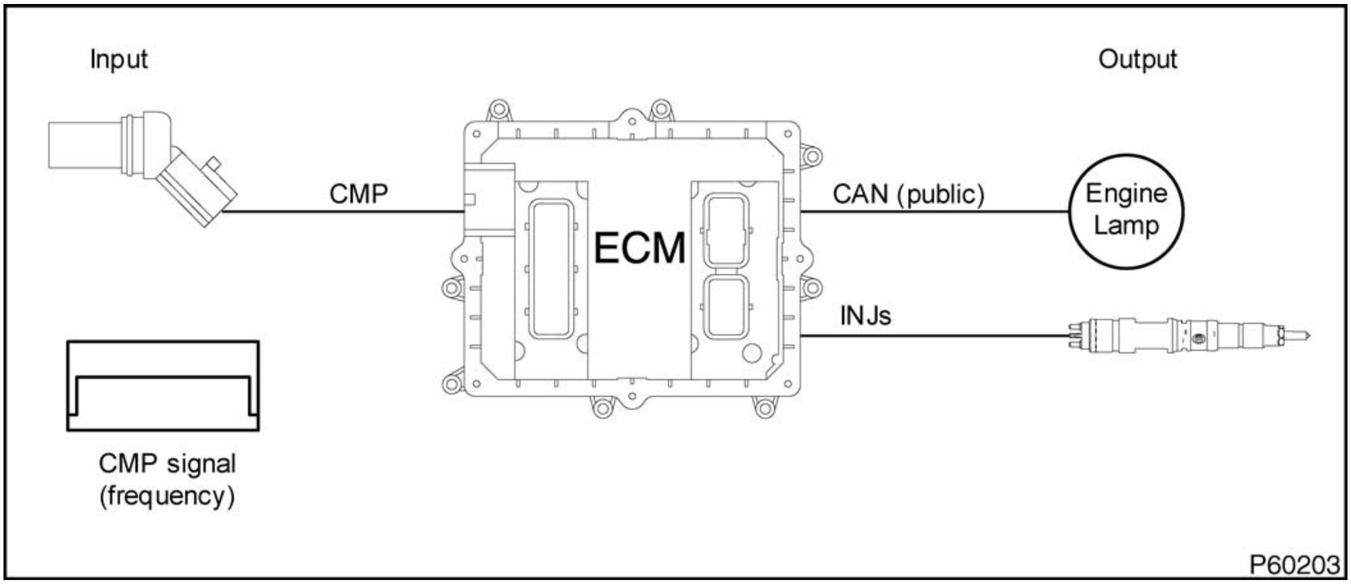

Figure 201 Functional diagram for the CMP sensor

The functional diagram for the CMP sensor includes the following:

- CMP sensor
- Engine Control Module (ECM)
- Fuel Injector (INJ)
- Engine lamp (amber)

Function

The CMP sensor provides the ECM with a camshaft speed and position signal. The ECM uses this signal with the Crankshaft Position (CKP) signal to calculate engine speed and position.

Sensor Location

The CMP sensor is installed on the left rear side of the cylinder head.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)

- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- Terminal Test Adapter Kit (page 446)
- CMP, CKP and FPCV Breakout Harness (page 442)

CMP Sensor Pin-Point Diagnostics

DTC	Condition	Possible Causes
1607	CMP - No signal	• Circuit fault • Failed CMP sensor
1608	CMP sensor angle based phase system error disagreement	• Circuit fault • Failed CMP sensor
1609	CMP sensor time based phase system disagreement	• CMP-H signal OPEN or shorted to GND or PWR • CMP-L signal OPEN • Failed CMP sensor
1610	CMP circuits reversed	• CMP circuits reversed • Failed CMP sensor
1611	CMP signal out-of-range HIGH	• CMP-H signal OPEN or shorted to GND or PWR • CMP-L signal OPEN • Failed CMP sensor
1612	CMP signal out-of-range LOW	• CMP-H signal OPEN or shorted to GND or PWR • CMP-L signal OPEN • Failed CMP sensor

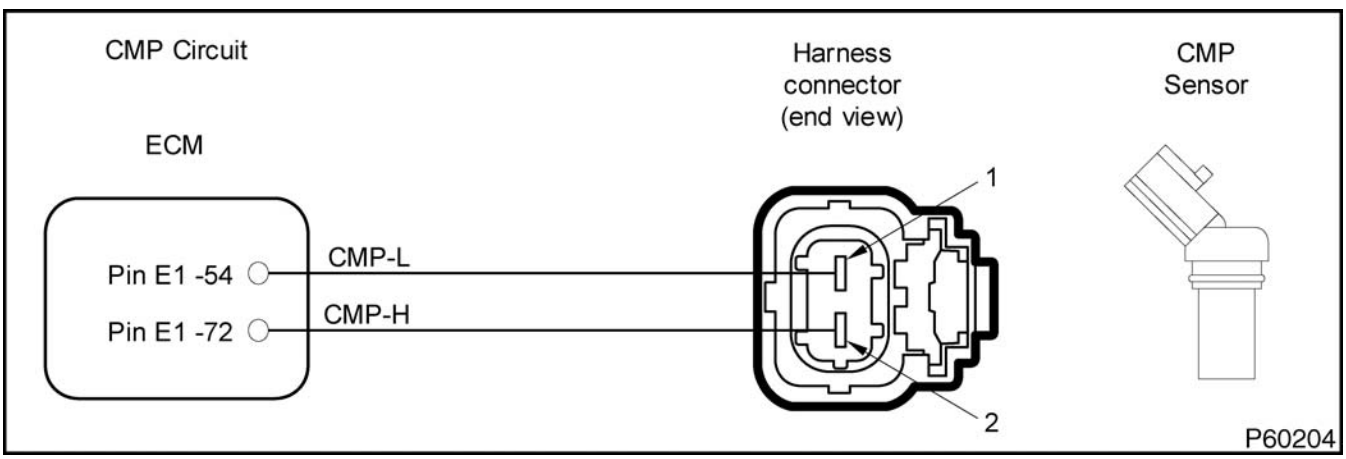

Figure 202 CMP sensor circuit diagram

Sensor Resistance Check

Turn the ignition switch to OFF. Connect breakout harness to CMP sensor and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to 2	774 Ω to 946 Ω	If measurement is within specification, do Harness Resistance Checks (page 273).
If measurement is not within specification, replace CMP sensor.		

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and leave ECM and CMP sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E1-72 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E1-72 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E1-54 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E1-54 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E1-72 to E1-54	> 1 kΩ	If < 1 kΩ, check for CMP-H short to CMP-L.
If measurements are within specification, do Operational Checks (page 273).		

Operational Checks

Connect breakout box between ECM and CMP sensor. Use DMM set to AC volts – RPM2.

Test Point	Condition	Spec
E1-54 to E1-72	Engine crank	100 rpm to 250 rpm
	Low idle	650 rpm to 700 rpm
	High idle	2180 rpm

CMP Sensor Circuit Operation

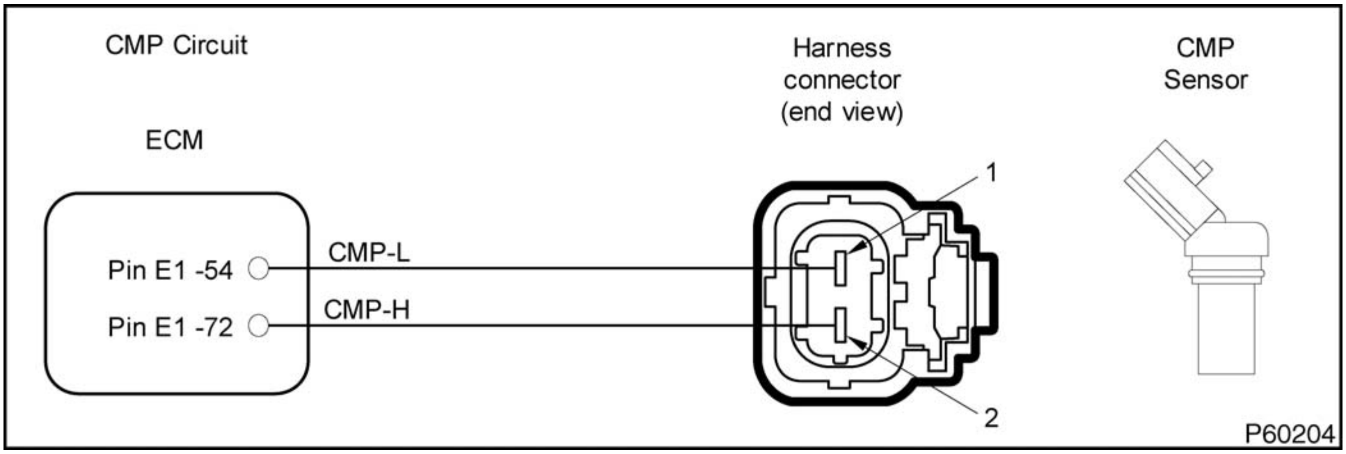

Figure 203 CMP sensor circuit diagram

The CMP sensor provides the ECM with a signal that indicates camshaft speed and position.

The CMP sensor contains a permanent magnet that creates a magnetic field. The signal is created when a peg on the camshaft disk rotates and breaks the magnetic field. As the cam rotates, the sensor identifies camshaft position. The ECM pins for the CMP sensor are CMP-L negative E1-54 and CMP-H positive E1-72.

By comparing the CMP signal with the CKP signal, the ECM calculates engine rpm and timing. Diagnostic information on the CMP input signal is obtained by performing accuracy checks on frequency and duty cycle with software strategies.

CMV (Coolant Mixer Valve)

DTC	SPN	FMI	Condition
1258	7320	5	Coolant Mixer Valve open circuit
1259	7320	11	Coolant Mixer Valve short circuit

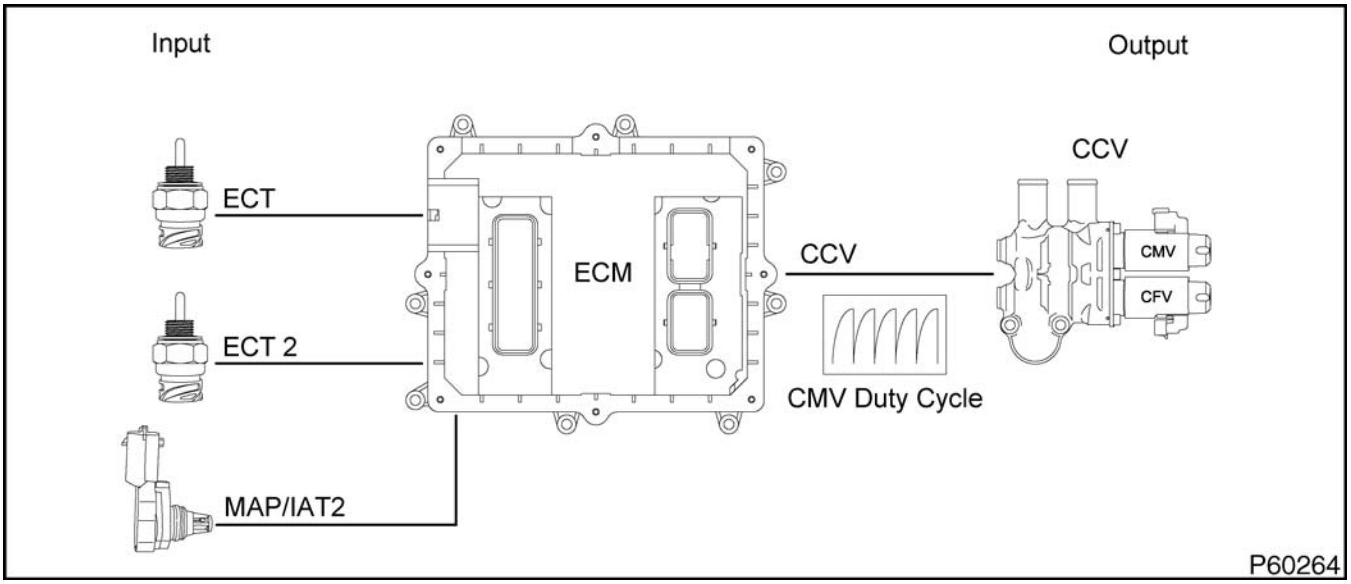

Figure 204 Functional diagram for CMV

The functional diagram for the CMV includes the following:

- CMV
- Engine Control Module (ECM)
- Engine Coolant Temperature (ECT) sensor
- ECT 2 sensor
- Manifold Absolute Pressure/Intake Air Temperature 2 (MAP/IAT2) sensor

Function

The CMV and Coolant Flow Valve (CFV) are located in the Coolant Control Valve (CCV). These valves are controlled by the ECM and regulate the flow, and mix coolant going through the Change Air Coolers (CAC).

CFV controls the rate of coolant flow through the CACs and the CMV regulates the temperature of the coolant, by directing the coolant either through the low temperature radiator or through an internal bypass.

Component Location

The CMV and CFV are mounted as an assembly on the right side of the front cover. They are serviced as an assembly.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- Coolant Mixer Valve Breakout Harness (page 442)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- Terminal Test Adapter Kit (page 446)

CMV Connector End Diagnostics

DTC	Condition	Possible Causes
1258	Coolant Mixer Valve open circuit	• CMV circuits OPEN • Failed CMV
1259	Coolant Mixer Valve short circuit	• CMV circuits shorted • Failed CMV

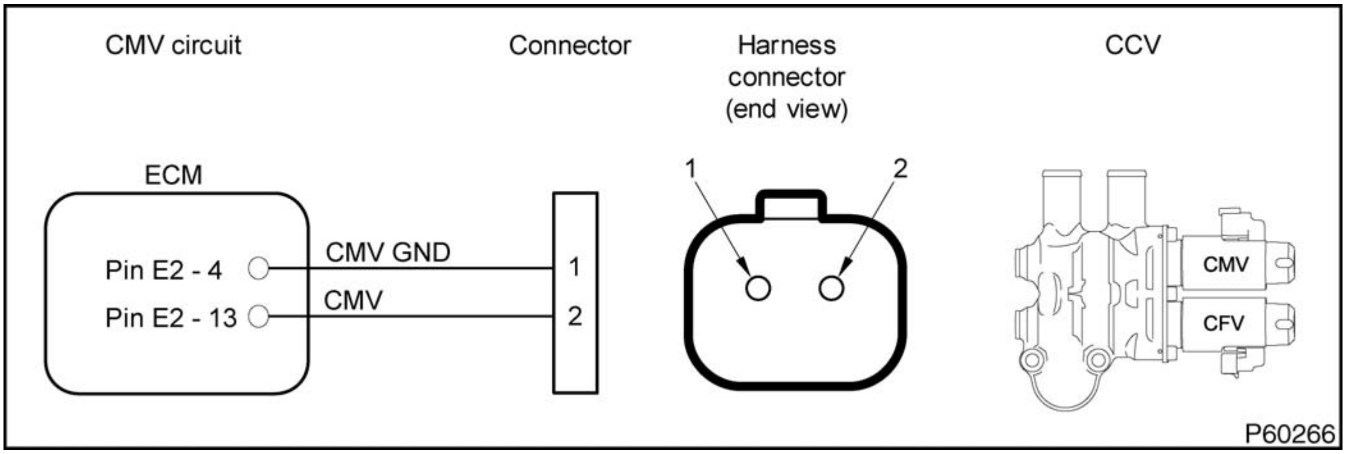

Figure 205 CMV circuit diagram

1. Key ON, engine OFF.
2. Connect the EST with MasterDiagnostics® software.
3. Verify correct engine is selected and launch EST
4. Open D_Actuator.ssn session.

Connector Voltage Check

Connect breakout harness to engine harness and leave CMV disconnected. Turn ignition switch ON. Use DMM to measure voltage after 60 seconds.

Test Point	Spec	Comment
1 to battery positive	B+	If < B+, check for OPEN CMV GND circuit.
1 to 2	6 V to 9 V	If 0 V, check for OPEN or short to GND. If < 6 V, check for poor connection, corroded circuits. If > 9 V, check for short to PWR
If measurements are within specifications, do Operational Voltage Check - Actuator Test (page 277).		

Operational Voltage Check - Actuator Test

Connect breakout harness between CMV and engine harness. Run Actuator Test. Use DMM to measure voltage. Batteries must be fully charged before performing this test.

Test Point	Spec	Comment
DMM - Measure Volts across pin 2 and GND		
Normal state	< 1 V	If > 1 V, check for short to PWR.
Actuator state LOW	1 V +/- 0.5 V	If > 1.5 V, check for OPEN circuit or CMV.
Actuator state HIGH	> 9 V	If < 9 V, check for OPEN circuit or short to GND
If measurements are within specifications, do Actuator Resistance Check (page 277).		

Actuator Resistance Check

Turn ignition switch OFF. Connect breakout harness to CMV and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to 2	4 Ω to 8 Ω	If not within specification, replace the CCV.
If measurements are within specifications, do Harness Resistance Check (page 277).		

Harness Resistance Check

Turn ignition switch OFF. Connect ECM breakout box and breakout harness to engine harness and leave CMV and ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1k Ω, check for short circuit.
1 to E2-4	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1 kΩ	If < 1k Ω, check for OPEN circuit.
2 to E2-13	< 5 Ω	If > 5 Ω, check for OPEN circuit.
If voltage and resistance checks are within specifications, the CMV is working correctly. See Coolant System (page 92) in the “Engine Symptoms Diagnostics” section in this manual to diagnose a mechanical fault.		

Actuator Test

The actuator test allows a technician to test the actuators by measuring voltage changes and visually monitoring actuator movement.

This test first runs through the Engine Control Module (ECM) actuators, then the Aftertreatment Control Module (ACM) actuators, and finishes with the Engine Interface Module (EIM) actuators.

ECM Actuators

During the ECM portion of the actuator test, all ECM actuators are commanded to LOW state, 8% to 15% duty cycle. Then one by one, each actuator is commanded to HIGH state, 80% to 100% duty cycle. This test will not cycle the Fuel Pressure Control Valve (FPCV) or the Exhaust Lambda Sensor (ELS) heater.

ACM Actuators

During the ACM portion of the actuator test, all ACM actuators remain at 0% duty cycle. Then one by one, each actuator is cycled on. The Aftertreatment Fuel Supply (AFS) valve and Aftertreatment Fuel Drain (AFD) valve are commanded to 100%, then drop to 66%. The Aftertreatment Fuel Injector (AFI) is commanded to a low duty cycle measured in seconds from 0 (off) to 0.1 (on).

EIM Actuators

During the EIM portion of the actuator test, the actuators cycle simultaneously. Fan Control Status is 1 (on), then cycles to 0 (off). The Cold Start Relay (CSR) and Cold Start Solenoid (CSS) is 0 (off), then cycles to 1 (on).

NOTE: When the Actuator Test is running, the sensor monitoring Parameter Identifiers (PIDs) are turned off.

This test cycles the following actuators:

- ECM actuators:
  - Intake Throttle Valve (ITV)
  - Boost Control Solenoid (BCS) valve
  - Exhaust Gas Recirculation (EGR) control valve
  - Coolant Mixer Valve (CMV)
  - Coolant Flow Valve (CFV)
- EIM actuators:
  - Cold Start Relay (CSR)
  - Cold Start Solenoid (CSS) valve
  - Electronic Fan Control (EFAN)
- ACM actuators:
  - Aftertreatment Fuel Drain (AFD) valve
  - Aftertreatment Fuel Supply (AFS) valve
  - Aftertreatment Fuel Injector (AFI)

Control Module Self-Diagnostics

DTC	SPN	FMI	Condition
1151	108	3	BAP signal out-of-range HIGH
1152	108	4	BAP signal out-of-range LOW
1153	108	10	BAP signal abnormal rate of change
1377	1136	3	ECM Temp above maximum
1378	1136	4	ECM Temp below minimum
1379	158	0	B+ to ECM out-of-range HIGH
4511	8358	2	Bank A Injector driver over voltage
4512	8358	3	Bank A Injector driver under voltage
4513	8358	4	Bank A Injector driver under current
4514	8358	5	Bank A Injector driver over current
4515	8358	6	Bank A Injector low driver over current
4516	8358	8	Bank A Injector on phase time-out
4517	8358	10	Bank A Injector time-out
4521	8359	2	Bank B Injector driver over voltage
4522	8359	3	Bank B Injector driver under voltage
4523	8359	4	Bank B Injector driver under current
4524	8359	5	Bank B Injector driver over current
4525	8359	6	Bank B Injector low driver over current
4526	8359	8	Bank B Injector on phase time-out
4527	8359	10	Bank B Injector time-out
4528	7253	14	ECM Error - Injector control out of normal operating range
5536	8253	1	EIM Error - Manufacturing defaults were selected
5541	8254	8	EIM Error - Unexpected reset fault
5549	8240	11	EIM Error - RAM programmable parameter list corrupted
5632	8254	12	EIM Error - RAM/CPU self-test fault
5637	3511	5	ECM Error - Fuel Rail Pressure error
6319	8487	19	EFRC information not received by ECM
6320	8484	19	EFRC invalid value or time-out by ECM

Fault Detection / Management

The Engine Control Module (ECM) and Engine Interface module (EIM) automatically perform diagnostic self-checks. The ECM and EIM self-tests include memory, programming, and internal power supply checks. The ECM and EIM detect internal module failure and set the Diagnostic Trouble Codes (DTCs) depending on the severity of the problem. Additionally, the ECM provides DTC management strategies to permit limited engine and vehicle operation.

ECM Self Diagnostic Trouble Codes (DTCs)

DTC 1151 - Barometric Absolute Pressure (BAP) signal out-of-range HIGH

Checks whether the signal from the BAP sensor is above the maximum threshold.

Pin-Point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 1152 - BAP signal out-of-range LOW

Checks whether the signal from the BAP sensor is below the minimum threshold.

Pin-Point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 1153 - BAP signal abnormal rate of change

Checks whether the signal from the BAP increases of decreases within expected range.

Pin-Point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 1377 - ECM Temp above maximum

Checks whether the signal from the ECM temperature sensor is below the maximum threshold.

Pin-Point ECM Self-Diagnostic Fault

1. Correct any abnormal condition of ECM overheating.
2. If DTC is set in cool conditions, then replace ECM.

DTC 1378 - ECM Temp below minimum

Checks whether the signal from the ECM temperature sensor is below the above minimum threshold.

Pin-Point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 1379 - B+ to ECM out-of-range HIGH

Pin-Point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 4511 - Bank A Injector driver over voltage

Pin-Point ECM Self-Diagnostic Fault

1. Check for injector circuit faults. See Injector (INJ) Circuits (page 396) in this section.
2. If OK, clear DTC, cycle ignition switch.
3. If DTC is still active, replace ECM.

DTC 4512 - Bank A Injector driver under voltage

Pin-Point ECM Self-Diagnostic Fault

1. Check for injector circuit faults. See Injector (INJ) Circuits (page 396) in this section.
2. If OK, clear DTC, cycle ignition switch.
3. If DTC is still active, replace ECM.

DTC 4513 - Bank A Injector driver under current

Pin-Point ECM Self-Diagnostic Fault

1. Check for injector circuit faults. See Injector (INJ) Circuits (page 396) in this section.
2. If OK, clear DTC, cycle ignition switch.
3. If DTC is still active, replace ECM.

DTC 4514 - Bank A Injector driver over current

Pin-Point ECM Self-Diagnostic Fault

1. Check for injector circuit faults. See Injector (INJ) Circuits (page 396) in this section.
2. If OK, clear DTC, cycle ignition switch.
3. If DTC is still active, replace ECM.

DTC 4515 - Bank A Injector low driver over current

Pin-Point ECM Self-Diagnostic Fault

1. Check for injector circuit faults. See Injector (INJ) Circuits (page 396) in this section.
2. If OK, clear DTC, cycle ignition switch.
3. If DTC is still active, replace ECM.

DTC 4516 - Bank A Injector on phase time-out

Pin-Point ECM Self-Diagnostic Fault

1. Check for injector circuit faults. See Injector (INJ) Circuits (page 396) in this section.
2. If OK, clear DTC, cycle ignition switch.
3. If DTC is still active, replace ECM.

DTC 4517 - Bank A Injector time-out

Pin-Point ECM Self-Diagnostic Fault

1. Check for injector circuit faults. See Injector (INJ) Circuits (page 396) in this section.
2. If OK, clear DTC, cycle ignition switch.
3. If DTC is still active, replace ECM.

DTC 4521 - Bank B Injector driver over voltage

Pin-Point ECM Self-Diagnostic Fault

1. Check for injector circuit faults. See Injector (INJ) Circuits (page 396) in this section.
2. If OK, clear DTC, cycle ignition switch.
3. If DTC is still active, replace ECM.

DTC 4522 - Bank B Injector driver under voltage

Pin-Point ECM Self-Diagnostic Fault

1. Check for injector circuit faults. See Injector (INJ) Circuits (page 396) in this section.
2. If OK, clear DTC, cycle ignition switch.
3. If DTC is still active, replace ECM.

DTC 4523 - Bank B Injector driver under current

Pin-Point ECM Self-Diagnostic Fault

1. Check for injector circuit faults. See Injector (INJ) Circuits (page 396) in this section.
2. If OK, clear DTC, cycle ignition switch.
3. If DTC is still active, replace ECM.

DTC 4524 - Bank B Injector driver over current

Pin-Point ECM Self-Diagnostic Fault

1. Check for injector circuit faults. See Injector (INJ) Circuits (page 396) in this section.
2. If OK, clear DTC, cycle ignition switch.
3. If DTC is still active, replace ECM.

DTC 4525 - Bank B Injector low driver over current

Pin-Point ECM Self-Diagnostic Fault

1. Check for injector circuit faults. See Injector (INJ) Circuits (page 396) in this section.
2. If OK, clear DTC, cycle ignition switch.
3. If DTC is still active, replace ECM.

DTC 4526 - Bank B Injector on phase time-out

Pin-Point ECM Self-Diagnostic Fault

1. Check for injector circuit faults. See Injector (INJ) Circuits (page 396) in this section.
2. If OK, clear DTC, cycle ignition switch.
3. If DTC is still active, replace ECM.

DTC 4527 - Bank B Injector time-out

Pin-Point ECM Self-Diagnostic Fault

1. Check for injector circuit faults. See Injector (INJ) Circuits (page 396) in this section.
2. If OK, clear DTC, cycle ignition switch.
3. If DTC is still active, replace ECM.

DTC 4528 - ECM Error - Injector control out of normal operating range

Pin-Point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5536 - EIM Error - Manufacturing defaults were selected

Pin-Point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, reprogram or update EIM with the latest calibration.
3. Check for other DTCs or drive symptoms for further action.

DTC 5541 - EIM Error - Unexpected reset fault

Pin-Point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, check for intermittent loss of B+ to EIM.
3. If DTC is still active, replace EIM.

DTC 5549 - EIM Error - RAM programmable parameter list corrupted

Pin-Point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, reprogram or update module with the latest calibration.
3. If DTC is still active, replace EIM.

DTC 5632 - EIM Error - RAM/CPU self-test fault

Pin-Point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace EIM.

DTC 5637 - ECM Error - Fuel Rail Pressure error

Pin-Point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 6319 - EFRC information not received by ECM

Pin-Point ECM Self-Diagnostic Fault

1. Check EIM for correct vehicle configuration.
2. Clear DTC, cycle ignition switch.
3. If DTC is still active, replace EIM.

DTC 6320 - EFRC invalid value or time-out by ECM

Pin-Point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, reprogram or update module with the latest calibration.

CSR (Cold Start Relay)

DTC	SPN	FMI	Condition
1372	676	17	Cold Start Relay control fault
1373	7263	11	Cold Start Relay fault
1375	7264	7	Cold Start Relay circuit fault

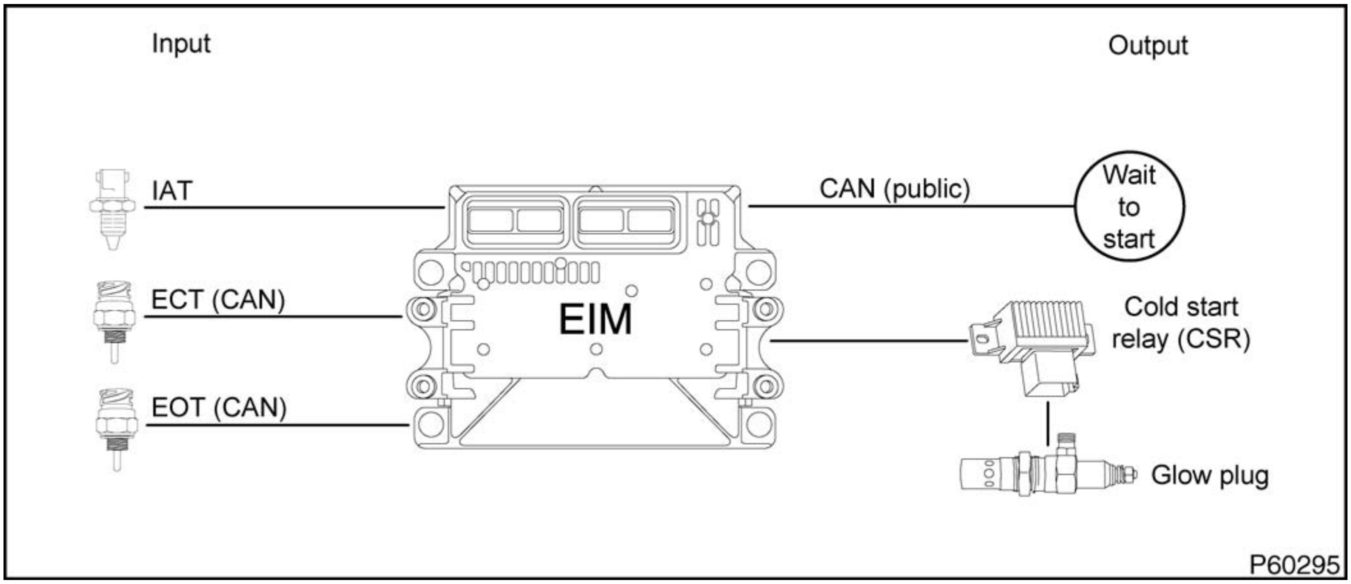

Figure 206 Functional diagram for CSR

The functional diagram for the CSR includes the following:

- CSR
- Engine Coolant Temperature (ECT) sensor
- Engine Interface Module (EIM)
- Engine Oil Temperature (EOT) sensor
- Glow plug
- Intake Air Temperature (IAT) sensor
- Wait to Start indicator

Function

The CSR provides voltage to the glow plug and is controlled by the EIM.

Component Location

The CSR is located on the left side of the engine above the Engine Control Module (ECM).

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- Cold Start Relay Breakout Harness (page 441)
- 96-Pin Breakout Box – DLC II (page 438)

CSR Pin-Point Diagnostics

DTC	Condition	Possible Causes
1372	Cold Start Relay control fault	• Control circuit fault • Failed CSR
1373	Cold Start Relay fault	• Circuit fault • Failed CSR
1375	Cold Start Relay circuit fault	• Circuit fault • Failed CSR

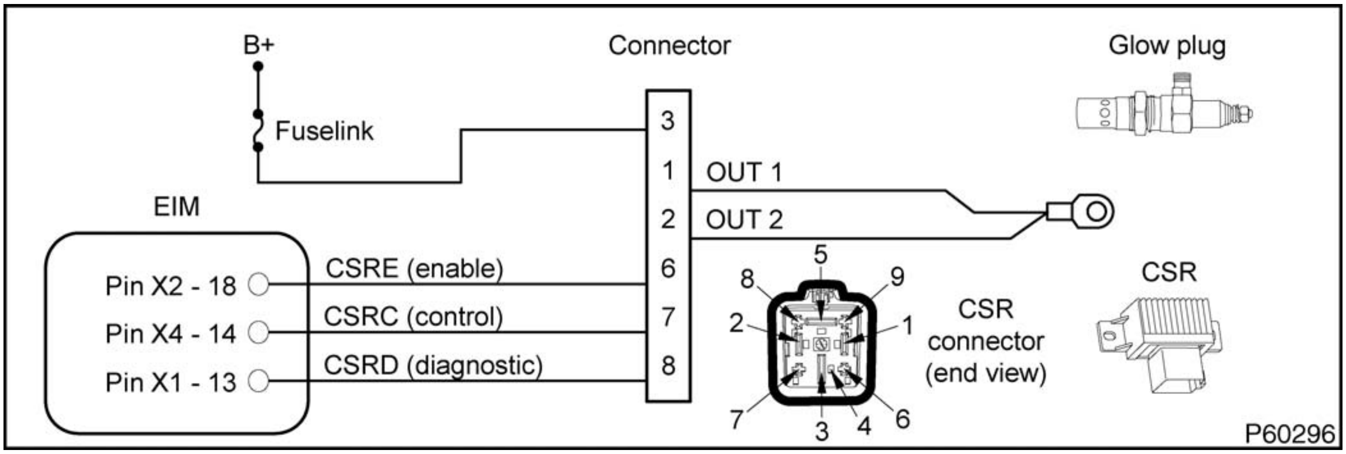

Figure 207 CSR circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

NOTE: Air tanks must be above 620 kPa (90 psi) before running this test.

1. Key ON, Engine OFF.
2. Connect the EST with MasterDiagnostics® software.
3. Verify correct engine is selected and launch EST.
4. Open D_Actuator.ssn session.

Voltage Check on Glow Plug - Actuator Test

Turn the ignition switch to ON. Run Actuator Test. Use DMM to measure voltage when CSR is cycled on. Batteries must be fully charged before performing this test.

Test Point	Spec	Comment
Glow Plug to GND	B+	If > 0 V to B+, do Amperage Draw Check - Actuator Test (page 287).
		If 0 V, do Voltage Checks on Relay Connector (page 287).

Amperage Draw Check - Actuator Test

Turn the ignition switch to ON. Run Actuator Test. Measure amperage draw to glow plug using DMM and Amp clamp. Set the DMM to DCmV and Zero the Amp clamp. Batteries must be fully charged before performing this test.

Test Point	Spec	Comment
DMM - Measure amperage to glow plug		
Glow plug	30 Amps (within 2 seconds)	If within specification, CSR and glow plug are working correctly.
		If not within specification, do Voltage Checks on Relay - Actuator Test (page 288).
If Amps are within specification, do Harness Resistance Check (page 289) for CSRD circuit.		

Voltage Checks on Relay Connector

Connect breakout box to CSR harness, leave CSR disconnected. Turn ignition switch to ON. Use DMM to measure voltage after 60 seconds.

Test Point	Spec	Comment
1 to GND	0 V	If > 0 V, check for short to PWR.
2 to GND	0 V	If > 0 V, check for short to PWR.
3 to GND	B+	If < B+, check for OPEN or short to GND.
6 to GND	9 V +/- 1 V	If < 9 V, check for OPEN or short to GND.
7 to GND	4 V +/- 1 V	If < 4 V, check for OPEN or short to GND.
		If > 5.5 V, check for short to PWR.
8 to GND	5 V +/- 1 V	If < 4 V, check for OPEN or short to GND.
		If > 5.5 V, check for short to PWR.
If voltages are within specification, do Voltage Checks on Relay - Actuator Test (page 288).		

Voltage Checks on Relay - Actuator Test

Connect breakout harness between CSR and engine harness. Turn the ignition switch ON. Use DMM to measure voltage. Batteries must be fully charged before performing this test.

Test Point	Spec	Comment
6 to GND, Run Actuator Test		
Normal state	> 8 V	If < 8 V, check CSRE circuit for OPEN or short to GND. Do Harness Resistance Check (page 289).
Actuator state LOW	> 8 V	If < 8 V, check CSRE circuit for OPEN or short to GND. Do Harness Resistance Check (page 289).
Actuator state HIGH	< 0.5 V	If > 0.5 V, check CSRE circuit for short to PWR. Do Harness Resistance Check (page 289).
7 to GND, Run Actuator Test.		
Normal state	> 8 V	If < 8 V, check CSRC circuit for OPEN or short to GND. Do Harness Resistance Check (page 289).
Actuator state LOW	> 8 V	If < 8 V, check CSRC circuit for OPEN or short to GND. Do Harness Resistance Check (page 289).
Actuator state HIGH	< 0.5 V	If > 0.5 V, check CSRD circuit for short to PWR. Do Harness Resistance Check (page 289).
8 to GND, Run Actuator Test.		
Normal state	5 V +/- 0.5 V	If < 5 V, check CSRD circuit for OPEN or short to GND. Do Harness Resistance Check (page 289).
Actuator state LOW	5 V +/- 0.5 V	If < 5 V, check CSRD circuit for OPEN or short to GND. Do Harness Resistance Check (page 289).
Actuator state HIGH	5 V +/- 0.5 V	If < 5 V, check CSRD circuit for OPEN or short to GND. Do Harness Resistance Check (page 289).
1 to GND, Run Actuator Test.		
Normal state	0 V	If > 0 V, replace CSR.
Actuator state LOW	0 V	If > 0 V, replace CSR.
Actuator state HIGH	B+	If < B+, replace CSR.
2 to GND, Run Actuator Test.		
Normal state	0 V	If > 0 V, replace CSR.
Actuator state LOW	0 V	If > 0 V, replace CSR.
Actuator state HIGH	B+	If < B+, replace CSR.
If measurements are not within specifications, do Harness Resistance Check (page 289).		

Glow Plug Resistance Check

Turn ignition switch OFF. Use DMM to measure resistance between glow plug and engine GND.

Test Point	Spec	Comment
Glow Plug to GND	< 5 Ω	If > 5 Ω, replace failed glow plug.

Harness Resistance Check

Connect breakout harness and breakout box and leave EIM and CSR disconnected. Use DMM to measure resistances.

Test Point	Spec	Comment
1 to Glow Plug	< 5 Ω	If > 5 Ω, check for OPEN circuit.
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN glow plug.
2 to Glow Plug	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	< 5 Ω	If > 5 Ω, check for OPEN glow plug.
3 to B+	< 5 Ω	If > 5 Ω, check for OPEN circuit.
6 to X2-18	< 5 Ω	If > 5 Ω, check for OPEN circuit.
6 to GND	> 1 kΩ	If < 1 kΩ check for short to GND.
7 to X4-14	< 5 Ω	If > 5 Ω, check for OPEN circuit.
7 to GND	> 1 kΩ	If < 1 kΩ check for short to GND.
8 to X1-13	< 5 Ω	If > 5 Ω, check for OPEN circuit.
8 to GND	> 1 kΩ	If < 1 kΩ check for short to GND.
If all checks are within specification, but DTCs are still active, replace the CSR.		

CSR Operation

The CSRE Pin X2–18 is connected to a switched B+ output from the EIM and is energized for the duration of the CSR controlling the glow plug. The CSRC Pin X4–14 is connected to a Pulse Width Modulated (PWM) output on the EIM that controls the heating of the glow plug. The CSRE and CSRC outputs work in conjunction.

The CSRD Pin X1–13 provides a PWM signal back to the EIM that mimics or is identical to the CSRC signal under normal conditions. When a fault condition occurs, the CSRD signal goes high when the CSRC signal is low to indicate to the EIM that a fault is present.

Actuator Test

The actuator test allows a technician to test the actuators by measuring voltage changes and visually monitoring actuator movement.

This test first runs through the Engine Control Module (ECM) actuators, then the Aftertreatment Control Module (ACM) actuators, and finishes with the Engine Interface Module (EIM) actuators.

ECM Actuators

During the ECM portion of the actuator test, all ECM actuators are commanded to LOW state, 8% to 15% duty cycle. Then one by one, each actuator is commanded to HIGH state, 80% to 100% duty cycle. This test will not cycle the Fuel Pressure Control Valve (FPCV) or the Exhaust Lambda Sensor (ELS) heater.

ACM Actuators

During the ACM portion of the actuator test, all ACM actuators remain at 0% duty cycle. Then one by one, each actuator is cycled on. The Aftertreatment Fuel Supply (AFS) valve and Aftertreatment Fuel Drain (AFD) valve are commanded to 100%, then drop to 66%. The Aftertreatment Fuel Injector (AFI) is commanded to a low duty cycle measured in seconds from 0 (off) to 0.1 (on).

EIM Actuators

During the EIM portion of the actuator test, the actuators cycle simultaneously. Fan Control Status is 1 (on), then cycles to 0 (off). The Cold Start Relay (CSR) and Cold Start Solenoid (CSS) is 0 (off), then cycles to 1 (on).

NOTE: When the Actuator Test is running, the sensor monitoring Parameter Identifiers (PIDs) are turned off.

This test cycles the following actuators:

- ECM actuators:
  - Intake Throttle Valve (ITV)
  - Boost Control Solenoid (BCS) valve
  - Exhaust Gas Recirculation (EGR) control valve
  - Coolant Mixer Valve (CMV)
  - Coolant Flow Valve (CFV)
- EIM actuators:
  - Cold Start Relay (CSR)
  - Cold Start Solenoid (CSS) valve
  - Electronic Fan Control (EFAN)
- ACM actuators:
  - Aftertreatment Fuel Drain (AFD) valve
  - Aftertreatment Fuel Supply (AFS) valve
  - Aftertreatment Fuel Injector (AFI)

CSS Valve (Cold Start Solenoid)

DTC	SPN	FMI	Condition
1371	676	18	Cold Start Solenoid fault

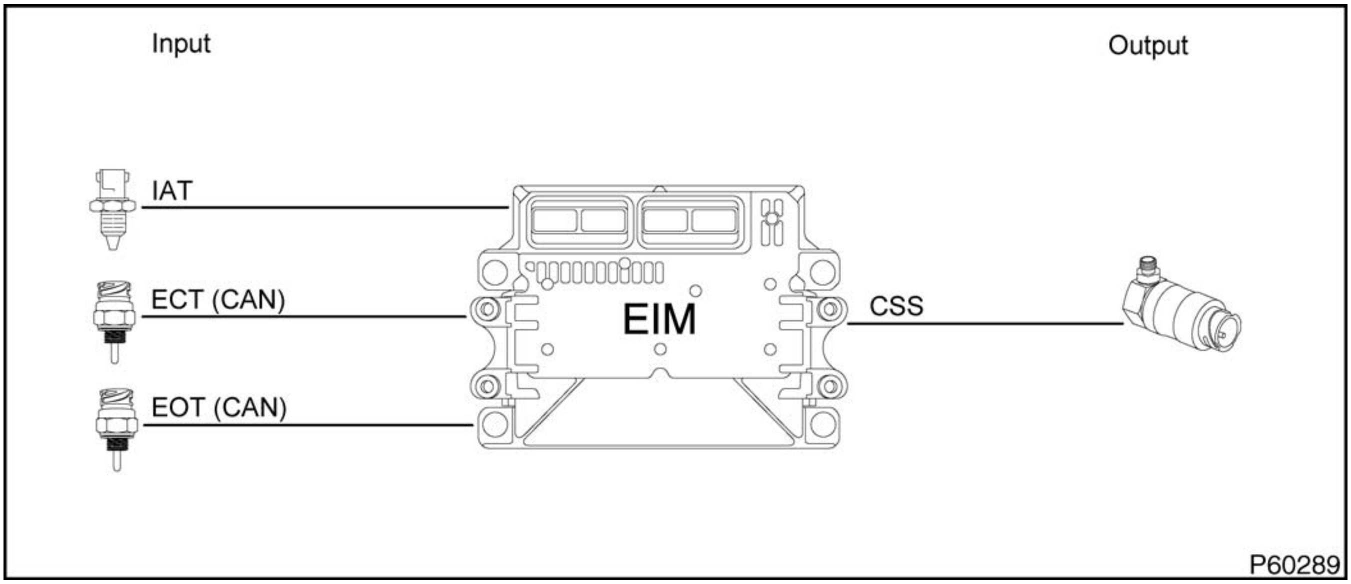

Figure 208 Functional diagram for CSS valve

The functional diagram for the CSS valve includes the following:

- CSS valve
- Engine Coolant Temperature (ECT) sensor
- Engine Interface Module (EIM)
- Engine Oil Temperature (EOT) sensor
- Intake Air Temperature (IAT) sensor

Function

The CSS valve is controlled by the EIM and allows low pressure fuel from the fuel filter assembly to flow through the cold start supply tube to the glow plug.

Component Location

The CSS valve is located in the front, on the left side of the engine

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 4-Pin Round Black Breakout Harness (page 437)
- 96-Pin Breakout Box – DLC II (page 438)

CSS Valve Connector End Diagnostics

DTC	Condition	Possible Causes
1371	Cold Start Solenoid fault	• CSS circuit short to GND or OPEN • CSS GND circuit OPEN • Failed CSS valve

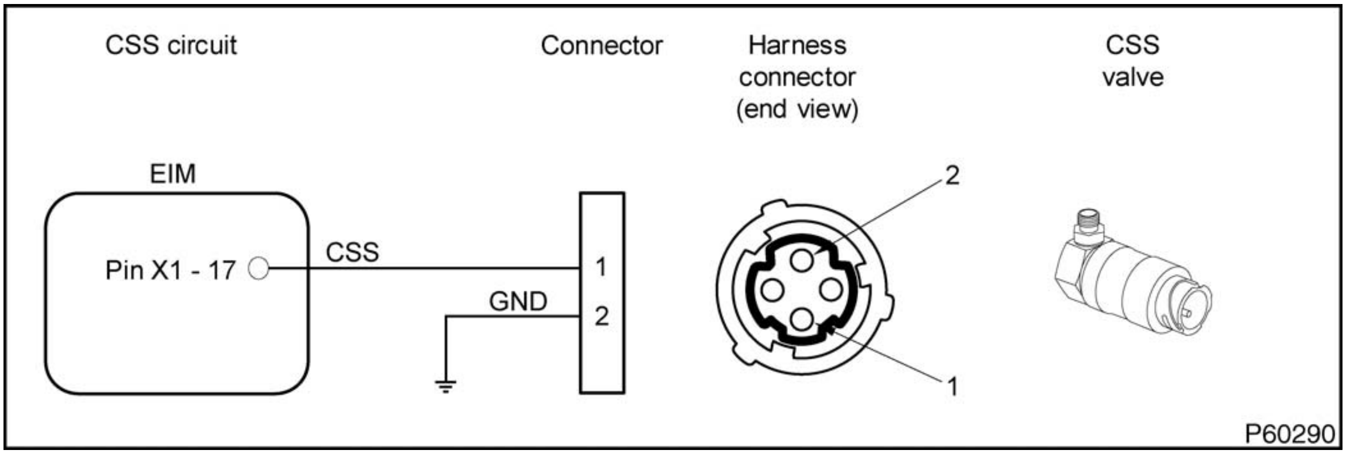

Figure 209 CSS valve circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

NOTE: Air tanks must be above 620 kPa (90 psi) before running this test.

