Table of Contents

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 check
- Operational voltage check (most components)

Electronic Control System Diagnostics Form

EGED-365 Diagnostic Form Example

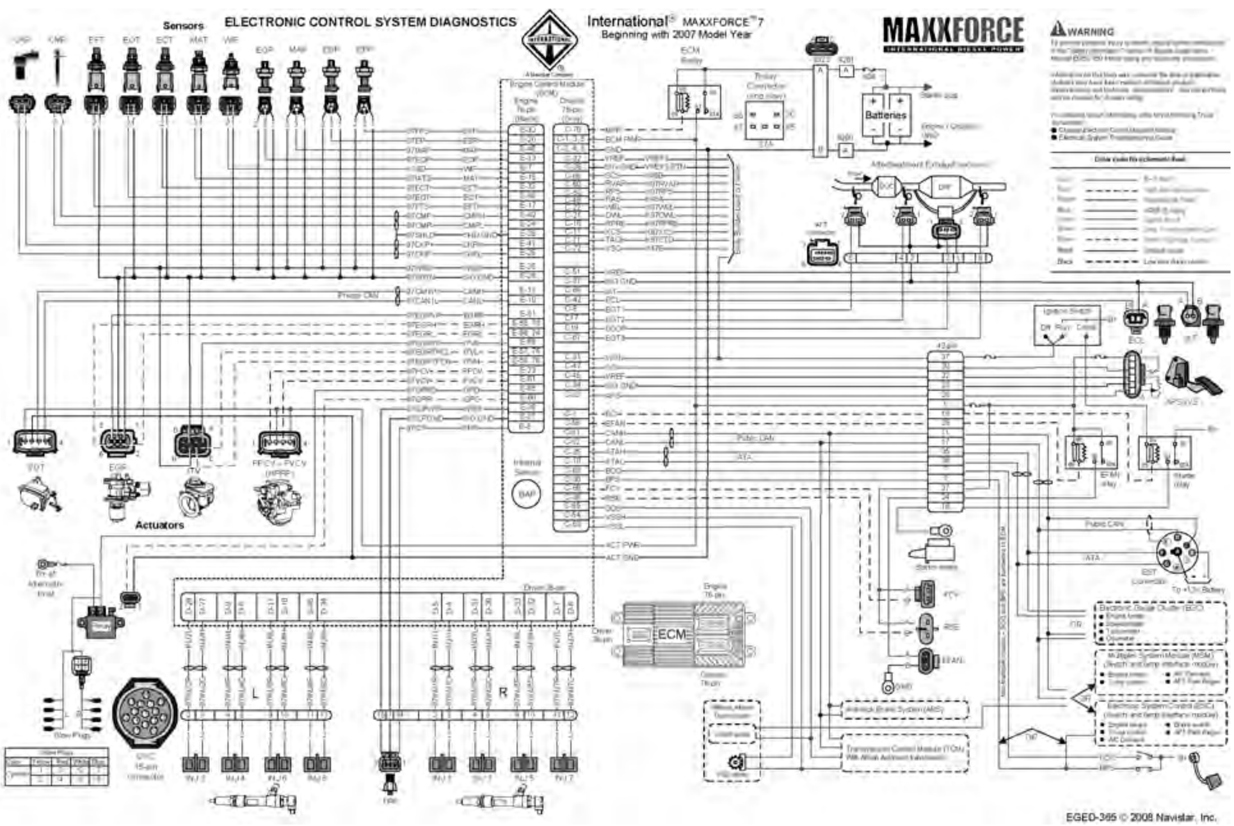

Figure 129 EGED-365 (Front Side)

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

The front side of the Electronic Control System Diagnostics form consists of a circuit diagram for electrical components mounted on the engine and chassis side. For a detailed description of chassis circuits, circuit numbers, or connector and fuse locations, see truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*. The back side of the form consists of signal values.

Diagnostic Form EGED-365 is available in 50 sheet pads. To order technical service literature, contact your International dealer.

Diagnostic Procedure Process

Description

The test procedures in this section are written based on the assumption there is a Diagnostic Trouble Code (DTC) or 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 test points, unless additional assistance is needed to pin-point the fault.

Pin Grip Inspection

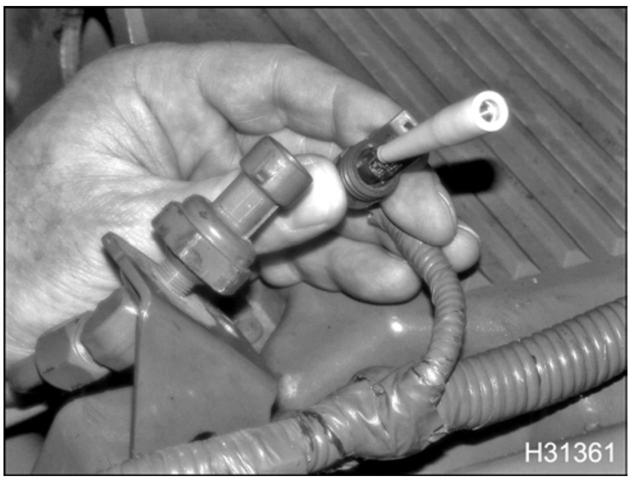

Figure 130 Pin grip check

1. Disconnect the harness 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 tool monitors sensor signal back to the Electronic Control Module (ECM) while testing the sensor's harness connection. Start this procedure with Sensor End Diagnostics.