1. Key ON, engine OFF.
2. Connect the EST with MasterDiagnostics® software.
3. Verify correct engine is selected and launch EST.
4. Open D_Actuator.ssn session.

Connector Voltage Check

Connect breakout harness to engine harness and leave CSS valve disconnected. Turn ignition switch ON. Use DMM to measure voltage.

Test Point	Spec	Comment
2 to battery positive	B+	If < B+, check for OPEN in GND circuit.
1 to 2	6 V to 9 V	If 0 V, check for OPEN or short to GND.
		If < 6 V, check for poor connection, corroded circuits.
		If > 9 V, check for short to PWR
If measurements are within specifications, do Operational Voltage Check - Actuator Test (page 293).		

Operational Voltage Check - Actuator Test

Connect breakout harness between CSS valve and engine harness. Run Actuator Test. Use DMM to measure voltage. Batteries must be fully charged before performing this test.

Test Point	Spec	Comment
DMM - Measure Volts across pin 1 and GND		
Normal state	< 1 V	If > 1 V, check for short to PWR.
Actuator state LOW	1 V +/- 0.5 V	If > 1.5 V, check for OPEN circuit or CSS valve.
Actuator state HIGH	> 9 V	If < 9 V, check for OPEN circuit or short to GND
If measurements are within specifications, do Actuator Resistance Check (page 293).		

Actuator Resistance Check

Turn ignition switch OFF. Connect breakout harness to CSS valve and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to 2	7.2 Ω to 8.8 Ω	If not within specification, replace the CSS valve.
If measurements are within specifications, do Harness Resistance Check (page 293).		

Harness Resistance Check

Turn ignition switch OFF. Connect EIM breakout box and breakout harness to engine harness and leave CSS valve and EIM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1k Ω, check for short circuit.
1 to X1-17	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
If voltage and resistance checks are within specifications, replace the CSS valve.		

CSS Valve Operation

Pin 1 of the CSS valve is driven by a switched B+ output from the EIM module, pin X1–17. Pin 2 of the CSS valve is grounded. The solenoid is held on for a fixed duration of time allowing fuel to enter the heater.

Actuator Test

The actuator test allows a technician to test the actuators by measuring voltage changes and visually monitoring actuator movement.

This test first runs through the Engine Control Module (ECM) actuators, then the Aftertreatment Control Module (ACM) actuators, and finishes with the Engine Interface Module (EIM) actuators.

ECM Actuators

During the ECM portion of the actuator test, all ECM actuators are commanded to LOW state, 8% to 15% duty cycle. Then one by one, each actuator is commanded to HIGH state, 80% to 100% duty cycle. This test will not cycle the Fuel Pressure Control Valve (FPCV) or the Exhaust Lambda Sensor (ELS) heater.

ACM Actuators

During the ACM portion of the actuator test, all ACM actuators remain at 0% duty cycle. Then one by one, each actuator is cycled on. The Aftertreatment Fuel Supply (AFS) valve and Aftertreatment Fuel Drain (AFD) valve are commanded to 100%, then drop to 66%. The Aftertreatment Fuel Injector (AFI) is commanded to a low duty cycle measured in seconds from 0 (off) to 0.1 (on).

EIM Actuators

During the EIM portion of the actuator test, the actuators cycle simultaneously. Fan Control Status is 1 (on), then cycles to 0 (off). The Cold Start Relay (CSR) and Cold Start Solenoid (CSS) is 0 (off), then cycles to 1 (on).

NOTE: When the Actuator Test is running, the sensor monitoring Parameter Identifiers (PIDs) are turned off.

This test cycles the following actuators:

- ECM actuators:
  - Intake Throttle Valve (ITV)
  - Boost Control Solenoid (BCS) valve
  - Exhaust Gas Recirculation (EGR) control valve
  - Coolant Mixer Valve (CMV)
  - Coolant Flow Valve (CFV)
- EIM actuators:
  - Cold Start Relay (CSR)
  - Cold Start Solenoid (CSS) valve
  - Electronic Fan Control (EFAN)
- ACM actuators:
  - Aftertreatment Fuel Drain (AFD) valve
  - Aftertreatment Fuel Supply (AFS) valve
  - Aftertreatment Fuel Injector (AFI)

Cylinder Balance

DTC	SPN	FMI	Condition
4571	8001	0	Cyl 1 cyl balance max limit exceeded
4572	8002	0	Cyl 2 cyl balance max limit exceeded
4573	8003	0	Cyl 3 cyl balance max limit exceeded
4574	8004	0	Cyl 4 cyl balance max limit exceeded
4575	8005	0	Cyl 5 cyl balance max limit exceeded
4576	8006	0	Cyl 6 cyl balance max limit exceeded

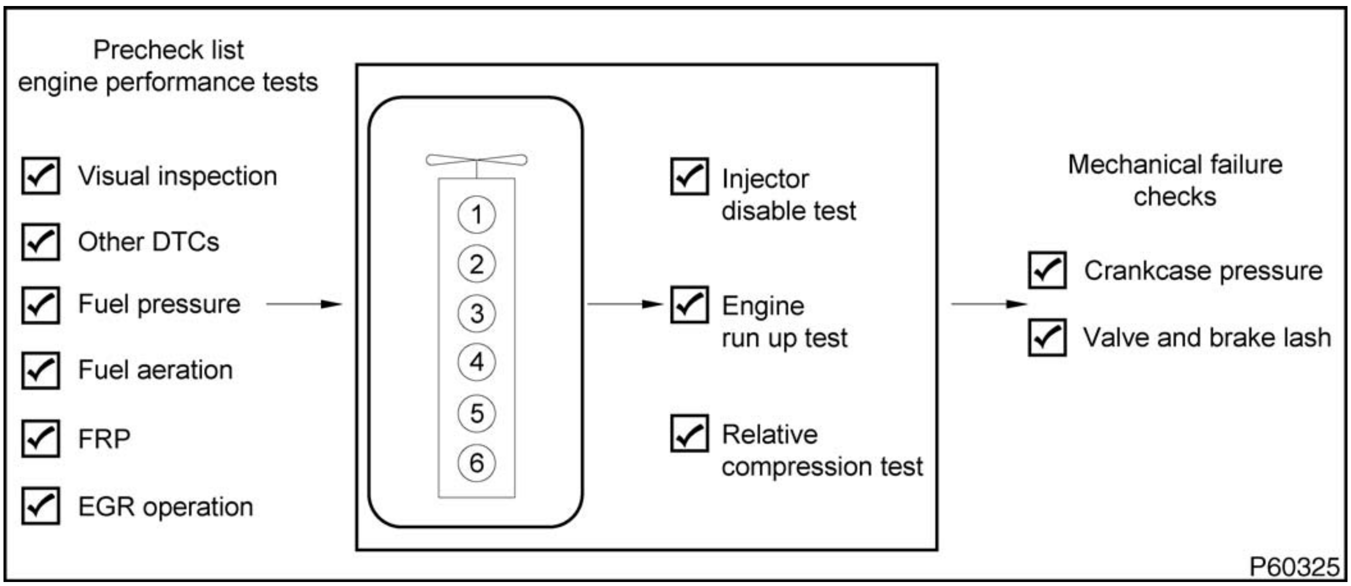

Figure 210 Functional diagram for the cylinder balance

Cylinder Balance Operation

Many factors influence the combustion process in a power cylinder. This can affect the production of torque or horsepower from that cylinder. Some of the factors include piston and cylinder geometry, injector performance, and fuel rail pressure. Variations in these factors can cause unevenness in torque and horsepower from one cylinder to the next. Power cylinder unevenness also causes increased engine noise and vibration, especially at low idle conditions. This is also referred to as rough idle.

The Engine Control Module (ECM) uses a Cylinder Balance control strategy to even the power contribution of the cylinders, particularly at low idle conditions. This strategy incorporates information from the Crankshaft Position (CKP) system. The ECM uses the instantaneous engine speed near Top Dead Center (TDC) for each cylinder as an indication of that cylinder's power contribution. The ECM computes a nominal instantaneous engine speed value based on all cylinders. The nominal value would be the expected value from all cylinders if the engine is balanced. By knowing the error quantities, the ECM can add or subtract fuel from a particular cylinder. The control strategy attempts to correct the cylinder unbalance by using fuel quantity compensation through adjustments of the pulse width values for each fuel injector. This method of compensation is repeated until all error quantities are close to zero causing all cylinders to contribute the same amount.

Cylinder Balance Diagnostics

DTC	Condition	Possible Causes
4571–4576	Cyl (number) balance max limit exceeded	• Electrical fault • Low fuel pressure • Aerated fuel • Contaminated fuel • EGR control valve stuck open • Failed injector • Base engine compression imbalance

DTC 4571–4576 – Cylinder balance max limit exceeded

The ECM continuously calculates the balance of each cylinder during normal engine operation. If a cylinder is over performing, a cylinder balance Diagnostic Trouble Code (DTC) sets.

Pin-Point Cylinder Balance Fault

1. Visually inspect engine for damaged or disconnected components.
   - Check all fluid levels.
   - Check engine and control system for electrical or mechanical damage.
2. Check for other active DTCs that could cause a cylinder imbalance.
   - If injector electrical faults are set, diagnose the electrical fault before diagnosing a cylinder imbalance.
3. Check fuel pressure, fuel aeration, and possible fuel contamination.

   Note: See Fuel Pressure and Aeration (page 114) in the “Engine Symptoms Diagnostics” section of this manual.
4. Check Fuel Rail Pressure (FRP) and voltage.
   - Check FRP voltage at KOEO.

     See “Appendix A: Performance Specifications” in this manual for specification.
   - Check FRP system pressure during KOER. Run Engine Run-Up Test.
5. Inspect Exhaust Gas Recirculation (EGR) control valve. Verify valve is not stuck open.

Repair any faults found in any of the preceding checks before continuing.

1. Run Injector Disable Test and Engine Run Up Test to identify imbalanced cylinder.
2. Run Relative Compression Test to verify if cylinder imbalance is a mechanical issue or an injector issue.

   If the Relative Compression Test fails the same cylinder as indicated by the Injector Disable Test, the fault is a mechanical failure.

   See “Appendix A: Performance Specifications” in this manual for specification.
   - Check crankcase pressure.

EBP Sensor (Exhaust Back Pressure)

DTC	SPN	FMI	Condition
3341	7129	4	EBP signal out-of-range LOW
3342	7129	3	EBP signal out-of-range HIGH

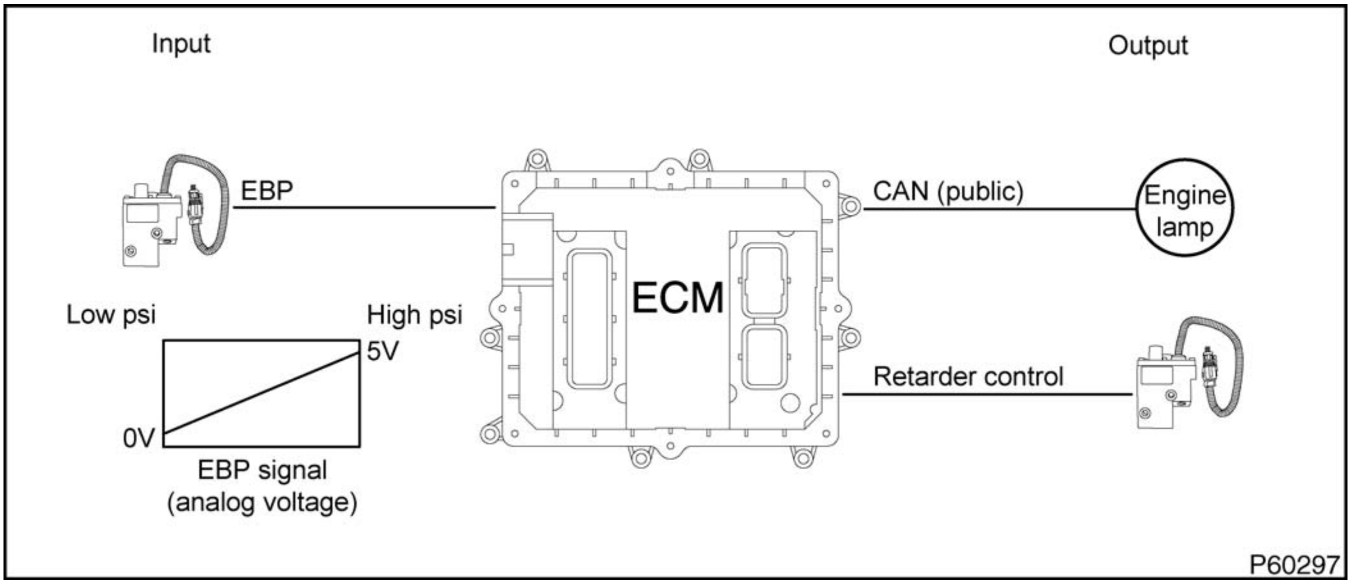

Figure 211 Functional diagram for the EBP sensor

The functional diagram for the EBP sensor includes the following:

- Engine Control Module (ECM)
- Engine lamp (amber)
- Retarder control

Function

The EBP sensor measures exhaust back pressure and allows the ECM to control the retarder control system.

Sensor Location

The EBP sensor is internal to the retarder control and is installed on the lower right side of the engine.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 3-Banana Plug Harness (page 437)
- 500 Ohm Resistor Harness (page 439)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- Retarder Control Breakout Harness (page 446)
- Terminal Test Adapter Kit (page 446)

EBP Sensor End Diagnostics

DTC	Condition	Possible Causes
3341	EBP signal out-of-range LOW	• EBP circuit OPEN or short to GND • Failed sensor
3342	EBP signal out-of-range HIGH	• EBP circuit short to PWR • Failed sensor

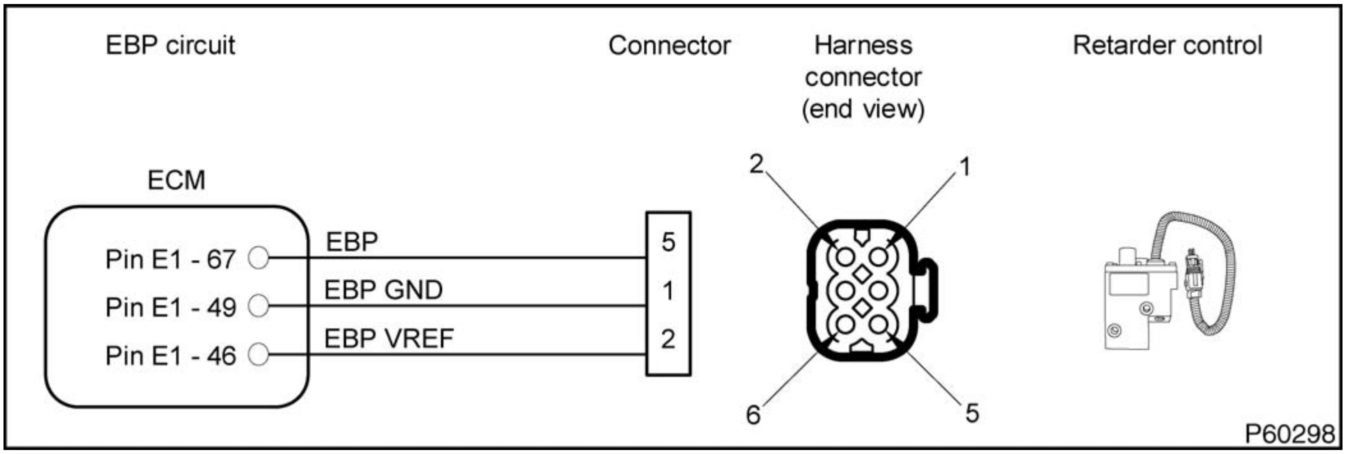

Figure 212 EBP circuit diagram

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from retarder control. Inspect connectors for damaged pins, corrosion, or loose pins using the Pin Grip Inspection (page 197). Repair if necessary.
4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect breakout harness. Leave retarder control disconnected. Turn the ignition switch to ON. Use EST to monitor PID and DMM to measure voltage.

Test Point	Spec	Comment
EST – Monitor EBPv	5 V	If < 4.5 V, check EBP signal circuit for to GND. Do Connector Resistance Check to GND (page 301).
DMM — Measure voltage 2 to GND	5.0 V +/- 0.5 V	If > 5.5 V, check EBP VREF for short to PWR. If < 4.5 V, check EBP VREF for OPEN or short to GND. Do Harness Resistance Check (page 301).
DMM — Measure voltage 1 to 2	5 V +/- 0.5 V	If < 4.5 V, check EBP GND for OPEN. Do Harness Resistance Check (page 301).
EST – Monitor EBPv Short across breakout harness pins 1 and 5	0 V	If > 0.25 V, check EBP signal for OPEN. Do Harness Resistance Check (page 301).
If checks are within specification, connect retarder control and clear DTCs. If active code remains, replace retarder control.		

EBP Pin-Point Diagnostics

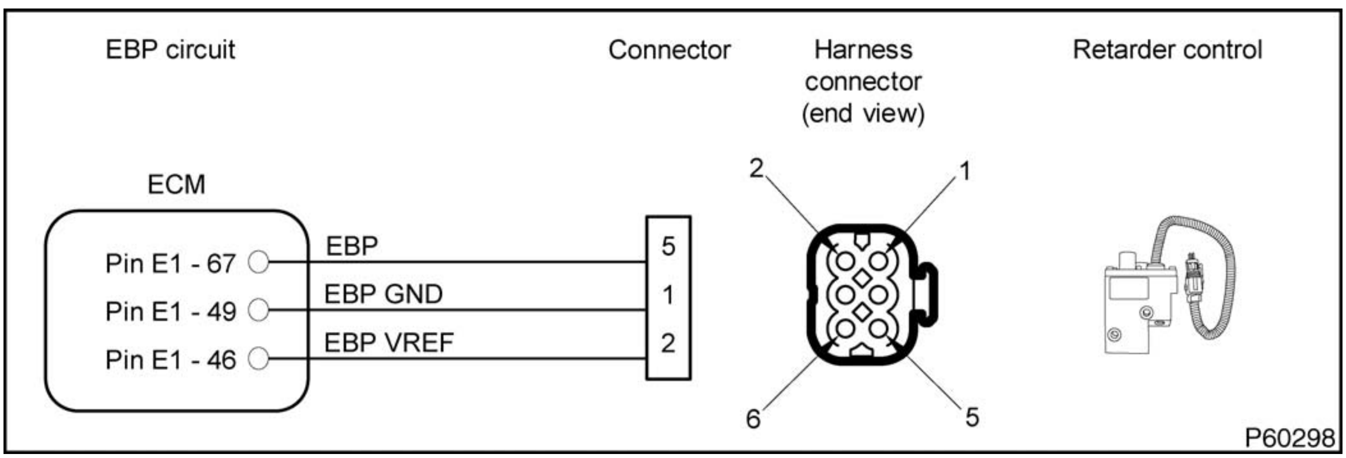

Figure 213 EBP circuit diagram

Connector Voltage Check

Connect breakout harness. Leave retarder control disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
2 to GND	5 V	If > 5.5 V, check EBP VREF for short to PWR. If < 4.5 V, check EBP VREF for OPEN or short to GND. Do Harness Resistance Checks (page 301).
1 to GND	0 V	If > 0.25 V, check EBP GND circuit for short to PWR.
5 to GND	> 4.5 V	If < 4.5 V, check EBP signal circuit for short to GND. Do Connector Resistance Check to GND (page 301).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave retarder control disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Do Harness Resistance Checks (page 301).
5 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and retarder control breakout harness. Leave ECM and retarder control disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
5 to E1-67	< 5 Ω	If > 5 Ω, check EBP signal circuit for OPEN.
1 to E1-49	< 5 Ω	If > 5 Ω, check EBP GND circuit for OPEN.
2 to E1-46	< 5 Ω	If > 5 Ω, check EBP VREF circuit for OPEN.

EBP Circuit Operation

The EBP sensor is a variable capacitance sensor that is supplied with a 5 V reference voltage at Pin 2 from ECM Pin E1-46. The sensor is grounded at Pin 1 from ECM Pin E1-49. The sensor returns a variable voltage signal proportional to the measured pressure from Pin 5 to ECM Pin E1-67.

ECL Switch (Engine Coolant Level)

DTC	SPN	FMI	Condition
1236	111	2	ECL switch circuit fault

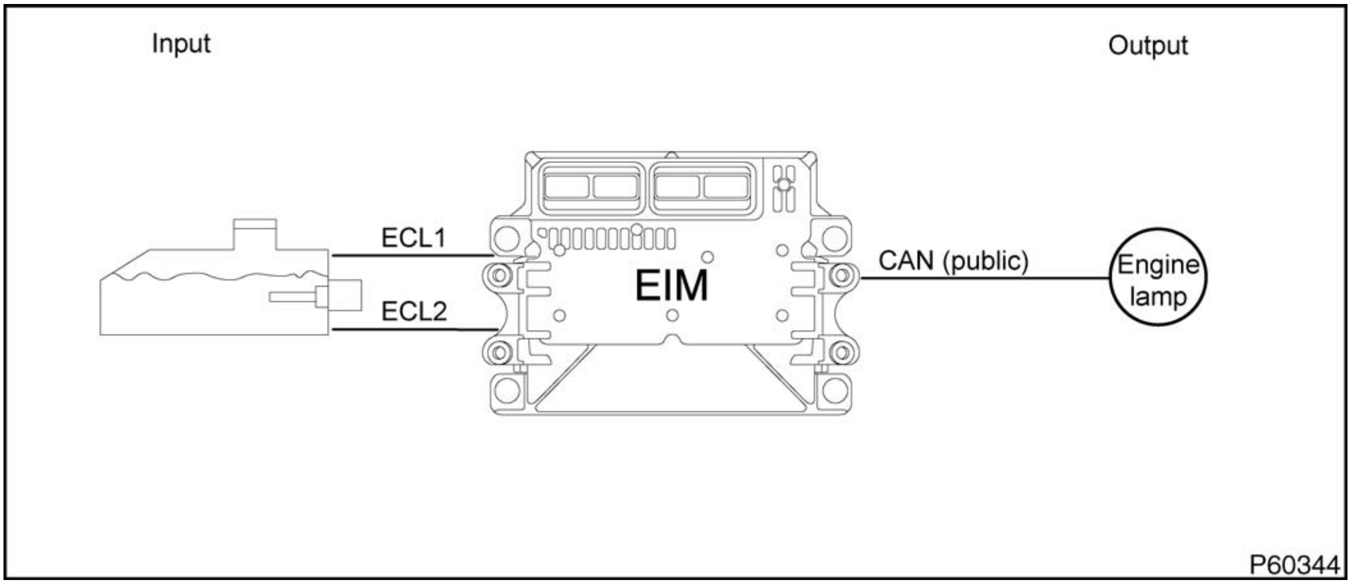

Figure 214 Functional diagram for the ECL switch

The functional diagram for the ECL switch includes the following:

- ECL switch
- Engine Interface Module (EIM)
- Engine lamp (red)

Function

The Engine Interface Module (EIM) monitors engine coolant level and alerts the operator when coolant is low. The ECM can be programmed to shut the engine off when coolant is low.

Coolant level monitoring is a customer programmable feature that can be programmed by the Electronic Service Tool (EST). The coolant level feature is operational if programmed for 3-way warning or 3-way protection.

Location

The ECL switch is installed in the vehicle plastic deaeration tank.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 96-Pin Breakout Box – DLC II (page 438)

ECL Switch Pin-point Diagnostics

DTC	Condition	Possible Causes
1236	ECL switch circuit fault	• ECL1 or ECL2 circuit short to GND or OPEN • ECL switch

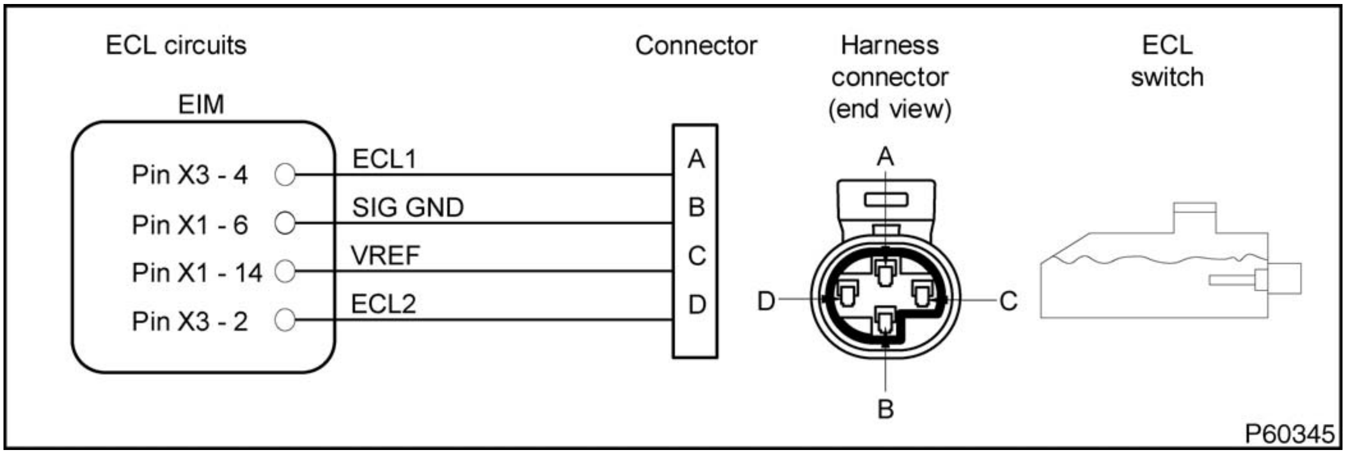

Figure 215 ECL switch circuit diagram

Connector Voltage Check

Disconnect ECL switch. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
C to GND	5 V +/- 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 304).
B to C	5 V +/- 0.5 V	If < 4.5 V, check SIG RTN circuit for OPEN or short to GND. Do Harness Resistance Check (page 304).
A to GND	5 V	If < 5 V, check the ECL1 circuit for OPEN or short to GND. Do Connector Resistance Check to GND (page 304).
D to GND	5 V	If < 5 V, check the ECL2 circuit for OPEN or short to GND. Do Connector Resistance Check to GND (page 304).

Connector Resistance Check to GND

Turn ignition switch to OFF. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
A to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
C to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
B to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Do Harness Resistance Check (page 304).
D to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box. Leave EIM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
A to X3-4	< 5 Ω	If > 5 Ω, check for OPEN circuit.
B to X1-6	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C to X1-14	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D to X3-2	< 5 Ω	If > 5 Ω, check for OPEN circuit.

ECL Circuit Operation

The ECL switch operates on a capacitance sensing principle. The probe of the ECL switch is installed in the plastic deaeration tank and it forms one plate of the capacitor, while the coolant forms the other plate. With the coolant present the capacitance is greater than when the coolant is absent. This difference in capacitance is used by the electronic sensor to provide a solid-state ON-OFF signal at EIM Pins X3–4 and X3–2. The ECL switch is supplied VREF from EIM Pin X1–14 and SIG GND from Pin X1–6.

Fault Detection / Management

The EIM continuously monitors the ECL circuit for in-range faults. The EIM does not detect open or short circuits in the ECL system. When the EIM detects an in-range fault, a Diagnostic Trouble Code (DTC) sets.

ECM Power (Engine Control Module)

DTC	SPN	FMI	Condition
1380	158	1	B+ to ECM out-of-range LOW
1381	158	3	B+ to ECM out-of-range spiked HIGH
1382	158	4	B+ to ECM out-of-range spiked LOW

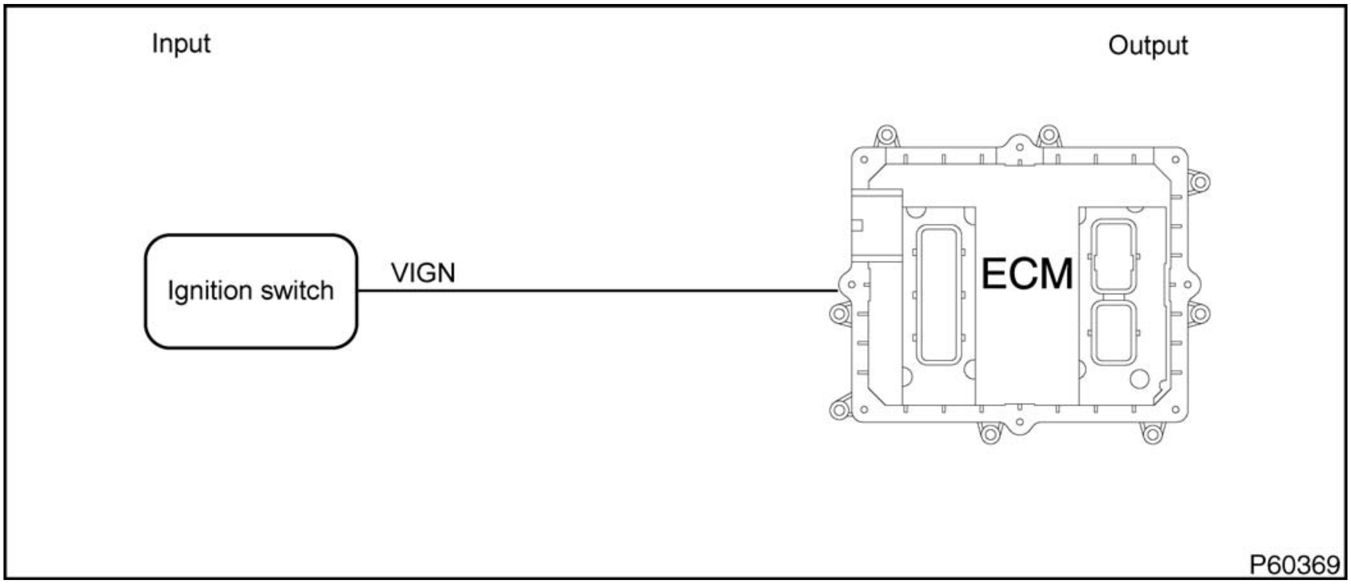

Figure 216 Functional diagram for the ECM PWR

The functional diagram for ECM PWR includes the following:

- Engine Control Module (ECM)
- Ignition switch

Function

The ECM requires battery power to operate the electronic control system. When the ECM receives the VIGN signal from the ignition switch, the ECM powers up. When the ignition switch is turned off, the ECM performs internal maintenance through an internal relay, then disables itself.

ECM Location

The ECM is located on the upper left side of the engine.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)

ECM PWR Pin-Point Diagnostics

DTC	Condition	Possible Causes
1380	B+ to ECM out-of-range LOW	• ECM PWR below 7.5 V • Charging system fault • Low batteries
1381	B+ to ECM out-of-range spiked HIGH	• ECM PWR spiked above 16 V • Charging system fault • 24 V jump start
1382	B+ to ECM out-of-range spiked LOW	• ECM PWR spiked below 7 V, low battery voltage during engine crank • ECM PWR circuit fault

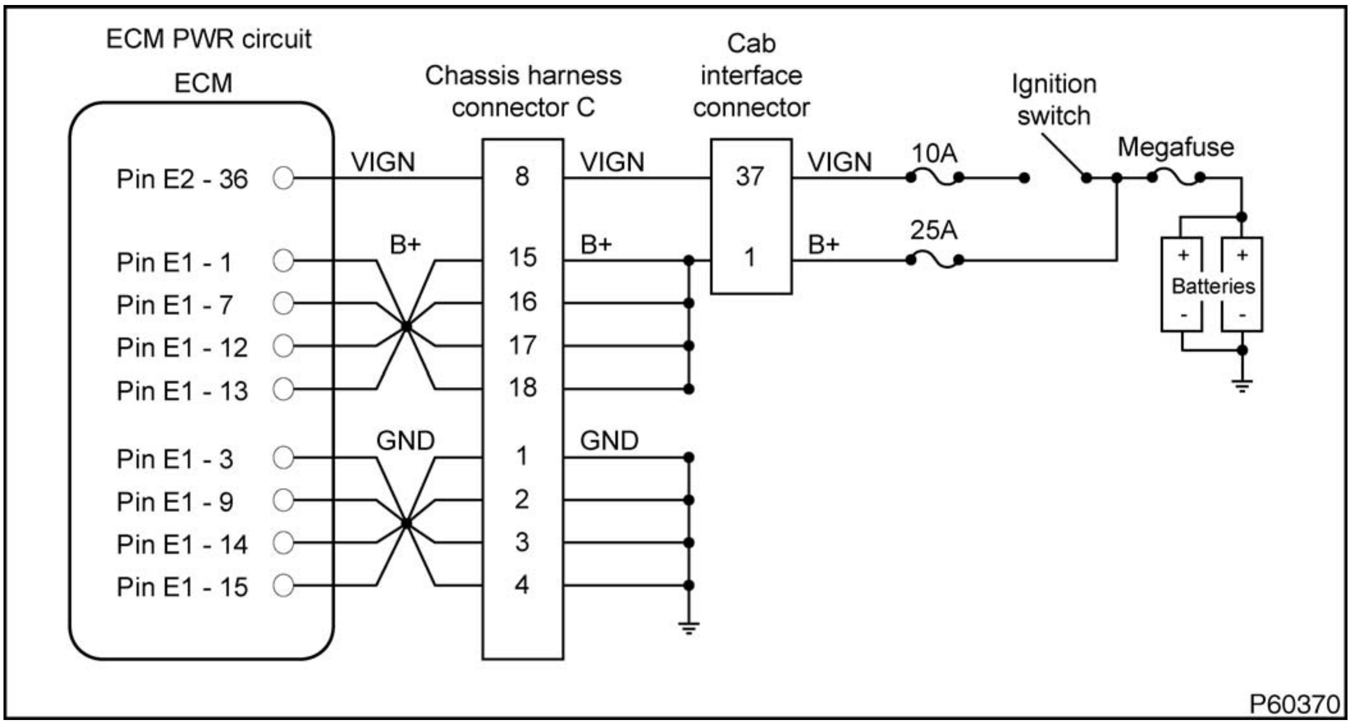

Figure 217 ECM PWR circuit diagram

NOTE: Reference the truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for vehicle side electrical system.

Voltage Checks at ECM

Connect breakout box between ECM and vehicle harness. Turn the ignition switch ON. Use DMM to measure voltage.

Test Point	Spec	Comment
E1-1 to GND	B+	If < B+, check B+ circuit for OPEN or short to GND, or blown fuse.
E1-7 to GND	B+	If < B+, check B+ circuit for OPEN or short to GND, or blown fuse.
E1-12 to GND	B+	If < B+, check B+ circuit for OPEN or short to GND, or blown fuse.
E1-13 to GND	B+	If < B+, check B+ circuit for OPEN or short to GND, or blown fuse.
E2-36 to GND	B+	If < B+, check VIGN circuit for OPEN or short to GND, or blown fuse.
E1-3 to GND	< 0.5 V	If > 0.5 V, check GND circuit for short to PWR.
E1-9 to GND	< 0.5 V	If > 0.5 V, check GND circuit for short to PWR.
E1-14 to GND	< 0.5 V	If > 0.5 V, check GND circuit for short to PWR.
E1-15 to GND	< 0.5 V	If > 0.5 V, check GND circuit for short to PWR.

ECM PWR Circuit Operation

The ECM receives VIGN power at Pin E2-36.

B+ is supplied to the ECM through Pins E1-1, E1-7, E1-12, and E1-13.

The ECM is grounded through Pins E1-3, E1-9, E1-14, and E1-15.

Fault Detection / Management

The ECM internally monitors battery voltage. When the ECM continuously receives less than 7.5 V or more than 19 V, a Diagnostic Trouble Code (DTC) sets.

ECT Sensor (Engine Coolant Temperature)

DTC	SPN	FMI	Condition
1114	110	4	ECT signal out-of-range LOW
1115	110	3	ECT signal out-of-range HIGH

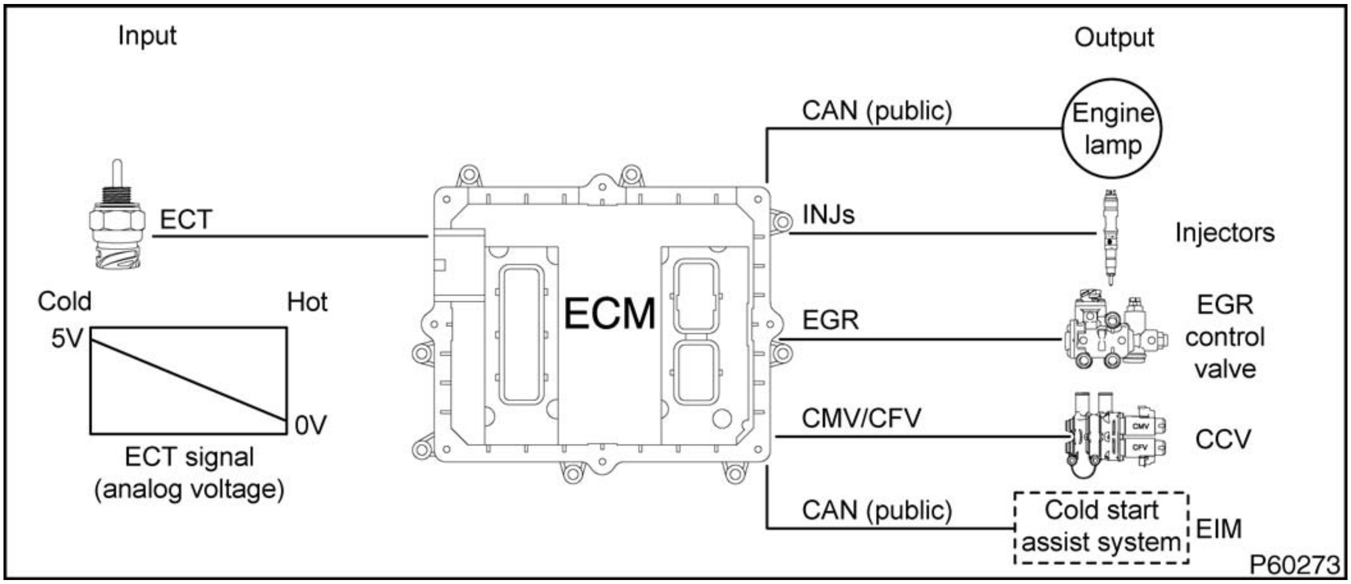

Figure 218 Functional diagram for the ECT sensor

The functional diagram for the ECT sensor includes the following:

- Coolant Control Valve (CCV)
- Coolant Flow Valve (CFV)
- Coolant Mixer Valve (CMV)
- Engine Control Module (ECM)
- ECT sensor
- Engine lamp (red)
- Exhaust Gas Recirculation (EGR) control valve
- Fuel Injector (INJ)

Function

The ECT sensor provides a feedback signal to the ECM indicating engine coolant temperature. During engine operation, the ECM monitors the ECT signal to control the following features:

- Instrument panel temperature gauge
- Engine Warning and Protection System (EWPS)
- Cold Ambient Protection (CAP)
- Idle Shutdown Timer (IST)
- Cold idle advance
- Coolant compensation

The Engine Warning Protection System (EWPS) is an optional feature that can be enabled or disabled. When the EWPS is enabled, the operator is warned of an overheat condition and, if programmed, shuts down the engine.

Sensor Location

The ECT sensor is installed in the underside of the EGR coolant elbow at the back of the engine.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)

- 3-Banana Plug Harness (page 437)
- 500 Ohm Resistor Harness (page 439)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- 4-Pin Round Black Breakout Harness (page 437)
- Terminal Test Adapter Kit (page 446)

ECT Sensor Connector End Diagnostics

DTC	Condition	Possible Causes
1114	ECT signal out-of-range LOW	• ECT signal circuit short to GND • Failed sensor
1115	ECT signal out-of-range HIGH	• ECT signal OPEN or short to PWR • ECT GND circuit OPEN • Failed sensor

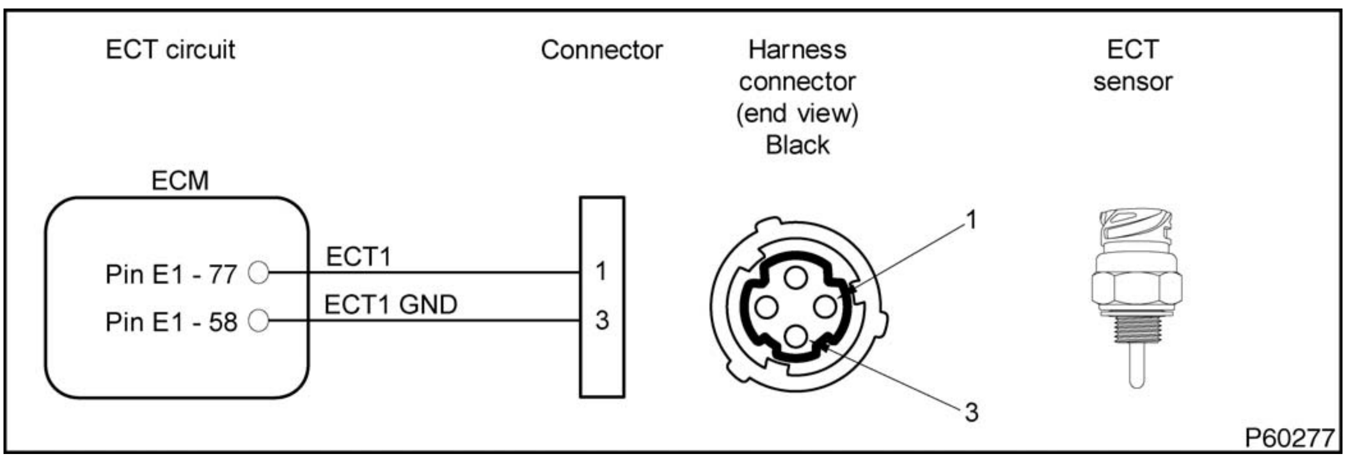

Figure 219 ECT sensor circuit diagram

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor. Inspect connectors for damaged pins, corrosion, or loose pins using the Pin Grip Inspection (page 197). Repair if necessary.
4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect breakout harness. Leave sensor disconnected. Turn the ignition switch to ON. Use EST to monitor PIDs and DMM to measure voltage.

Test Point	Spec	Comment
EST-Monitor ECTv	5 V	If < 4.5 V, check ECT signal circuit for short to GND. Do Connector Resistance Checks to GND (page 311).
EST-Monitor ECTv Short breakout harness across pin 1 and GND	0 V	If > 0.25 V, check ECT signal circuit for OPEN. Do Harness Resistance Check (page 311).
EST-Monitor ECTv Short breakout harness across pins 1 and 3	0 V	If > 0.25 V, check ECT GND circuit for OPEN. Do Harness Resistance Check (page 311).
EST-Monitor ECTv Short 500 Ω resistor across pins 1 and 3	< 1.0 V	If > 1.0 V, check ECT signal circuit for short to PWR.

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace ECT sensor.

ECT Sensor Pin-Point Diagnostics

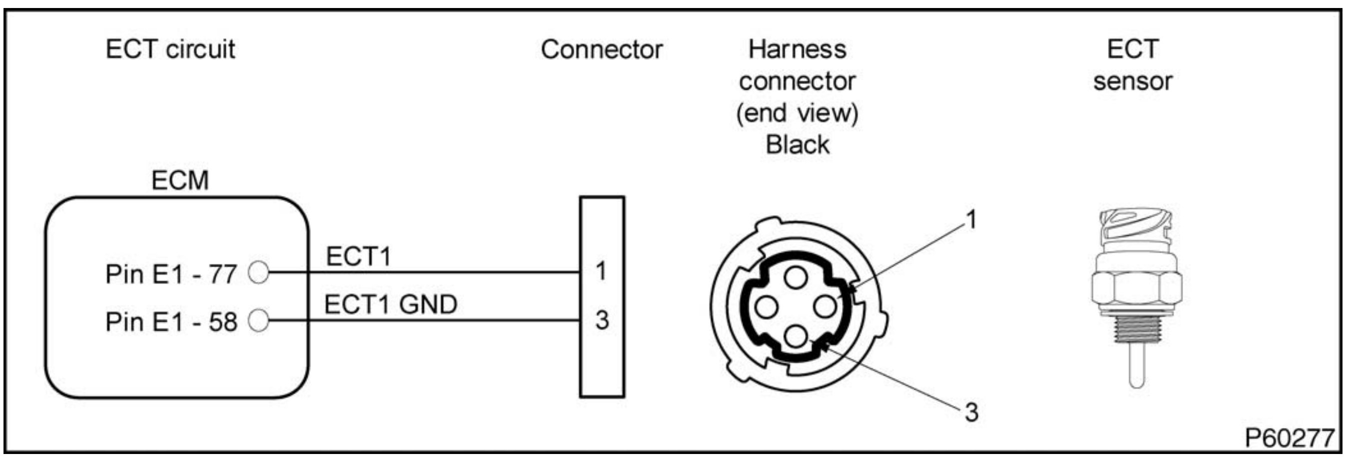

Figure 220 ECT sensor circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	4.5 V to 5 V	If < 4.5 V, check for short to GND. Do Connector Resistance Checks to GND (page 311).
3 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 311).

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
3 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Do Harness Resistance Check (page 311).

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E1-77	< 5 Ω	If > 5 Ω, check ECT signal for OPEN.
3 to E1-58	< 5 Ω	If > 5 Ω, check ECT GND signal for OPEN.

ECT Circuit Operation

The ECT sensor is a thermistor sensor that is supplied with a 5 V reference voltage at Pin 1 from ECM Pin E1–77. The sensor is grounded at Pin 3 from ECM Pin E1–58. As the coolant temperature increases, the resistance of the thermistor decreases, causing the signal voltage to decrease.

Fault Detection / Management

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM disregards the sensor signal and uses a calibrated default value. The ECM sets a DTC, illuminates the amber engine lamp, and runs the engine in a default range.

When this occurs, the EWPS, CAP, IST, cold idle advance, and coolant temperature compensation features are disabled.

ECT2 Sensor (Engine Coolant Temperature 2)

DTC	SPN	FMI	Condition
1635	7311	4	ECT2 signal out-of-range LOW
1636	7311	3	ECT2 signal out-of-range HIGH

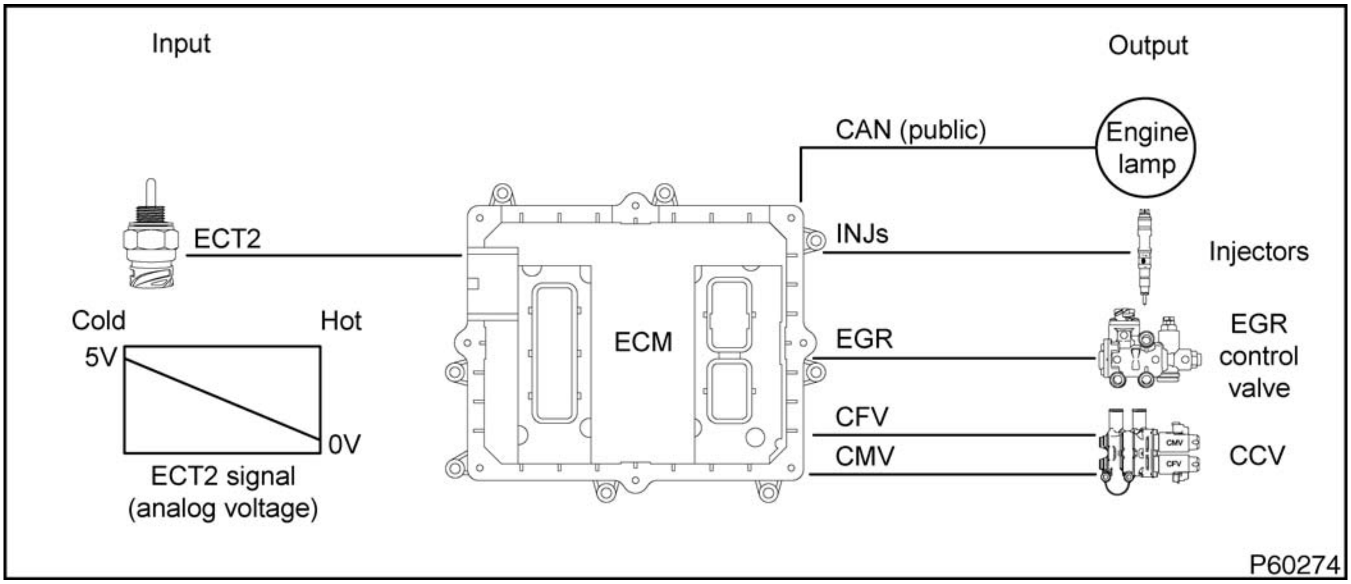

Figure 221 Functional diagram for the ECT2 sensor

The functional diagram for the ECT2 sensor includes the following:

- Coolant Control Valve (CCV)
- Coolant Flow Valve (CFV)
- Coolant Mixer Valve (CMV)
- Engine Control Module (ECM)
- ECT2 sensor
- Engine lamp (red)
- Exhaust Gas Recirculation (EGR) control valve
- Fuel Injector (INJ)

Function

The ECT2 signal is monitored by the ECM for operation of coolant temperature compensation, charge air temperature control, optional Engine Warning Protection System (EWPS), and the wait to start lamp.

Sensor Location

The ECT2 sensor is installed in the Charge Air Cooler (CAC) coolant return pipe on the upper right side of the engine.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 3-Banana Plug Harness (page 437)
- 500 Ohm Resistor Harness (page 439)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- 4-Pin Round Black Breakout Harness (page 437)

- Terminal Test Adapter Kit (page 446)

ECT2 Sensor Connector End Diagnostics

DTC	Condition	Possible Causes
1635	ECT2 signal out-of-range LOW	• ECT2 signal circuit short to GND • Failed sensor
1636	ECT2 signal out-of-range HIGH	• ECT2 signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor

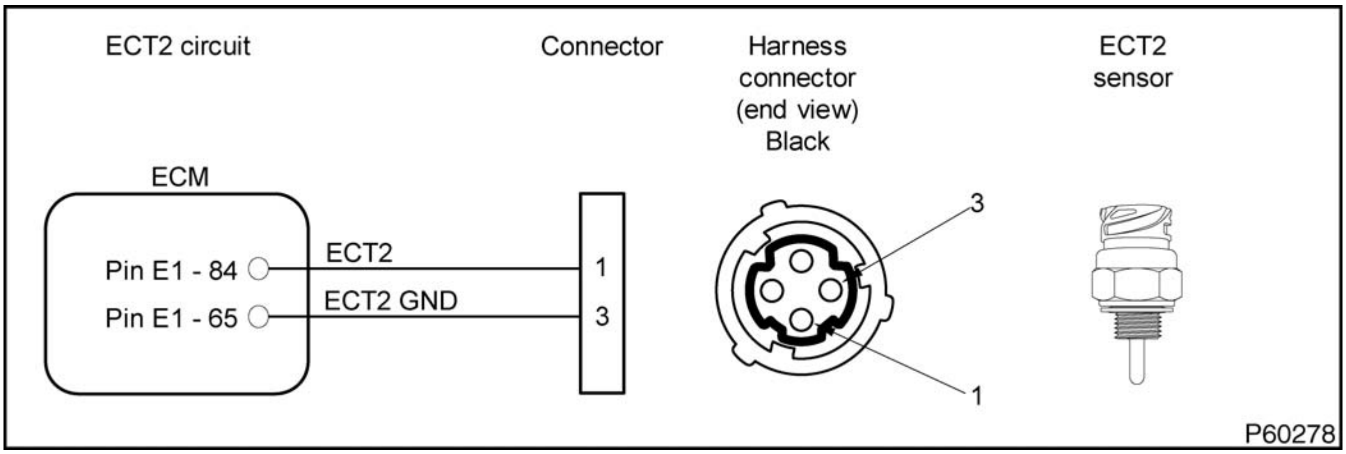

Figure 222 ECT2 sensor circuit diagram

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor. Inspect connectors for damaged pins, corrosion, or loose pins using Pin Grip Inspection (page 197). Repair if necessary.
4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect breakout harness. Leave sensor disconnected. Turn the ignition switch to ON. Use EST to monitor PID and DMM to measure voltage.

Test Point	Spec	Comment
EST-Monitor ECTv	5 V	If < 4.5 V, check ECT2 signal circuit for short to GND. Do Connector Resistance Checks to GND (page 315).
EST-Monitor ECTv Short breakout harness across pin 1 and GND	0 V	If > 0.25 V, check ECT2 signal circuit for OPEN. Do Harness Resistance Check (page 315).
EST-Monitor ECTv Short breakout harness across pins 1 and 3	0 V	If > 0.25 V, check ECT2 GND circuit for OPEN. Do Harness Resistance Check (page 315).
EST-Monitor ECTv Short 500 Ω resistor across pins 1 and 3	< 1.0 V	If > 1.0 V, check ECT2 signal circuit for short to PWR.

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace ECT2 sensor.

ECT2 Sensor Pin-Point Diagnostics

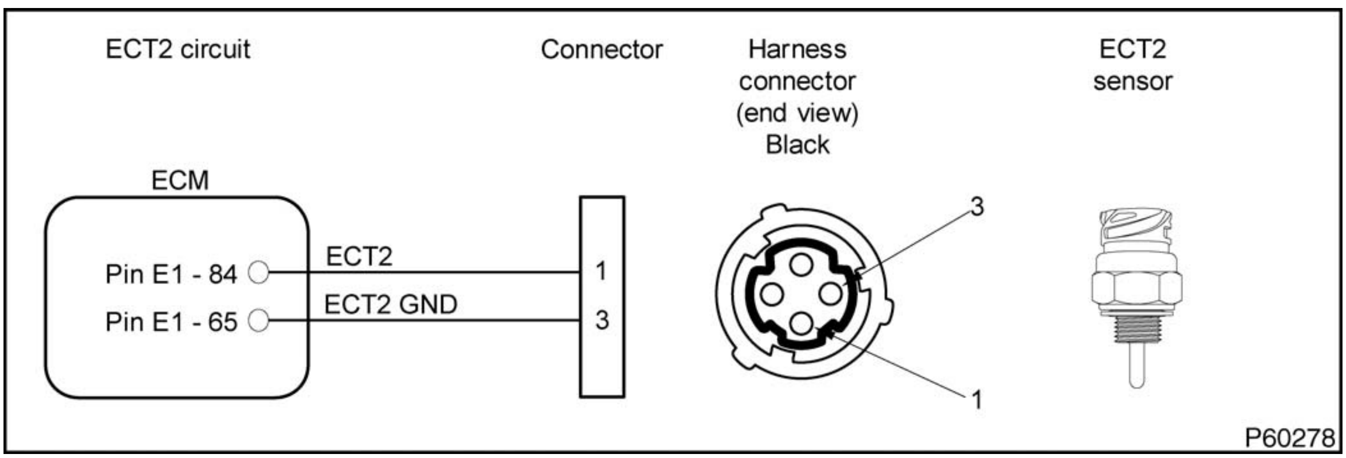

Figure 223 ECT2 sensor circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	4.5 V to 5 V	If < 4.5 V, check for short to GND. Do Connector Resistance Checks to GND (page 315).
3 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Checks (page 315).

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND. Do Harness Resistance Check (page 315).
3 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Do Harness Resistance Check (page 315).

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E1-84	< 5 Ω	If > 5 Ω, check ECT2 signal for OPEN.
3 to E1-65	< 5 Ω	If > 5 Ω, check ECT2 GND signal for OPEN.

ECT2 Circuit Operation

The ECT2 sensor is a thermistor sensor that is supplied with a 5 V reference voltage at Pin 1 from ECM Pin E1–84. The sensor is grounded at Pin 3 from ECM Pin E1–65. As the coolant temperature increases, the resistance of the thermistor decreases, causing the signal voltage to decrease.

Fault Detection / Management

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM disregards the sensor signal and uses a calibrated default value. The ECM sets a DTC, illuminating the amber engine lamp, and runs the engine in a default range.

EFP Sensor (Engine Fuel Pressure)

DTC	SPN	FMI	Condition
1136	94	4	EFP signal out-of-range LOW
1137	94	3	EFP signal out-of-range HIGH
2371	94	0	Fuel pressure above normal
2372	94	1	Fuel pressure below normal

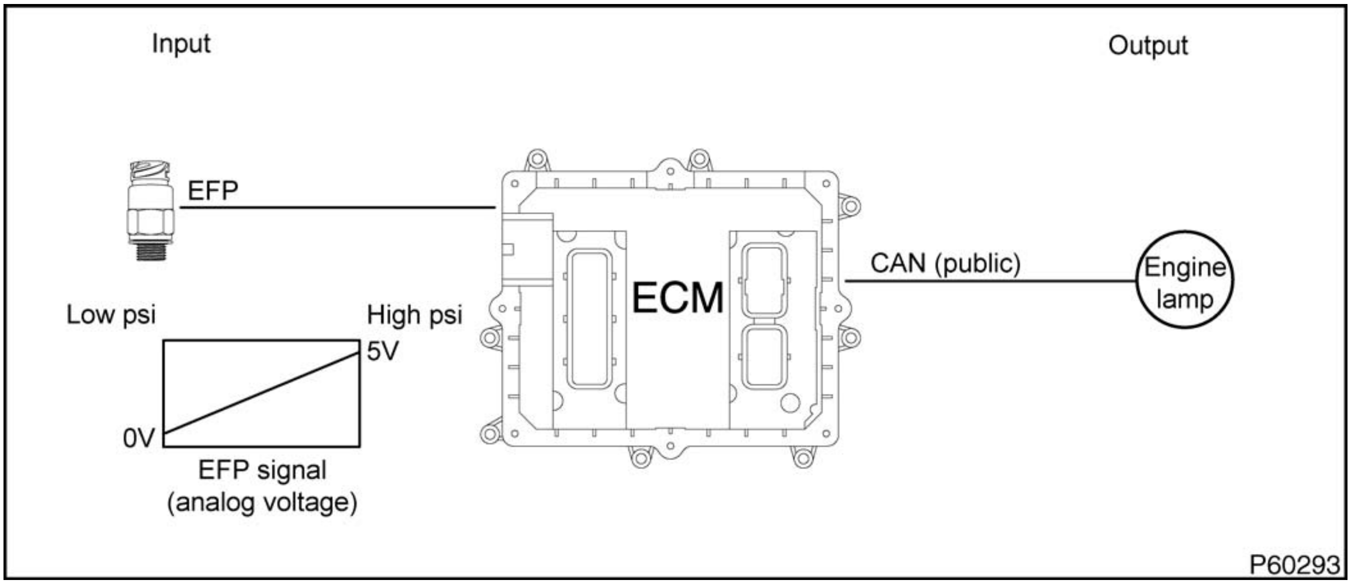

Figure 224 Functional diagram for the EFP sensor

The functional diagram for the EFP sensor includes the following:

- EFP sensor
- Engine Control Module (ECM)
- Engine lamp (amber)

Function

The EFP sensor measures fuel pressure between the low pressure fuel pump and the filter cartridge. The EFP sensor provides a feedback signal to the ECM indicating engine fuel pressure. During engine operation, if pressure is not satisfactory, the ECM turns on the amber FUEL lamp to alert the operator when the fuel filter needs servicing.

Sensor Location

The EFP sensor is installed on the front side of the fuel filter housing assembly.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 3-Banana Plug Harness (page 437)
- 500 Ohm Resistor Harness (page 439)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- 4-Pin Round Gray Breakout Harness (page 437)

- Terminal Test Adapter Kit (page 446)

EFP Sensor End Diagnostics

DTC	Condition	Possible Causes
1136	EFP signal out-of-range LOW	• EFP signal circuit OPEN or short to GND • EFP VREF circuit short to GND or OPEN • Failed sensor
1137	EFP signal out-of-range HIGH	• EFP signal circuit short to PWR • EFP GND circuit OPEN • Failed sensor
2371	Fuel pressure above normal	• Biased EFP sensor or circuit • Restricted fuel return line • Regulator valve
2372	Fuel pressure below normal	• Biased EFP sensor or circuit • Restricted fuel filter • Regulator valve • Low fuel supply level

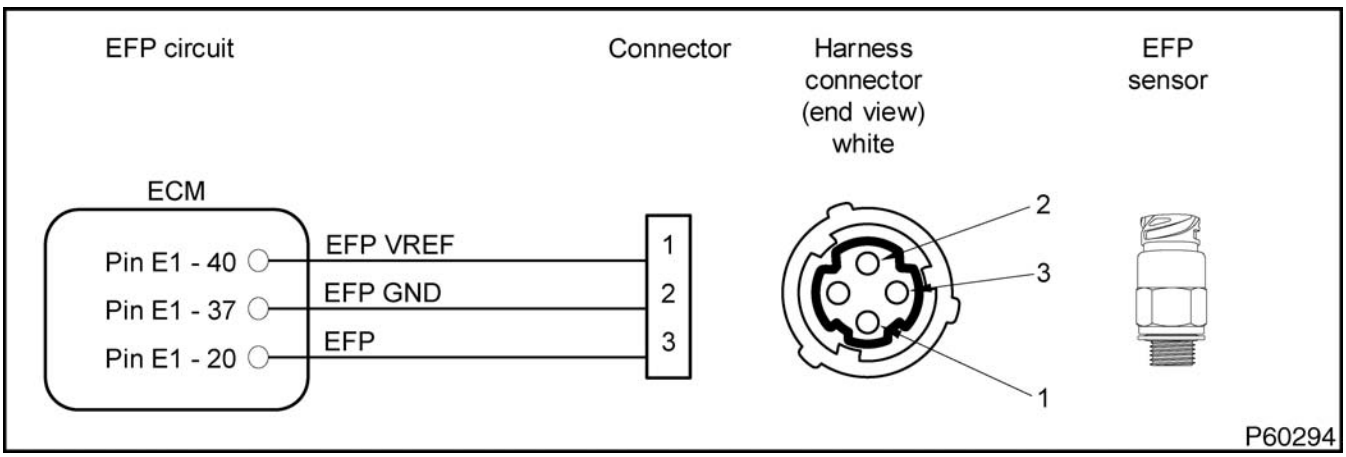

Figure 225 EFP sensor circuit diagram

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID spikes and the DTC goes active.

- If DTC is active, proceed to the next step.

3. Disconnect engine harness from sensor. Inspect connectors for damaged pins, corrosion, or loose pins using Pin Grip Inspection (page 197). Repair if necessary.
4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect breakout harness. Leave sensor disconnected. Turn the ignition switch to ON. Use EST to monitor PID and DMM to measure voltage.

Test Point	Spec	Comment
EST – Monitor EFPv	0 V	If > 0.25 V, check EFP signal circuit for short to PWR
DMM — Measure volts 1 to GND	5.0 V +/- 0.5 V	If > 5.5 V, check EFP VREF for short to PWR. If < 4.5 V, check EFP VREF for OPEN or short to GND. Do Harness Resistance Check (page 319).
EST – Monitor EFPv Short across breakout harness pins 1 and 3	5 V	If < 4.5 V, check EFP signal for OPEN. Do Harness Resistance Check (page 319).
DMM — Measure voltage 1 and 2	5 V +/- 0.5 V	If < 4.5 V, check EFP GND for OPEN. Do Harness Resistance Check (page 319).
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace EFP sensor.		

EFP Sensor Pin-Point Diagnostics

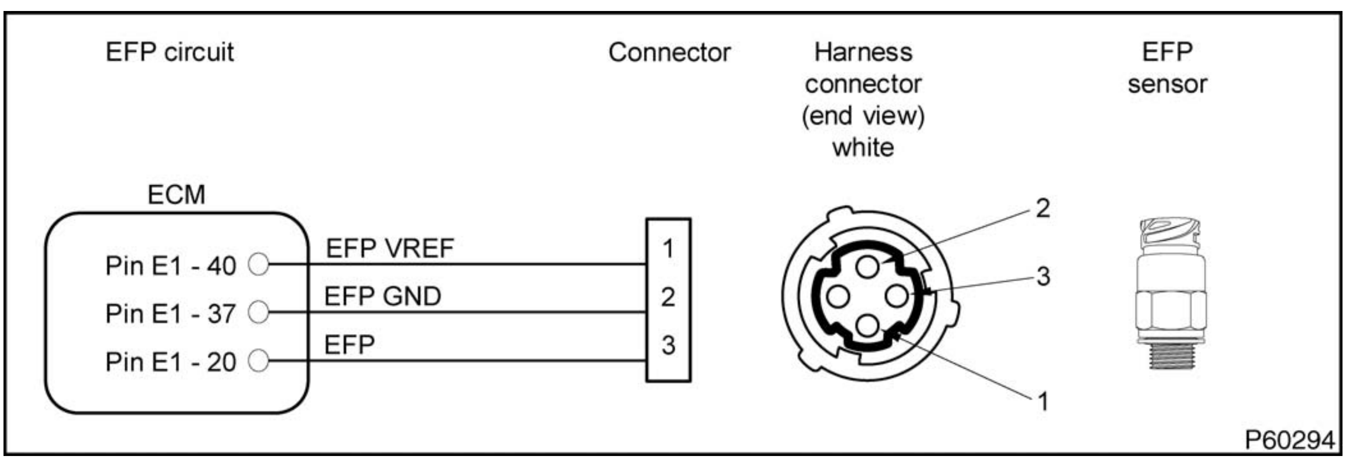

Figure 226 EFP sensor circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	5 V	If > 5.5 V, check EFP VREF for short to PWR. If < 4.5 V, check EFP VREF for OPEN or short to GND. Do Harness Resistance Check (page 319).
2 to GND	0 V	If > 0.25 V, check EFP GND circuit for short to PWR.
3 to GND	0 V	If > 0.25 V, check EFP signal circuit for short to PWR.

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
2 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Do Harness Resistance Check (page 366).
3 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E1-40	< 5 Ω	If > 5 Ω, check EFP VREF circuit for OPEN.
2 to E1-37	< 5 Ω	If > 5 Ω, check EFP GND circuit for OPEN.
3 to E1-20	< 5 Ω	If > 5 Ω, check EFP signal circuit for OPEN.

EFP Circuit Operation

The EFP sensor is a variable capacitance sensor that is supplied with a 5 V reference voltage at Pin 1 from ECM Pin E1-40. The sensor is grounded at Pin 2 from ECM Pin E1-37 and returns a variable voltage signal proportional to the measured pressure from Pin 3 to ECM Pin E1-20.

EGDP Sensor (Exhaust Gas Differential Pressure)

DTC	SPN	FMI	Condition
1729	3251	4	EGDP signal out-of-range LOW
1731	3251	3	EGDP signal out-of-range HIGH
2732	3251	2	EGDP stuck in-range fault

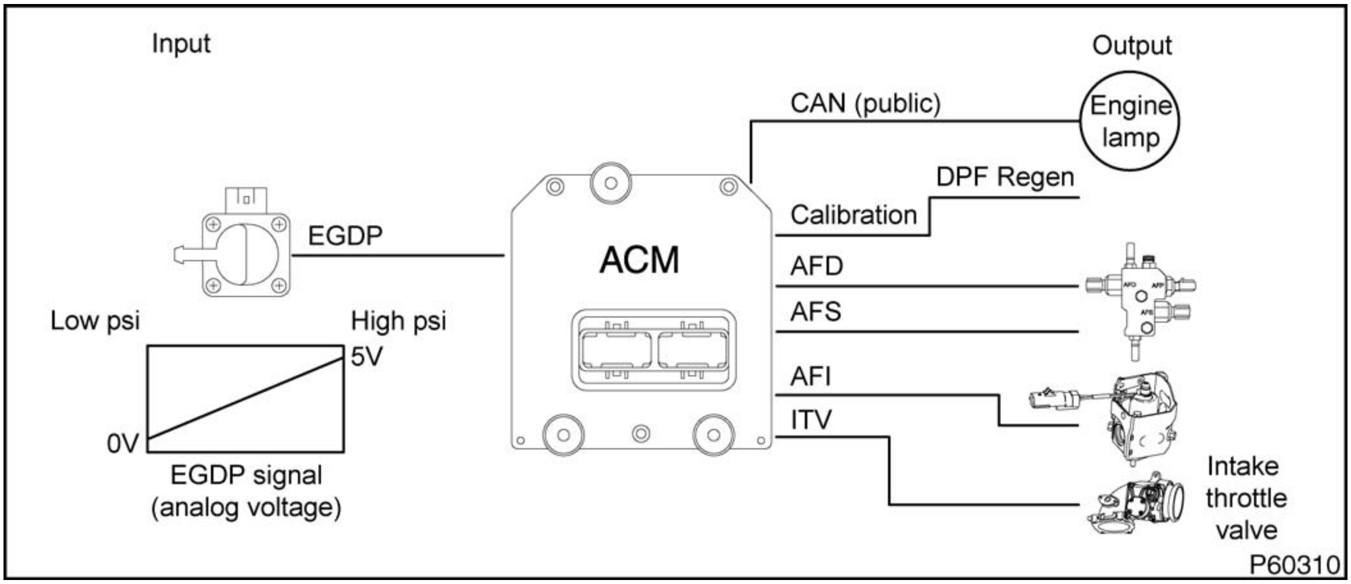

Figure 227 Functional diagram for the EGDP sensor

The functional diagram for the EGDP sensor includes the following:

- Aftertreatment Control Module (ACM)
- EGDP sensor
- Aftertreatment Fuel Supply (AFS) valve
- Aftertreatment Fuel Drain (AFD) valve
- Aftertreatment Fuel Injector (AFI)
- Intake Throttle Valve (ITV)
- Engine lamp

Function

The EGDP sensor provides a feedback signal to the ACM indicating the pressure difference between the inlet and outlet of the Diesel Particulate Filter (DPF). During a catalyst regeneration, the ACM monitors this sensor along with three aftertreatment system temperature sensors, Exhaust Gas Temperature 1 (EGT1), Exhaust Gas Temperature 2 (EGT2) and Exhaust Gas Temperature 3 (EGT3).

Sensor Location

The EGDP sensor is a differential pressure sensor with two tap-offs installed past the turbocharger. A tap-off is located before and after the DPF.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 3-Banana Plug Harness (page 437)
- 500 Ohm Resistor Harness (page 439)
- 180-Pin Breakout Box (page 438)
- Aftertreatment Harness (page 439)
- EGDP Breakout Harness (page 443)

- Terminal Test Adapter Kit (page 446)

EGDP Sensor End Diagnostics

DTC	Condition	Possible Causes
1729	EGDP signal out-of-range LOW	• EGDP signal circuit OPEN or short to GND • VREF circuit OPEN or short to GND • Failed sensor
1731	EGDP signal out-of-range HIGH	• EGDP signal short to PWR • SIG GND circuit OPEN • Failed sensor
2732	EGDP stuck in-range fault	• Biased circuit or sensor • EGDP sensor tubes restricted, open, or assembled incorrectly

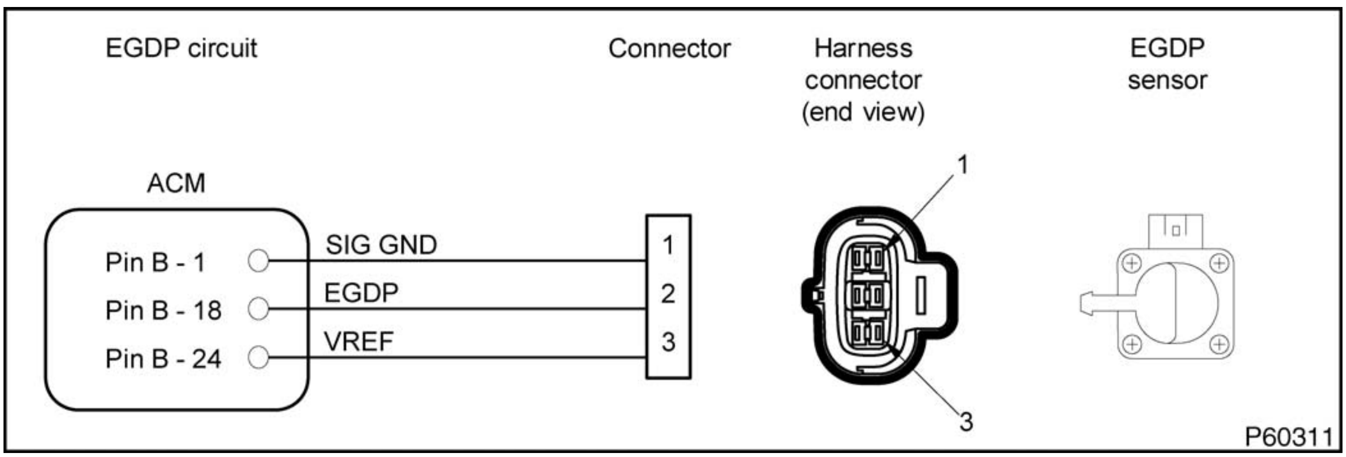

Figure 228 EGDP sensor circuit diagram

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor. Inspect connectors for damaged pins, corrosion, or loose pins using Pin Grip Inspection (page 197). Repair if necessary.
4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect breakout harness. Leave sensor disconnected. Turn the ignition switch to ON. Use EST to monitor PID and DMM to measure voltage.

Test Point	Spec	Comment
EST – Monitor EGDPv	0 V	If > 0.25 V, check EGDP signal circuit for short to PWR
DMM — Measure volts 3 to GND	5.0 V +/- 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 324).
EST – Monitor EGDPv Short across breakout harness pins 2 and 3	5 V	If < 4.5 V, check EGDP signal circuit for OPEN. Do Harness Resistance Check (page 324).
DMM — Measure voltage 1 to 3	5 V +/- 0.5 V	If < 4.5 V, check SIG GND for OPEN. Do Harness Resistance Check (page 324).

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace EGDP sensor.

EGDP Sensor Pin-Point Diagnostics

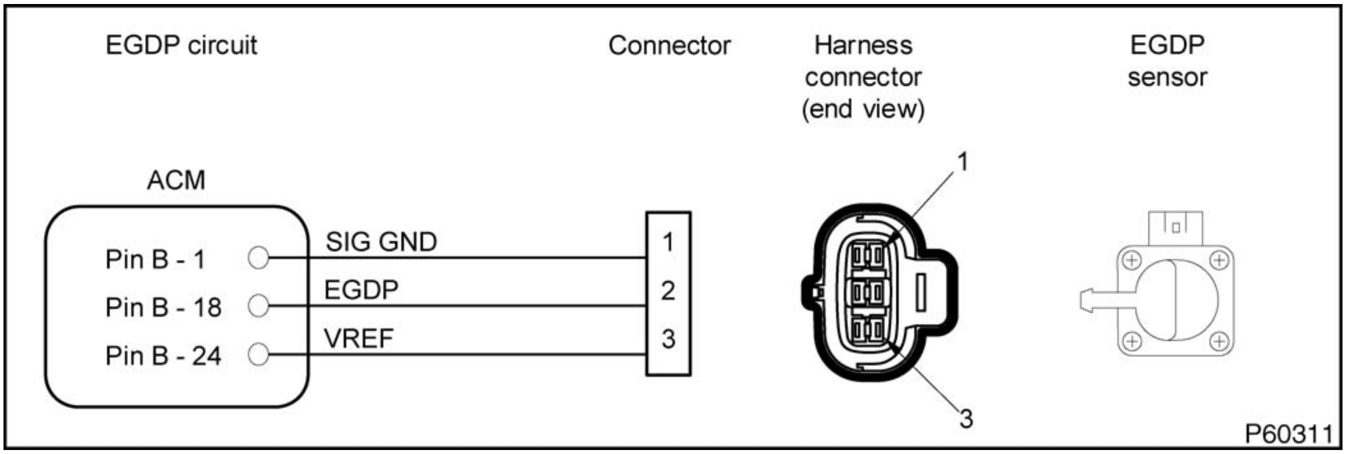

Figure 229 EGDP sensor circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	0 V	If > 0.25 V, check SIG GND circuit for short to PWR.
2 to GND	0 V	If > 0.25 V, check EGDP for short to PWR
3 to GND	5 V	If > 5.5 V, check VREF for short to PWR.
		If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 324).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Do Harness Resistance Check (page 324).
2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
3 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave ACM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to B-1	< 5 Ω	If > 5 Ω, check SIG RTN circuit for OPEN.
2 to B-18	< 5 Ω	If > 5 Ω, check EGPD circuit for OPEN.
3 to B-24	< 5 Ω	If > 5 Ω, check VREF signal circuit for OPEN.

EGDP Sensor Circuit Operation

The EGDP sensor is a differential pressure sensor that is supplied with a 5 V reference voltage at Pin 3 from ACM Pin B-24. The sensor is grounded at Pin 1 from ACM Pin B-1 and returns a variable voltage signal from Pin 2 to ACM Pin B-18.

EGR Control Valve (Exhaust Gas Recirculation)

DTC	SPN	FMI	Condition
2391	2791	11	EGR internal circuit failure
6262	2791	5	EGR control valve open circuit

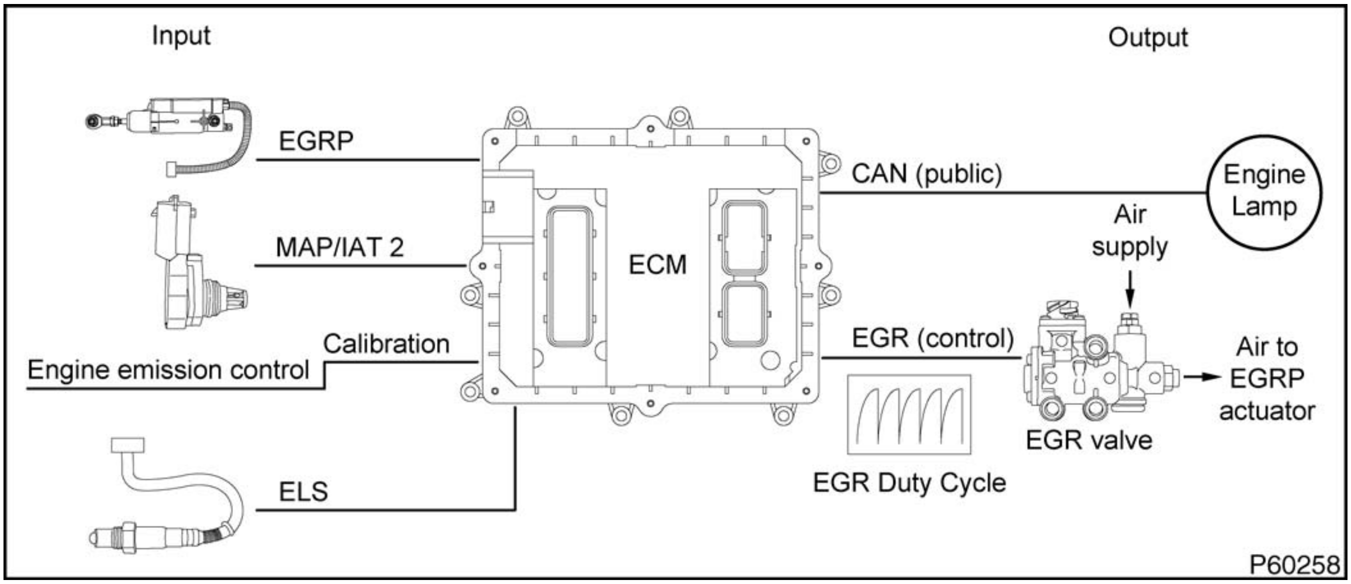

Figure 230 Functional diagram for the EGR system

The functional diagram for the EGR system includes the following:

- Engine Control Module (ECM)
- Engine lamp (amber)
- Exhaust Gas Recirculation Position (EGRP) sensor
- EGR control valve
- Manifold Absolute Pressure/Intake Air Temperature 2 (MAP/IAT 2) sensor
- Exhaust Lambda Sensor (ELS)

EGR throttle valve function

Oxides of nitrogen (NO_X) in the atmosphere contribute to the production of smog. NO_X is formed when temperatures in the combustion chamber get too hot.

The EGR system is used to reduce the amount of NO_X created by the engine. The EGR control valve recirculates exhaust back into the intake stream. Exhaust gases that have already burned do not burn again. This cools the combustion process and reduces the formation of NO_X.

Component Location

EGR control valve is installed on top of the coolant elbow (upper).

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 4-Pin Round Black Breakout Harness (page 437)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- Terminal Test Adapter Kit (page 446)

EGR Connector End Diagnostics

DTC	Condition	Possible Causes
2391	EGR valve internal circuit failure	• EGR control valve circuit fault • EGR control valve fault
6262	EGR control valve open circuit	• EGR control open circuit • EGR control valve fault

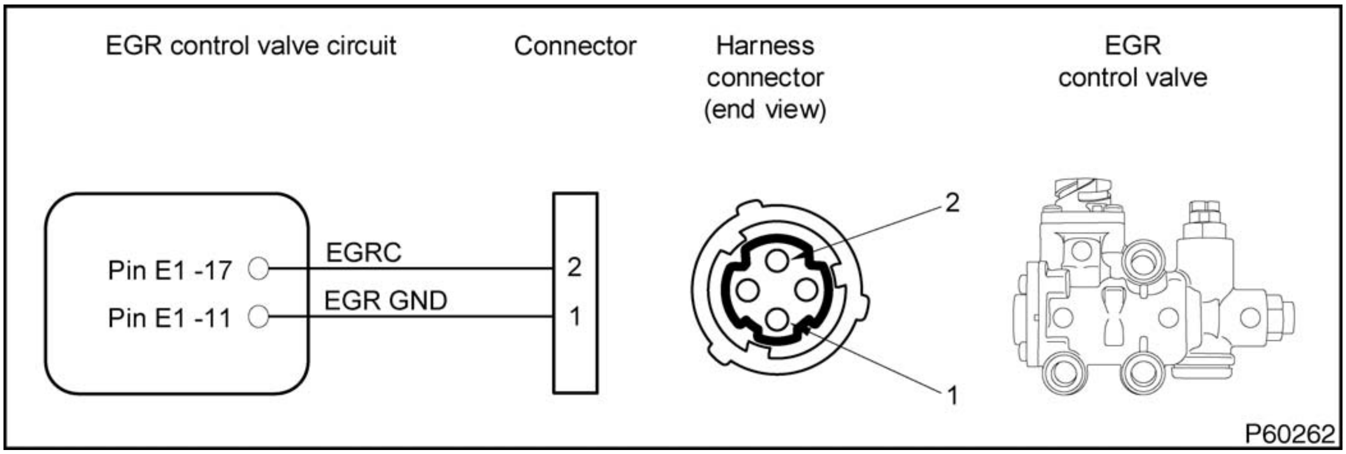

Figure 231 EGR control valve circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

NOTE: Air tanks must be above 620 kPa (90 psi) before running this test.

1. Key ON, engine OFF.
2. Connect the EST with MasterDiagnostics® software.
3. Verify correct engine is selected and launch EST.
4. Open D_Actuator.ssn session.
5. Run Actuator Test.
6. Visually monitor EGR throttle valve actuator linkage movement.
   - If linkage moves through its full travel, the system is working correctly.
   - If linkage does not move full travel, check for mechanical problem such as sticking linkage, low actuator supply pressure, plugged or open air supply hose.
   - If the linkage does not move at all, do Connector Voltage Check (page 327).

Connector Voltage Check

Connect breakout harness to harness and leave EGR control valve disconnected. Turn ignition switch ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to battery positive	B+	If < B+, check for OPEN EGR GND circuit.
1 to 2	6 V to 9 V	If 0 V, check for OPEN or short to GND. If < 6 V, check for poor connection, corroded circuits. If > 9 V, check for short to PWR
If measurements are within specifications, do Operational Voltage Check - Actuator Test (page 327).		

Operational Voltage Check - Actuator Test

Connect breakout harness between EGR control valve and harness. Run Actuator Test. Use DMM to measure voltage. Batteries must be fully charged before performing this test.

Test Point	Spec	Comment
DMM - Measure Volts across pin 2 and GND		
Normal state	< 1 V	If > 1 V, check for short to PWR.
Actuator state LOW	1 V +/- 0.5 V	If > 1.5 V, check for OPEN circuit or EGR control valve.
Actuator state HIGH	> 9 V	If < 9 V, check for OPEN circuit or short to GND
If measurements are within specifications, do Actuator Resistance Check (page 327).		

Actuator Resistance Check

Turn ignition switch OFF. Connect breakout harness to EGR control valve and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to 2	4 Ω to 8 Ω	If not within specification, replace the EGR control valve.
If measurements are within specifications, do Harness Resistance Check (page 328).		

Harness Resistance Check

Turn ignition switch OFF. Connect ECM breakout box and breakout harness to harness and leave EGR control valve and ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
2 to GND	> 1 kΩ	If < 1k Ω, check for short circuit.
2 to E1-17	< 5 Ω	If > 5 Ω, check for OPEN circuit.
1 to GND	> 1 kΩ	If < 1k Ω, check for OPEN circuit.
1 to E1-11	< 5 Ω	If > 5 Ω, check for OPEN circuit.
If voltage and resistance checks are within specifications, and there are no mechanical faults, such as low actuator supply psi, damaged air supply hoses, failed EGR throttle valve actuator or sticky linkage, and the actuator does not actuate, replace EGR control valve.		

Actuator Test

The actuator test allows a technician to test the actuators by measuring voltage changes and visually monitoring actuator movement.

This test first runs through the Engine Control Module (ECM) actuators, then the Aftertreatment Control Module (ACM) actuators, and finishes with the Engine Interface Module (EIM) actuators.

ECM Actuators

During the ECM portion of the actuator test, all ECM actuators are commanded to LOW state, 8% to 15% duty cycle. Then one by one, each actuator is commanded to HIGH state, 80% to 100% duty cycle. This test will not cycle the Fuel Pressure Control Valve (FPCV) or the Exhaust Lambda Sensor (ELS) heater.

ACM Actuators

During the ACM portion of the actuator test, all ACM actuators remain at 0% duty cycle. Then one by one, each actuator is cycled on. The Aftertreatment Fuel Supply (AFS) valve and Aftertreatment Fuel Drain (AFD) valve are commanded to 100%, then drop to 66%. The Aftertreatment Fuel Injector (AFI) is commanded to a low duty cycle measured in seconds from 0 (off) to 0.1 (on).

EIM Actuators

During the EIM portion of the actuator test, the actuators cycle simultaneously. Fan Control Status is 1 (on), then cycles to 0 (off). The Cold Start Relay (CSR) and Cold Start Solenoid (CSS) is 0 (off), then cycles to 1 (on).

NOTE: When the Actuator Test is running, the sensor monitoring Parameter Identifiers (PIDs) are turned off.

This test cycles the following actuators:

- ECM actuators:
  - Intake Throttle Valve (ITV)
  - Boost Control Solenoid (BCS) valve
  - Exhaust Gas Recirculation (EGR) control valve
  - Coolant Mixer Valve (CMV)
  - Coolant Flow Valve (CFV)
- EIM actuators:
  - Cold Start Relay (CSR)
  - Cold Start Solenoid (CSS) valve
  - Electronic Fan Control (EFAN)
- ACM actuators:
  - Aftertreatment Fuel Drain (AFD) valve
  - Aftertreatment Fuel Supply (AFS) valve
  - Aftertreatment Fuel Injector (AFI)

EGRP Sensor (Exhaust Gas Recirculation Position)

DTC	SPN	FMI	Condition
1163	2791	4	EGRP signal out-of-range LOW
1164	2791	3	EGRP signal out-of-range HIGH
6259	2791	7	EGR valve unable to achieve commanded position
6260	2791	0	EGRP unable to detect close position
6270	2791	14	EGRP valve stuck open
6271	2791	12	EGRP valve stuck closed

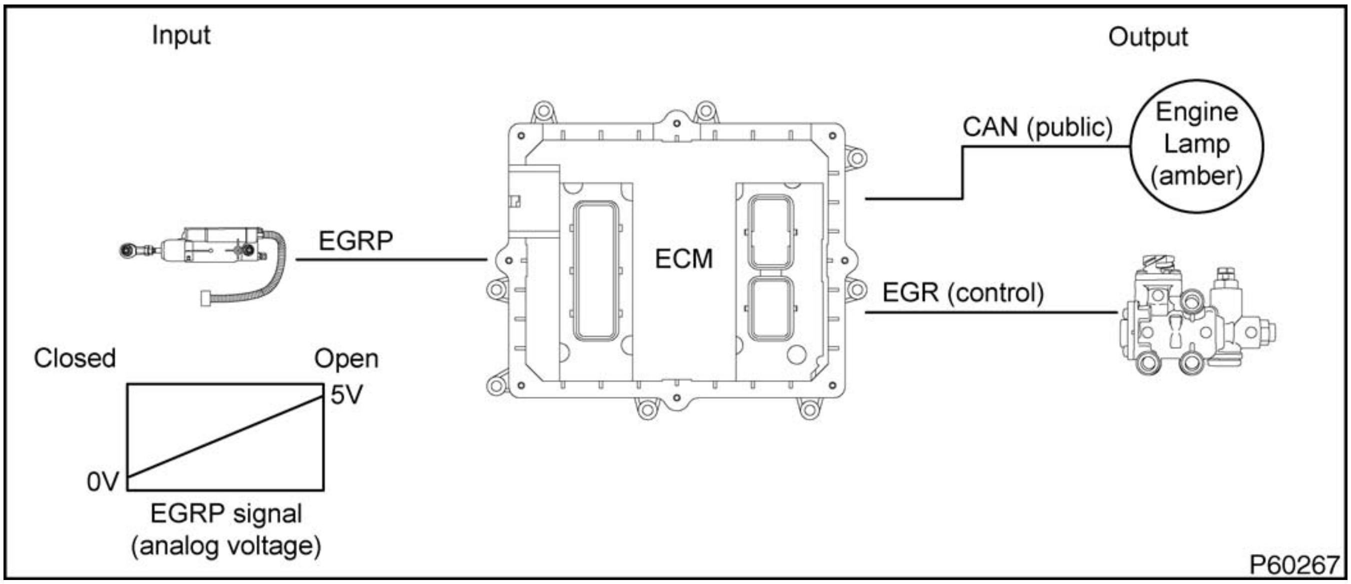

Figure 232 Functional diagram for the EGRP sensor

The functional diagram for the EGRP sensor includes the following:

- Engine Control Module (ECM)
- EGR control valve
- EGRP sensor
- Exhaust Lambda Sensor (ELS)
- Engine lamp (amber)

Function

The EGRP sensor is integrated into the EGR throttle valve actuator and uses compressed air controlled by the EGR control valve. The EGRP sensor monitors and provides an EGR throttle valve actuator position signal to the ECM.

Component Location

The EGRP sensor is integrated into the EGR throttle valve actuator which is part of the EGR throttle valve. The EGR throttle valve is located on the rear of the EGR module.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)

- EGR Position and ITV Breakout Harness (page 443)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- Terminal Test Adapter Kit (page 446)

EGRP Sensor Connector End Diagnostics

DTC	Condition	Possible Causes
1163	EGRP signal out-of-range LOW	• EGRP circuit short to GND • Failed sensor
1164	EGRP signal out-of-range HIGH	• EGRP circuit OPEN or short to PWR • Failed sensor
6259	EGR valve unable to achieve commanded position	• Air supply or mechanical linkage fault • Failed EGRP sensor • Failed EGR control valve
6260	EGRP unable to detect close position	• Air supply or mechanical linkage fault • Failed EGRP sensor • Failed EGR control valve
6270	EGRP value stuck open	• Air supply or mechanical linkage fault • EGRP sensor or circuit fault • EGR control valve or circuit fault
6271	EGRP value stuck closed	• Air supply or mechanical linkage fault • EGRP sensor or circuit fault • EGR control valve or circuit fault

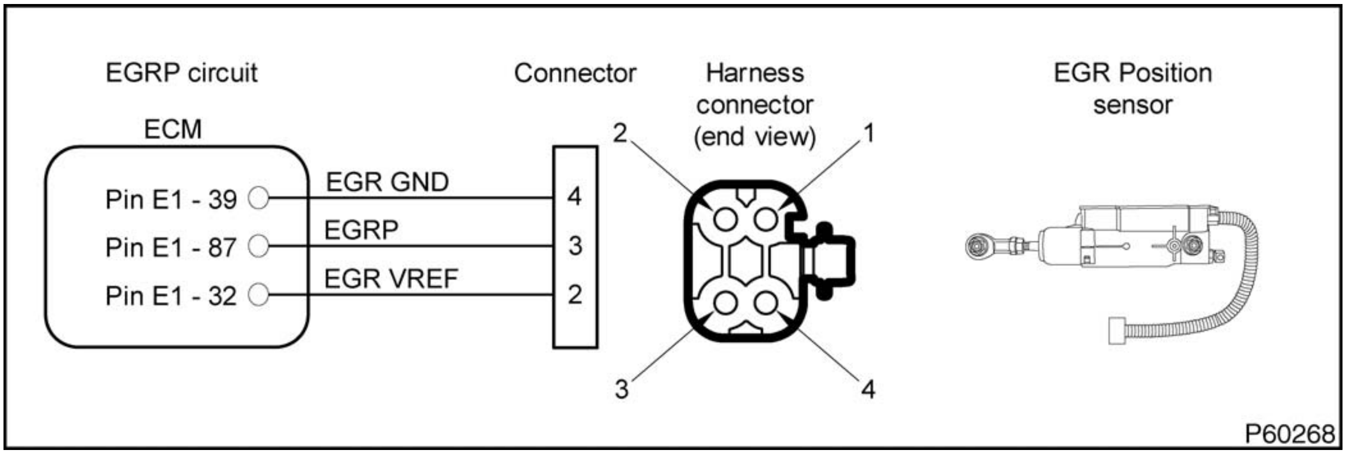

Figure 233 EGRP sensor circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

NOTE: Air tanks must be above 620 kPa (90 psi) before running this test.

1. Key ON, engine OFF.
2. Connect the EST with MasterDiagnostics® software.
3. Verify correct engine is selected and launch EST.
4. Open D_Actuator.ssn session.
5. Run Actuator Test.
6. Visually monitor EGR throttle valve actuator linkage movement.
   - If the linkage does not move at all, go to EGR Control Valve (Exhaust Gas Recirculation) (page 325).
   - If linkage does not move full travel, check for mechanical problem such as sticking linkage, low actuator supply pressure, plugged or open air supply hose.
   - If linkage moves through its full travel, proceed to the next step
7. Using EST, open the D_ContinuousMonitor.ssn.
8. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected locations. If the circuit is interrupted, the PID spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
9. Disconnect engine harness from sensor. Inspect connector for damaged pins, corrosion, or lose pins using Pin Grip Inspection (page 197). Repair if necessary.
10. Connect breakout harness to engine harness. Leave sensor disconnected.

Connector Circuit Checks

Connect sensor breakout harness. Leave sensor disconnected. Turn the ignition switch to ON. Use EST to verify correct DTC goes active when corresponding fault is induced. Used DMM to measure circuits.

Test Point	Spec	Comment
EST – Monitor EGRPv	5 V	If < 4.5 V, check EGRP signal circuit for short to GND. Do Connector Resistance Check to GND (page 333).
DMM – Measure volts 2 to GND	5.0 V +/- 0.5 V	If > 5.5 V, check EGR VREF for short to PWR. If < 4.5 V, check EGR VREF for OPEN or short to GND. Do Harness Resistance Check (page 333).
DMM – Measure voltage 2 to 4	5 V +/- 0.5 V	If < 4.5 V, check EGRP GND for OPEN. Do Harness Resistance Check (page 333).
EST – Monitor EGRPv Short across breakout harness pins 3 and 4	0 V	If > 0.5 V, check EGRP signal for OPEN or short to PWR. Do Harness Resistance Check (page 333).

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace EGRP throttle valve.

EGRP Sensor Pin-Point Diagnostics

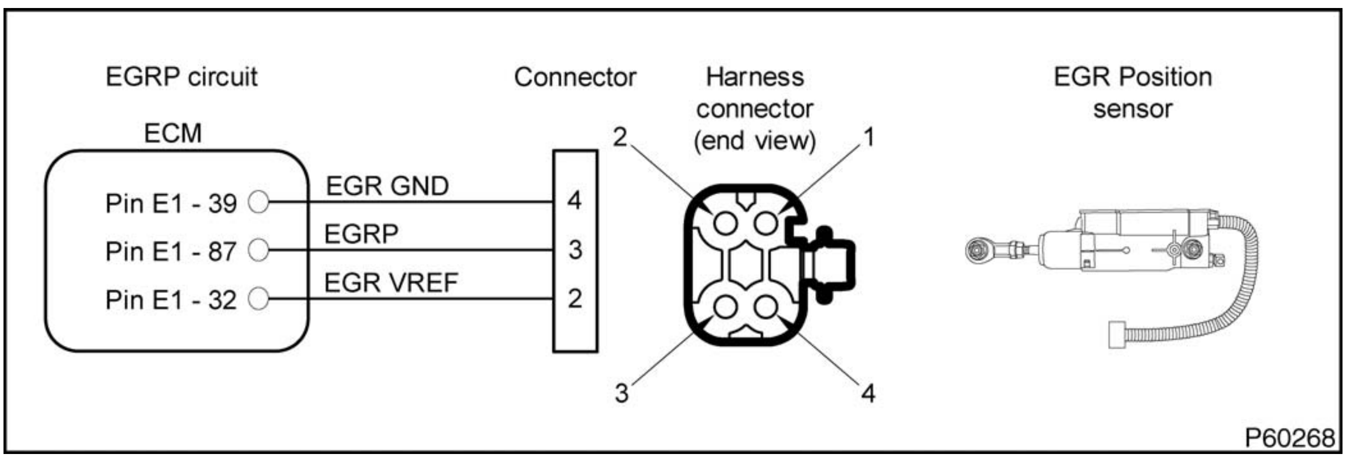

Figure 234 EGRP sensor circuit diagram

Connector Voltage Check

Connect breakout harness to engine harness and leave EGR control valve disconnected. Turn ignition switch ON. Use DMM to measure voltage.

Test Point	Spec	Comment
3 to GND	5 V	If < 4.5 V, check EGRP signal circuit for short to GND.
2 to GND	5 V	If > 5.5 V, check EGR VREF for short to PWR. If < 4.5 V, check EGR VREF for OPEN or short to GND. Do Harness Resistance Check (page 333).
4 to GND	0 V	If > 0.25 V, check EGR GND for short to PWR.

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
4 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
3 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
4 to E1-39	< 5 Ω	If > 5 Ω, check EGR GND circuit for OPEN.
2 to E1-32	< 5 Ω	If > 5 Ω, check EGR VREF circuit for OPEN.
3 to E1-87	< 5 Ω	If > 5 Ω, check EGRP circuit for OPEN.

If voltage and resistance checks are within specifications, and there are no mechanical faults, such as low actuator supply psi, damaged air supply hoses, failed EGR throttle valve actuator or sticky linkage, and the actuator does not actuate, replace EGR throttle valve.

Operational Voltage Check

Turn Ignition switch to ON. Run Actuator Test. Use EST to monitor S_EGRP Volts and EGR Position PIDs or DMM to measure EGRP signal voltage.

Test Point	Actuator State	Volts	Position
3 to GND or E1-87 to GND	LOW	0.7 V	0.00%
	HIGH	3.9 V	98.8%

EGRP Sensor Circuit Operation

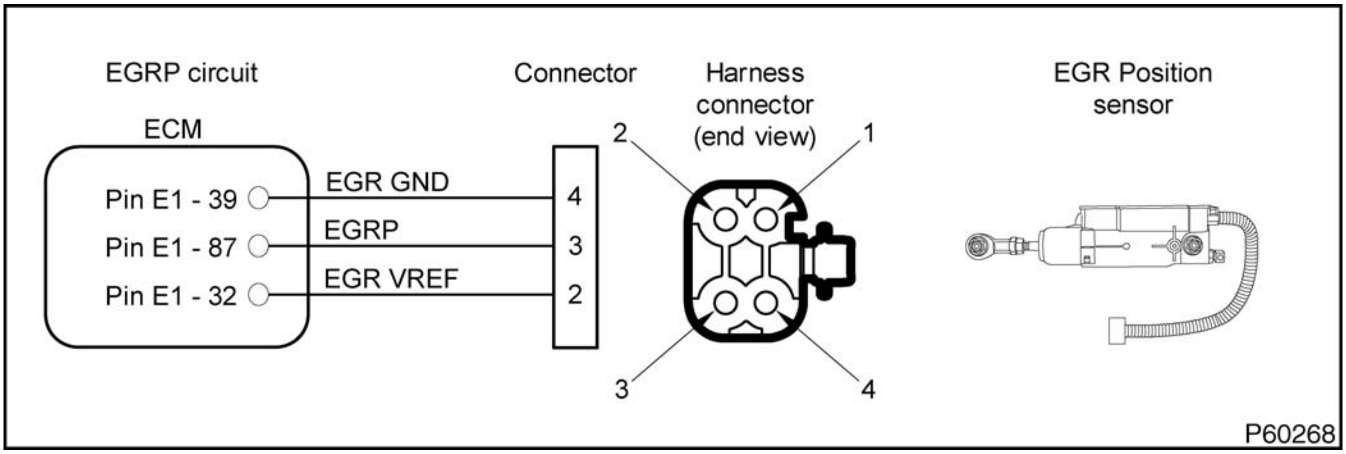

Figure 235 EGRP sensor circuit diagram

Fault Detection / Management

The ECM continuously monitors the EGR system. If EGRP sensor signal is higher or lower than expected, the ECM disregards the sensor signal and uses a calibrated default value. The ECM sets a DTC and illuminates the amber engine lamp.

Actuator Test

The actuator test allows a technician to test the actuators by measuring voltage changes and visually monitoring actuator movement.

This test first runs through the Engine Control Module (ECM) actuators, then the Aftertreatment Control Module (ACM) actuators, and finishes with the Engine Interface Module (EIM) actuators.

ECM Actuators

During the ECM portion of the actuator test, all ECM actuators are commanded to LOW state, 8% to 15% duty cycle. Then one by one, each actuator is commanded to HIGH state, 80% to 100% duty cycle. This test will not cycle the Fuel Pressure Control Valve (FPCV) or the Exhaust Lambda Sensor (ELS) heater.

ACM Actuators

During the ACM portion of the actuator test, all ACM actuators remain at 0% duty cycle. Then one by one, each actuator is cycled on. The Aftertreatment Fuel Supply (AFS) valve and Aftertreatment Fuel Drain (AFD) valve are commanded to 100%, then drop to 66%. The Aftertreatment Fuel Injector (AFI) is commanded to a low duty cycle measured in seconds from 0 (off) to 0.1 (on).

EIM Actuators

During the EIM portion of the actuator test, the actuators cycle simultaneously. Fan Control Status is 1 (on), then cycles to 0 (off). The Cold Start Relay (CSR) and Cold Start Solenoid (CSS) is 0 (off), then cycles to 1 (on).

NOTE: When the Actuator Test is running, the sensor monitoring Parameter Identifiers (PIDs) are turned off.

This test cycles the following actuators:

- ECM actuators:
  - Intake Throttle Valve (ITV)
  - Boost Control Solenoid (BCS) valve
  - Exhaust Gas Recirculation (EGR) control valve
  - Coolant Mixer Valve (CMV)
  - Coolant Flow Valve (CFV)
- EIM actuators:
  - Cold Start Relay (CSR)
  - Cold Start Solenoid (CSS) valve
  - Electronic Fan Control (EFAN)

- ACM actuators:
    - Aftertreatment Fuel Drain (AFD) valve
    - Aftertreatment Fuel Supply (AFS) valve
    - Aftertreatment Fuel Injector (AFI)

EGT1 Sensor (Exhaust Gas Temperature 1)

DTC	SPN	FMI	Condition
1737	3241	4	EGT1 signal out-of-range LOW
1738	3241	3	EGT1 signal out-of-range HIGH
2675	3241	2	EGT1 signal in-range fault
6813	3241	0	EGT1 or EGT2 high temp without regen

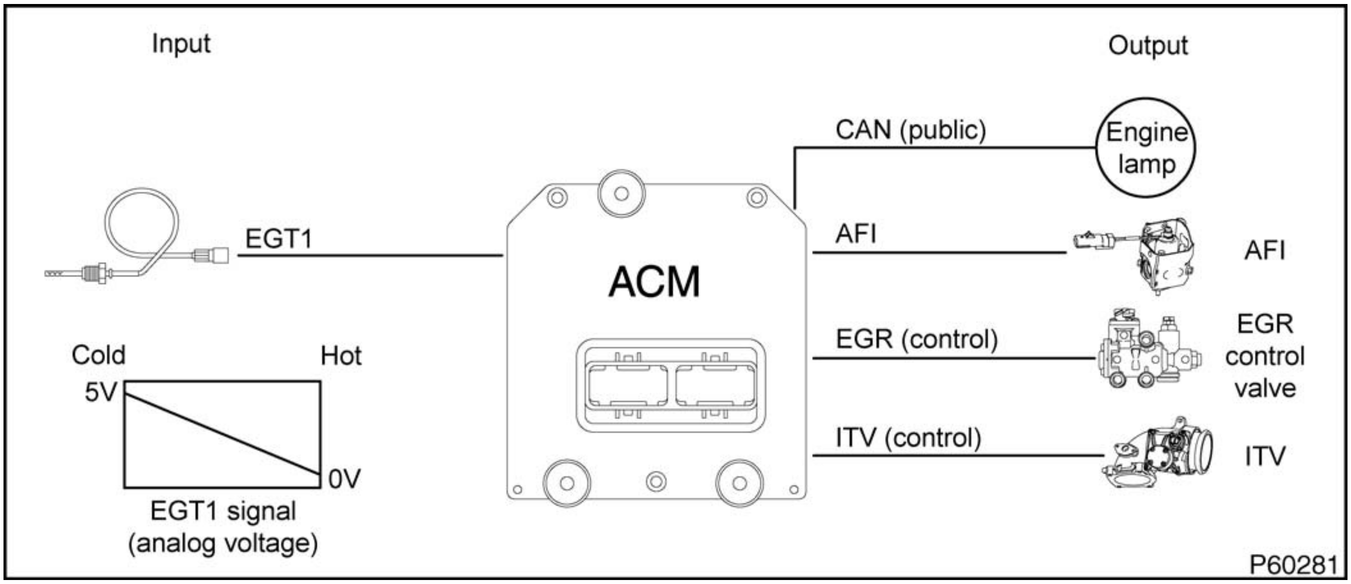

Figure 236 Functional diagram for the EGT1 sensor

The functional diagram for the EGT1 sensor includes the following:

- Aftertreatment Control Module (ACM)
- Engine lamp (amber)
- EGT1 sensor
- Aftertreatment Fuel Injector (AFI)
- Exhaust Gas Recirculation (EGR) control valve
- Intake Throttle Valve (ITV)

Function

The EGT1 sensor provides a feedback signal to the ACM indicating Diesel Oxidation Catalyst (DOC) inlet temperature. Before and during a catalyst regeneration, the ACM monitors this sensor along with the Exhaust Gas Temperature 2 (EGT2) sensor, Exhaust Gas Temperature 3 (EGT3) sensor and the Exhaust Gas Differential Pressure (EGDP) sensor.

Sensor Location

The EGT1 sensor is the first temperature sensor installed past the turbocharger and just before the DOC.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 3-Banana Plug Harness (page 437)
- 500 Ohm Resistor Harness (page 439)
- 180-Pin Breakout Box (page 438)
- Aftertreatment Harness (page 439)
- Aftertreatment 2-pin Breakout Harness (page 439)
- Terminal Test Adapter Kit (page 446)

EGT1 Sensor End Diagnostics

DTC	Condition	Possible Causes
1737	EGT1 signal out-of-range LOW	• EGT1 signal circuit short to GND • Failed sensor
1738	EGT1 signal out-of-range HIGH	• EGT1 signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor
2675	EGT1 signal in-range fault	• EGT1 biased sensor or circuit
6813	EGT1 or EGT2 high temp without regen	• EGT1 or EGT2 biased sensor or circuit • Engine over-fueling • Fuel leaking into exhaust

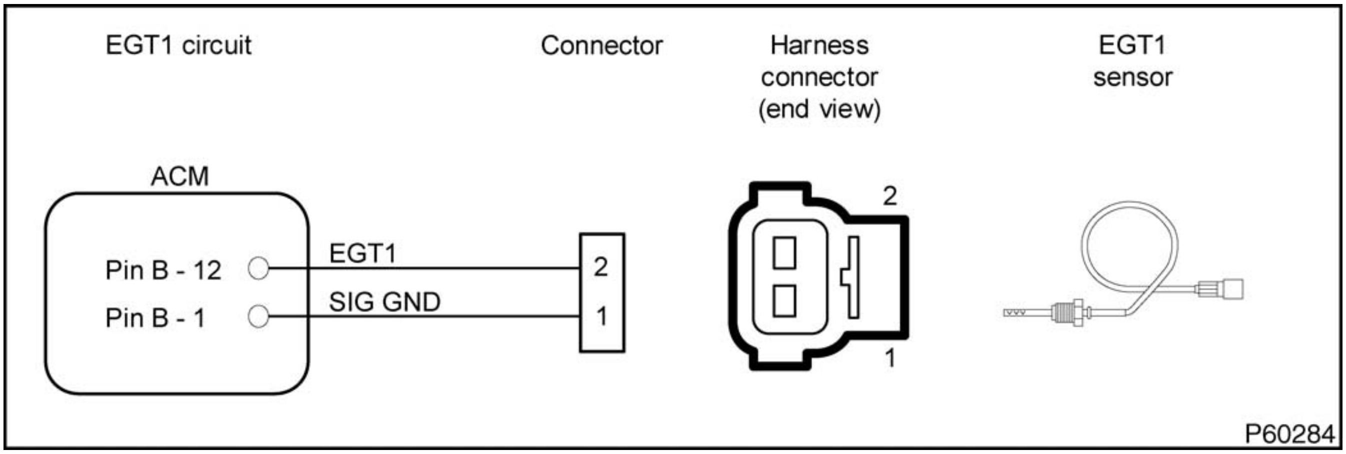

Figure 237 EGT1 circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor. Inspect connectors for damaged pins, corrosion, or loose pins using Pin Grip Inspection (page 197). Repair if necessary.
4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect breakout harness. Leave sensor disconnected. Turn the ignition switch to ON. Use EST to monitor PID during Continuous Monitor test.

Test Point	Spec	Comment
EST - Monitor EGT1v	5 V	If < 4.5 V, check EGT1 signal for short to GND. Do Connector Resistance Checks to GND (page 340).
EST - Monitor EGT1v Short breakout harness across pins 1 and GND	0 V	If > 0.25 V, check EGT1 signal circuit for OPEN. Do Harness Resistance Check (page 340).
EST - Monitor EGT1v Short breakout harness across pins 1 and 2	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 340).
EST - Monitor EGT1v Short 500-Ohm resistor across pins 1 and 2	< 1.0 V	If > 1.0 V, check EGT1 signal circuit for short to PWR.
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace EGT1 sensor.		

EGT1 Sensor Pin-Point Diagnostics

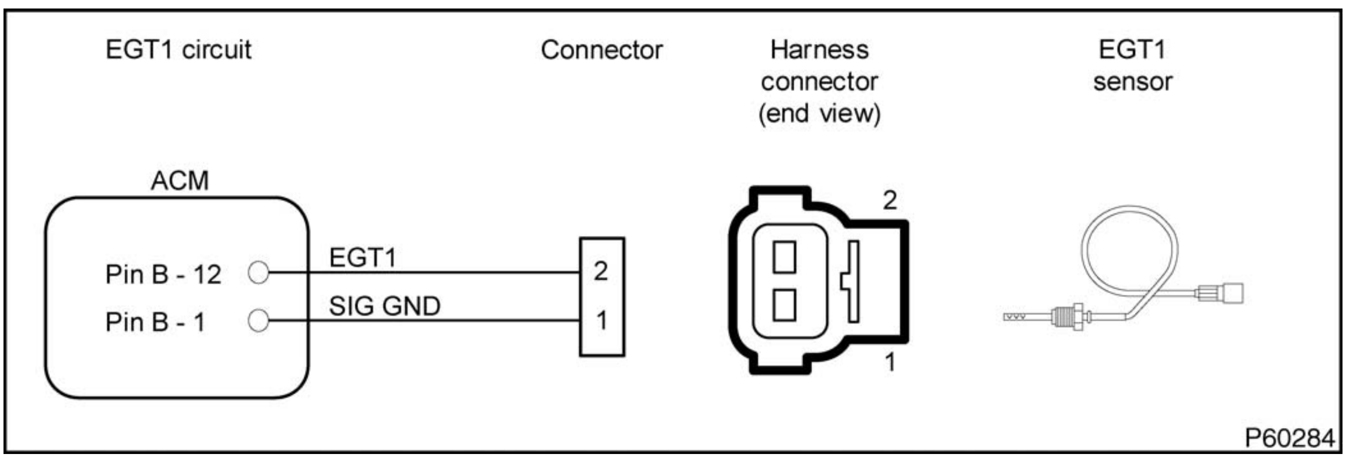

Figure 238 EGT1 sensor circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	0 V	If > 0.25 V, check for short to PWR.
2 to GND	4.5 V to 5 V	If < 4.5 V, check short to GND. Do Connector Resistance Checks to GND (page 340).

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Do Harness Resistance Check (page 340).
2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND. Do Harness Resistance Check (page 340).

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave ACM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to B-1	< 5 Ω	If > 5 Ω, check SIG GND signal for OPEN.
2 to B-12	< 5 Ω	If > 5 Ω, check EGT1 signal for OPEN.

EGT1 Circuit Operation

The EGT1 is a thermistor sensor that is supplied with a 5 V reference voltage at Pin 2 from ACM Pin B-12. The sensor is grounded at Pin 1 from ACM Pin B-1. As temperature increases, the resistance of the thermistor decreases, causing the signal voltage to decrease.

Fault Detection / Management

The ACM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ACM disregards the sensor signal and uses a calibrated default value. The ACM sets a DTC, illuminates the amber engine lamp, and runs the engine in a default range.

EGT2 Sensor (Exhaust Gas Temperature 2)

DTC	SPN	FMI	Condition
1741	3242	4	EGT2 signal out-of-range LOW
1742	3242	3	EGT2 signal out-of-range HIGH
2674	3242	2	EGT2 signal in-range fault
6813	3241	0	EGT1 or EGT2 high temp without regen

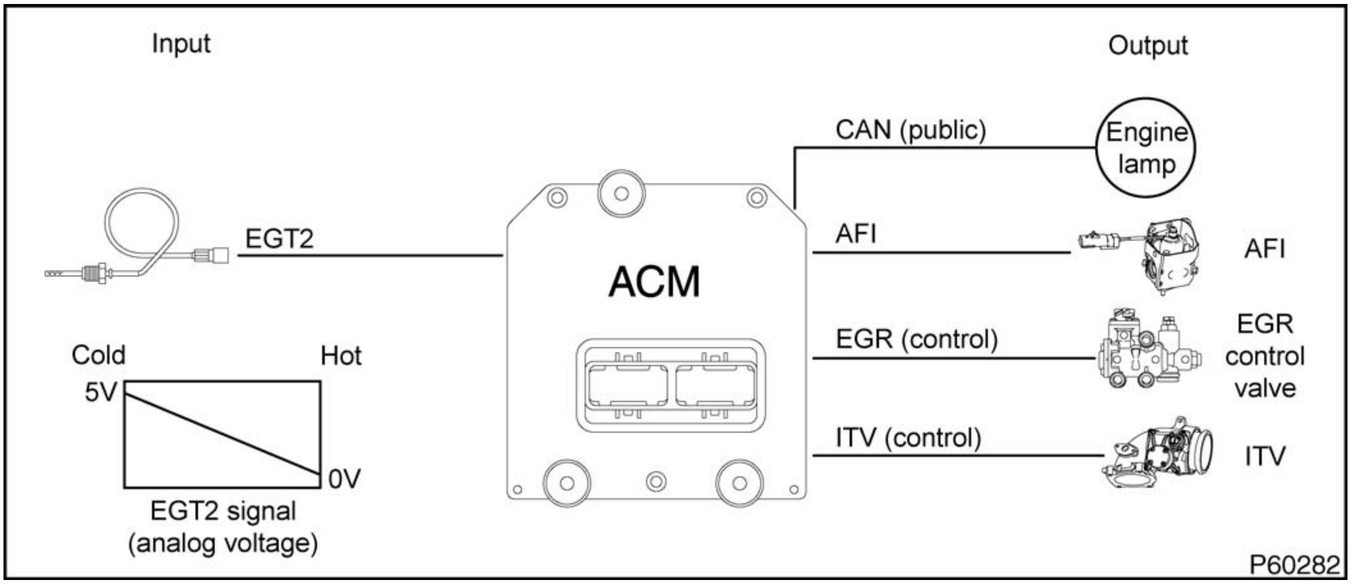

Figure 239 Functional diagram for the EGT2 sensor

The functional diagram for the EGT2 sensor includes the following:

- Aftertreatment Control Module (ACM)
- Engine lamp (amber)
- EGT2 sensor
- Aftertreatment Fuel Injector (AFI)
- Exhaust Gas Recirculation (EGR) control valve
- Intake Throttle Valve (ITV)

Function

The EGT2 sensor provides a feedback signal to the ACM indicating Diesel Particulate Filter (DPF) inlet temperature. Before and during a catalyst regeneration, the ACM monitors this sensor along with the Exhaust Gas Temperature 1 (EGT1) sensor, Exhaust Gas Temperature 3 (EGT3) sensor and the Exhaust Gas Differential Pressure (EGDP) sensor.

Sensor Location

The EGT2 sensor is the second exhaust temperature sensor installed downstream of the turbocharger. It is located between the Diesel Oxidation Catalyst (DOC) and the DPF.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 3-Banana Plug Harness (page 437)
- 500 Ohm Resistor Harness (page 439)
- 180-Pin Breakout Box (page 438)
- Aftertreatment Harness (page 439)

- Aftertreatment 2-pin Breakout Harness (page 439)
- Terminal Test Adapter Kit (page 446)

EGT2 Sensor End Diagnostics

DTC	Condition	Possible Causes
1741	EGT2 signal out-of-range LOW	• EGT2 signal circuit short to GND • Failed sensor
1742	EGT2 signal out-of-range HIGH	• EGT2 signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor
2674	EGT2 signal in-range fault	• EGT2 biased sensor or circuit
6813	EGT1 or EGT2 high temp without regen	• EGT1 or EGT2 biased sensor or circuit • Engine over-fueling • Fuel leaking into exhaust

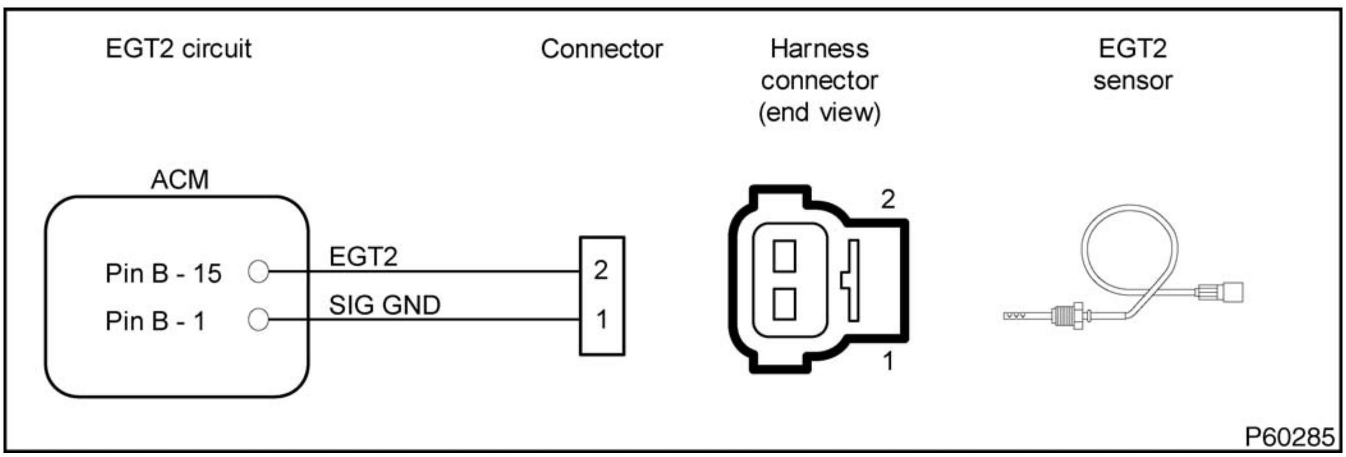

Figure 240 EGT2 sensor circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.

3. Disconnect engine harness from sensor. Inspect connectors for damaged pins, corrosion, or loose pins using Pin Grip Inspection (page 197). Repair if necessary.
4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect breakout harness. Leave sensor disconnected. Turn the ignition switch to ON. Use EST to monitor PID during Continuous Monitor test.

Test Point	Spec	Comment
EST - Monitor EGT2v	5 V	If < 4.5 V, check EGT2 signal for short to GND. Do Connector Resistance Checks to GND (page 344).
EST - Monitor EGT2v Short breakout harness across pin 1 and GND	0 V	If > 0.25 V, check EGT2 signal circuit for OPEN. Do Harness Resistance Check (page 344).
EST - Monitor EGT2v Short breakout harness across pins 1 and 2	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 344).
EST - Monitor EGT2v Short 500-Ohm resistor across pins 1 and 2	< 1.0 V	If > 1.0 V, check EGT2 signal circuit for short to PWR.

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace EGT2 sensor.

EGT2 Sensor Pin-Point Diagnostics

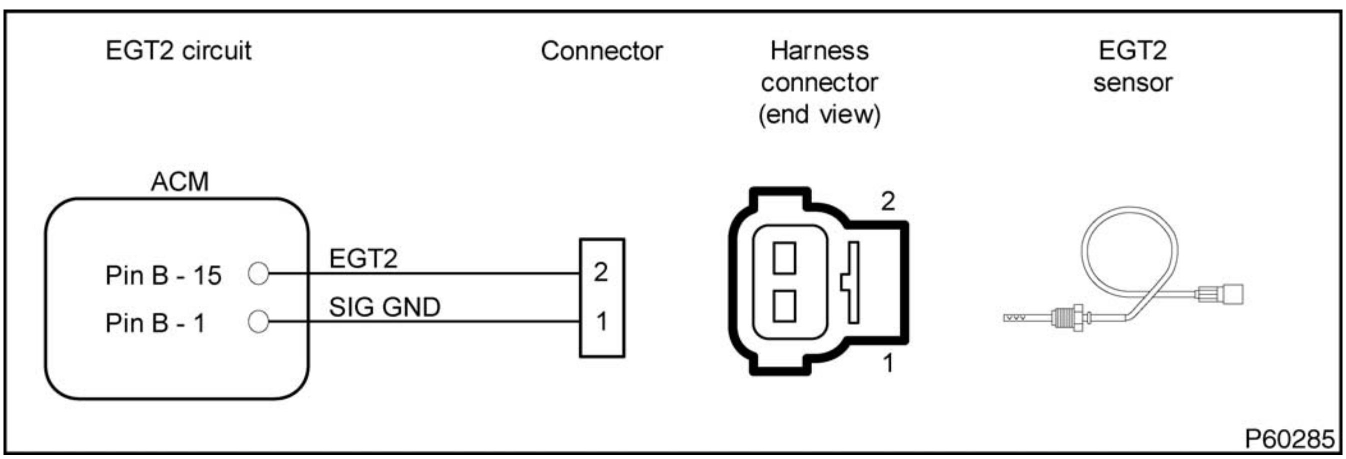

Figure 241 EGT2 sensor circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	0 V	If > 0.25 V, check for short to PWR.
2 to GND	4.5 V to 5 V	If < 4.5 V, check for short to GND. Do Connector Resistance Checks to GND (page 344).

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Do Harness Resistance Check (page 344).
2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND. Do Harness Resistance Check (page 344).

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave ACM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to B-1	< 5 Ω	If > 5 Ω, check SIG GND signal for OPEN.
2 to B-15	< 5 Ω	If > 5 Ω, check EGT2 signal for OPEN.

EGT2 Sensor Circuit Operation

The EGT2 sensor is a thermistor sensor that is supplied with a 5 V reference voltage at Pin 2 from ACM Pin B-15. The sensor is grounded at Pin 1 from ACM Pin B-1. As temperature increases, the resistance of the thermistor decreases, causing the signal voltage to decrease.

Fault Detection / Management

The ACM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ACM disregards the sensor signal and uses a calibrated default value. The ACM sets a DTC, illuminates the amber engine lamp, and runs the engine in a default range.

EGT3 Sensor (Exhaust Gas Temperature 3)

DTC	SPN	FMI	Condition
1744	3245	4	EGT3 signal out-of-range LOW
1745	3245	3	EGT3 signal out-of-range HIGH
2676	3245	2	EGT3 signal in-range fault

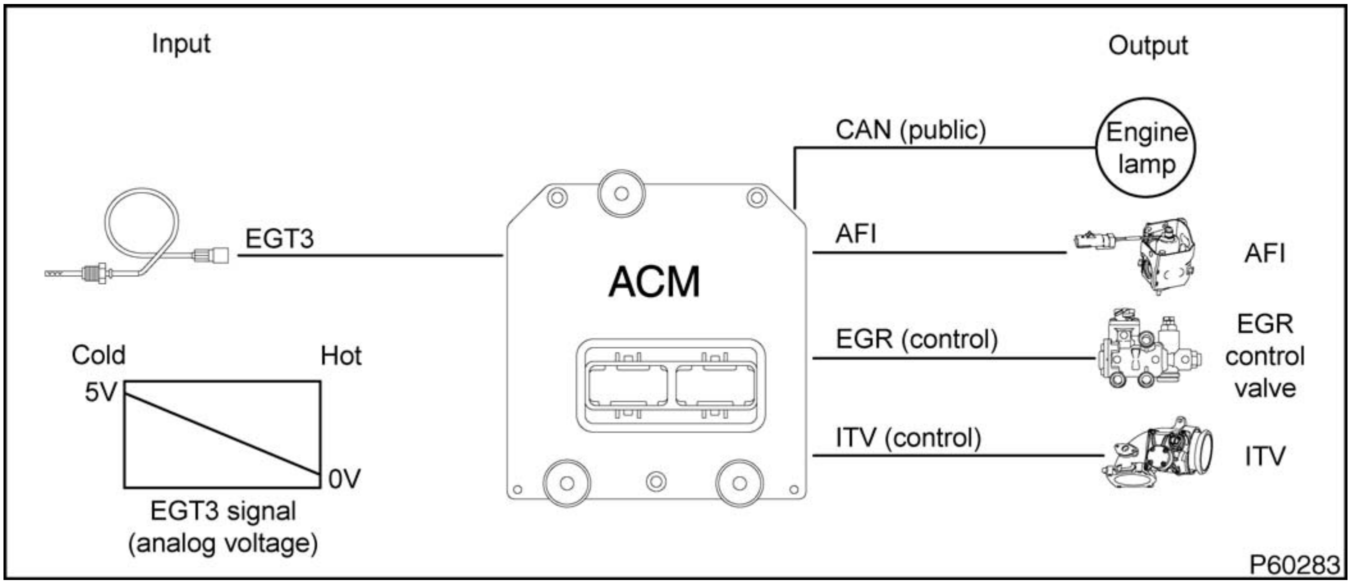

Figure 242 Functional diagram for the EGT3 sensor

The functional diagram for the EGT3 sensor includes the following:

- Aftertreatment Control Module (ACM)
- Engine lamp (amber)
- EGT3 sensor
- Aftertreatment Fuel Injector (AFI)
- Exhaust Gas Recirculation (EGR) control valve
- Intake Throttle Valve (ITV)

Function

The EGT3 sensor provides a feedback signal to the ACM indicating Diesel Particulate Filter (DPF) outlet temperature. Before and during a catalyst regeneration, the ACM monitors this sensor along with the Exhaust Gas Temperature 1 (EGT1) sensor, Exhaust Gas Temperature 2 (EGT2) sensor and Exhaust Gas Differential Pressure (EGDP) sensor.

Sensor Location

The EGT3 sensor is the third exhaust temperature sensor installed downstream of the turbocharger. It is located just after the DPF.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 3-Banana Plug Harness (page 437)
- 500 Ohm Resistor Harness (page 439)
- 180-Pin Breakout Box (page 438)
- Aftertreatment Harness (page 439)
- Aftertreatment 2-pin Breakout Harness (page 439)
- Terminal Test Adapter Kit (page 446)

EGT3 Sensor End Diagnostics

DTC	Condition	Possible Causes
1744	EGT3 signal out-of-range LOW	• EGT3 signal circuit short to GND • Failed sensor
1745	EGT3 signal out-of-range HIGH	• EGT3 signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor
2676	EGT3 signal in-range fault	• EGT3 biased sensor or circuit

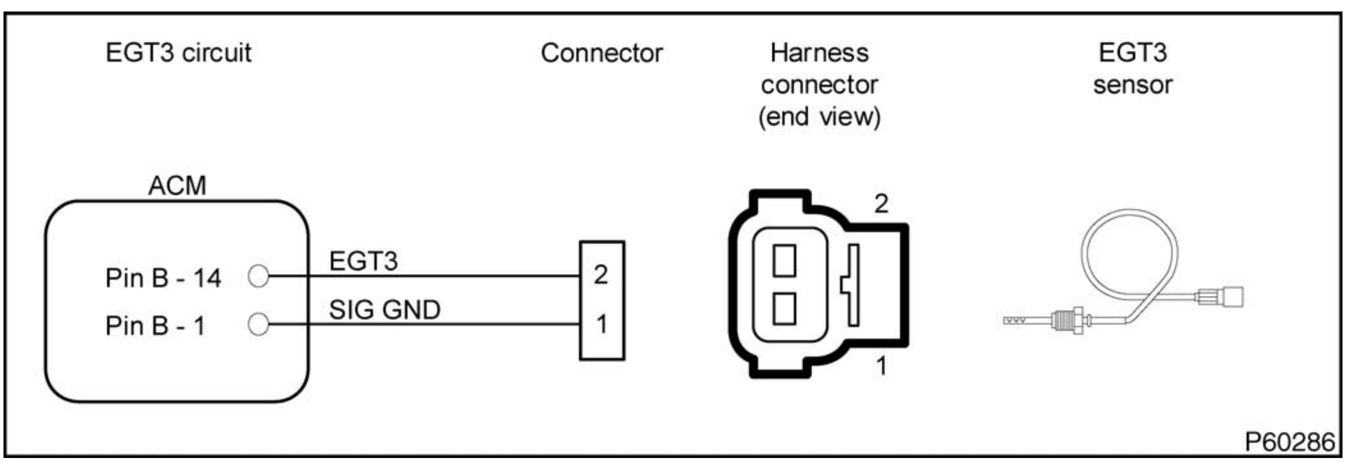

Figure 243 EGT3 sensor circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor. Inspect connectors for damaged pins, corrosion, or loose pins using Pin Grip Inspection (page 197). Repair if necessary.
4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect breakout harness. Leave sensor disconnected. Turn the ignition switch to ON. Use EST to monitor PID during Continuous Monitor test.

Test Point	Spec	Comment
EST - Monitor EGT3v	5 V	If < 4.5 V, check EGT3 signal for short to GND. Do Connector Resistance Checks to GND (page 348).
EST - Monitor EGT3v Short breakout harness across pin 1 and GND	0 V	If > 0.25 V, check EGT3 signal circuit for OPEN. Do Harness Resistance Check (page 348).
EST - Monitor EGT3v Short breakout harness across pins 1 and 2	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 348).
EST - Monitor EGT3v Short 500 Ohm resistor across pins 1 and 2	< 1.0 V	If > 1.0 V, check EGT3 signal circuit for short to PWR.
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace EGT3 sensor.		

EGT3 Sensor Pin-Point Diagnostics

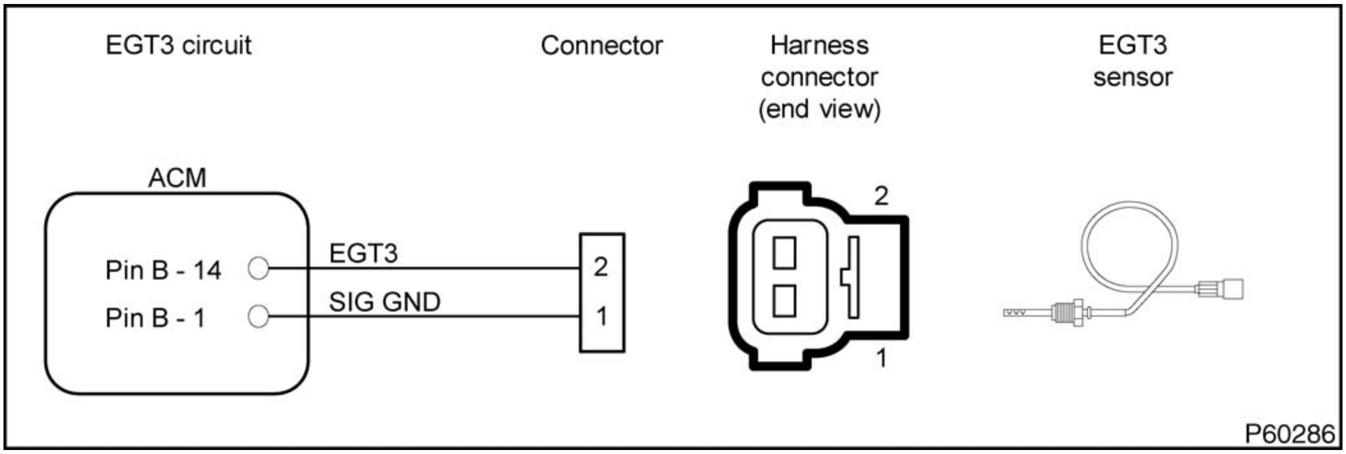

Figure 244 EGT3 sensor circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	0 V	If > 0.25 V, check for short to PWR.
2 to GND	4.5 V to 5 V	If < 4.5 V, check for short to GND. Do Connector Resistance Checks to GND (page 348).

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Do Harness Resistance Check (page 348).
2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND. Do Harness Resistance Check (page 348).

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave ACM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to B-1	< 5 Ω	If > 5 Ω, check SIG GND signal for OPEN.
2 to B-14	< 5 Ω	If > 5 Ω, check EGT3 signal for OPEN.

EGT3 Sensor Circuit Operation

The EGT3 sensor is a thermistor sensor that is supplied with a 5 V reference voltage at Pin 2 from ACM Pin B-14. The sensor is grounded at Pin 1 from ACM Pin B-1. As temperature increases, the resistance of the thermistor decreases, causing the signal voltage to decrease.

Fault Detection / Management

The ACM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ACM disregards the sensor signal and uses a calibrated default value. The ACM sets a DTC, illuminates the amber engine lamp, and runs the engine in a default range.

EIM/ACM Power (Engine Interface Module/Aftertreatment Control Module)

DTC	SPN	FMI	Condition
1112	168	3	B+ to EIM out-of-range HIGH
1113	168	4	B+ to EIM out-of-range LOW

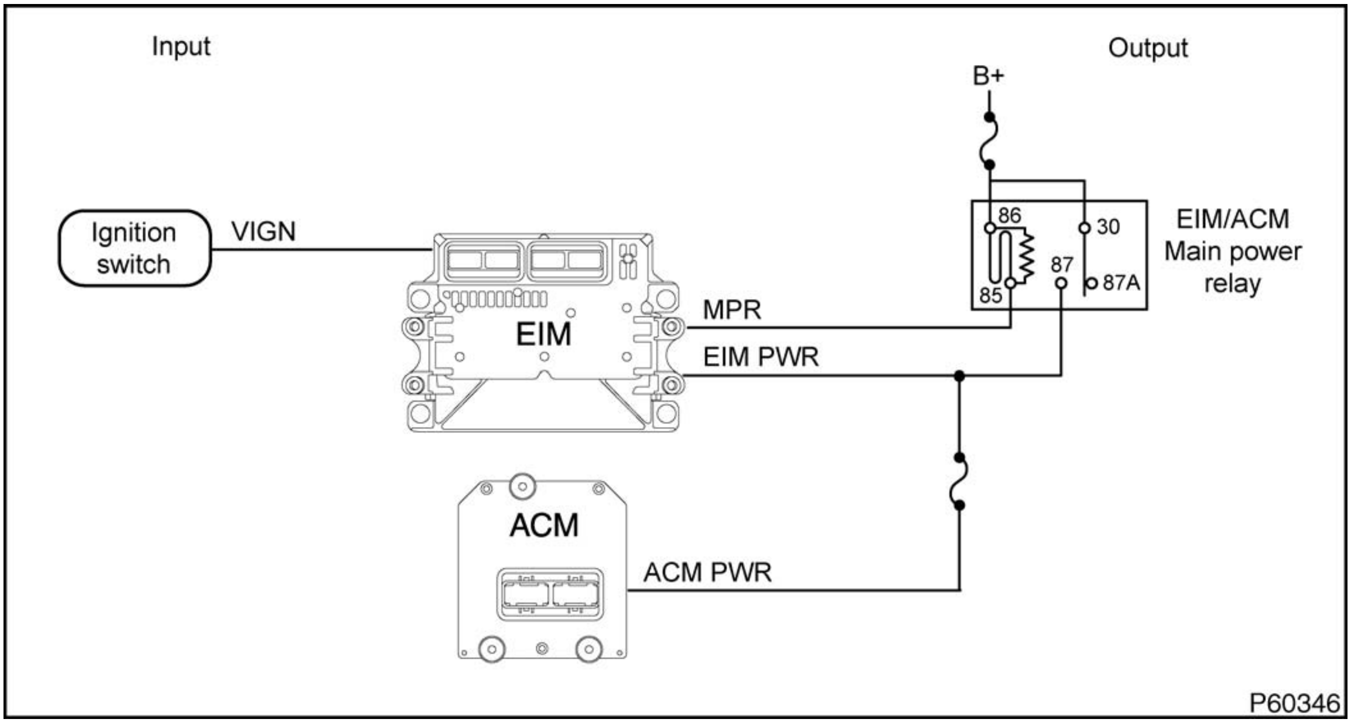

Figure 245 Functional diagram for the EIM/ACM Power

The functional diagram for EIM/ACM Power includes the following:

- ACM
- EIM/ACM main power relay
- EIM
- Ignition switch
- Fuses

Function

The ACM and EIM require battery power to operate the electronic control system and perform maintenance after the ignition switch is turned off. To do this, the EIM must control its own power supply. When the EIM receives the VIGN signal from the ignition switch, it enables the relay to power-up. When the ignition switch is turned off, the EIM performs internal maintenance, then disables the EIM/ACM main power relay.

Component Location

The EIM/ACM relay is located inside the cab in the main fuse/relay block.

The ACM is located on the inside of the left frame rail, adjacent to the flywheel housing.

The EIM is located on the left side of the engine behind the fuel filter housing assembly.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)

- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 96-Pin Breakout Box – DLC II (page 438)
- 180-Pin Breakout Box (page 438)
- Aftertreatment Harness (page 439)
- EIM Power Relay Breakout Harness (page 444)
- Terminal Test Adapter Kit (page 446)

EIM/ACM Power Pin-Point Diagnostics

DTC	Condition	Possible Causes
1112	B+ to EIM out-of-range HIGH	• EIM PWR above 17 volts • Charging system fault
1113	B+ to EIM out-of-range LOW	• EIM PWR below 7.5 volts • Low discharged batteries • Charging system fault • High resistance in EIM powering circuits (EIM PWR, EIM GND, or VIGN) • Failed EIM Relay

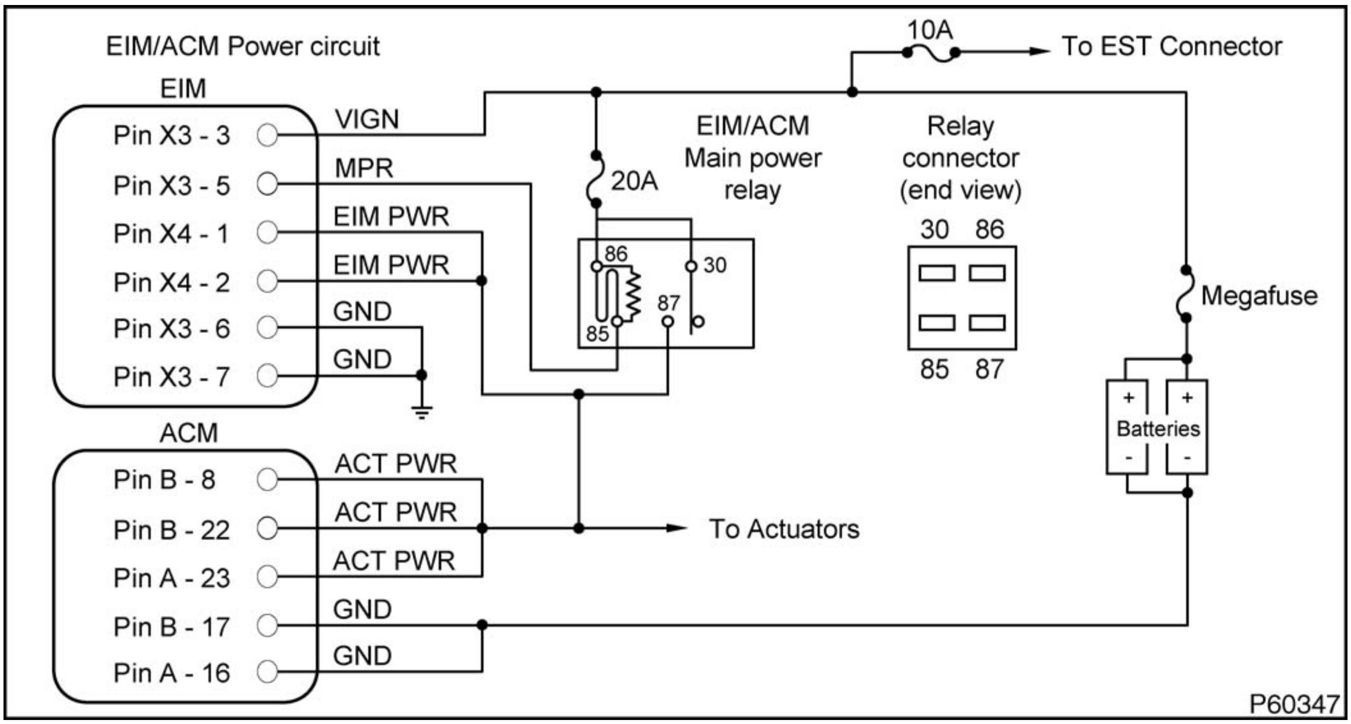

Figure 246 EIM/ACM Power circuit diagram

NOTE: Refer to the truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for vehicle side electrical system.

Voltage Checks at Relay

Connect relay breakout harness between relay and relay socket. Turn the ignition switch ON. Use DMM to measure voltage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before removing main power relay or any EIM connector supplying power to the EIM. Failure to turn the ignition switch to OFF causes a voltage spike and damage to electrical components.

Test Point	Spec	Comment
86 to GND	B+	If 0 V, check power circuit to relay coil for OPEN or short to GND, or blown fuse.
		If < B+, check for failed circuitry between batteries and relay. Do Relay Power Circuit Harness Resistance Check (page 354).
30 to GND	B+	If 0 V, check power circuit to relay switch for OPEN or short to GND, or blown fuse.
		If < B+, check for failed circuitry between batteries and relay. Do Relay Power Circuit Harness Resistance Check (page 354).
85 to GND	0 V to 2 V	If > 2 V, check MPR control circuit for OPEN or short to PWR. Do Relay Power Circuit Harness Resistance Check (page 354).
87 to GND	B+	If < B+, replace relay.

Voltage Checks at EIM

Connect breakout box between EIM and vehicle harness. Turn the ignition switch ON. Use DMM to measure voltage at battery GND or PWR.

Test Point	Spec	Comment
X3-3 to GND	B+	If < B+, check VIGN circuit for OPEN or short to GND, or blown fuse.
X3-6 to PWR	B+	If < B+, check GND for OPEN circuit. Do EIM Harness Resistance Check (page 354).
X3-7 to PWR	B+	
X3-5 to GND	0 V to 2 V	If > 2 V, check MPR control circuit for OPEN or short to PWR. Do EIM Harness Resistance Check (page 354).
X4-1 to GND	B+	If < B+, check for OPEN circuit, failed relay, or blown fuse. Do EIM Harness Resistance Check (page 354).
X4-2 to GND	B+	

Voltage Checks at ACM

Connect breakout box between ACM and vehicle harness. Turn the ignition switch ON. Use DMM to measure voltage at battery GND or PWR.

Test Point	Spec	Comment
A-16 to PWR	B+	If < B+, check GND for OPEN circuit. Do ACM Harness Resistance Check (page 354).
B-17 to PWR	B+	
B-8 to GND	B+	If < B+, check for OPEN circuit, failed relay, or blown fuse. Do ACM Harness Resistance Check (page 354).
B-22 to GND	B+	
A-23 to GND	B+	

EIM Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and relay breakout harness. Leave EIM, EIM/ACM Main Power relay disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
X3-5 to 85	< 5 Ω	If > 5 Ω, check MPR control circuit for OPEN.
X3-5 to GND	> 1 kΩ	If < 1 kΩ, check MPR control circuit for short to GND.
X4-1 to 87	< 5 Ω	If > 5 Ω, check EIM PWR circuit for OPEN.
X4-1 to GND	> 1 kΩ	If < 1 kΩ, check EIM PWR circuit for short to GND.
X4-2 to 87	< 5 Ω	If > 5 Ω, check EIM PWR circuit for OPEN.
X4-2 to GND	> 1 kΩ	If < 1 kΩ, check EIM PWR circuit for short to GND.
X3-6 to GND	< 5 Ω	If > 5 Ω, check EIM GND circuit for OPEN.
X3-7 to GND	< 5 Ω	If > 5 Ω, check EIM GND circuit for OPEN.

ACM Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and relay breakout harness. Leave ACM, EIM/ACM Main Power relay disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
B-8 to 87	< 5 Ω	If > 5 Ω, check ACT PWR circuit for OPEN.
B-8 to GND	> 1 kΩ	If < 1 kΩ, check ACT PWR circuit for short to GND.
B-22 to 87	< 5 Ω	If > 5 Ω, check ACT PWR circuit for OPEN.
B-22 to GND	> 1 kΩ	If < 1 kΩ, check ACT PWR circuit for short to GND.
A-23 to 87	< 5 Ω	If > 5 Ω, check ACT PWR circuit for OPEN.
A-23 to GND	> 1 kΩ	If < 1 kΩ, check ACT PWR circuit for short to GND.
A-16 to GND	< 5 Ω	If > 5 Ω, check ACM GND circuit for OPEN.
B-17 to GND	< 5 Ω	If > 5 Ω, check ACM GND circuit for OPEN.

Harness Resistance Checks on Relay Power Circuits

Turn ignition switch to OFF. Disconnect both battery GND cables. Use DMM to measure resistance.

WARNING: To prevent personal injury or death, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Test Point	Spec	Comment
Relay (30) to battery positive post	< 5 Ω	If > 5 Ω, check for OPEN circuit or blown fuse.
Relay (30) to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
Relay (86) to battery positive post	< 5 Ω	If > 5 Ω, check for OPEN circuit or blown fuse.
Relay (86) to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

EIM/ACM Power Circuit Operation

The EIM receives VIGN power at Pin X3-3. This signals the EIM to provide a ground path MPR from Pin X3-5 to 85 to switch the EIM/ACM Main Power relay. Switching the relay provides power from the battery positive terminal through one fuse and relay contacts 30 and 87 to EIM Pins X4-1, X4-2 and ACM Pins B-8, B-22 and A-23.

The EIM is grounded through Pins X3-6 and X3-7. The ACM is grounded through Pins B-17 and A-16.

Fault Detection Management

The Engine Interface Module (EIM) internally monitors battery voltage. When the EIM continuously receives less than 7 V or more than 17.5 V, a Diagnostic Trouble Code (DTC) is set.

ELS (Exhaust Lambda Sensor)

DTC	SPN	FMI	Condition
1618	1119	0	Lambda Sensor correction value above normal
1619	1119	1	Lambda Sensor not plausible
1620	1119	2	Lambda Sensor circuit intermittent contact
1621	1119	5	Lambda Sensor monitoring below lower limit
1622	1119	7	Lambda Sensor circuit fault
1623	1119	11	Lambda heater circuit fault
1624	7319	16	Lambda Temp calculation above normal
1625	7319	17	Lambda Temp calculation below normal
1626	7319	18	Lambda Temp calibration calculation value above normal
1627	7319	19	Lambda Temp calibration calculation value below normal
1628	1119	22	Lambda Sensor Temp above maximum
1629	1119	12	Lambda Sensor not detected in exhaust system
1630	1119	15	Lambda Sensor SPI communication error status

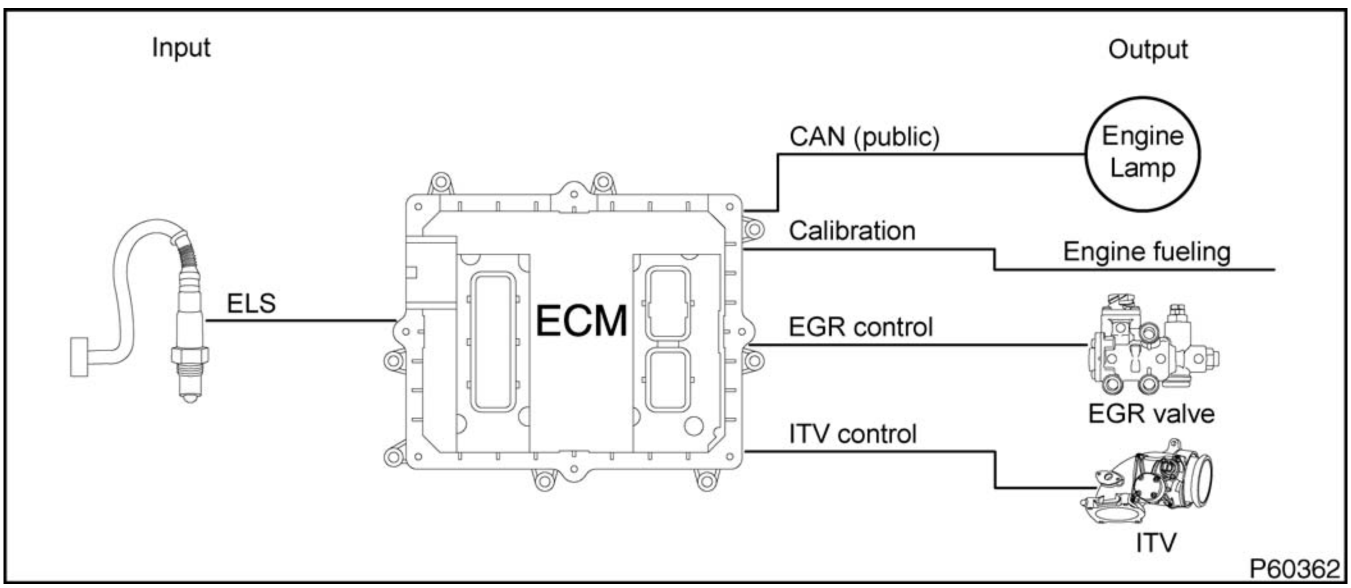

Figure 247 Functional diagram for ELS

The functional diagram for the ELS includes the following:

- ELS
- Engine lamp (amber)
- Engine fueling calibration
- Exhaust Gas Recirculation (EGR) control valve
- Intake Throttle Valve (ITV)

Function

The Exhaust Lambda Sensor (ELS) is an emission control feedback sensor. The ELS is used to monitor the amount of oxygen entering the exhaust system. The Engine Control Module (ECM) uses this information to control engine fueling and Exhaust Gas Recirculation (EGR) operation.

Component Location

The ELS is located on the right side of the engine and is installed on the turbo exhaust pipe before the Aftertreatment Fuel Injector (AFI).

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- ELS and V8 EGR Breakout Harness (page 444)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- Terminal Test Adapter Kit (page 446)

ELS Connector End Diagnostics

DTC	Condition	Possible Causes
1618	Lambda Sensor correction value above normal	• Correction value above 200 mV for more then 2 seconds • Intermittent circuit fault • Failed ELS sensor

1619	Lambda Sensor not plausible	• Lambda sensor signal changed more than 5 V within 2 seconds • Intermittent open or short circuit
1620	Lambda Sensor circuit intermittent contact	• Lambda sensor intermittent circuit fault
1621	Lambda sensor monitoring below lower limit	• Lambda sensor circuit fault • Failed sensor
1622	Lambda Sensor circuit fault	• Lambda sensor below 0.2 V
1623	Lambda heater circuit fault	• Lambda heater circuit fault • Failed sensor
1624	Lambda Temp calculation above normal	• Lambda temp above 800 °C (1472 °F) for 60 seconds • Plugged exhaust • Over-fueling • Biased sensor
1625	Lambda Temp calculation below normal	• Lambda temperature below 650°C (1202°F) for 60 seconds when it should be fully warmed up. • Failed Lambda heater or circuit fault
1626	Lambda Temp calibration calculation value above normal	• Biased ELS sensor or circuit • Failed ELS sensor
1627	Lambda Temp calibration calculation value below normal	• Biased ELS sensor or circuit • Failed ELS sensor
1628	Lambda Sensor Temp above maximum	• Lambda temp above 800 °C (1472 °F) for 60 seconds • Plugged exhaust • Over-fueling • Biased sensor
1629	Lambda sensor not detected in exhaust system	• Lambda sensor internal resistance has changed more than 1500 Ω • Circuit faults • Failed sensor
1630	Lambda Sensor SPI communication error status	• Biased ELS sensor or circuit • Failed ELS sensor

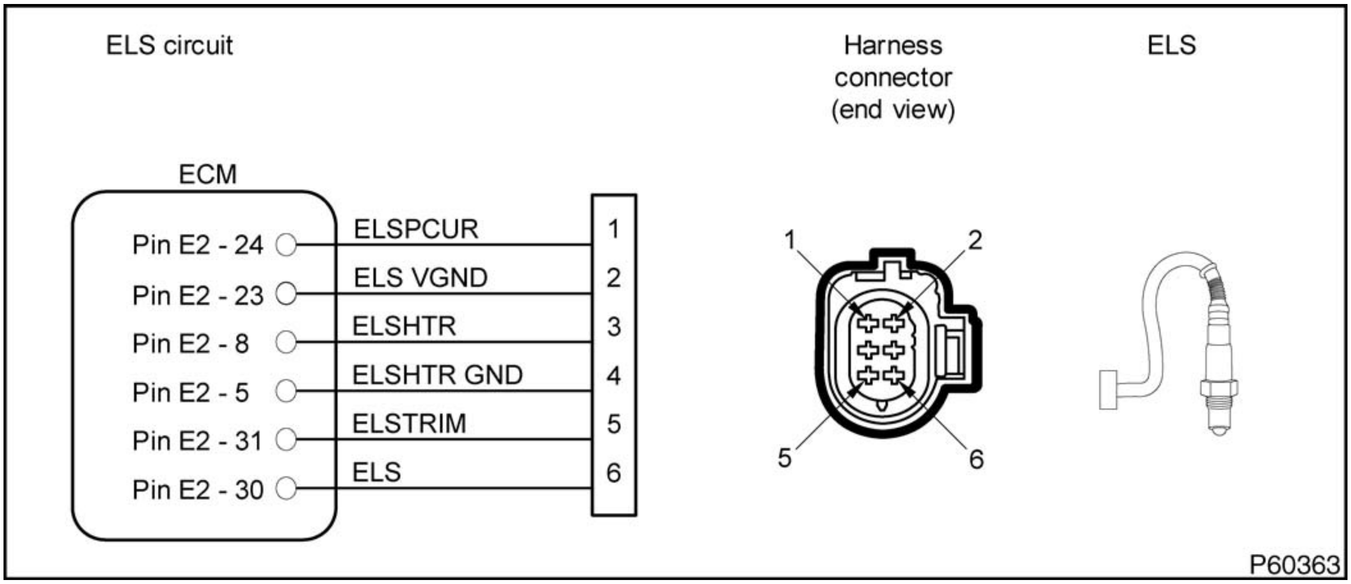

Figure 248 ELS circuit diagram

Connector Voltage Check

Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	2.82 V +/- 1 V	If < specification, check for OPEN or short to GND. If > specification, check for short to PWR.
2 to GND	2.48 V +/- 1 V	If < specification, check for OPEN or short to GND. If > specification, check for short to PWR.
3 to GND	6.7 V +/- 1 V	If < specification, check for OPEN or short to GND. If > specification, check for short to PWR.
4 to GND	0 V	If > 0 V, check for short to PWR.
5 to GND	2.82 V +/- 1 V	If < specification, check for OPEN or short to GND. If > specification, check for short to PWR.
6 to GND	2.91 V +/- 1 V	If < specification, check for OPEN or short to GND. If > specification, check for short to PWR.
If measurements are within specification, do Harness Resistance Check (page 360).		

Harness Resistance Check

Turn ignition switch to OFF. Connect the ECM breakout box. Leave ECM and ELS disconnected.

Test Point	Spec	Comment
1 to E2-24	< 5 Ω	If > 5 Ω, check ELSPCUR for OPEN in circuit.
1 to GND	> 1 kΩ	If < 1 kΩ, check ELSPCUR for short to GND.
2 to E2-23	< 5 Ω	If > 5 Ω, check ELSVGND for OPEN in circuit.
2 to GND	> 1 kΩ	If < 1 kΩ, check ELSVGND for short to GND.
3 to E2-8	< 5 Ω	If > 5 Ω, check ELSHTR for OPEN in circuit.
3 to GND	> 1 kΩ	If < 1 kΩ, check ELSHTR for short to GND.

Harness Resistance Check (cont.)

4 to E2-5	< 5 Ω	If > 5 Ω, check ELSHTR GND for OPEN in circuit.
4 to GND	> 1 kΩ	If < 1 kΩ, check ELSHTR GND for short to GND.
5 to E2-31	< 5 Ω	If > 5 Ω, check ELSTRIM for OPEN in circuit.
5 to GND	> 1 kΩ	If < 1 kΩ, check ELSTRIM for short to GND.
6 to E2-30	< 5 Ω	If > 5 Ω, check ELS for OPEN in circuit.
6 to GND	> 1 kΩ	If < 1 kΩ, check ELS for short to GND.
If measurements are in specification, replace the ELS.		

ELS Operation

The ELS monitors exhaust emissions and operates in an open loop/closed loop system. The system remains in open loop until the following conditions are met:

- No active Engine Coolant Temperature (ECT) or ELS fault codes.
- Engine Speed above 500 rpm.
- Battery voltage above 10.8 V.
- Engine Coolant Temperature above 40 °C (104 °F).
- Exhaust Gas Temperature above 100 °C (212 °F) for 10 seconds.

Once the above conditions are met, the ECM enables the ELS internal heater and raises sensor temperature above 750 °C (1,382 °F) and goes into closed loop operation.

Actuator Test

The actuator test will not cycle the Fuel Pressure Control Valve (FPCV) or Exhaust Lambda Sensor (ELS) heater.

EOP Sensor (Engine Oil Pressure)

DTC	SPN	FMI	Condition
1211	100	4	EOP signal out-of-range LOW
1212	100	3	EOP signal out-of-range HIGH
2310	100	10	EOP abnormal rate of change
2311	100	0	EOP above maximum

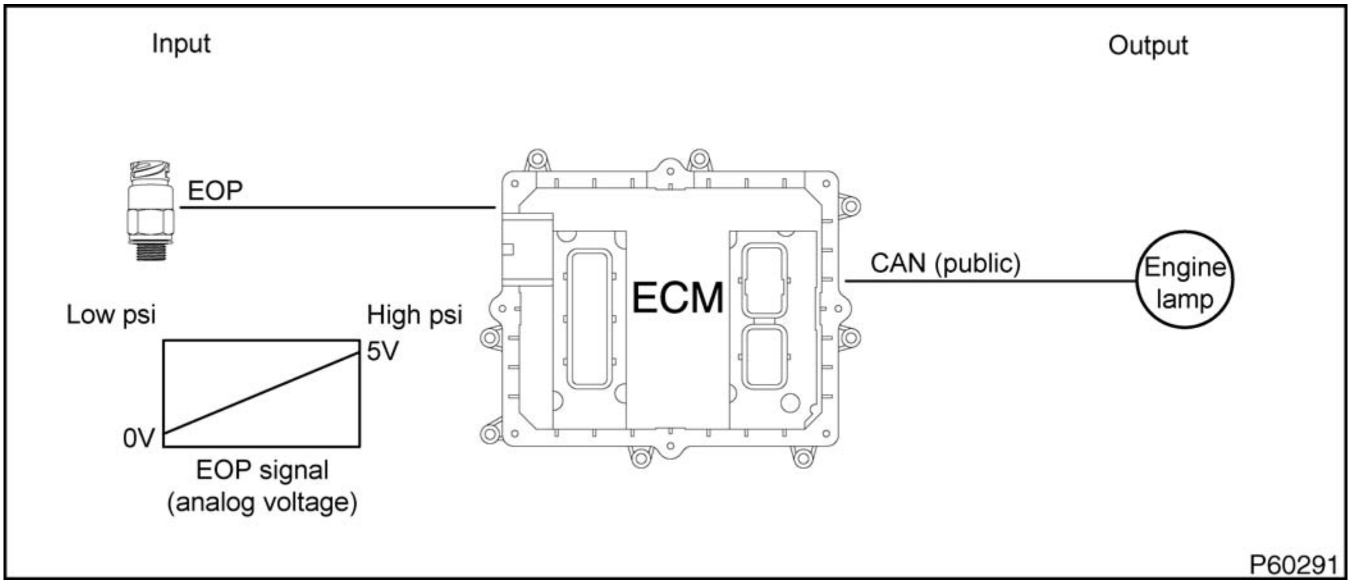

Figure 249 Functional diagram for the EOP sensor

The functional diagram for the EOP sensor includes the following:

- EOP sensor
- Engine Control Module (ECM)
- Engine lamp (red)

Function

The EOP sensor provides a feedback signal to the ECM indicating engine oil pressure. During engine operation, the ECM monitors the EOP signal to determine if the oil pressure is satisfactory. If oil pressure is below desired pressure, the ECM illuminates the red engine lamp.

An optional feature, the Engine Warning Protection System (EWPS), can be enabled to warn the engine operator through the red engine lamp and buzzer, and shut the engine down when a low engine oil pressure condition occurs.

Sensor Location

The EOP sensor is installed in the side of the oil module, on the right side of the engine.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 3-Banana Plug Harness (page 437)
- 500 Ohm Resistor Harness (page 439)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- 4-Pin Round Green Breakout Harness (page 438)

- Terminal Test Adapter Kit (page 446)

EOP Sensor End Diagnostics

DTC	Condition	Possible Causes
1211	EOP signal out-of-range LOW	• EOP signal circuit OPEN or short to GND • EOP VREF circuit short to GND or OPEN • Failed sensor
1212	EOP signal out-of-range HIGH	• EOP signal circuit short to PWR • EOP GND circuit OPEN • Failed sensor
2310	EOP abnormal rate of change	• Intermittent circuit fault • EOP sensor wired incorrectly • Failed sensor
2311	EOP above maximum	• Oil pressure above 48 kPa (7 psi) with engine not running • Biased EOP circuit • Biased sensor

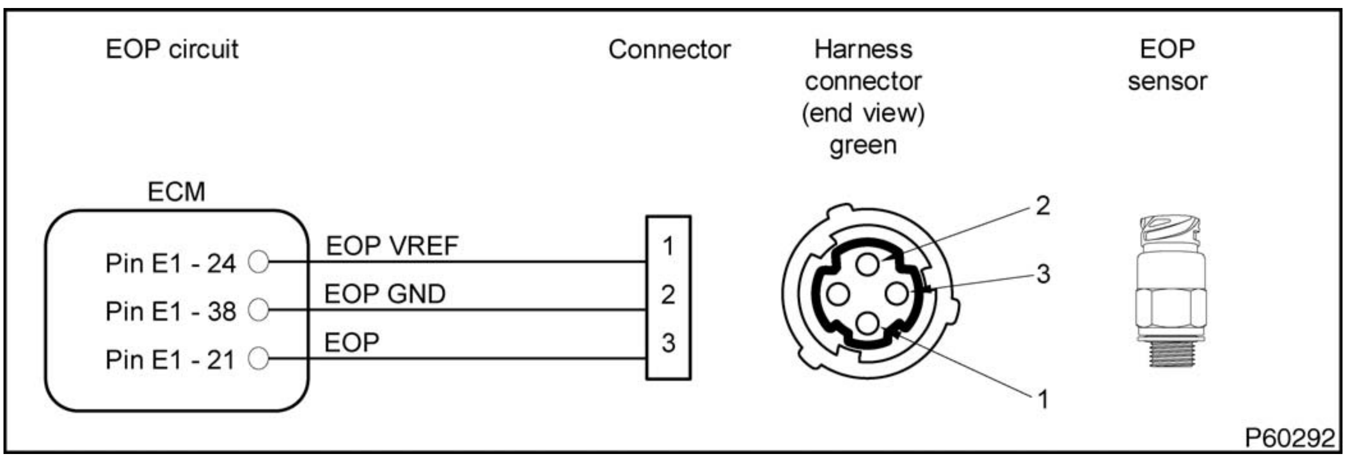

Figure 250 EOP sensor circuit diagram

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from EOP sensor adapter line. Inspect connectors for damaged pins, corrosion, or loose pins using the Pin Grip Inspection (page 197). Repair if necessary.
4. Connect breakout harness to engine harness. Leave EOP sensor adapter line disconnected.

Sensor Circuit Check

Connect breakout harness. Leave EOP sensor adapter line disconnected. Turn the ignition switch to ON. Use EST to monitor PID and DMM to measure voltage.

Test Point	Spec	Comment
EST – Monitor EOPv	0 V	If > 0.25 V, check EOP signal circuit for to PWR
DMM – Measure volts 1 to GND	5.0 V +/- 0.5 V	If > 5.5 V, check EOP VREF for short to PWR. If < 4.5 V, check EOP VREF for OPEN or short to GND. Do Harness Resistance Check (page 366).
EST – Monitor EOPv Short across breakout harness pins 1 and 3	5 V	If < 4.5 V, check EOP signal for OPEN. Do Harness Resistance Check (page 366).
DMM – Measure voltage 1 to 2	5 V +/- 0.5 V	If < 4.5 V, check EOP GND for OPEN. Do Harness Resistance Check (page 366).

If checks are within specification, connect sensor and clear DTCs. If active code remains, verify EOP sensor adapter line integrity. If OK, replace EOP sensor.

EOP Sensor Pin-Point Diagnostics

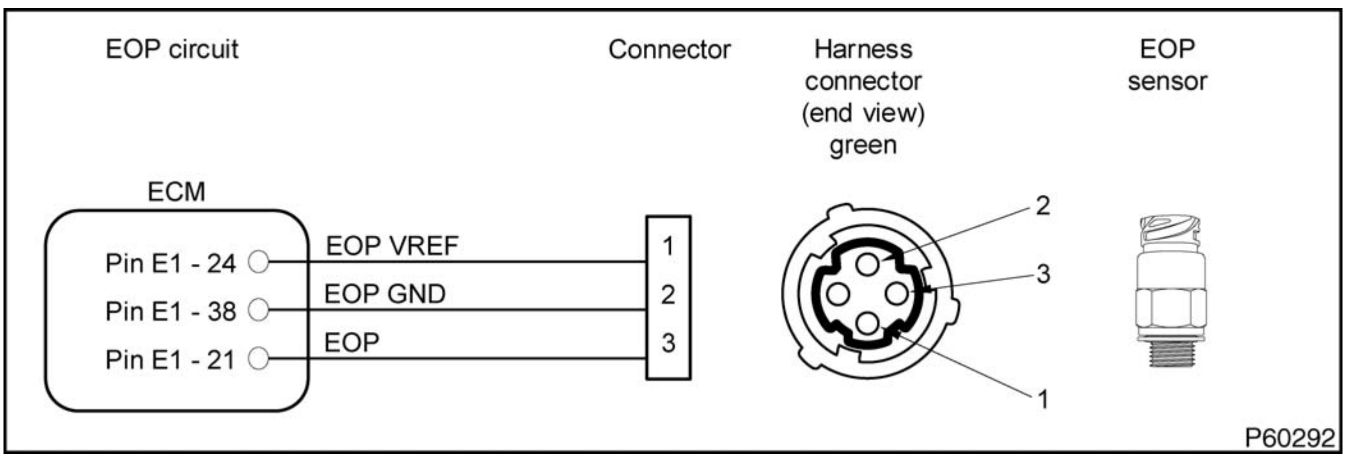

Figure 251 EOP sensor circuit diagram

Connector Voltage Check

Connect breakout harness. Leave EOP sensor adapter line disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	5 V	If > 5.5 V, check EOP VREF for short to PWR. If < 4.5 V, check EOP VREF for OPEN or short to GND. Do Harness Resistance Check (page 366).
2 to GND	0 V	If > 0.25 V, check EOP GND circuit for short to PWR.
3 to GND	0 V	If > 0.25 V, check EOP signal circuit for short to PWR.

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave EOP sensor adapter line disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
2 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Do Harness Resistance Check (page 366).
3 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave ECM and EOP sensor adapter line disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E1-24	< 5 Ω	If > 5 Ω, check EOP VREF circuit for OPEN.
2 to E1-38	< 5 Ω	If > 5 Ω, check EOP GND circuit for OPEN.
3 to E1-21	< 5 Ω	If > 5 Ω, check EOP signal circuit for OPEN.

EOP Sensor Circuit Operation

The EOP sensor is a variable capacitance sensor that is supplied with a 5 V reference voltage at Pin 1 from ECM Pin E1-24. The sensor is grounded at Pin 2 from ECM Pin E1-38 and returns a variable voltage signal proportional to the measured pressure from Pin 3 to ECM Pin E1-21.

EOT Sensor (Engine Oil Temperature)

DTC	SPN	FMI	Condition
1311	175	4	EOT signal out-of-range LOW
1312	175	3	EOT signal out-of-range HIGH

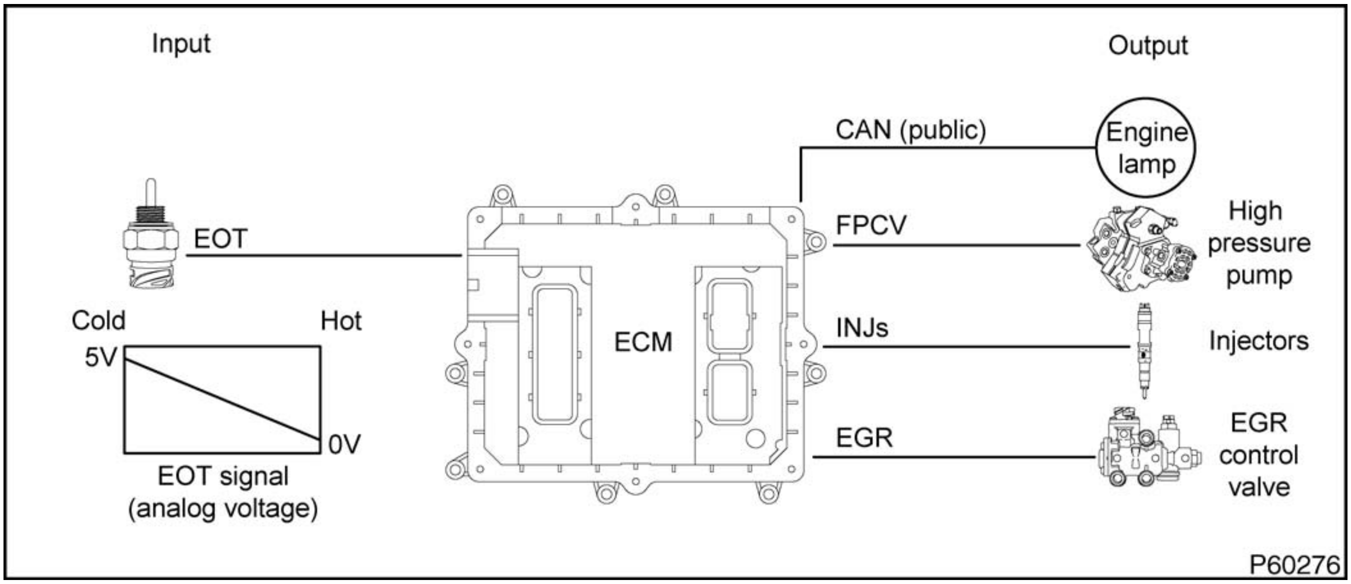

Figure 252 Functional diagram for the EOT sensor

The functional diagram for the EOT sensor includes the following:

- Engine Control Module (ECM)
- EOT sensor
- Engine lamp (amber)
- Exhaust Gas Recirculation (EGR) control valve
- Fuel Injector (INJ)
- High pressure fuel pump

Function

The EOT sensor provides a feedback signal to the ECM indicating engine oil temperature. The ECM monitors the EOT signal to control fuel quantity and timing throughout the operating range of the engine. The EOT signal allows the ECM to compensate for oil viscosity variations due to temperature changes in the operating environment, ensuring that adequate power and torque are available for all operating conditions.

Fast Idle Advance

Fast idle advance increases engine cold idle speed up to 750 rpm (normally 600 rpm) for faster warm-up to operating temperature. This is accomplished by the ECM monitoring the EOT sensor input and adjusting the fuel injector operation accordingly.

Low idle speed is increased proportionally when the engine oil temperature is between 15 °C (59 °F) at 600 rpm to below -10 °C (14 °F) at 750 rpm.

Sensor Location

The EOT sensor is installed in the side of the oil module, on the right side of the engine.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)

- 3-Banana Plug Harness (page 437)
- 500 Ohm Resistor Harness (page 439)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- 4-Pin Round Black Breakout Harness (page 437)
- Terminal Test Adapter Kit (page 446)

EOT Sensor Connector End Diagnostics

DTC	Condition	Possible Causes
1311	EOT signal out-of-range LOW	• EOT signal circuit short to GND • Failed sensor
1312	EOT signal out-of-range HIGH	• EOT signal OPEN or short to PWR • EOT GND circuit OPEN • Failed sensor

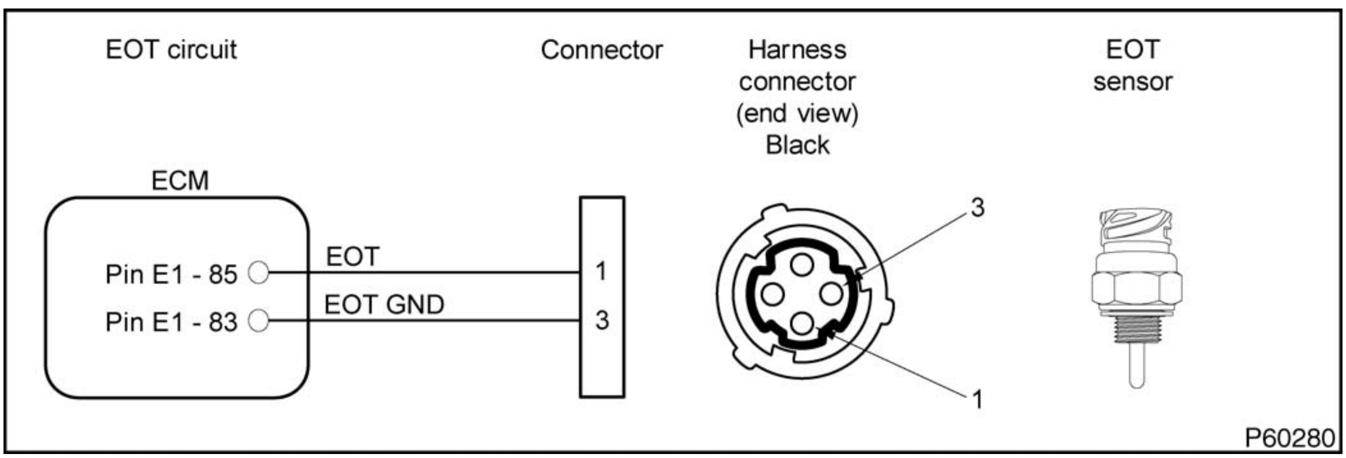

Figure 253 EOT sensor circuit diagram

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from EOT sensor adapter line. Inspect connectors for damaged pins, corrosion, or loose pins using Pin Grip Inspection (page 197). Repair if necessary.
4. Connect breakout harness to engine harness. Leave EOT sensor adapter line disconnected.

Sensor Circuit Check

Connect breakout harness. Leave EOT sensor adapter line disconnected. Turn the ignition switch to ON. Use EST to monitor PID and DMM to measure voltage.

Test Point	Spec	Comment
EST-Monitor EOTv	5 V	If < 4.5 V, check EOT signal circuit for short to GND. Do Connector Resistance Checks to GND (page 370).
EST-Monitor EOTv Short breakout harness across pin 1 and GND	0 V	If > 0.25 V, check EOT signal circuit for OPEN. Do Harness Resistance Check (page 370).
EST-Monitor EOTv Short breakout harness across pins 1 and 3	0 V	If > 0.25 V, check EOT GND circuit for OPEN. Do Harness Resistance Check (page 370).
EST-Monitor EOTv Short 500 Ω resistor across pins 1 and 3	< 1.0 V	If > 1.0 V, check EOT signal circuit for short to PWR.

If checks are within specification, connect EOT sensor adapter line and clear DTCs. If active code remains, verify EOT sensor adapter line integrity. If OK, replace EOT sensor.

EOT Sensor Pin-Point Diagnostics

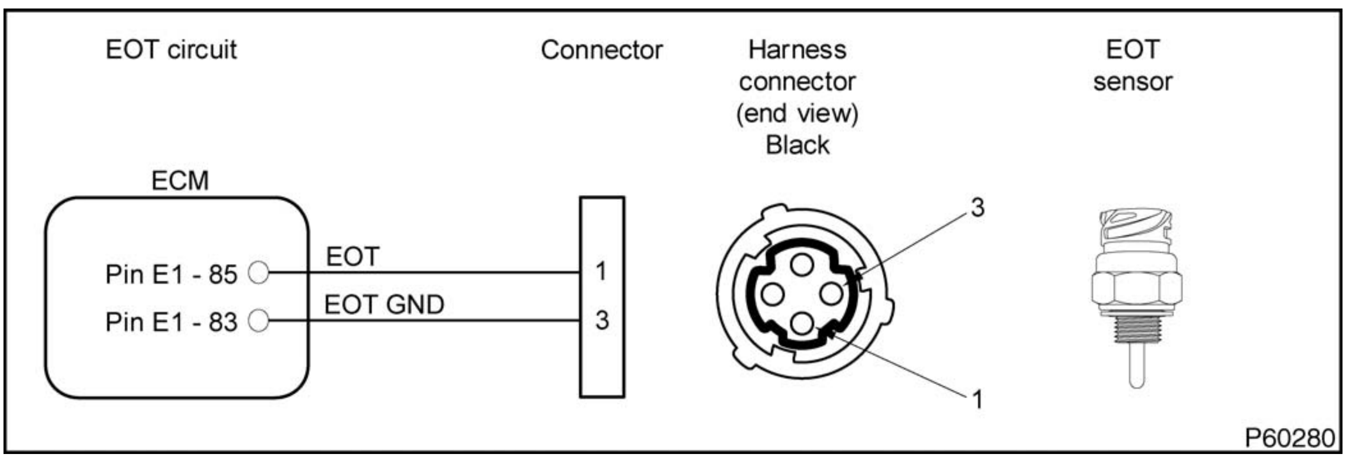

Figure 254 EOT sensor circuit diagram

Connector Voltage Check

Connect breakout harness. Leave EOT sensor adapter line disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	4.5 V to 5 V	If < 4.5 V, check for short to GND. Do Connector Resistance Checks to GND (page 370).
3 to GND	0 V	If > 0.25 V, check for short to PWR.

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness. Leave EOT sensor adapter line disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND. Do Harness Resistance Check (page 370).
3 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Do Harness Resistance Check (page 370).

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave ECM and EOT sensor adapter line disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E1-85	< 5 Ω	If > 5 Ω, check EOT signal for OPEN.
3 to E1-83	< 5 Ω	If > 5 Ω, check EOT GND signal for OPEN.

EOT Sensor Circuit Operation

The EOT sensor is a thermistor sensor that is supplied with a 5 V reference voltage at Pin 1 from ECM Pin E1–85. The sensor is grounded at Pin 3 from ECM Pin E1–83. As the temperature increases, the resistance of the thermistor decreases, causing the signal voltage to decrease.

Fault Detection / Management

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM disregards the sensor signal and use a calibrated default value. The ECM sets a DTC, illuminates the amber engine lamp, and runs the engine in a default range of -20 °C (-4 °F) for starting and 100 °C (212 °F) for engine running conditions.

EWPS (Engine Warning Protection System)

DTC	SPN	FMI	Condition
1119	110	12	ECT Temp above maximum
2212	175	0	EOT Temp above maximum
2312	190	11	EOP below minimum
2313	100	1	EOP below warning level
2314	100	7	EOP below critical level
2315	190	0	Engine speed above warning level
2316	190	16	Engine speed above maximum at ECM
2321	110	0	ECT above warning level
2322	110	7	ECT above critical level
2323	111	1	ECL below warning/critical level
2325	110	14	ECT value reached de-rate temperature
6321	7311	0	ECT2 above warning level
6322	7311	7	ECT2 above critical level
6823	7311	14	ECT2 Temp above maximum

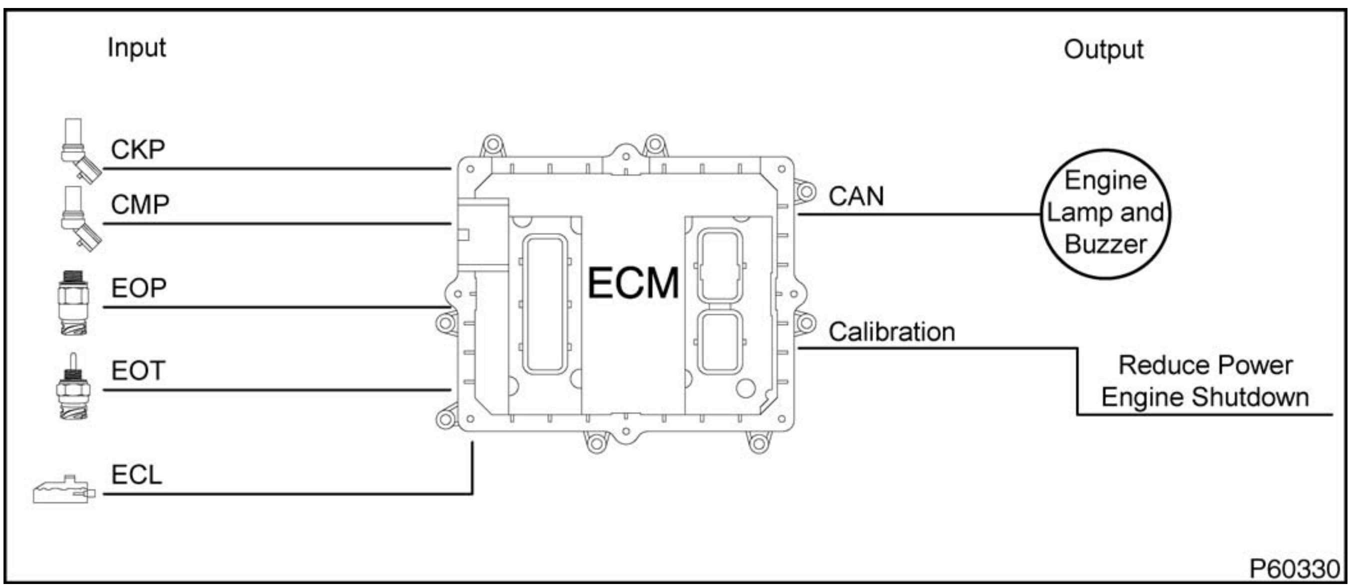

Figure 255 Functional diagram for the EWPS

The functional diagram for the EWPS includes the following:

- Camshaft Position (CMP) sensor
- Crankshaft Position (CKP) sensor
- Engine Control Module (ECM)
- Engine Coolant Level (ECL) sensor
- Engine Coolant Temperature (ECT) sensor
- Engine Oil Pressure (EOP) switch

- Engine lamp (red) and buzzer
- Calibration/Reduce power, Engine shutdown

Function

The EWPS warns the operator of conditions that can damage the engine.

The Standard Warning System is the base system in which all engines are equipped. If one of these faults are detected, the ECM illuminates the red engine lamp and sets a corresponding Diagnostic Trouble Code (DTC).

Standard Warning – No engine shut down available.

- RPM - Engine overspeed warning
- ECT - Engine overheat warning

The following optional features to this base system provide added warning or protection.

2-way Warning – No engine shutdown available.

- ECT - Engine overheat warning
- EOP - Low engine oil pressure warning

3-way Warning – No engine shutdown available.

- ECT - Engine overheat warning
- EOP - Low engine oil pressure warning
- ECL - Low engine coolant level warning

3-way Protection – Engine shutdown is available if critical condition is detected.

- ECT, EOP, ECL - Same as 3-way Warning
- ECT - Engine overheat critical protection
- EOP - Low engine oil pressure critical protection
- ECL - Low engine coolant level critical protection

Warning – Temperature above specific threshold sounds a buzzer, illuminates the red OIL/WATER (OWL) lamp and sets a DTC.

Critical – Temperature above specific threshold shuts down the engine and sets a DTC.

Event log – This feature logs occurrences of the event according to the engine hours and odometer readings.

EWPS Programmable Parameters

ENG-PROT-MODE

- 0 = Standard Warning
- 1 = 3-way Warning
- 2 = 3-way Protection
- 3 = 2-way Warning

ECT-WARNING – Specifies temperature threshold where the OIL/WATER lamp and warning buzzer is turned on.

ECT-CRITICAL – Specifies temperature threshold where an engine shutdown is commanded.

PROT-ENG SPD1 – Specifies at what RPM a specified oil pressure (OIL-PRES-CRIT-SPD1) should be detected.

PROT-ENG SPD2 – Specifies at what RPM a specified oil pressure (OIL-PRES-CRIT-SPD2) should be detected.

PROT-ENG SPD3 – Specifies at what RPM a specified oil pressure (OIL-PRES-CRIT-SPD3) should be detected.

OIL-PRES-WARN-SPD1 – Specifies the minimum oil pressure with engine speed greater than (PROT-ENG-SPD1). Failure to meet set point turns on the OIL/WATER lamp and warning buzzer.

OIL-PRES-WARN-SPD2 – Specifies the minimum oil pressure with engine speed greater than (PROT-ENG-SPD1) but less than (PROT-ENG-SPD2). Failure to meet set point turns on the OIL/WATER lamp and warning buzzer.

OIL-PRES-WARN-SPD3 – Specifies the minimum oil pressure with engine speed greater than (PROT-ENG-SPD2) but less than (PROT-ENG-SPD3). Failure to meet set point turns on the OIL/WATER lamp and warning buzzer.

OIL-PRES-CRIT-SPD1 – Specifies the minimum oil pressure with engine speed greater than (PROT-ENG-SPD1). Failure to meet set point commands an engine shut down.

OIL-PRES-CRIT-SPD2 – Specifies the minimum oil pressure with engine speed greater than (PROT-ENG-SPD1) but less than (PROT-ENG-SPD2). Failure to meet set point commands an engine shutdown.

OIL-PRES-CRIT-SPD3 – Specifies the minimum oil pressure with engine speed greater than (PROT-ENG-SPD2) but less than (PROT-ENG-SPD3). Failure to meet set point commands an engine shutdown.

DTC 1119
ECT Temp above maximum

- DTC 1119 is set by the ECM when the engine coolant temperature is above 120 °C (128 °F). The ECM illuminates the red lamp. When the temperature drops below 120 °C (128 °F) the DTC becomes inactive. For diagnostics, see Coolant Over-Temperature (page 101) in the “Engine Symptoms Diagnostics” section in this manual.

DTC 2212
EOT Temp above maximum

- DTC 2212 is set by the ECM when the engine oil temperature is above 122 °C (252 °F). The ECM illuminates the red lamp. When the temperature drops below 122 °C (252 °F) the DTC becomes inactive. For diagnostics, see EOT Sensor (page 367) in this section.
- DTC 2212 can be set by a biased EOT sensor or circuit.

DTC 2312
EOP below minimum

- DTC 2312 is set by the ECM when engine oil pressure is lower than expected while the engine is idling. The specifications for the warning are:
- For diagnostics, see Low Oil Pressure (page 108) in the “Engine Symptoms Diagnostics” section in this manual.
- DTC 2312 can be set by a biased EOP sensor or circuit or by low engine oil pressure.
- When DTC 2312 is active, the red lamp is illuminated.

DTC 2313
EOP below warning level

- DTC 2313 is set by the ECM when engine oil pressure is lower than expected while the engine is running.
- Dealer programmable option. Dealer sets threshold pressure.
- For diagnostics, see Low Oil Pressure (page 108) in the “Engine Symptoms Diagnostics” section in this manual.
- DTC 2313 can be set by an open, circuit short to voltage source in the EOP circuit, a loose or failed EOP sensor, or low oil pressure.
- When DTC 2313 is active, the red lamp is illuminated.

DTC 2314
EOP below critical level

- DTC 2314 is set by the ECM when the engine oil pressure drops below the critical level while the engine is running.
- Dealer programmable option. Dealer sets threshold pressure.
- For diagnostics, see Low Oil Pressure in the “Engine Symptoms Diagnostics” section in this manual.
- DTC 2314 can be set by an open, circuit short to voltage source in the EOP circuit, a loose or failed EOP sensor, or low oil pressure.
- When DTC 2314 is active, the red lamp flashes and sounds an audible signal.

DTC 2315
Engine speed above warning level

- DTC 2315 is set by the ECM when the engine rpm exceeds 2450 rpm.
- DTC 2315 can be set by any of the following conditions:
  - Excessive engine speed in an unintended downshift
  - Steep acceleration downhill without correct brake application
  - External fuel source being ingested into air intake system
- When DTC 2315 is active, the amber lamp is illuminated. The engine hours and miles of the last two over speed occurrences are recorded in the engine event log.

DTC 2316
Engine speed above maximum at ECM

- DTC 2316 is set by the ECM when the engine rpm exceeds 2500 rpm.
- DTC 2316 can be set by any of the following conditions:
  - Excessive engine speed in an unintended downshift
  - Steep acceleration downhill without correct brake application
  - External fuel source being ingested into air intake system
- When DTC 2316 is active, the amber lamp is illuminated. The engine hours and miles of the last two over speed occurrences are recorded in the engine event log.

DTC 2321
ECT above warning level

- Dealer programmable option
- DTC 2321 is set by the ECM when the engine coolant temperature is above dealer set point. For diagnostics, see Coolant Over-Temperature (page 101) in the “Engine Symptoms Diagnostics” section in this manual.

DTC 2322
ECT above critical level

- Dealer programmable option
- DTC 2322 is set by the ECM when the engine coolant temperature is above dealer set point. For diagnostics, see Coolant Over-Temperature (page 101) in the “Engine Symptoms Diagnostics” section in this manual.

DTC 2323
ECL below warning/critical level

- Dealer programmable option
- DTC 2323 is set by the ECM when coolant is low. When the EWPS mode is 3-way protection and DTC 2323 is active, the engine shuts down. The ECM logs the engine hours and odometer reading at the time of occurrence. After the shutdown, the engine can be restarted for thirty seconds. When the coolant has returned to correct levels, DTC 2323 becomes inactive.
- If the coolant level is correct, do ECL Connector Voltage Check (page 303) in this section.

DTC 2325
ECT value reached de-rate temperature

- Dealer programmable option
- DTC 2325 is set by the ECM when the engine coolant temperature is above a dealer programmed set point. The ECM illuminates the red lamp and the engine enters in de-rate mode. For diagnostics, see Coolant Over-Temperature (page 101) in the “Engine Symptoms Diagnostics” section in this manual.

DTC 6321
ECT2 above warning level

- Dealer programmable option
- DTC 6321 is set by the ECM when the engine coolant temperature at the ECT2 is above a dealer programmed set point. The ECM illuminates the red lamp. For diagnostics, see Coolant Over-Temperature (page 101) in the “Engine Symptoms Diagnostics” section in this manual.

DTC 6322
ECT2 above critical level

- Dealer programmable option
- DTC 6322 is set by the ECM when the engine coolant temperature at the ECT2 is above a dealer programmed set point. The ECM illuminates the red lamp. For diagnostics, see Coolant Over-Temperature (page 101) in the “Engine Symptoms Diagnostics” section in this manual.

DTC 6823
ECT2 Temp above Maximum

- DTC 6823 is set by the ECM when the engine coolant temperature is above 119 °C (246 °F), or above 135 °C (275 °F) for 10 seconds during engine retarder operation. For diagnostics, see Coolant Over-Temperature (page 101) in the “Engine Symptoms Diagnostics” section of this manual.

FPCV (Fuel Pressure Control Valve)

DTC	SPN	FMI	Condition
1616	1442	5	Fuel Pressure Control Valve open circuit
1617	1442	11	Fuel Pressure Control Valve short circuit

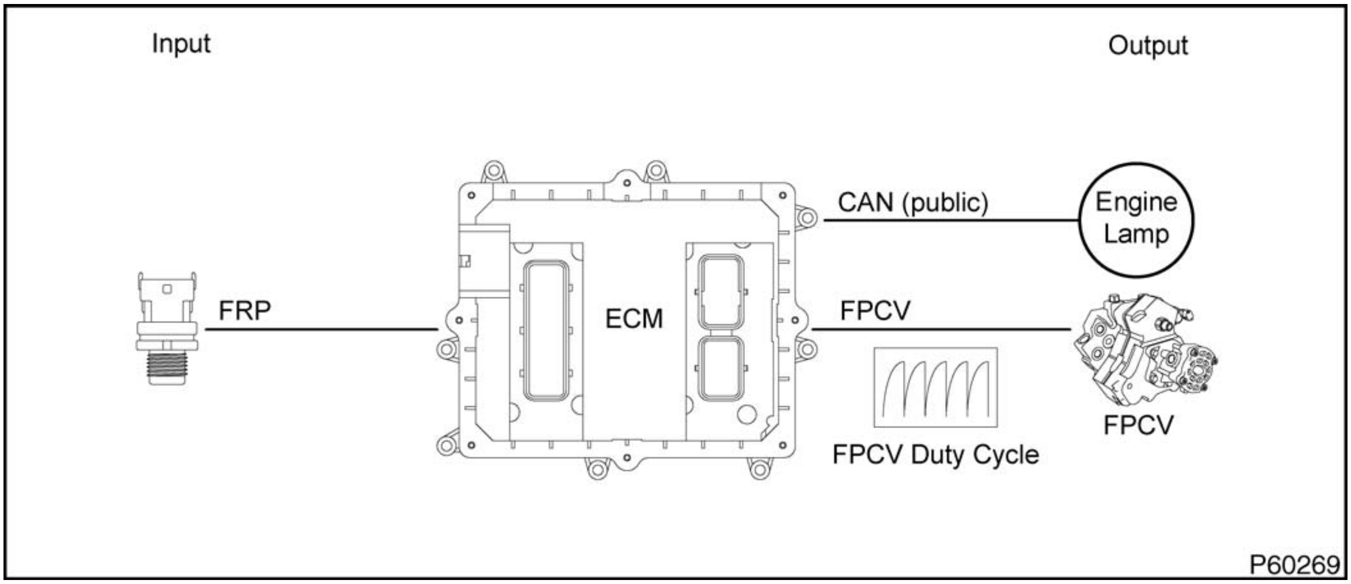

Figure 256 Functional diagram for FPCV

The functional diagram for the FPCV includes the following:

- Engine lamp (amber)
- Engine Control Module (ECM)
- FPCV
- Fuel Rail Pressure (FRP) sensor

Function

The FPCV is a variable position valve that regulates fuel pressure in the pressure pipe rail.

The FPCV changes valve position through Pulse Width Modulated (PWM) signals from the ECM. It controls the flow of fuel to the suction side of the high pressure pump.

Component Location

The FPCV is mounted on the upper side of the high pressure pump on the left side of the engine. They are serviced as an assembly.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- CMP, CKP and FPCV Breakout Harness (page 442)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- Terminal Test Adapter Kit (page 446)

FPCV Connector End Diagnostics

DTC	Condition	Possible Causes
1616	Fuel Pressure Control Valve open circuit	• FPCV circuit OPEN • Failed FPCV
1617	Fuel Pressure Control Valve short circuit	• FPCV circuits shorted • Failed FPCV

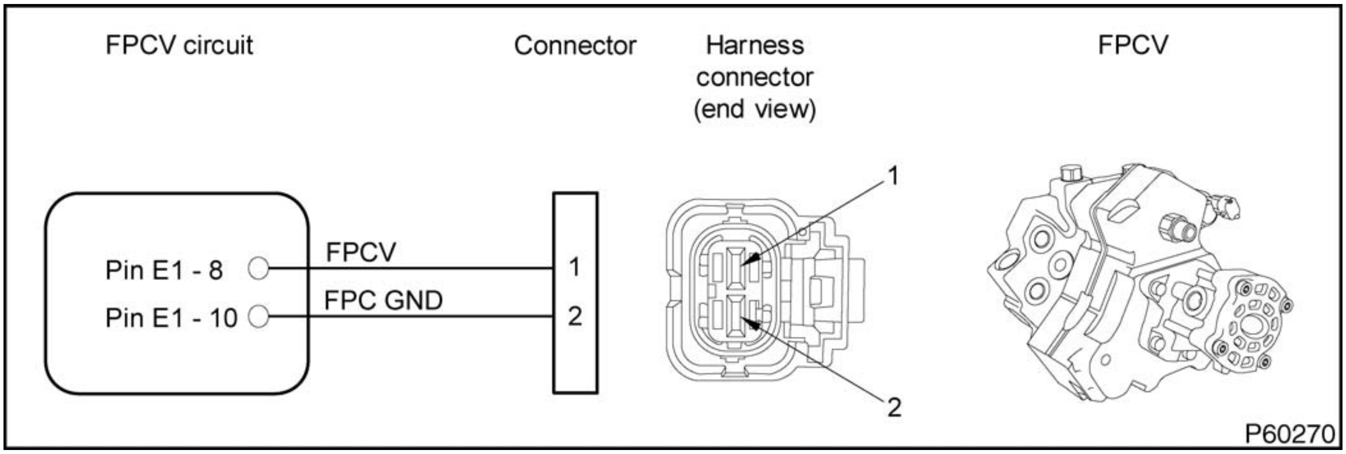

Figure 257 FPCV circuit diagram

1. Key ON, engine OFF.
2. Connect the EST with MasterDiagnostics® software.
3. Verify correct engine is selected and launch EST.
4. Open D_Actuator.ssn session.

CAUTION: Do not try to start the engine with the FPCV disconnected. This may cause damage to the fuel pressure relief valve.

NOTE: When the ignition is switched ON, the ECM commands the FPCV on at 50% duty cycle for 60 seconds.

Connector Voltage Check

Connect breakout harness to engine harness, leave FPCV disconnected. Turn ignition switch ON and wait 60 seconds before reading voltage. Use DMM to measure voltage. The batteries must be fully charged before performing this test.

Test Point	Spec	Comment
2 to battery positive	B+	If < B+, check for FPC GND circuit for OPEN.
1 to 2	5 V to 11 V	If < 5 V, check FPCV control circuit for OPEN or short to GND.
If measurements are within specifications, do Operational Voltage Check (page 379).		

Operational Voltage Check

Connect breakout harness between FPCV and engine harness. Turn the ignition switch ON. Use DMM to measure voltage. Batteries must be fully charged before performing this test.

Test Point	Spec	Comment
DMM - Measure Volts across pins 1 and GND		
Key ON within 60 seconds	4 V +/- 2 V	If > 6 V, check FPCV GND circuit for OPEN, or failed open FPCV. If < 2 V, check FPCV control circuit for OPEN or short to GND.
Key ON after 60 seconds	< 0.2 V	If > 1 V, check for short to PWR.
DMM - Measure Duty Cycle across 1 and 2	40% - 60%	If not within specification, replace the ECM.
If measurements are within specifications, do Actuator Resistance Check (page 379).		

Actuator Resistance Check

Turn ignition switch OFF. Connect breakout harness to FPCV and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to 2	2 Ω to 6 Ω	If not within specification, replace the high pressure pump following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
If measurements are within specifications, do Harness Resistance Check (page 380).		

Harness Resistance Check

Turn ignition switch OFF. Connect ECM breakout box and breakout harness to engine harness and leave FPCV and ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
1 to E1-8	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1 kΩ	If < 1 kΩ, check for OPEN circuit.
2 to E1-10	< 5 Ω	If > 5 Ω, check for OPEN circuit.
If voltage and resistance checks are within specifications, the FPCV is working correctly. See High Pressure Fuel System (page 140) in the “Hard Start and No Start Diagnostics” section of this manual.		

FPCV Operation

The FPCV regulates fuel pressure to the fuel injectors. The ECM uses the FRP sensor to monitor system pressure and adjust the duty cycle of the valve to match engine requirements (starting, engine load, speed and temperature).

When the ignition switch is turned on, the ECM commands a 50% duty cycle to the FPCV for 60 seconds, then turns it off if the engine is not started.

NOTE: The Actuator Test does not cycle this valve.

FRP Sensor (Fuel Rail Pressure)

DTC	SPN	FMI	Condition
1124	164	4	FRP signal out-of-range LOW
1125	164	3	FRP signal out-of-range HIGH
6233	3511	3	FRP VREF out-of-range HIGH
6234	3511	4	FRP VREF out-of-range LOW

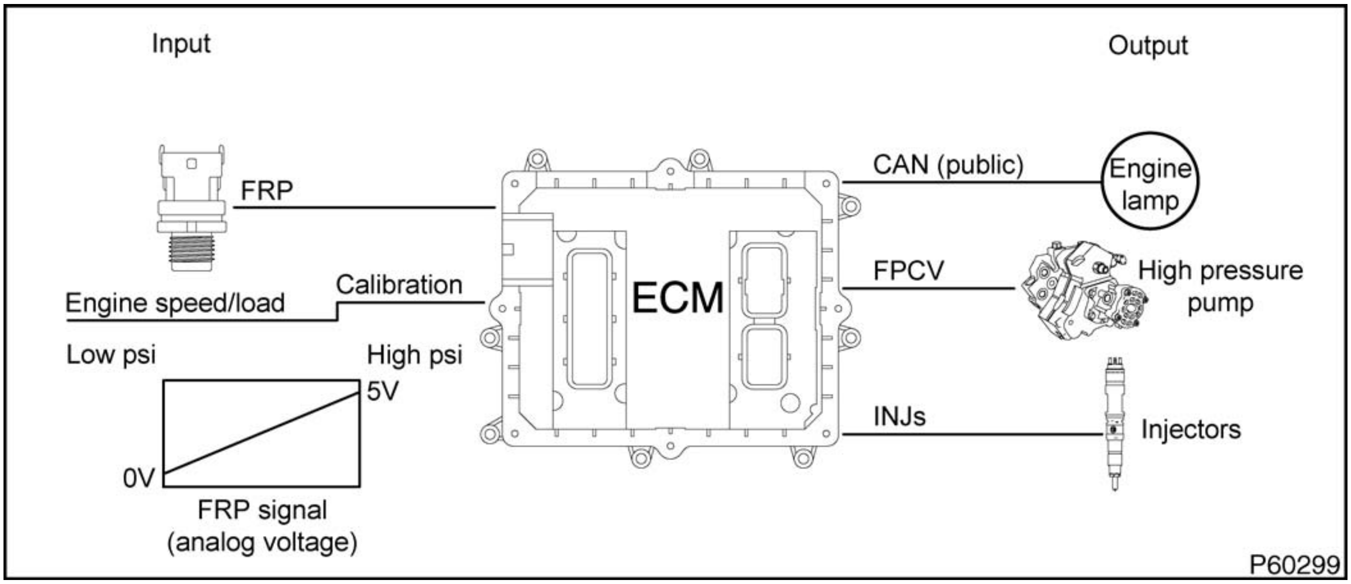

Figure 258 Functional diagram for the FRP sensor

The functional diagram for the FRP sensor includes the following:

- Engine Control Module (ECM)
- Engine lamp (amber)
- Engine speed/load calibration
- FRP sensor
- High pressure pump
- Injectors

Function

The FRP sensor is a variable capacitance sensor that monitors the fuel pressure in the pressure pipe rail. The ECM controls the Fuel Pressure Control Valve (FPCV) while monitoring the FRP sensor to provide the engine with the desired starting and operating pressures.

Sensor Location

The FRP sensor is mounted in the front of the high pressure pipe rail on the left side of the engine.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 3-Banana Plug Harness (page 437)
- 500 Ohm Resistor Harness (page 439)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- FRP Breakout Harness (page 445)

- Terminal Test Adapter Kit (page 446)

FRP Sensor End Diagnostics

DTC	Condition	Possible Causes
1124	FRP signal out-of-range LOW	• FRP signal circuit short to GND • FRP VREF circuit short to GND or OPEN • Failed sensor
1125	FRP signal out-of-range HIGH	• FRP signal circuit OPEN or short to PWR • FRP GND circuit OPEN • Failed sensor
6233	FRP VREF out-of-range HIGH	• FRP VREF circuit short to PWR
6234	FRP VREF out-of-range LOW	• FRP VREF circuit short to GND

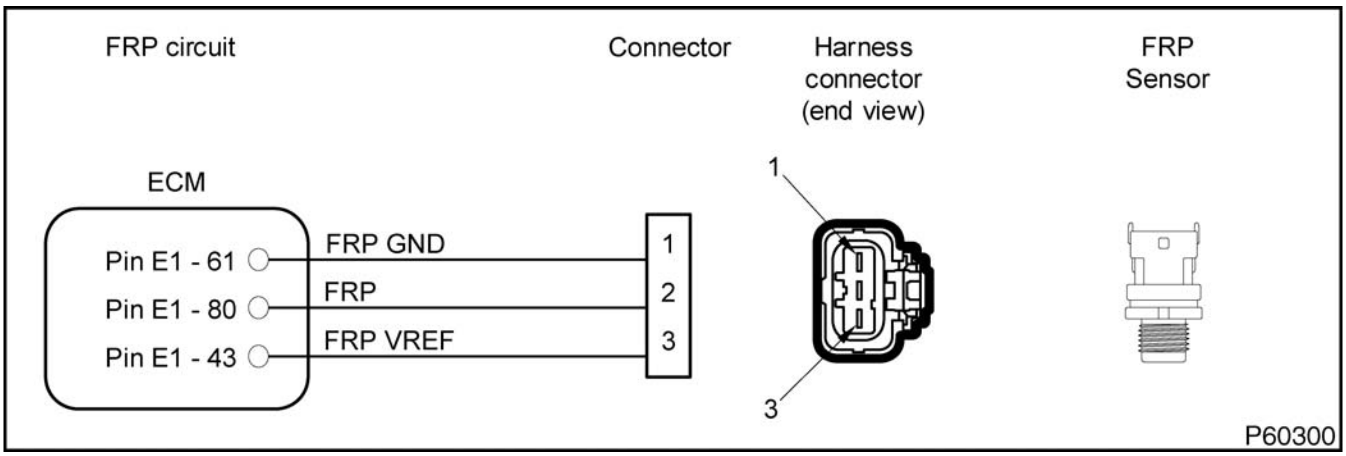

Figure 259 FRP sensor circuit diagram

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor. Inspect connectors for damaged pins, corrosion, or loose pins using Pin Grip Inspection (page 197). Repair if necessary.
4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect breakout harness. Leave sensor disconnected. Turn the ignition switch to ON. Use EST to monitor PID and DMM to measure voltage.

Test Point	Spec	Comment
EST – Monitor FRPv	5 V	If < 4.5 V, check FRP signal circuit for to GND. Do Connector Resistance Check to GND (page 384).
DMM – Measure volts 3 to GND	5.0 V +/- 0.5 V	If > 5.5 V, check FRP VREF for short to PWR. If < 4.5 V, check FRP VREF for OPEN or short to GND. Do Harness Resistance Check (page 384).
DMM – Measure voltage 1 to 3	5.0 V +/- 0.5 V	If < 4.5 V, check FRP GND for OPEN. Do Harness Resistance Check (page 384).
EST – Monitor FRPv Short across breakout harness pins 1 and 2	0 V	If > 0.25 V, check FRP signal for OPEN or short to PWR. Do Harness Resistance Check (page 384).
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace FRP sensor.		

FRP Sensor Pin-Point Diagnostics

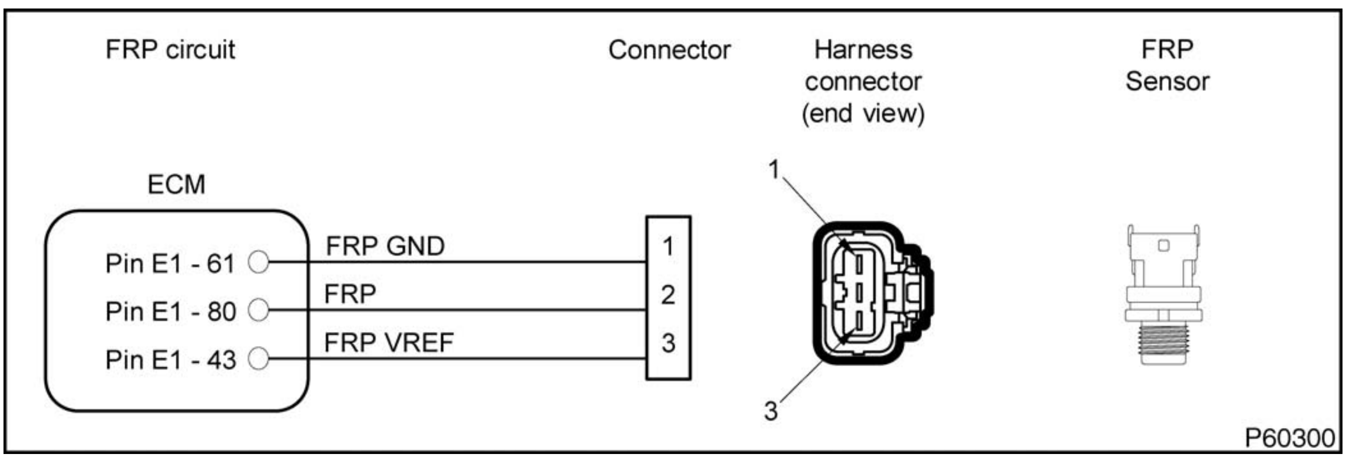

Figure 260 FRP sensor circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
3 to GND	5 V	If > 5.5 V, check FRP VREF for short to PWR. If < 4.5 V, check FRP VREF for OPEN or short to GND. Do Harness Resistance Check (page 384).
1 to GND	0 V	If > 0.25 V, check FRP GND circuit for short to PWR.
2 to GND	5 V	If < 4.5 V, check FRP signal circuit for short to GND. Do Connector Resistance Check to GND (page 384).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
3 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Do Harness Resistance Check (page 384).
2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E1-61	< 5 Ω	If > 5 Ω, check FRP GND circuit for OPEN.
2 to E1-80	< 5 Ω	If > 5 Ω, check FRP signal circuit for OPEN.
3 to E1-43	< 5 Ω	If > 5 Ω, check FRP VREF circuit for OPEN.

FRP Circuit Operation

The FRP sensor is a variable capacitance sensor that is supplied with a 5 V reference voltage at Pin 3 from ECM Pin E1-43. The sensor is grounded at Pin 1 from ECM Pin E1-61 and returns a variable voltage signal proportional to the measured pressure from Pin 2 to ECM Pin E1-80.

FRP System (Fuel Rail Pressure)

DTC	SPN	FMI	Condition
2235	8354	1	FRP unable to build during engine cranking
2243	8351	7	FRP above pressure relieve valve limitation
2244	8351	0	Fuel Rail Pressure Relief Valve opened (pressure was too high)
2245	8352	1	Fuel Pressure Controller output high at low idle
2246	8352	0	FRP above or below desired
2247	8353	7	HP fuel pump erratic fuel quantity balancing
2248	8354	0	Fuel Rail pressure above maximum
3333	164	0	Fuel Rail Pressure above maximum

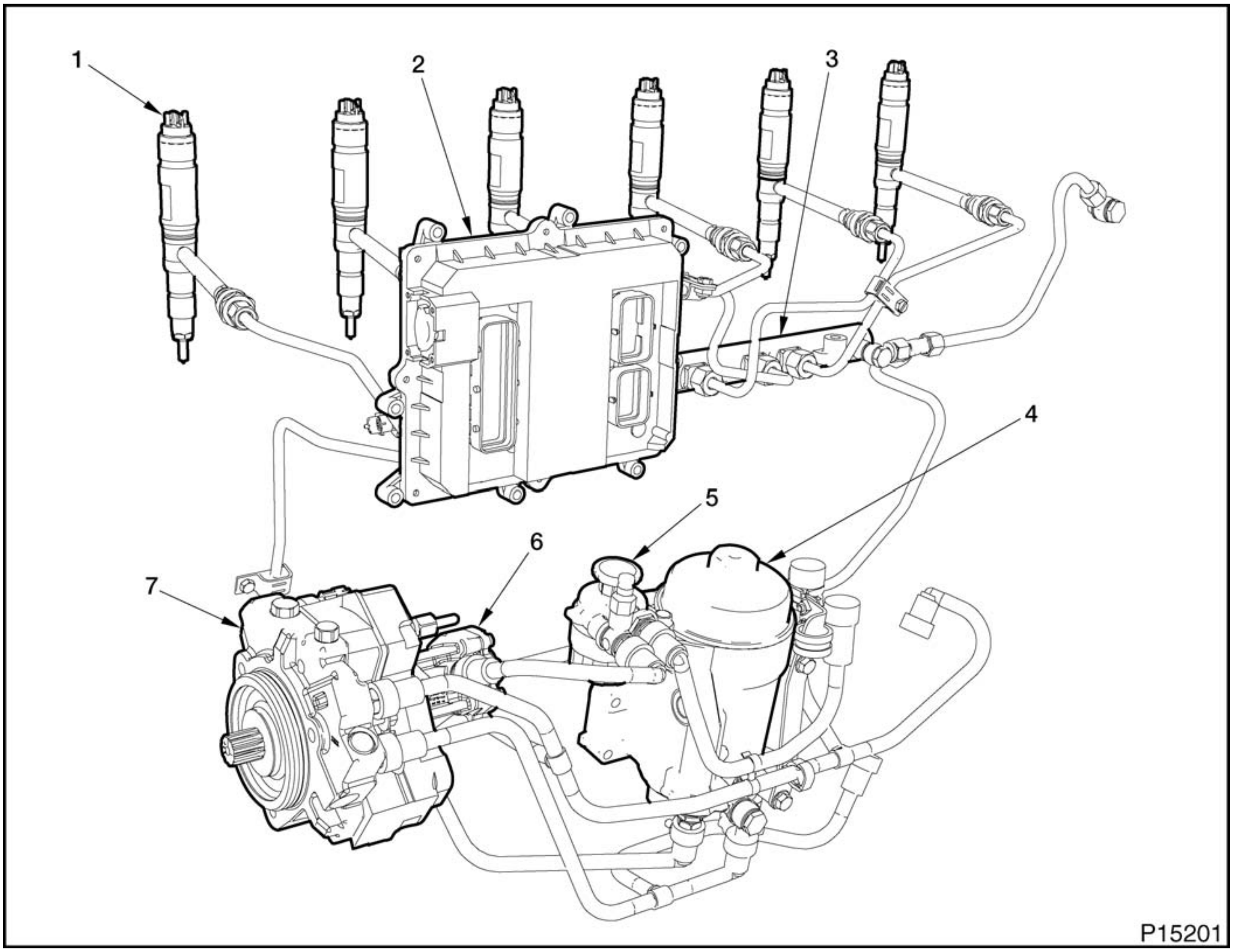

Figure 261 FRP system

1. Injector (6)
2. Engine Control Module (ECM)
3. Pressure pipe rail
4. Fuel filter housing assembly
5. Fuel primer pump assembly
6. Low pressure fuel pump
7. High pressure pump

Function

The ECM controls the Fuel Pressure Control Valve (FPCV) while monitoring the FRP sensor to provide the engine with the desired starting and operating pressures.

The FPCV changes valve position through Pulse Width Modulated (PWM) signals from the ECM. It controls the flow of fuel to the suction side of the high pressure pump.

The injector injects fuel into the cylinders. The ECM controls the timing and the amount of fuel being sprayed from each injector. The ECM also controls the Fuel Rail Pressure (FRP) system to regulate the amount of pressure of fuel being sprayed.

System Component Location

The FRP sensor is mounted in the front of the high pressure pipe rail on the left side of the engine. The FPCV is mounted on the upper side of the high pressure pump on the left side of the engine. The FPCV is not serviced separately but as an assembly with the high pressure pump. The injectors are installed in the cylinder head under the valve cover.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)

FRP System Diagnostics

DTC	Condition	Possible Causes
2235	FRP unable to build during engine cranking	• Failed FPCV • Fuel system restriction • Low fuel supply pressure • Failed high pressure pump
2243	FRP above pressure relieve valve limitation	• Pressure relief valve failed to open • Biased FRP sensor or circuit • Failed pressure relief valve
2244	Fuel Rail Pressure Relief Valve opened (pressure was too high)	• FRP circuit OPEN or short to PWR • FPCV circuit OPEN • Fuel rail pressure too high
2245	Fuel Pressure Controller output high at low idle	• High pressure fuel system leak • Low fuel supply pressure • Failed high pressure pump • Biased FRP sensor or circuit • Stuck or sticking FPCV or circuit fault
2246	FRP above or below desired	• High pressure fuel system leak • Biased FRP sensor or circuit • Stuck or sticking FPCV or circuit fault
2247	HP fuel pump erratic fuel quantity balancing	• Fuel system leak • Low fuel supply pressure • Fuel supply restriction • Fuel system aeration • Biased FRP sensor or circuit • Stuck or sticking FPCV or circuit fault
2248	Fuel Rail pressure above maximum	• FPCV circuit OPEN • FPCV stuck closed • Biased FRP sensor or circuit
3333	Fuel Rail Pressure above maximum	• Biased FPCV or circuit • FPCV circuit OPEN • FPCV stuck closed • Biased FRP sensor or circuit

DTC 2235 - FRP unable to build during engine cranking

DTC 2235 is set when the fuel rail pressure is below 10 MPa (1450 psi) during engine crank

Pin-point FRP System Fault

1. Check for active FPCV faults or DTCs. See FPCV (Fuel Pressure Control Valve) (page 377) in this section.
2. Check for low fuel supply pressure, restriction, or aeration. See Low Pressure Fuel System (page 156) in the “Performance Diagnostics” section of this manual.
3. Check for a damaged high pressure pump. See High Pressure Fuel System (page 140) in the “Hard Start and No Start Diagnostics” section of this manual.

DTC 2243 - FRP above pressure relief valve limitation

DTC 2243 is set when the fuel pressure is above maximum and the fuel rail pressure relief valve did not open.

Pin-point FRP System Fault

1. Check for a damaged fuel rail pressure relief valve. See High Pressure Fuel System (page 140) in the “Hard Start and No Start Diagnostics” section of this manual.
2. Check for active FPCV faults or DTCs. See FPCV (Fuel Pressure Control Valve) (page 377) in this section.

DTC 2244 - Fuel Rail Pressure Relief Valve opened (pressure was too high)

DTC 2244 is set when the ECM detects 5 Volts from the FRP sensor, or if the FPCV circuit is open.

Pin-point FRP System Fault

1. Check for active FRP sensor faults or DTCs. See FRP Sensor (Fuel Rail Pressure) (page 381) in this section of the manual.
2. Check for active FPCV faults or DTCs. See FPCV (Fuel Pressure Control Valve) (page 377) in this section of the manual.

DTC 2245 - Fuel Pressure Controller output high at low idle

DTC 2245 is set when the engine is at low idle and the FPCV needs more than 10% duty cycle to meet fuel demand.

Pin-point FRP System Fault

1. Check for low fuel supply level or problems with the low pressure fuel system. See Low Pressure Fuel System (page 137) in the “Hard Start and No Start Diagnostics” section of this manual.
2. Check for high pressure fuel system leaks. See High Pressure Fuel System (page 140) in the “Hard Start and No Start Diagnostics” section of this manual.
3. Run High Pressure Pump Run-Up Test (page 180) in the “Performance Diagnostics” section of this manual.
4. Check for active FPCV faults or DTCs. See FPCV (Fuel Pressure Control Valve) (page 377) in this section.

DTC 2246 - FRP above or below desired

DTC 2246 is set when the fuel pressure cannot meet (too high or too low) the desired fuel pressure set point for 5 seconds.

Pin-point FRP System Fault

1. Test the low pressure fuel system. Check for low fuel pressure and aeration. See Fuel Pressure and Aeration (page 114) in the “Engine Symptoms Diagnostics” section of this manual.
2. Check for intermittent FRP sensor or FPCV circuit faults. Run Continuous Monitor session and wiggle harness connections.

DTC 2247 - HP fuel pump erratic fuel quantity balancing

DTC 2247 is set when the control signal to the fuel pressure controller is monitored and saved. If, on the very next zero fueling condition, the same controller output results in a fuel pressure difference of more than 5 MPa (725 psi), this DTC sets.

Pin-point FRP System Fault

1. Test the low pressure fuel system. Check for low fuel pressure and aeration. See Fuel Pressure and Aeration (page 114) in the “Engine Symptoms Diagnostics” section of this manual.
2. Check for intermittent FRP sensor or FPCV circuit faults. Run Continuous Monitor session and wiggle harness connections.

DTC 2248 - Fuel Rail pressure above maximum

DTC 2248 is set when the fuel pressure rises higher than 195 MPa (28,282 psi) for 5 seconds.

Pin-point FRP System Fault

1. Check for active FRP sensor faults or DTCs. See FRP Sensor (Fuel Rail Pressure) (page 381) in this section.
2. Check for active FPCV faults or DTCs. See FPCV (Fuel Pressure Control Valve) (page 377) in this section.

DTC 3333 - Fuel Rail Pressure above maximum

DTC 3333 is set when the fuel rail pressure is too high.

Pin-point FRP System Fault

1. Check for active FRP sensor faults or DTCs. See FRP Sensor (Fuel Rail Pressure) (page 381) in this section.
2. Check for active FPCV faults or DTCs. See FPCV (Fuel Pressure Control Valve) (page 377) in this section.

FRP System Operation

Electrical Operation

The FRP system is a closed loop system. The ECM controls the FPCV duty cycle while monitoring the FRP sensor. This provides the engine with the desired starting and operating pressure. When demand for fuel pressure increases, the ECM increases duty cycle to the FPCV. When demand for fuel pressure decreases, the ECM decreases the duty cycle to the FPCV.

Fault Detection / Management

The Diagnostic Trouble Codes (DTCs) associated with this system may indicate an electrical or mechanical problem with the FRP system.

The ECM continuously monitors the FRP sensor to ensure the system constantly provides correct pressure. When feedback from the FRP sensor does not meet desired pressure, the ECM sets a DTC and illuminates the amber engine lamp.

IAT Sensor (Intake Air Temperature)

DTC	SPN	FMI	Condition
1154	171	4	IAT signal out-of-range LOW
1155	171	3	IAT signal out-of-range HIGH

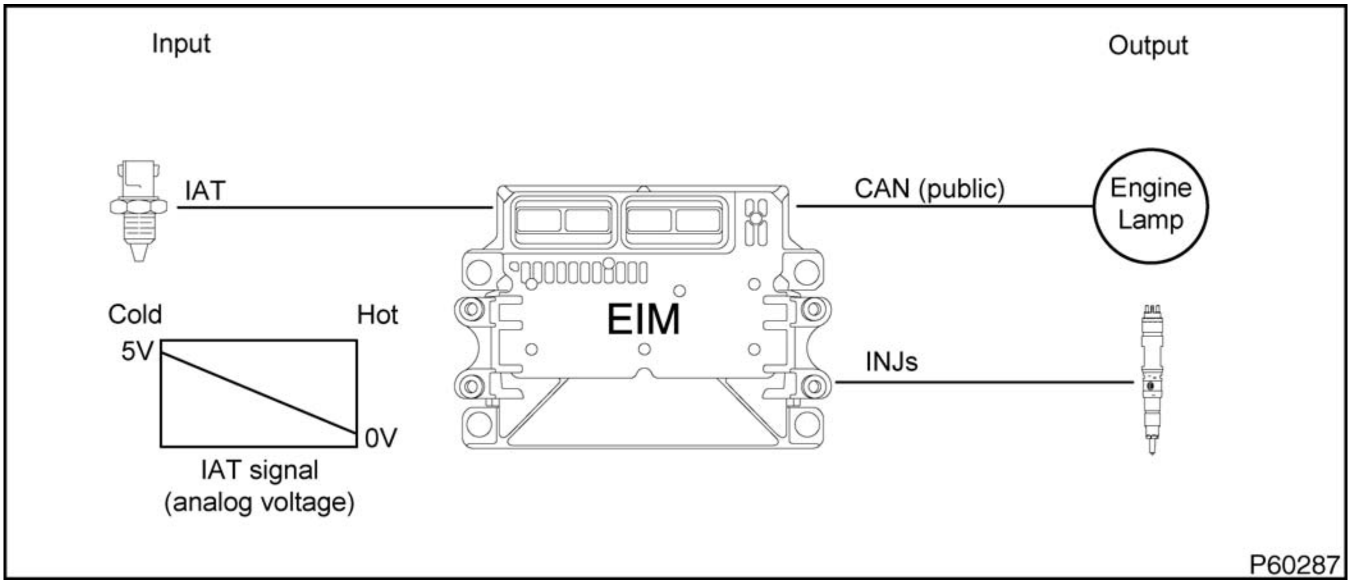

Figure 262 Functional diagram for the IAT sensor

The functional diagram for the IAT sensor includes the following:

- IAT sensor
- Engine Interface Module (EIM)
- Engine lamp (amber)
- Fuel Injector (INJ)

Function

The IAT sensor provides a feedback signal to the EIM indicating intake air temperature. The EIM monitors the IAT signal to control the timing and fuel rate for cold starting. The IAT sensor is monitored while the engine is running to limit smoke and reduce exhaust emissions.

Sensor Location

The IAT sensor is installed in the intake tube next to the air cleaner, on top of the engine.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 3-Banana Plug Harness (page 437)
- 500 Ohm Resistor Harness (page 439)
- 96-Pin Breakout Box – DLC II (page 438)
- Temperature Sensor Breakout Harness (page 446)
- Terminal Test Adapter Kit (page 446)

IAT Sensor Connector End Diagnostics

DTC	Condition	Possible Causes
1154	IAT signal out-of-range LOW	• IAT signal circuit short to GND • Failed sensor
1155	IAT signal out-of-range HIGH	• IAT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor

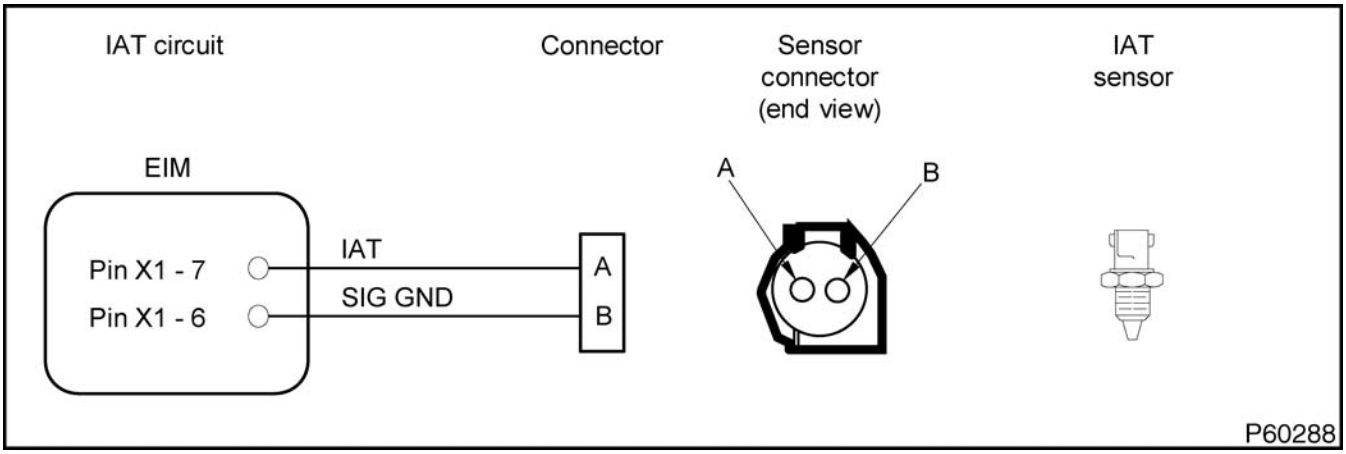

Figure 263 IAT sensor circuit diagram

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor. Inspect connectors for damaged pins, corrosion, or loose pins using Pin Grip Inspection (page 197). Repair if necessary.
4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect breakout harness. Leave sensor disconnected. Turn the ignition switch to ON. Use EST to monitor PIDs and DMM to measure voltage.

Test Point	Spec	Comment
EST-Monitor IATv	5 V	If < 4.5 V, check IAT signal circuit for short to GND. Do Connector Resistance Checks to GND (page 395).
EST-Monitor IATv Short breakout harness across pin A and GND	0 V	If > 0.25 V, check IAT signal circuit for OPEN. Do Harness Resistance Check (page 395).
EST-Monitor IATv Short breakout harness across pins A and B	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 395).
EST-Monitor IATv Short 500 Ω resistor across pins A and B	< 1.0 V	If > 1.0 V, check IAT signal circuit for short to PWR.
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace IAT sensor.		

IAT Sensor Pin-Point Diagnostics

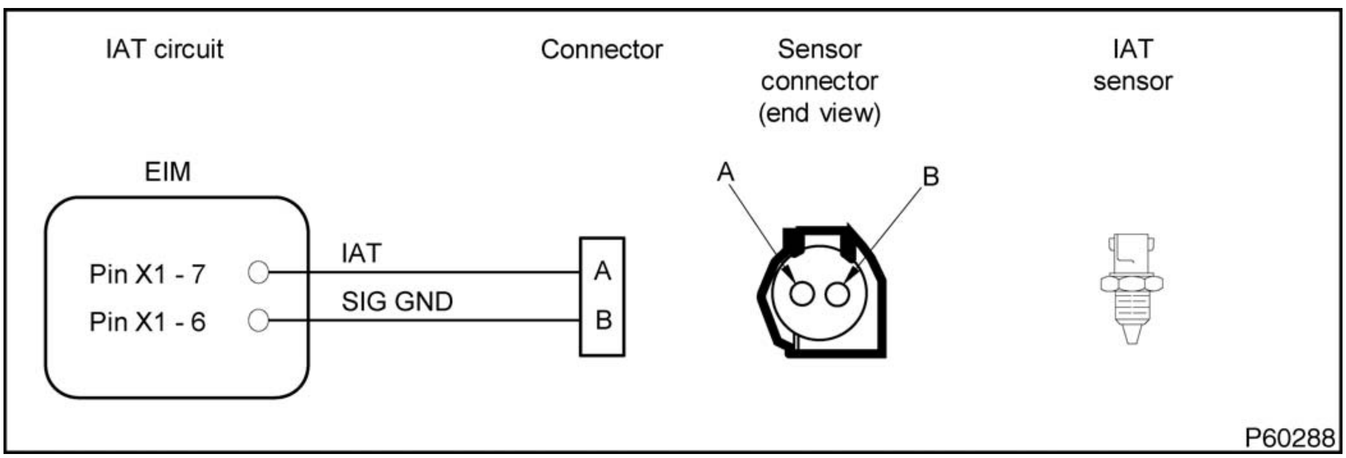

Figure 264 IAT sensor circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
A to GND	4.5 V to 5 V	If < 4.5 V, check for short to GND. Do Connector Resistance Checks to GND (page 395).
B to GND	0 V	If > 0.25 V, check for short to PWR.

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
A to GND	> 1 kΩ	If < 1 kΩ, check for short to GND. Do Harness Resistance Check (page 395).
B to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Do Harness Resistance Check (page 395).

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave EIM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
A to X1-7	< 5 Ω	If > 5 Ω, check IAT signal for OPEN.
B to X1-6	< 5 Ω	If > 5 Ω, check SIG GND signal for OPEN.

IAT Sensor Circuit Operation

The IAT sensor is a thermistor sensor that is supplied with a 5 V reference voltage at Pin A from EIM Pin X1-7. The sensor is grounded at Pin B from EIM Pin X1-6. As the temperature increases, the resistance of the thermistor decreases, causing the signal voltage to decrease.

Injector (INJ) Circuits

DTC	SPN	FMI	Condition
4421-4426	8001-8006	5	(Cyl no.) open coil, open circuit

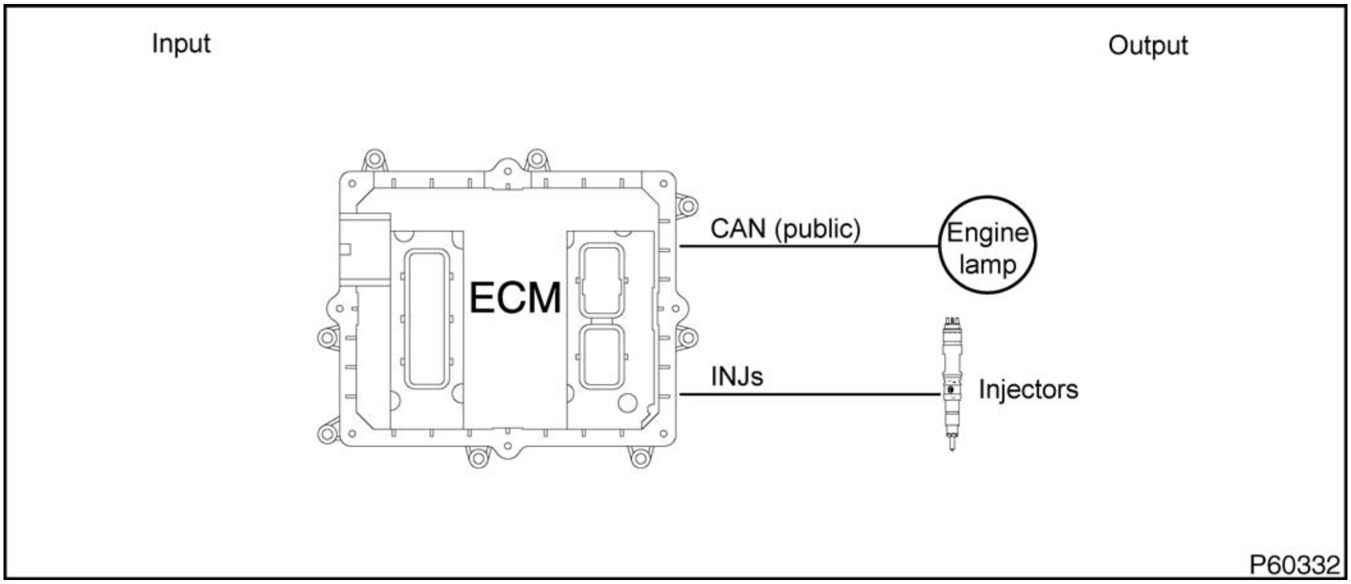

Figure 265 Functional diagram for the INJ circuit

The functional diagram for INJ circuit includes the following:

- Fuel Injectors (INJ)
- Engine Control Module (ECM)
- Engine lamp (amber)

Function

The injector injects fuel into the cylinders. The ECM controls the timing and the amount of fuel being sprayed from each injector. The ECM also controls the Fuel Rail Pressure (FRP) system to regulate the amount of pressure of fuel being sprayed.

The injectors operate with pre-injection and main injection. Pre-injection reduces combustion noise, mechanical load and exhaust emissions.

Component Location

The injectors are installed in the cylinder head under the valve cover.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- Terminal Test Adapter Kit (page 446)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)

Injector 1 Checks

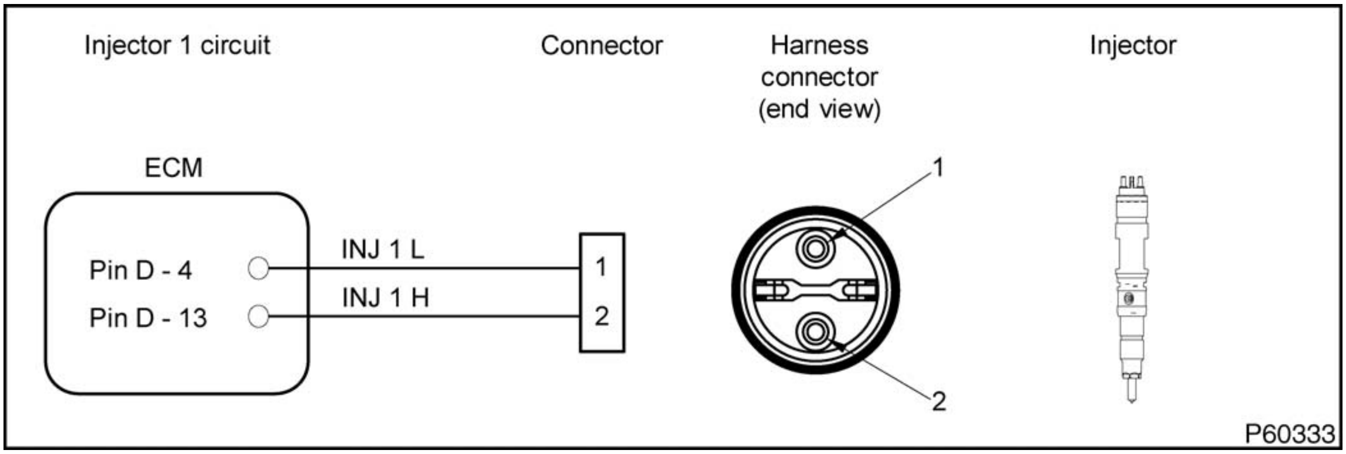

Figure 266 Injector 1 circuit diagram

Injector 1 – Resistance Checks Through Harness and Injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch OFF. Connect 180-Pin Breakout Box to the ECM harness connector. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
D-4 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
D-13 to GND	> 1 kΩ	
D-4 to D-13	0.4 Ω to 0.6 Ω	If > 0.6 Ω, check for OPEN circuit or OPEN injector coil. If < 0.4 Ω, check for cross-shorted circuits or injector coil for internal short.

Injector 2 Checks

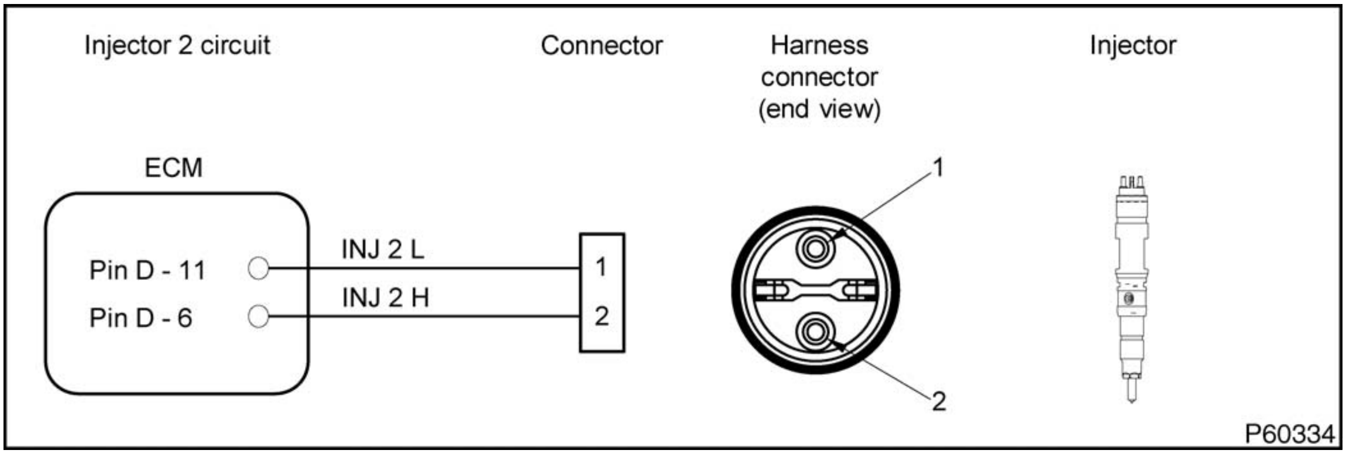

Figure 267 Injector 2 circuit diagram

Injector 2 – Resistance Checks Through Harness and Injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch OFF. Connect 180-Pin Breakout Box to the ECM harness connector. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
D-6 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
D-11 to GND	> 1 kΩ	
D-6 to D-11	0.4 Ω to 0.6 Ω	If > 0.6 Ω, check for OPEN circuit or OPEN injector coil. If < 0.4 Ω, check for cross-shorted circuits or injector coil for internal short.

Injector 3 Checks

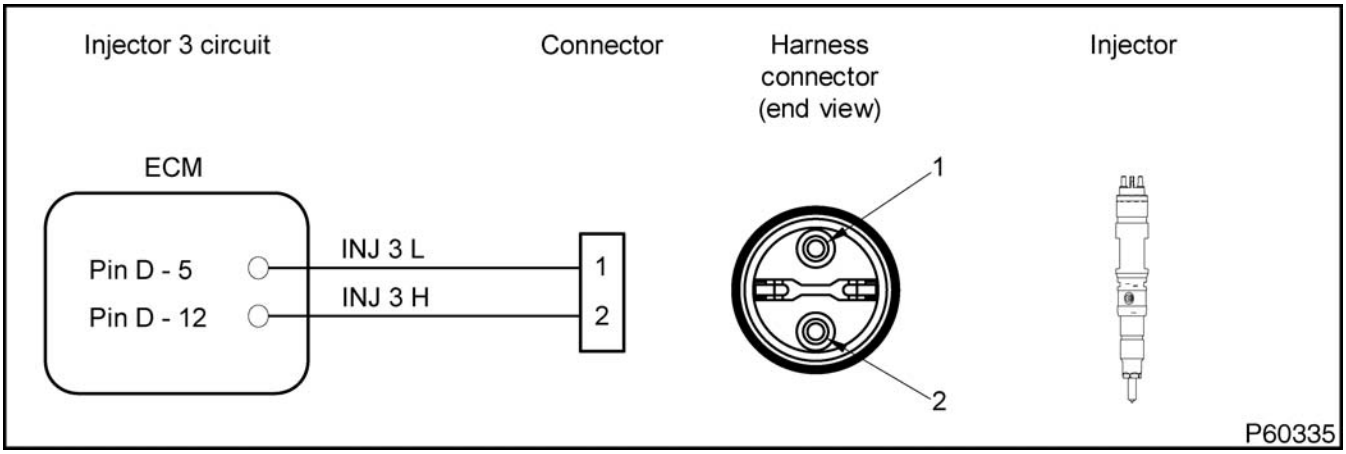

Figure 268 Injector 3 circuit diagram

Injector 3 – Resistance Checks Through Harness and Injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch OFF. Connect 180-Pin Breakout Box to the ECM harness connector. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
D-5 to GND D-12 to GND	> 1 kΩ > 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
D-5 to D-12	0.4 Ω to 0.6 Ω	If > 0.6 Ω, check for OPEN circuit or OPEN injector coil. If < 0.4 Ω, check for cross-shorted circuits or injector coil for internal short.

Injector 4 Checks

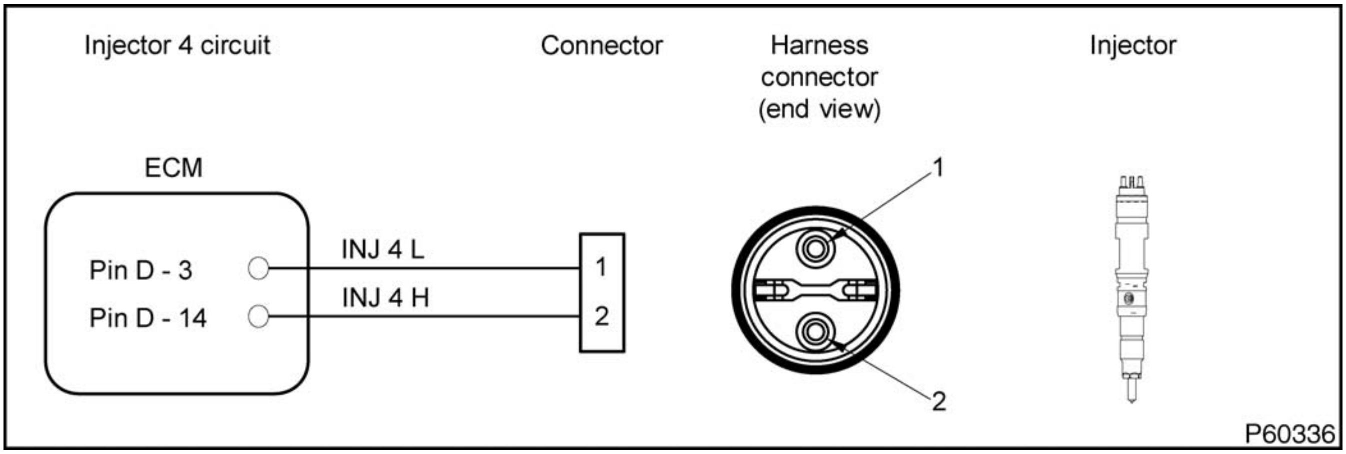

Figure 269 Injector 4 circuit diagram

Injector 4 – Resistance Checks Through Harness and Injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch OFF. Connect 180-Pin Breakout Box to the ECM harness connector. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
D-3 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
D-14 to GND	> 1 kΩ	
D-3 to D-14	0.4 Ω to 0.6 Ω	If > 0.6 Ω, check for OPEN circuit or OPEN injector coil. If < 0.4 Ω, check for cross-shorted circuits or injector coil for internal short.

Injector 5 Checks

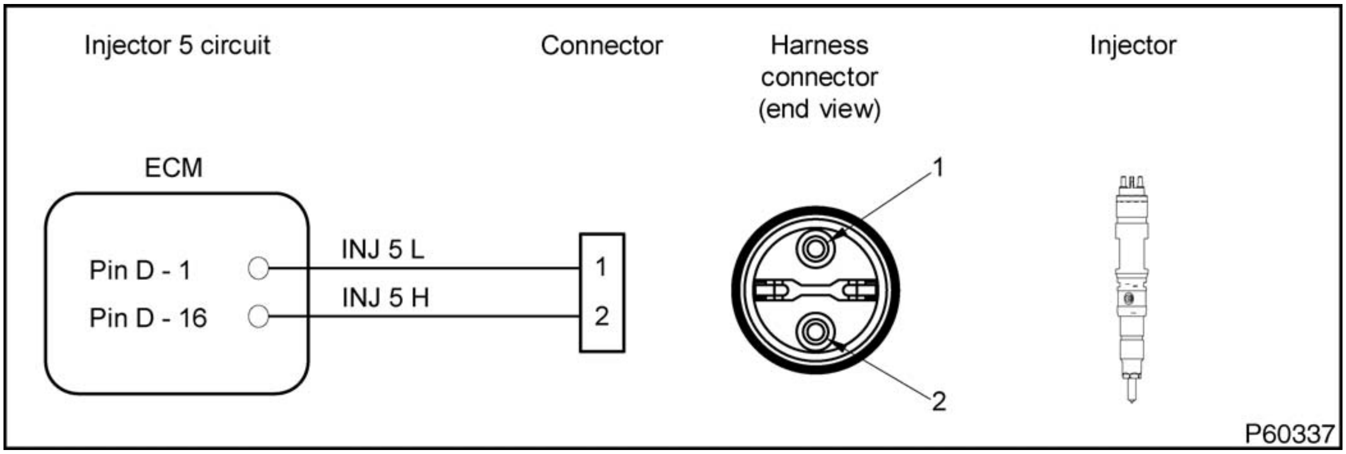

Figure 270 Injector 5 circuit diagram

Injector 5 – Resistance Checks Through Harness and Injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch OFF. Connect 180-Pin Breakout Box to the ECM harness connector. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
D-1 to GND D-16 to GND	> 1 kΩ > 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
D-1 to D-16	0.4 Ω to 0.6 Ω	If > 0.6 Ω, check for OPEN circuit or OPEN injector coil. If < 0.4 Ω, check for cross-shorted circuits or injector coil for internal short.

Injector 6 Checks

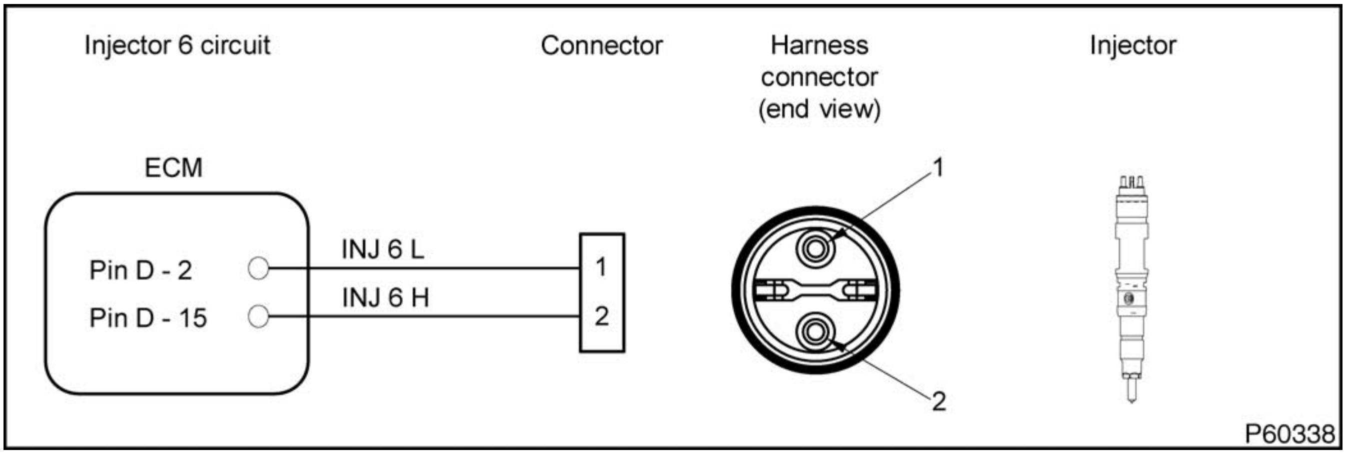

Figure 271 Injector 6 circuit diagram

Injector 6 – Resistance Checks Through Harness and Injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch OFF. Connect 180-Pin Breakout Box to the ECM harness connector. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
D-2 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
D-15 to GND	> 1 kΩ	
D-2 to D-15	0.4 Ω to 0.6 Ω	If > 0.6 Ω, check for OPEN circuit or OPEN injector coil. If < 0.4 Ω, check for cross-shorted circuits or injector coil for internal short.

Injector Circuit Operation

Each injector has an actuator that indirectly opens or closes the injector nozzle. Charging the actuator opens the nozzle, and discharging it closes the nozzle. The ECM charges and discharges the actuators by switching on the appropriate high side and low side output. The high side output supplies the actuator with voltage. The low side output supplies a return circuit for each injector actuator.

High Side Drive Output

There is one high side switch circuit that is common to all injector circuits. DC voltage is present on these circuits.

Low Side Drive Return

The injector actuators are grounded through the low side return switches; one for each injector.

Fault Detection/Management

The ECM can detect if the output is shorted to ground/battery, output is open load or short of injector.

IST (Idle Shutdown Timer) System (California - Standard)

DTC	SPN	FMI	Condition
2324	593	14	Engine stopped by IST

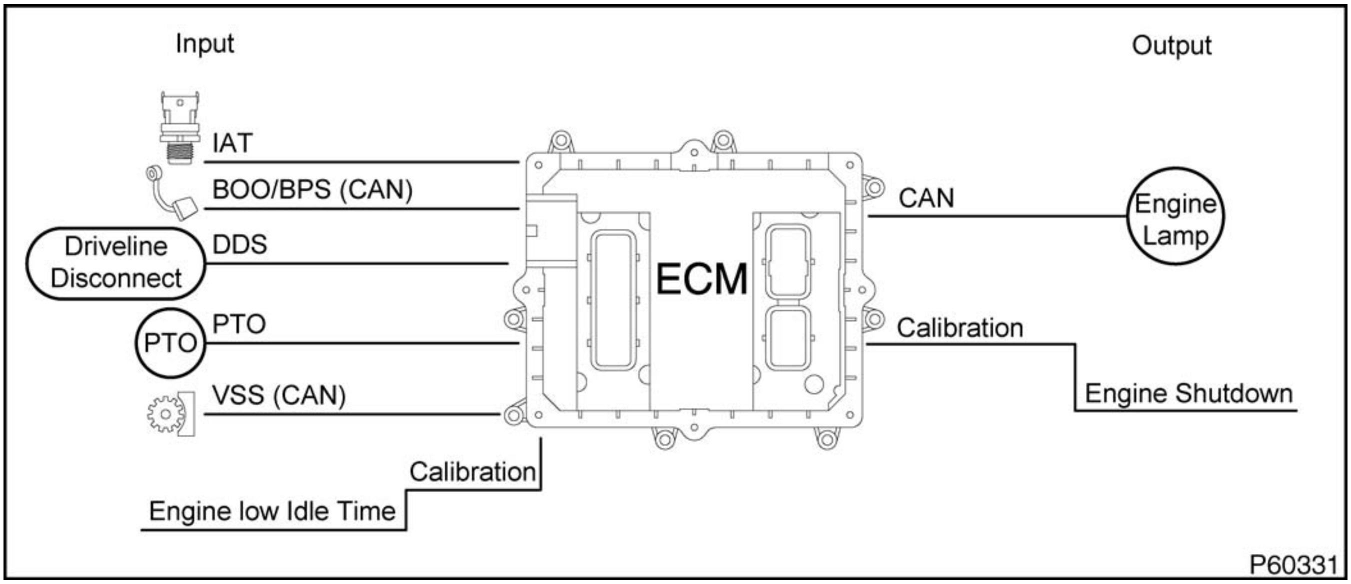

Figure 272 Functional diagram for the IST system

The functional diagram for the IST system includes the following:

- Brake ON/OFF (BOO) input
- Brake Pressure Switch (BPS) input
- Driveline Disengagement Switch (DDS)
- Engine Control Module (ECM)
- Engine lamp (red)
- Intake Air Temperature (IAT) sensor
- Power Takeoff (PTO)
- Vehicle Speed Sensor (VSS)
- Engine low idle time/Calibration
- Engine shutdown/Calibration

IST Operation

The California Air Resources Board (CARB) Idle Shutdown Timer (IST) allows the ECM to shut down the engine during extended idle. When parking brake is set, the idle time can be programmed up to 5 minutes. When parking brake is released, the idle time can be programmed up to 15 minutes. No parking brake, the idle time can be programmed up to 15 minutes. During service, the idle time can be programmed up to 60 minutes. The ECM deactivates the IST when the PTO is active.

Thirty seconds before engine shutdown, the red engine lamp illuminates. This continues until the engine shuts down or the low idle shutdown timer is reset. Idle time is measured from the last clutch or brake pedal transition. The engine must be out of gear for the IST to work. Engine shutdown time deactivates for one or more of the following conditions:

- Engine speed is not at idle speed (600 rpm).
- Vehicle movement or a Vehicle Speed Sensor (VSS) fault is detected.
- Manual DPF Regeneration is enabled.
- Accelerator pedal movement or an Accelerator Pedal Sensor (APS) fault is detected.

- Engine coolant operating temperature is below 16 °C (60 °F).
- Brake pedal movement or a brake switch fault is detected.
- Parking brake transition is detected.
- Clutch pedal is pressed or clutch pedal switch fault is detected (manual transmissions, if equipped with a clutch switch).
- Shift selector is moved from neutral (automatic transmissions).
- If the IST is enabled, the CAP will not function.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)

Fault Detection / Management

The IST DTC does not indicate a system fault. DTC 2324 is set by the ECM when the engine has been shut down due to exceeding the programmed idle time criteria. The IST feature must be enabled for DTC 2324 to be displayed.

IST (Idle Shutdown Timer) System (Federal - Optional)

DTC	SPN	FMI	Condition
2324	593	14	Engine stopped by IST

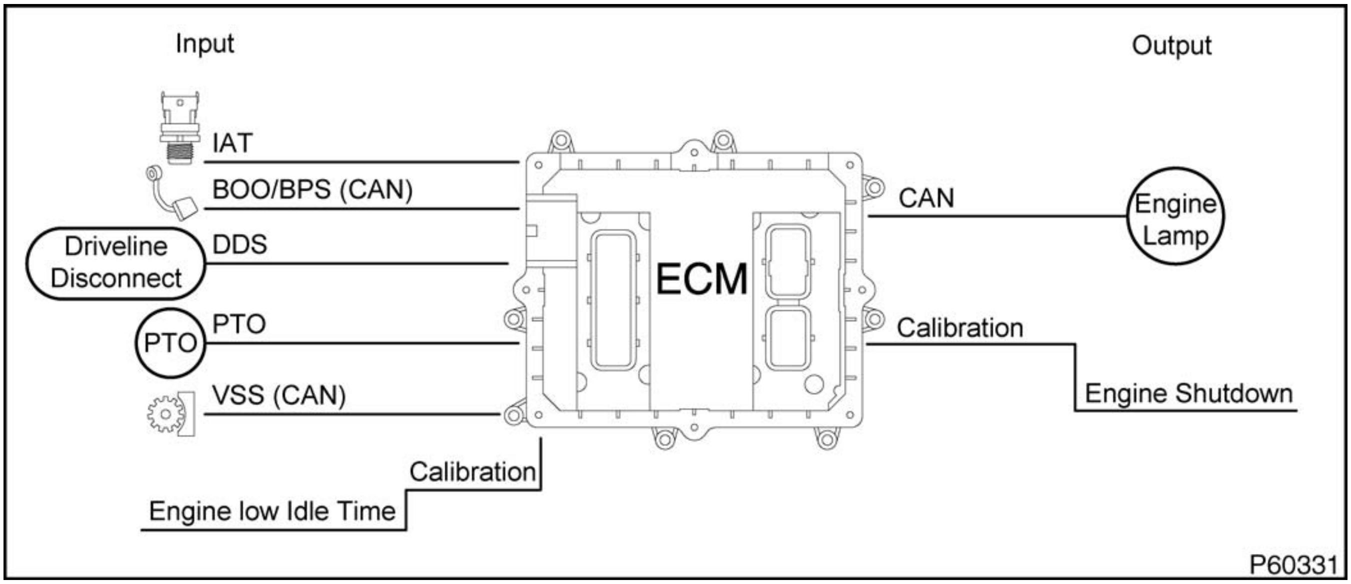

Figure 273 Functional diagram for the IST system

The functional diagram for the IST system includes the following:

- Brake ON/OFF (BOO) input
- Brake Pressure Switch (BPS) input
- Driveline Disengagement Switch (DDS)
- Engine Control Module (ECM)
- Engine lamp (red)
- Intake Air Temperature (IAT) sensor
- Power Takeoff (PTO)
- Vehicle Speed Sensor (VSS)
- Engine low idle time/Calibration
- Engine shutdown/Calibration

IST Operation

The optional Idle Shutdown Timer (IST) allows the ECM to shut down the engine during extended idle. Idle time can be programmed from 5 to 120 minutes.

The ECM can be programmed to deactivate the IST when the Power Takeoff (PTO) is active.

Thirty seconds before engine shutdown, the red engine lamp illuminates. This continues until the engine shuts down or the low idle shutdown timer is reset. Idle time is measured from the last clutch or brake pedal transition. The engine must be out of gear for the IST to work. Engine shutdown time deactivates for one or more of the following conditions:

- Engine speed is not at idle speed (600 rpm).
- Vehicle movement or a Vehicle Speed Sensor (VSS) fault is detected.
- Manual DPF Regeneration is enabled.
- Accelerator pedal movement or an Accelerator Pedal Sensor (APS) fault is detected.
- Engine coolant operating temperature is below 60 °C (140 °F).
- Ambient temperature below 16 °C (60 °F) or above 44 °C (110 °F).

- Brake pedal movement or a brake switch fault is detected.
- Parking brake transition is detected.
- Clutch pedal is pressed or clutch pedal switch fault is detected (manual transmissions, if equipped with a clutch switch).
- Shift selector is moved from neutral (automatic transmissions).
- If the IST is enabled, the CAP will not function.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)

Fault Detection / Management

The IST DTC does not indicate a system fault. DTC 2324 is set by the ECM when the engine has been shut down due to exceeding the programmed idle time criteria. The IST feature must be enabled for DTC 2324 to be displayed.

ITV (Intake Throttle Valve)

DTC	SPN	FMI	Condition
1286	51	7	ITV unable to achieve commanded position
1289	51	0	ITV overtemperature
1295	3464	5	Intake Throttle Valve open circuit
1296	3464	11	Intake Throttle Valve short circuit
1297	51	5	ITV no input signal
1298	51	2	ITV operation fault - under V, over amp, over temp
6840	51	12	ITV broken spring or linkage
6841	51	8	ITV feedback outside duty cycle range
6842	51	19	ITV feedback signal not plausible

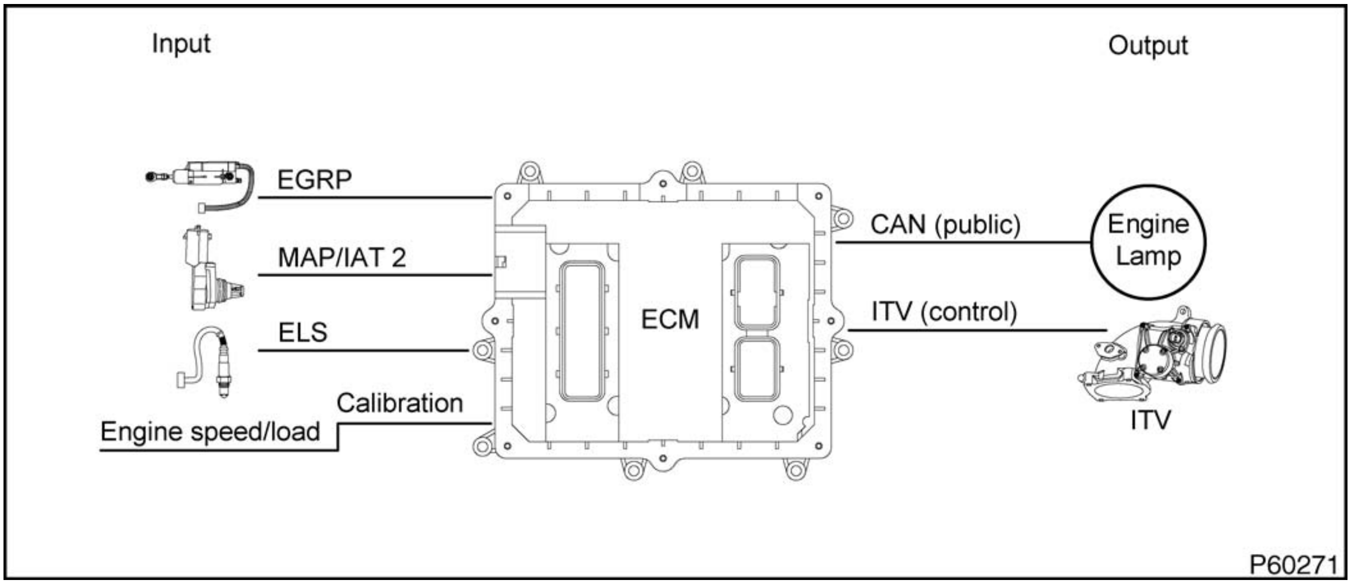

Figure 274 Functional diagram for the ITV

The functional diagram for the ITV includes the following:

- Exhaust Gas Recirculation Position (EGRP) sensor
- ITV
- Manifold Absolute Pressure/Intake Air Temperature 2 (MAP/IAT 2) sensor
- Exhaust Lambda Sensor (ELS)

Function

The ITV controls air/fuel mixture during a regeneration process of the aftertreatment system and helps reduce emissions during normal operation.

Component Location

The ITV is installed on the air intake between the High Pressure Charge Air Cooler (HPCAC) and the intake manifold.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 3-Banana Plug Harness (page 437)
- 500 Ohm Resistor Harness (page 439)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- EGR Position and ITV Breakout Harness (page 443)
- Terminal Test Adapter Kit (page 446)

ITV End Diagnostics

DTC	Condition	Possible Causes
1286	ITV unable to achieve commanded position	• Failed VIGN or GND circuits • Failed ITVC, ITVC GND or ITVD circuits • Failed ITV
1289	ITV overtemperature	• Failed ITV
1295	Intake Throttle Valve open circuit	• ITVC circuit OPEN • Failed ITV
1296	Intake Throttle Valve short circuit	• ITVC circuit shorted • Failed ITV
1297	ITV no input signal	• Failed VIGN or GND circuits • Failed ITVC, ITVC GND or ITVD circuits • Failed ITV
1298	ITV operation fault - under V, over amp, over temp	• Failed VIGN or GND circuits • Failed ITVC, ITVC GND or ITVD circuits • Failed ITV
6840	ITV broken spring or linkage	• Failed ITV
6841	ITV feedback outside duty cycle range	• Failed VIGN or GND circuits • Failed ITVC, ITVC GND or ITVD circuits • Failed ITV
6842	ITV feedback signal not plausible	• Failed VIGN or GND circuits • Failed ITVC, ITVC GND or ITVD circuits • Failed ITV

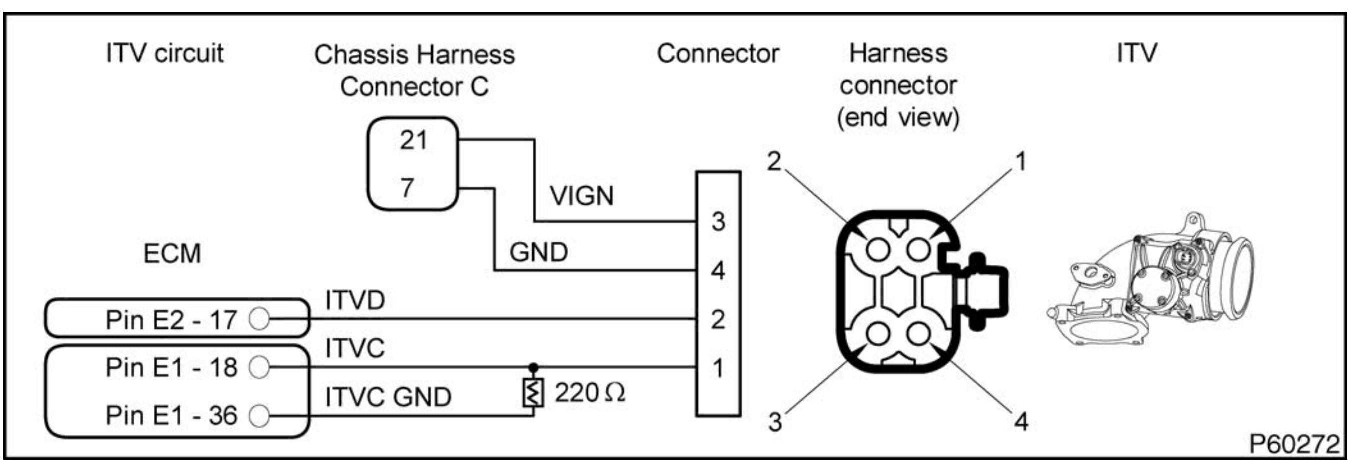

Figure 275 ITV valve circuit diagram

1. Key ON, engine OFF.
2. Connect the EST with MasterDiagnostics® software.
3. Verify correct engine is selected and launch EST.
4. Open D_Actuator.ssn session.

Connector Voltage Check — ITV Disconnected

Connect breakout harness to engine harness, leave ITV disconnected. Turn ignition switch ON and record voltage within 60 seconds of the key ON. Use DMM to measure voltage.

Test Point	Spec	Comment
4 to battery positive	B+	If < B+, check for OPEN in GND circuit.
3 to GND	B+	If < B+, check for OPEN in VIGN circuit or blown fuse.
2 to GND	5 V	If < 4 V, check for OPEN or short to GND in ITVD circuit. Do Harness Resistance Check (page 412).
1 to GND	1 V	If < 0.5 V, check for OPEN or short to GND in E1-18 circuit. Do Harness Resistance Check (page 412) If > 1.5 V, check for OPEN or short to PWR in E1-36 circuit.
If measurements are within specifications, do Connector Voltage Check (page 411).		

Connector Voltage Check

Connect breakout harness between engine harness and ITV. Turn ignition switch ON and record voltage within 60 seconds of the key ON. Use DMM to measure voltage.

Test Point	Spec	Comment
4 to battery positive	B+	If < B+, check for OPEN in GND circuit.
3 to GND	B+	If < B+, check for OPEN in VIGN circuit or blown fuse.
2 to GND	2.5 V	If < 2 V, check for short to GND in ITVD circuit. Do Harness Resistance Check (page 412). If > 3 V, check for OPEN in E1-18, or E1-36, or E2-17, or E2-17 short to PWR, or failed ITV. Do Harness Resistance Check (page 412).
1 to GND	1 V	If < 0.5 V, check for OPEN or short to GND in E1-18 circuit. Do Harness Resistance Check (page 412). If > 1.5 V, check for OPEN or short to PWR in E1-36 circuit.
If measurements are within specifications, do Operational Voltage Check - Actuator Test (page 412).		

Operational Voltage Check - Actuator Test

Connect breakout harness between ITV and engine harness. Run Actuator Test. Use DMM to measure voltage. Batteries must be fully charged before performing this test.

Test Point	Spec	Comment
DMM - Measure Volts across pins 1 and GND		
Actuator state LOW	2 V +/- 1 V	If < 1 V, check E1-18 circuit for OPEN, or check E1-18 or E1-36 for short to GND. Do Harness Resistance Check (page 412). If > 3 V, check E1-36 circuit for OPEN, or check E1-18 or E1-36 for short to PWR.
Actuator state HIGH	10 V +/- 1 V	If < 9 V, check E1-18 circuit for OPEN, or check E1-18 or E1-36 for short to GND. Do Harness Resistance Check (page 412). If > 11 V, check E1-36 circuit for OPEN, or check E1-18 or E1-36 for short to PWR.
If measurements are within specifications, do Harness Resistance Check (page 412).		

Harness Resistance Check

Turn ignition switch OFF. Connect ECM breakout box and breakout harness to engine harness and leave ITV and Engine Control Module (ECM) disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1k Ω, check for short circuit.
1 to E1-18	< 5 Ω	If > 5 Ω, check for OPEN circuit.
1 to E1-36	220 Ω	If not within the specification check for OPEN circuit.
2 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to E2-17	< 5 Ω	If > 5 Ω, check for OPEN circuit.
If voltage and resistance checks are within specifications, check for DTCs. If the DTC returns, replace the ITV.		

ITV Circuit Operation

The ITV is controlled by the ECM. The desired position request is sent from ECM Pins E1–18 and E1–36 to the ITV Pin 1. The request may vary between 0% and 100%. After the ITV receives the request from the ECM, the ITV motor controls the throttle plate to the desired position.

Fault Detection / Management

The ITV performs internal diagnostics and sends the fault status from Pin 2 back to the ECM Pin E2–17. Under normal conditions the feedback signal may be between 50% and 100%, indicating an actual position of the throttle plate which can be positioned between 0% and 100%. When the fault is present, the fault status changes to one of four signals; 10%, 20%, 30% or 40%. Each signal corresponds to a different failure mode.

Actuator Test

The actuator test allows a technician to test the actuators by measuring voltage changes and visually monitoring actuator movement.

This test first runs through the Engine Control Module (ECM) actuators, then the Aftertreatment Control Module (ACM) actuators, and finishes with the Engine Interface Module (EIM) actuators.

ECM Actuators

During the ECM portion of the actuator test, all ECM actuators are commanded to LOW state, 8% to 15% duty cycle. Then one by one, each actuator is commanded to HIGH state, 80% to 100% duty cycle. This test will not cycle the Fuel Pressure Control Valve (FPCV) or the Exhaust Lambda Sensor (ELS) heater.

ACM Actuators

During the ACM portion of the actuator test, all ACM actuators remain at 0% duty cycle. Then one by one, each actuator is cycled on. The Aftertreatment Fuel Supply (AFS) valve and Aftertreatment Fuel Drain (AFD) valve are commanded to 100%, then drop to 66%. The Aftertreatment Fuel Injector (AFI) is commanded to a low duty cycle measured in seconds from 0 (off) to 0.1 (on).

EIM Actuators

During the EIM portion of the actuator test, the actuators cycle simultaneously. Fan Control Status is 1 (on), then cycles to 0 (off). The Cold Start Relay (CSR) and Cold Start Solenoid (CSS) is 0 (off), then cycles to 1 (on).

NOTE: When the Actuator Test is running, the sensor monitoring Parameter Identifiers (PIDs) are turned off.

This test cycles the following actuators:

- ECM actuators:
  - Intake Throttle Valve (ITV)
  - Boost Control Solenoid (BCS) valve
  - Exhaust Gas Recirculation (EGR) control valve
  - Coolant Mixer Valve (CMV)
  - Coolant Flow Valve (CFV)
- EIM actuators:
  - Cold Start Relay (CSR)
  - Cold Start Solenoid (CSS) valve
  - Electronic Fan Control (EFAN)
- ACM actuators:
  - Aftertreatment Fuel Drain (AFD) valve
  - Aftertreatment Fuel Supply (AFS) valve
  - Aftertreatment Fuel Injector (AFI)

MAP/IAT2 Sensor (Manifold Absolute Pressure/Intake Air Temperature 2)

DTC	SPN	FMI	Condition
1121	102	3	MAP signal out-of-range HIGH
1122	102	4	MAP signal out-of-range LOW
1158	1131	0	IAT2 Temp above maximum
1159	1131	3	IAT2 signal out-of-range HIGH
1160	1131	4	IAT2 signal out-of-range LOW

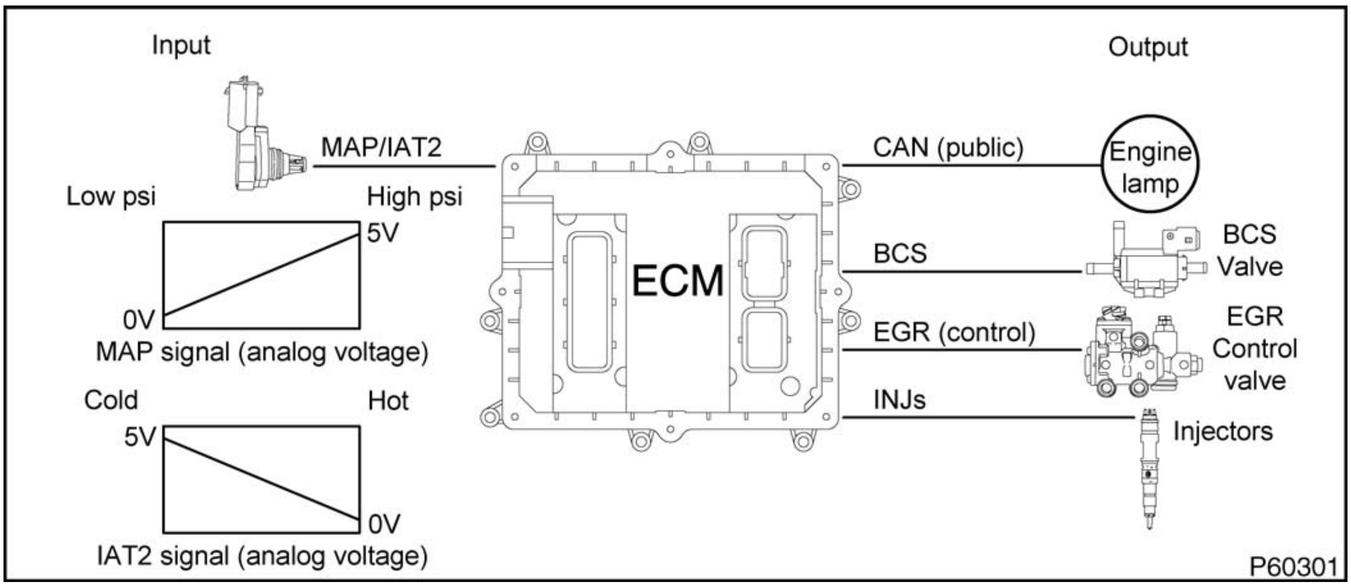

Figure 276 Functional diagram for the MAP/IAT2 sensor

The functional diagram for the MAP/IAT2 sensor includes the following:

- Boost Control Solenoid (BCS) valve
- Engine Control Module (ECM)
- Engine lamp (amber)
- Exhaust Gas Recirculation (EGR) control valve
- Fuel injectors
- MAP/IAT2 sensor

Function

The ECM monitors the MAP and IAT2 signals to determine intake manifold (boost) pressure and intake air temperature. From this information the ECM can optimize control of fuel rate and injection timing for all engine operating conditions. The ECM also uses the MAP and IAT2 signals to assist in the calculation of the EGR and BCS duty percentage.

Sensor Location

The MAP/IAT2 sensor is installed in the ITV on top of the engine.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 3-Banana Plug Harness (page 437)
- 500 Ohm Resistor Harness (page 439)

- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- MAP/IAT2 Breakout Harness (page 446)
- Terminal Test Adapter Kit (page 446)

MAP/IAT2 Sensor End Diagnostics

DTC	Condition	Possible Causes
1121	MAP signal out-of-range HIGH	• MAP signal circuit OPEN or short to PWR • MAP GND circuit OPEN • Failed sensor
1122	MAP signal out-of-range LOW	• MAP signal circuit short to GND • MAP VREF circuit OPEN or short to GND • Failed sensor
1158	IAT2 Temp above maximum	• Failed Charge Air Cooler (CAC) • IAT2 circuit fault • Failed sensor
1159	IAT2 signal out-of-range HIGH	• IAT2 signal circuit OPEN or short to PWR • Failed sensor
1160	IAT2 signal out-of-range LOW	• IAT2 signal circuit short to GND • Failed sensor

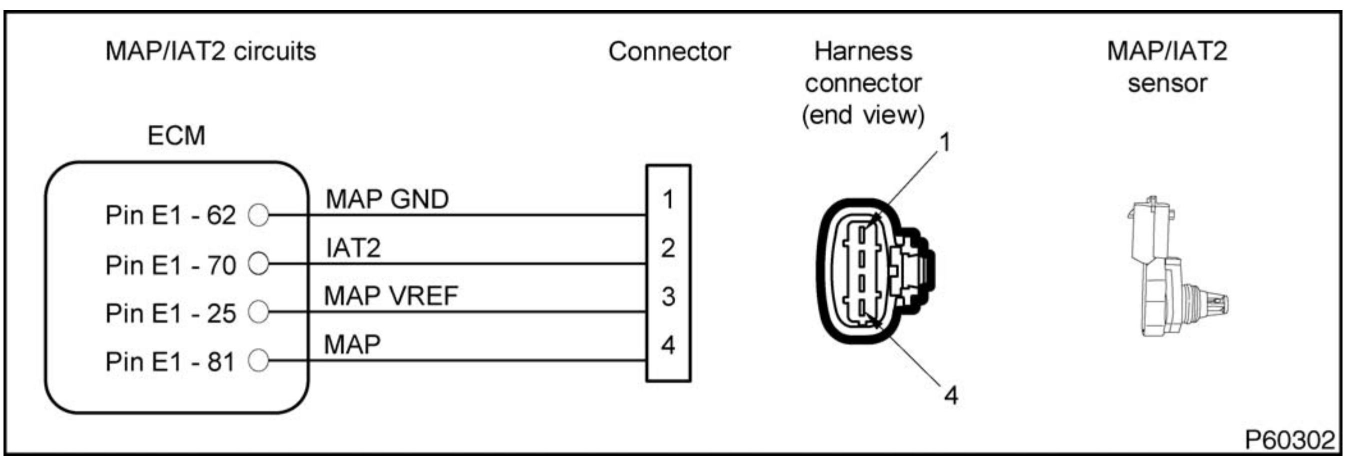

Figure 277 MAP/IAT2 sensor circuit diagram

1. Using EST, open the D_ContinuousMonitor.ssn.

2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor. Inspect connectors for damaged pins, corrosion, or loose pins using Pin Grip Inspection (page 197). Repair if necessary.
4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect breakout harness. Leave sensor disconnected. Turn the ignition switch to ON. Use EST to monitor PIDs and DMM to measure voltage.

Test Point	Spec	Comment
EST – Monitor MAPv	5 V	If < 4.5 V, check MAP signal circuit for short to GND. Do Connector Resistance Check to GND (page 417).
DMM – Measure volts 3 to GND	5.0 V +/- 0.5 V	If > 5.5 V, check MAP VREF for short to PWR. If < 4.5 V, check MAP VREF for OPEN or short to GND. Do Harness Resistance Check (page 418).
DMM – Measure voltage 1 to 3	5.0 V +/- 0.5 V	If < 4.5 V, check MAP GND for OPEN. Do Harness Resistance Check (page 418).
EST – Monitor MAPv Short across breakout harness pins 1 and 4	0 V	If > 0.25 V, check MAP signal for OPEN or short to GND. Do Harness Resistance Check (page 418).
EST-Monitor IAT2v	5 V	If < 4.5 V, check IAT2 signal circuit for short to GND. Do Harness Resistance Check (page 418).
EST-Monitor IAT2v Short breakout harness across pins 1 and 2	0 V	If > 0.25 V, check IAT2 signal circuit for OPEN. Do Harness Resistance Check (page 418).
EST-Monitor ECTv Short 500 Ω resistor across pins 1 and 2	< 1.0 V	If > 1.0 V, check IAT2 signal circuit for short to PWR. Do Harness Resistance Check (page 418).

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace MAP/IAT2 sensor.

MAP/IAT2 Sensor Pin-Point Diagnostics

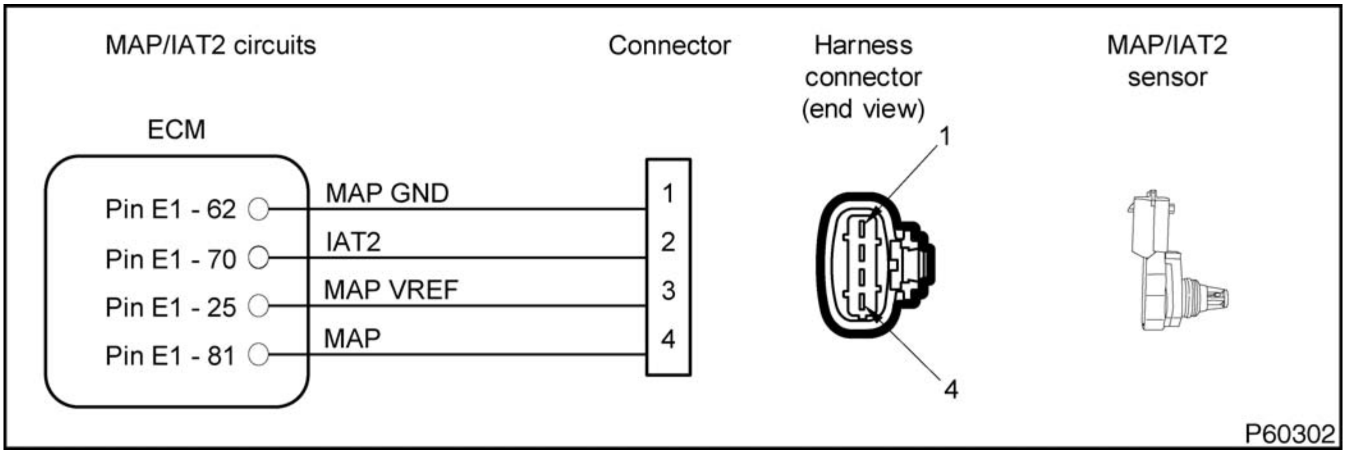

Figure 278 MAP/IAT2 sensor circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	0 V	If > 0.25 V, check MAP GND circuit for short to PWR.
2 to GND	5 V	If < 4.5 V, check IAT2 signal circuit for short to GND. Do Connector Resistance Check to GND (page 417).
3 to GND	5 V	If > 5.5 V, check MAP VREF for short to PWR. If < 4.5 V, check MAP VREF for OPEN or short to GND. Do Harness Resistance Check (page 418).
4 to GND	5 V	If < 4.5 V, check MAP signal circuit for short to GND. Do Connector Resistance Check to GND (page 417).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Do Harness Resistance Checks (page 418).
2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
3 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
4 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E1-62	< 5 Ω	If > 5 Ω, check MAP GND circuit for OPEN.
2 to E1-70	< 5 Ω	If > 5 Ω, check IAT2 signal circuit for OPEN.
3 to E1-25	< 5 Ω	If > 5 Ω, check MAP VREF circuit for OPEN.
4 to E1-81	< 5 Ω	If > 5 Ω, check MAP signal circuit for OPEN.

MAP/IAT2 Sensor Circuit Operation

The MAP/IAT2 sensor is a variable capacitance sensor that is supplied with a 5 V reference voltage at Pin 3 from ECM Pin E1-25. The sensor is grounded at Pin 1 from ECM Pin E1-62 and returns a variable voltage signal from Pin 4 to ECM Pin E1-81. The temperature signal returns to the ECM Pin E1-70 from the sensor Pin 2.

Fault Detection / Management

The ECM continuously monitors the control system. If sensor signal is higher or lower than expected, the ECM disregards the sensor signal and uses a calibrated default value. The ECM sets a DTC, illuminates the amber engine lamp, and runs the engine in a default range.

MAT Sensor (Manifold Air Temperature)

DTC	SPN	FMI	Condition
1161	105	4	MAT signal out-of-range LOW
1162	105	3	MAT signal out-of-range HIGH

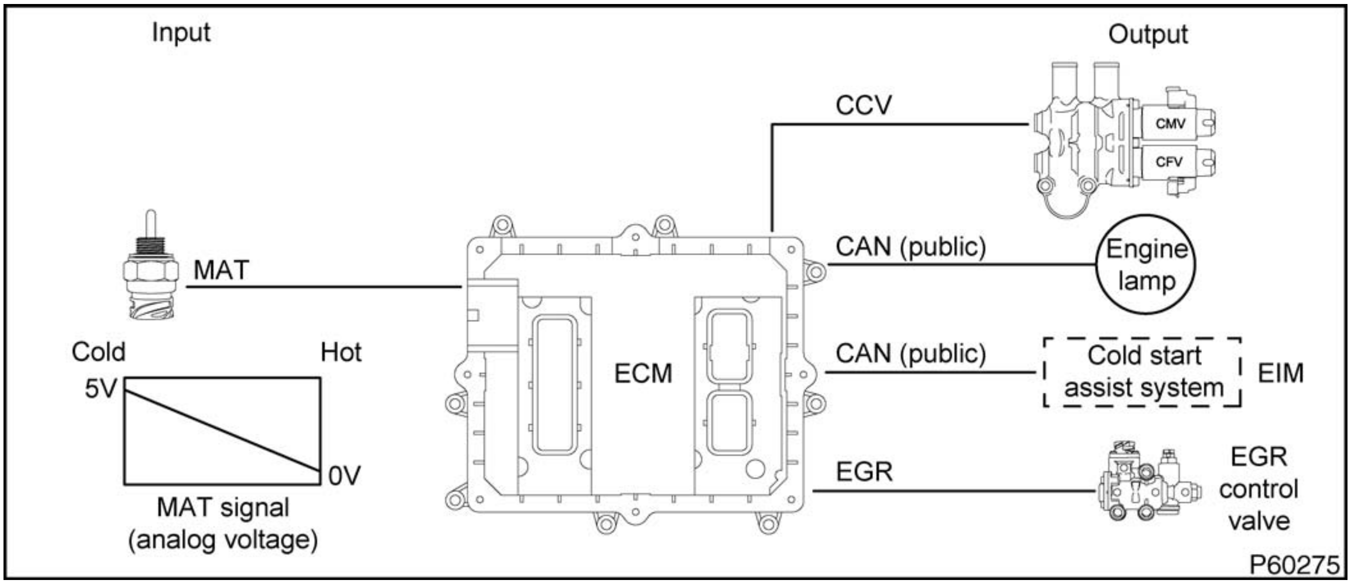

Figure 279 Functional diagram for the MAT sensor

The functional diagram for the MAT sensor includes the following:

- Cold start assist system
- Engine Control Module (ECM)
- Engine lamp (amber)
- Exhaust Gas Recirculation (EGR) control valve
- MAT sensor

Function

The MAT sensor provides a feedback signal to the ECM indicating manifold air temperature. The ECM controls the EGR and cold start assist systems based on the air temperature in the intake manifold. This aids in cold engine starting and warm-ups, and also reduces exhaust emissions.

Sensor Location

The MAT sensor is located on the left side of the engine in the intake manifold.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 3-Banana Plug Harness (page 437)
- 500 Ohm Resistor Harness (page 439)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)
- 4-Pin Round Blue Breakout Harness (page 437)
- Terminal Test Adapter Kit (page 446)

MAT Sensor Connector End Diagnostics

DTC	Condition	Possible Causes
1161	MAT signal out-of-range LOW	• MAT signal circuit short to GND • Failed sensor
1162	MAT signal out-of-range HIGH	• MAT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor

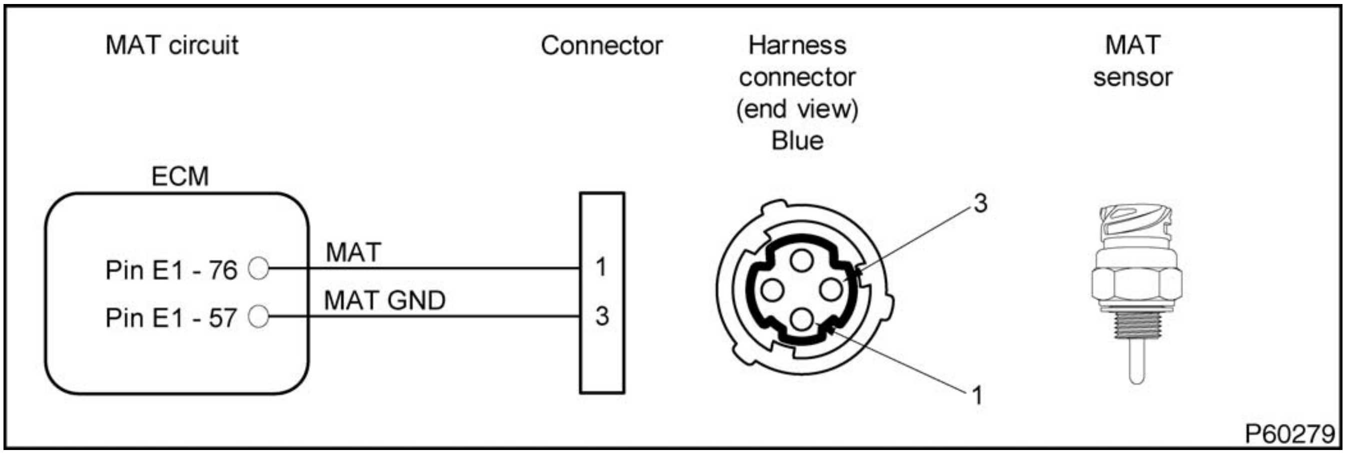

Figure 280 MAT sensor circuit diagram

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor. Inspect connectors for damaged pins, corrosion, or loose pins using Pin Grip Inspection (page 197). Repair if necessary.
4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect breakout harness. Leave sensor disconnected. Turn the ignition switch to ON. Use EST to monitor PIDs and DMM to measure voltage.

Test Point	Spec	Comment
EST-Monitor MATv	5 V	If < 4.5 V, check MAT signal circuit for short to GND. Do Connector Resistance Checks to GND (page 422).
EST-Monitor MATv Short breakout harness across pin 1 and GND	0 V	If > 0.25 V, check MAT signal circuit for OPEN. Do Harness Resistance Check (page 422).
EST-Monitor MATv Short breakout harness across pins 1 and 3	0 V	If > 0.25 V, check MAT GND circuit for OPEN. Do Harness Resistance Check (page 422).
EST-Monitor MATv Short 500 Ω resistor across pins 1 and 3	< 1.0 V	If > 1.0 V, check MAT signal circuit for short to PWR.

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace MAT sensor.

MAT Sensor Pin-Point Diagnostics

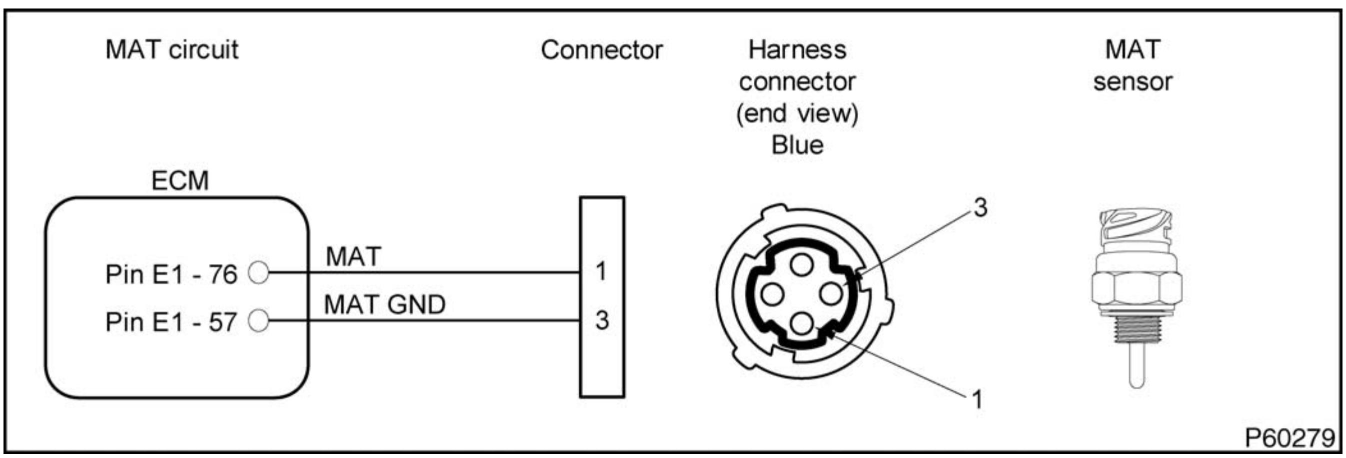

Figure 281 MAT sensor circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	4.5 V to 5 V	If < 4.5 V, check for short to GND. Do Connector Resistance Checks to GND (page 422).
3 to GND	0 V	If > 0.25 V, check for short to PWR.

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND. Do Harness Resistance Check (page 422).
3 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Do Harness Resistance Check (page 422).

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E1-76	< 5 Ω	If > 5 Ω, check MAT signal for OPEN.
3 to E1-57	< 5 Ω	If > 5 Ω, check MAT GND signal for OPEN.

MAT Sensor Circuit Operation

The MAT sensor is a thermistor sensor that is supplied with a 5 V reference voltage at Pin 1 from ECM Pin E1–76. The sensor is grounded at Pin 3 from ECM Pin E1–57. As temperature increases, the resistance of the thermistor decreases, causing the signal voltage to decrease.

Fault Detection / Management

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM disregards the sensor signal and uses a calibrated default value. The ECM sets a DTC, illuminates the amber engine lamp, and runs the engine in a default range.

Retarder Control

DTC	SPN	FMI	Condition
5565	7313	5	Retarder control valve open circuit
5566	7313	11	Retarder control valve short circuit

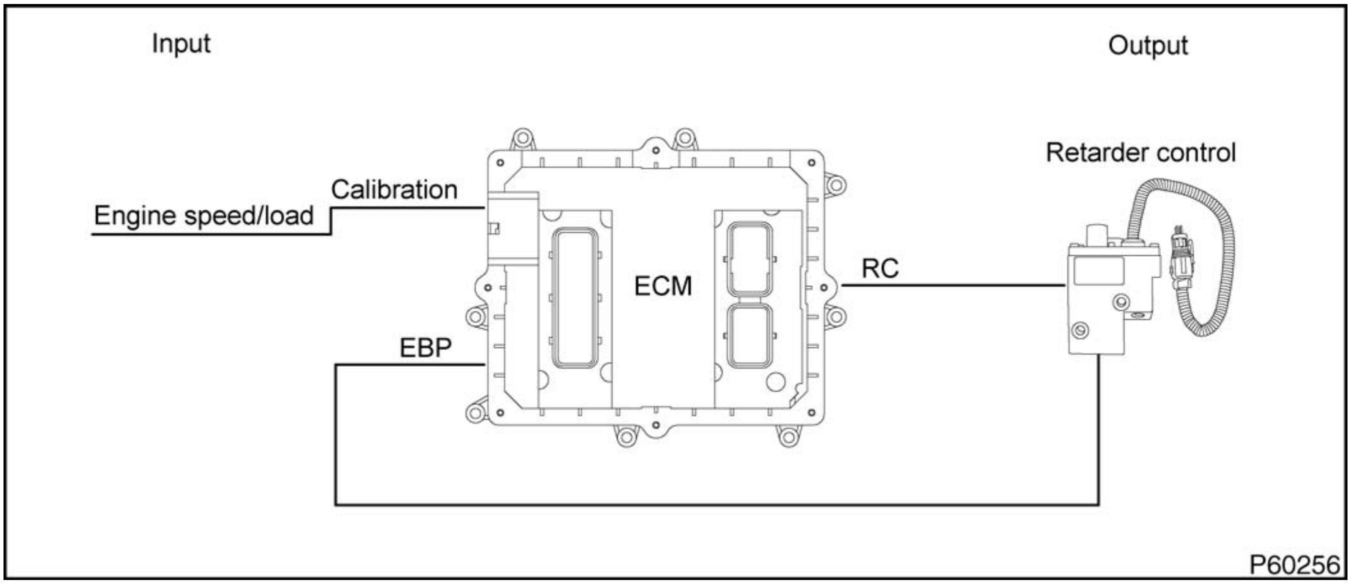

Figure 282 Functional diagram for the retarder control

The functional diagram for the retarder control includes the following:

- Engine Control Module (ECM)
- Retarder control
- Engine Speed/Load Calibration
- Exhaust Back Pressure (EBP) sensor input

Function

The retarder control controls the compressed air supply to the actuator located in the exhaust manifold with butterfly. The actuator moves the butterfly valve to increase exhaust back pressure in the cylinder head exhaust ports to activate the engine retarder system. Compressed air is supplied to the retarder control from the truck air system. The retarder control monitors the exhaust back pressure through a pressure line connected to the retarder exhaust manifold with butterfly.

Component Location

The retarder control is installed on the lower right side of the engine

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)
- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- Retarder Control breakout harness (page 446)
- 180-Pin Breakout Box (page 438)
- E1-Engine Harness (page 443)
- E2-Engine, D-Injector, C-Chassis Harness (page 443)

Retarder Control Connector End Diagnostics

DTC	Condition	Possible Causes
5565	Retarder control valve open circuit	• Retarder control circuits OPEN • Failed retarder control
5566	Retarder control valve short circuit	• Retarder control circuits shorted • Failed retarder control

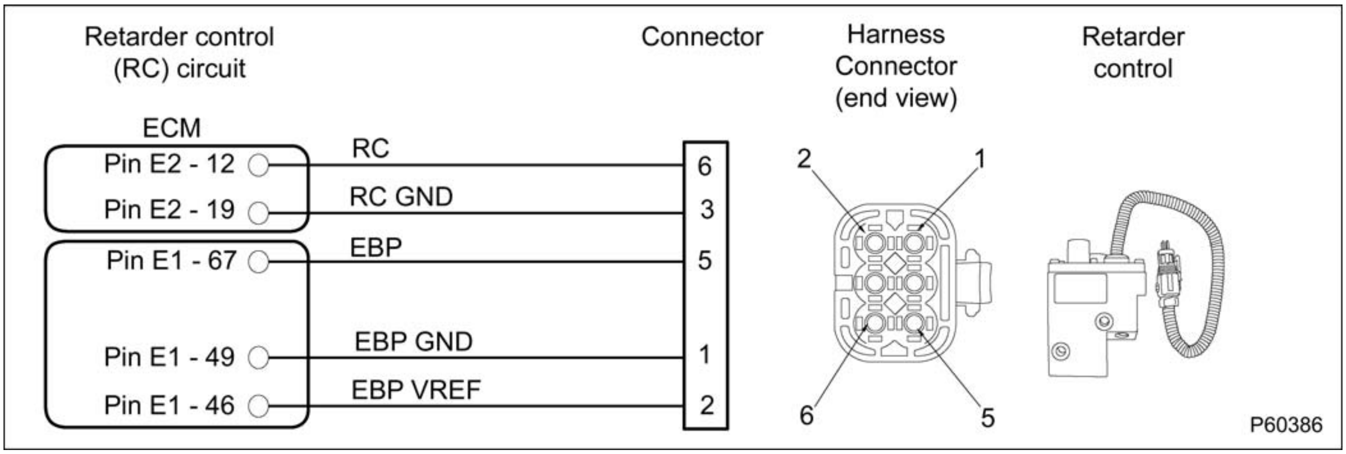

Figure 283 Retarder control circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

NOTE: Air tanks must be above 620 kPa (90 psi) before running this test.

1. Key ON, engine OFF.
2. Connect the EST with MasterDiagnostics® software.
3. Verify correct engine is selected, then Launch EST
4. Open D_Actuator.ssn session.
5. Run Actuator Test.
6. Visually monitor actuator linkage movement.
   - If linkage moves through its full travel, the system is working correctly.
   - If linkage does not move through full travel, check for mechanical problem such as sticking linkage, low actuator supply pressure, plugged or open air supply hose.
   - If the linkage does not move at all, do Connector Voltage Checks (page 425).

Connector Voltage Check

Connect breakout harness to engine harness, leave retarder control disconnected. Turn ignition switch ON. Use DMM to measure voltage.

Test Point	Spec	Comment
4 to battery positive	B+	If < B+, check for OPEN RC GND circuit.
4 to 6	5 V to 9 V	If 0 V, check for OPEN or short to GND.
		If < 5 V, check for poor connection, corroded circuits.
		If > 9 V, check for short to PWR
If measurements are within specifications, do Operational Voltage Check - Actuator Test (page 425).		

Operational Voltage Check - Actuator Test

Connect breakout harness between retarder control and harness. Run Actuator Test. Use DMM to measure voltage. Batteries must be fully charged before performing this test.

Test Point	Spec	Comment
DMM - Measure Volts across pin 6 and GND		
Normal state	< 1 V	If > 1 V, check for short to PWR.
Actuator state LOW	1 V +/- 0.5 V	If > 1.5 V, check for OPEN circuit or OPEN retarder control.
Actuator state HIGH	> 9 V	If < 9 V, check for OPEN circuit or short to GND
If measurements are within specifications, do Actuator Resistance Check (page 425).		

Actuator Resistance Check

Turn ignition switch OFF. Connect breakout harness to retarder control and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
4 to 6	4 Ω to 8 Ω	If not within specification, replace the retarder control.
If measurements are within specifications, do Harness Resistance Check (page 426).		

Harness Resistance Check

Turn ignition switch OFF. Connect ECM breakout box and breakout harness to engine harness and leave retarder control and ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
6 to GND	> 1 kΩ	If < 1k Ω, check for short circuit.
6 to E2-12	< 5 Ω	If > 5 Ω, check for OPEN circuit.
4 to GND	> 1 kΩ	If < 1k Ω, check for OPEN circuit.
4 to E2-19	< 5 Ω	If > 5 Ω, check for OPEN circuit.

If voltage and resistance checks are within specifications, and there are no mechanical faults such as low actuator supply psi, damaged air supply hoses, failed exhaust manifold with butterfly or sticky linkage, and the actuator does not actuate, replace exhaust manifold with butterfly.

Actuator Test

The actuator test allows a technician to test the actuators by measuring voltage changes and visually monitoring actuator movement.

This test first runs through the Engine Control Module (ECM) actuators, then the Aftertreatment Control Module (ACM) actuators, and finishes with the Engine Interface Module (EIM) actuators.

ECM Actuators

During the ECM portion of the actuator test, all ECM actuators are commanded to LOW state, 8% to 15% duty cycle. Then one by one, each actuator is commanded to HIGH state, 80% to 100% duty cycle. This test will not cycle the Fuel Pressure Control Valve (FPCV) or the Exhaust Lambda Sensor (ELS) heater.

ACM Actuators

During the ACM portion of the actuator test, all ACM actuators remain at 0% duty cycle. Then one by one, each actuator is cycled on. The Aftertreatment Fuel Supply (AFS) valve and Aftertreatment Fuel Drain (AFD) valve are commanded to 100%, then drop to 66%. The Aftertreatment Fuel Injector (AFI) is commanded to a low duty cycle measured in seconds from 0 (off) to 0.1 (on).

EIM Actuators

During the EIM portion of the actuator test, the actuators cycle simultaneously. Fan Control Status is 1 (on), then cycles to 0 (off). The Cold Start Relay (CSR) and Cold Start Solenoid (CSS) is 0 (off), then cycles to 1 (on).

NOTE: When the Actuator Test is running, the sensor monitoring Parameter Identifiers (PIDs) are turned off.

This test cycles the following actuators:

- ECM actuators:
  - Intake Throttle Valve (ITV)
  - Boost Control Solenoid (BCS) valve
  - Exhaust Gas Recirculation (EGR) control valve
  - Coolant Mixer Valve (CMV)
  - Coolant Flow Valve (CFV)
- EIM actuators:
  - Cold Start Relay (CSR)
  - Cold Start Solenoid (CSS) valve
  - Electronic Fan Control (EFAN)
- ACM actuators:
  - Aftertreatment Fuel Drain (AFD) valve
  - Aftertreatment Fuel Supply (AFS) valve
  - Aftertreatment Fuel Injector (AFI)

Service Interval Messages

DTC	SPN	FMI	Condition
2369	1378	2	Engine oil service required
2370	94	17	Fuel filter change reminder

Service Interval Messages Operation

The service interval messages are displayed on the instrument cluster message center and include engine oil and fuel filter change reminders.

The change oil reminder can be programmed for kilometers, miles, hours or calculated fuel consumption. These service interval limits may be adjusted at the owner’s discretion. The change engine oil message below the odometer illuminates after a preselected parameter is reached.

There fuel filter change message displays when the fuel filter needs replacement due to high filter restriction.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)

Fault Detection / Management

The service interval DTCs do not indicate a system fault. To deactivate DTCs 2369 and 2370, reset service intervals. See Service Interval Messages Reset (page 87) in the “Diagnostic Software Operation” section of this manual.

Single and Two-Speed EFAN Control (Electronic Engine Fan Control)

DTC	SPN	FMI	Condition
1246	7272	11	EFAN control circuit fault

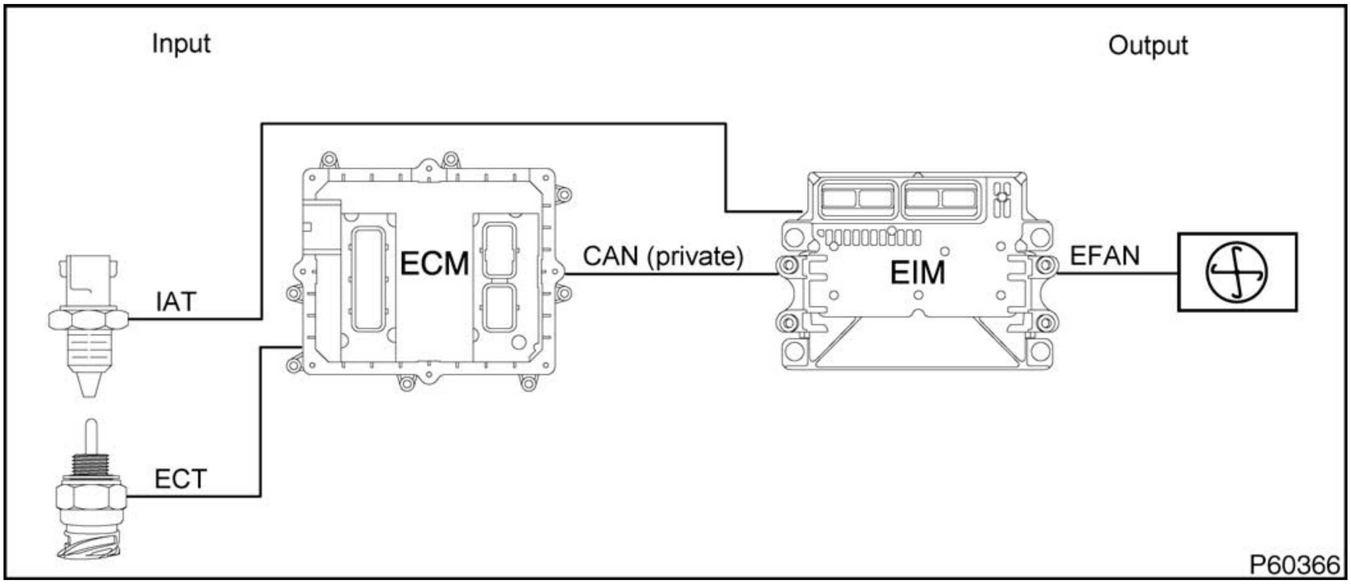

Figure 284 Function diagram for EFAN

The function diagram for EFAN includes the following:

- EFAN
- Engine Control Module (ECM)
- Engine Coolant Temperature (ECT) sensor
- Engine Interface Module (EIM)
- Intake Air Temperature (IAT) sensor

Function

The purpose of the engine fan is to force a higher airflow through the radiator when the A/C is on or the ECT or IAT goes above a set temperature.

The single-speed EFAN is an air-actuated belt-driven on-off design. When engaged the fan runs at input sheave speed, and when disengaged the fan speed is close to zero.

The two-speed EFAN is an air actuated belt-driven two-speed drive. When engaged the fan runs at input sheave speed, and when the air clutch releases, the fan runs at a nominal speed driven by a magnetic eddy current system that produces 300-400 rpm at idle and 700-900 rpm at when the engine rpm is 1900. This provides improved cooling and delays the fan coming on in high ambient temperatures or at high loads.

The difference between the single speed and two-speed EFANs is internal to the fan hub; both fans have identical external circuitry.

Location

The EFAN is mounted to the front of the engine.

Tools

- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 96-Pin Breakout Box – DLC II (page 438)
- Terminal Test Adapter Kit (page 446)

Single and Two-Speed EFAN Circuit Diagnostics

DTC	Condition	Possible Causes
1246	EFAN control circuit fault	• EFAN circuit fault • Failed EFAN

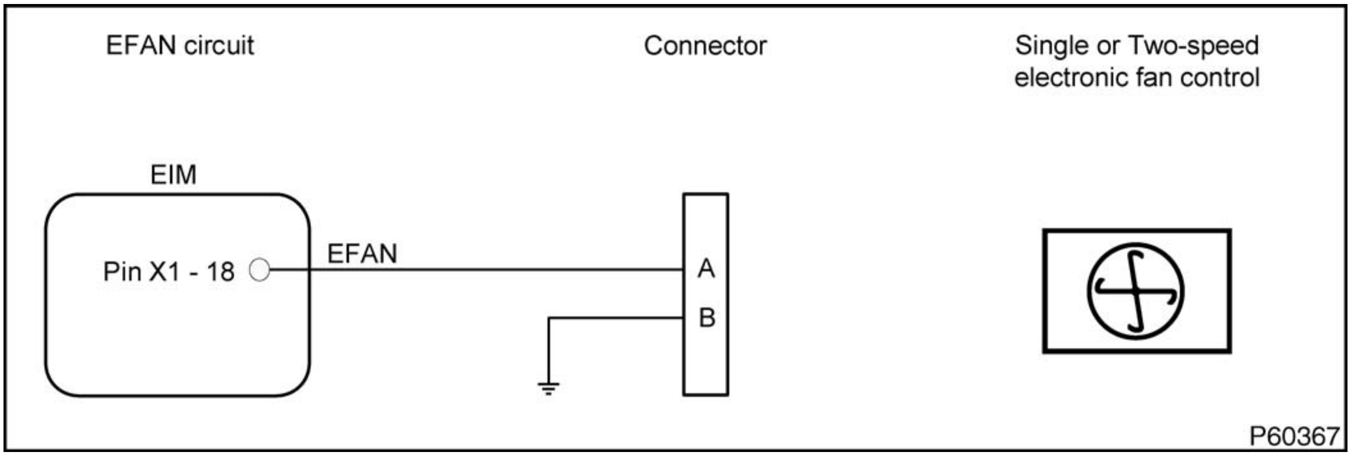

Figure 285 Single or Two-Speed EFAN circuit diagram

Voltage Check at Single or Two-Speed EFAN Connector - Actuator Test

Disconnect single or two-speed EFAN 2-pin connector. Turn the ignition switch to ON. Run Actuator Test. Use DMM to measure voltage.

Test Point	Spec	Comment
A to GND	0 V to 0.25 V	If > 0.25 V, check for short to PWR.
B to GND	0 V to 0.25 V	If > 0.25 V, check for short to PWR.
Actuator Test - at HIGH state		
A to GND	0 V to 0.25 V	If > 0.25 V, check for short to PWR.
Actuator Test - at LOW state		
A to GND	B+	If < B+, check EFAN circuit for OPEN or short to GND. Do Harness Resistance Check (page 429).

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box. Leave EIM disconnected.

Test Point	Spec	Comment
X1-18 to A	< 5 Ω	If > 5 Ω, check for OPEN circuit between EIM and EFAN.
B to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit between EFAN and GND.

If voltage and resistance measurements are within specification but DTC is still active, or EFAN does not work, replace the EFAN.

Single or Two-Speed EFAN Circuit Operation

The default state of the EFAN is ON. B+ is needed to turn the fan OFF.

EIM Pin X2-2 controls the EFAN to shut off by supplying PWR to the EFAN deactivating it.

Single or Two-Speed EFAN Programmable Parameters

By using an Electronic Service Tool (EST), an authorized service technician can program the EIM to turn the EFAN on for any desired temperature.

- Engine fan control - indicates to the on-board electronics whether or not the truck has the electronic engine fan control feature.
- Disable - enables or disables the EFAN feature.
- Fan on temperature - indicates at what coolant temperature that the fan will be electronically activated.
- Fan off temperature - indicates at what coolant temperature that the fan will be electronically deactivated.

Fault Detection / Management

An open or short to ground in the EFAN can be detected by the EIM during an on-demand engine standard test. The IAT and ECT are continuously monitored. If a DTC is detected in the IAT or ECT circuit, the EFAN control is disabled and the engine fan remains on.

Actuator Test

The actuator test allows a technician to test the actuators by measuring voltage changes and visually monitoring actuator movement.

This test first runs through the Engine Control Module (ECM) actuators, then the Aftertreatment Control Module (ACM) actuators, and finishes with the Engine Interface Module (EIM) actuators.

ECM Actuators

During the ECM portion of the actuator test, all ECM actuators are commanded to LOW state, 8% to 15% duty cycle. Then one by one, each actuator is commanded to HIGH state, 80% to 100% duty cycle. This test will not cycle the Fuel Pressure Control Valve (FPCV) or the Exhaust Lambda Sensor (ELS) heater.

ACM Actuators

During the ACM portion of the actuator test, all ACM actuators remain at 0% duty cycle. Then one by one, each actuator is cycled on. The Aftertreatment Fuel Supply (AFS) valve and Aftertreatment Fuel Drain (AFD) valve are commanded to 100%, then drop to 66%. The Aftertreatment Fuel Injector (AFI) is commanded to a low duty cycle measured in seconds from 0 (off) to 0.1 (on).

EIM Actuators

During the EIM portion of the actuator test, the actuators cycle simultaneously. Fan Control Status is 1 (on), then cycles to 0 (off). The Cold Start Relay (CSR) and Cold Start Solenoid (CSS) is 0 (off), then cycles to 1 (on).

NOTE: When the Actuator Test is running, the sensor monitoring Parameter Identifiers (PIDs) are turned off.

This test cycles the following actuators:

- ECM actuators:
  - Intake Throttle Valve (ITV)
  - Boost Control Solenoid (BCS) valve
  - Exhaust Gas Recirculation (EGR) control valve
  - Coolant Mixer Valve (CMV)
  - Coolant Flow Valve (CFV)
- EIM actuators:
  - Cold Start Relay (CSR)
  - Cold Start Solenoid (CSS) valve
  - Electronic Fan Control (EFAN)
- ACM actuators:
  - Aftertreatment Fuel Drain (AFD) valve
  - Aftertreatment Fuel Supply (AFS) valve
  - Aftertreatment Fuel Injector (AFI)

Variable EFAN Control (Electronic Engine Fan Control)

DTC	SPN	FMI	Condition
1245	7272	0	Fan speed above desired
1246	7272	11	EFAN control circuit fault

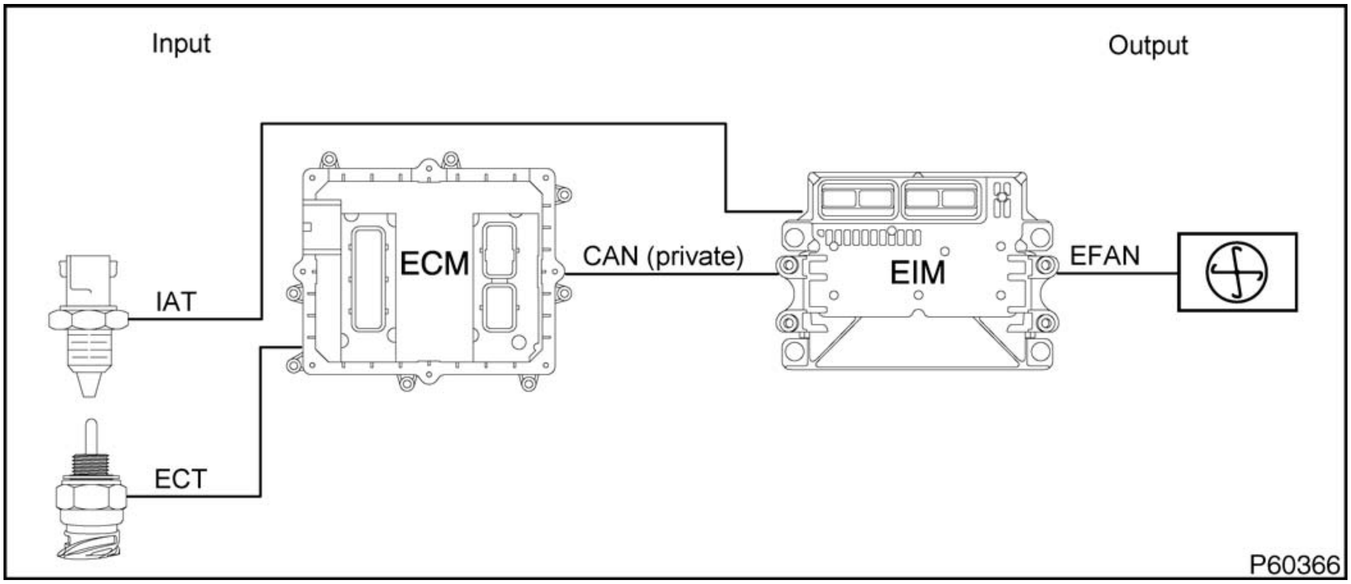

Figure 286 Function diagram for EFAN

The function diagram for EFAN includes the following:

- EFAN control
- Engine Control Module (ECM)
- Engine Coolant Temperature (ECT) sensor
- Engine Interface Module (EIM)
- Intake Air Temperature (IAT) sensor

Function

The purpose of the variable electronic engine fan is to force a higher airflow through the radiator when the A/C is on or when the ECT or IAT goes above a set temperature.

The variable EFAN is a direct-driven electronically controlled viscous fan drive. The fan has a number of operating regions.

- From 300 to 1100 engine rpm it is an on-off drive. Off is under 300 rpm, on is 99% of input speed.
- From 1100 to 1750 engine rpm it is a variable speed drive with an effective range of 800 rpm to 99% of input speed.
- From 1750 to 2150 engine rpm it is on-off again.
- From 2150 to 2450 engine rpm it is either off or 2625 rpm.
- Above 2450 engine rpm it is off.

Location

The variable EFAN is mounted on the front of the engine.

Tools

- Digital Multimeter (DMM) (Fluke 88V) (page 442)
- 96-Pin Breakout Box – DLC II (page 438)
- Engine Fan Control Breakout Harness (page 444)
- Terminal Test Adapter Kit (page 446)

EFAN Circuit Diagnostics

DTC	Condition	Possible Causes
1245	Fan speed above desired	• EFAN speed over 500 rpm for 45 seconds • EFAN circuits fault • Failed EFAN
1246	EFAN control circuit fault	• EFAN circuit fault • Failed EFAN

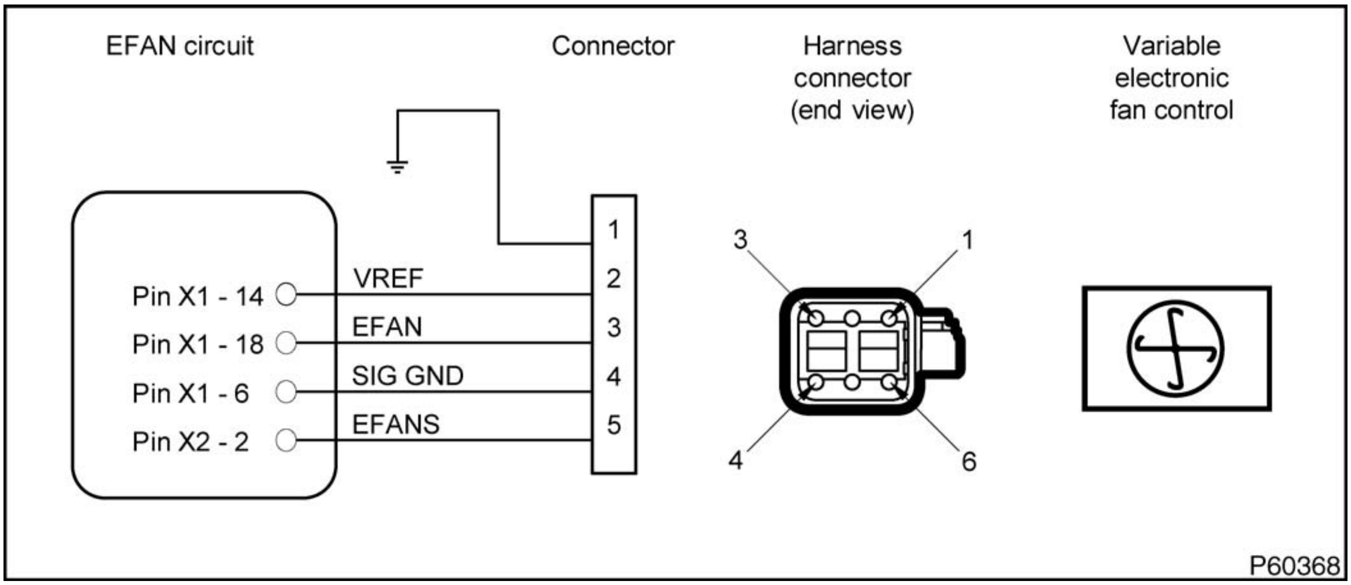

Figure 287 Variable EFAN circuit diagram

Voltage Check at Variable EFAN Connector - Actuator Test

Connect breakout harness to engine harness and leave Variable EFAN connector disconnected. Turn the ignition switch to ON. Run Actuator Test. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	0 V	If > 0.25 V, check GND for OPEN or short to PWR.
2 to GND	5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 433).
3 to GND	B+	If < B+, check EFAN for OPEN or short to GND.
4 to GND	0 V	If > 0.25 V, check SIG GND for OPEN or short to PWR.
5 to GND	5 V	If > 5.5 V, check EFANS for short to PWR. If < 4.5 V, check EFANS for OPEN or short to GND. Do Harness Resistance Check (page 433).

Voltage Check at Variable EFAN Connector - Actuator Test (cont.)

Actuator Test - at LOW state (normal state)		
3 to GND	B+	If < B+, check EFAN for OPEN or short to GND.
Actuator Test - at HIGH state		
3 to GND	0 V	If < 0 V, check EFAN for short to PWR.
If measurements are within specification, do Harness Resistance Check (page 433).		

Harness Resistance Check

Turn ignition switch to OFF. Connect the EIM breakout box. Leave EIM and EFAN disconnected.

Test Point	Spec	Comment
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN in circuit.
2 to X1-14	< 5 Ω	If > 5 Ω, check VREF for OPEN in circuit.
2 to GND	> 1 kΩ	If < 1 kΩ, check VREF for short to GND.
3 to X1-18	< 5 Ω	If > 5 Ω, check EFAN for OPEN in circuit.
3 to GND	> 1 kΩ	If < 1 kΩ, check EFAN for short to GND.
4 to X1-6	< 5 Ω	If > 5 Ω, check SIG GND for OPEN in circuit.
4 to GND	> 1 kΩ	If < 1 kΩ, check SIG GND for short to GND.
5 to X2-2	< 5 Ω	If > 5 Ω, check EFANS for OPEN in circuit.
5 to GND	> 1 kΩ	If < 1 kΩ, check EFANS for short to GND.
If voltage and resistance measurements are within specification but DTC is still active, or EFAN does not work, replace the EFAN mounted on engine.		

Variable EFAN Circuit Operation

The default state of the variable EFAN is ON. B+ is needed to turn the fan OFF.

EIM Pin X1-18 controls the EFAN to shut off by supplying B+ to the EFAN, deactivating it.

EIM Pin X2-2 controls EFAN speed by supplying a Pulse Width Modulated (PWM) signal to the EFAN.