Actuators can be diagnosed using an EST with MasterDiagnostics® software to command Output State test (high or low) while measuring voltage at the actuator's harness connection.

Diagnostics without Electronic Service Tool (EST)

Sensors can also be diagnosed using only a Digital Multimeter (DMM). Start this test procedure with Pin-point Diagnostics.

Sensor End Diagnostics (with MasterDiagnostics®)

Sensor End Diagnostics (2-Wire)

1. Connect the Electronic Service Tool (EST) to the EST connector.
2. Turn the ignition switch to ON. Leave engine off.
3. Start MasterDiagnostics® software.
4. Open the Continuous Monitor session. This session lists all engine sensors.

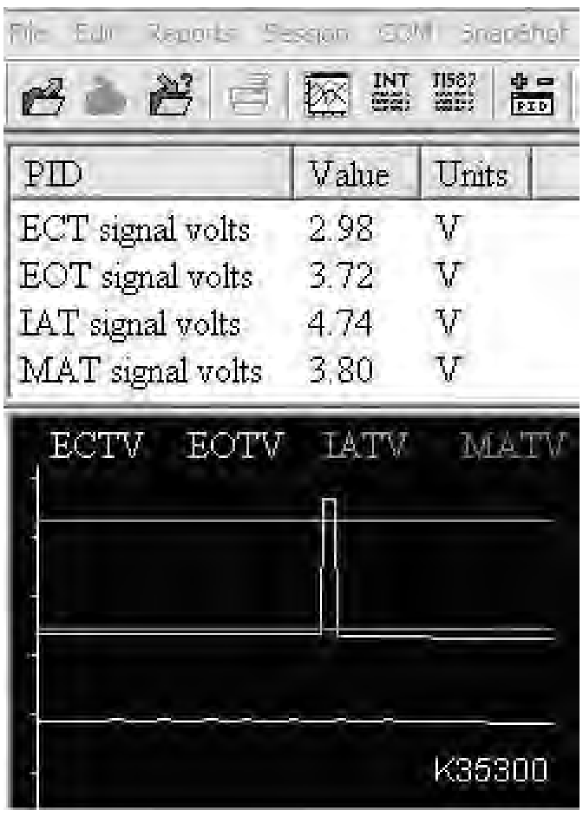

Figure 131 Sensor voltage

5. Monitor the sensor voltage and verify an active Diagnostic Trouble Code (DTC) is present.

   NOTE: If sensor signal circuit is shorted or open, the Parameter Identifier (PID) value reads NA or Error.

   - If the DTC is inactive, monitor the PID while wiggling the connector and all wires at suspected locations.

     If the circuit is interrupted, the signal spikes. Isolate the fault and repair.

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

6. Disconnect the sensor. Inspect the connector for damaged pins. Repair as necessary.

Example

Connect breakout harness, leave sensor disconnected. Verify correct DTC goes active when corresponding fault is induced.

Test Point	Spec	Comments
EST – Check DTC	DTC 1312	If DTC 1311 is active, check EOT signal for short to GND. Do Harness Resistance Checks.

- If corresponding DTC does not go active, repair short to ground on the sensor signal circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If corresponding DTC goes active, continue to next test point.

7. Short a 3-banana plug harness across the sensor signal circuit and engine ground.
8. The corresponding DTC should go active, unless the sensor signal circuit is open.

Example

Test Point	Spec	Comments
EST – Check DTC Short a 3-banana plug harness across 2 and GND	DTC 1311	If DTC 1312 is active, check EOT signal for OPEN. Do Harness Resistance Checks.

- If corresponding DTC does not go active, repair open in sensor signal circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If corresponding DTC goes active, continue to next test point.

9. Short a 3-banana plug harness across the sensor signal circuit and SIG GND circuit.
10. The corresponding DTC should go active, unless the SIG GND circuit is open.

Example

Test Point	Spec	Comments
EST – Check DTC Short a 3-banana plug harness across 1 and 2	DTC 1311	If DTC is active, check SIG GND for OPEN. Do Harness Resistance Checks.

- If corresponding DTC does not go active, repair open in SIG GND circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If within specification, and both circuits tested are okay, continue to the last step.

11. Connect the sensor and clear the DTCs, start the engine, and cycle the accelerator pedal a few times. If the active DTC remains, the sensor must be at fault. Replace the failed sensor.

Example

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

Sensor End Diagnostics (3-Wire)

1. Connect the Electronic Service Tool (EST) to the EST connector.
2. Turn the ignition switch to ON. Leave engine off.
3. Start MasterDiagnostics® software.
4. Run Continuous Monitor session. (This session lists all engine sensors.)

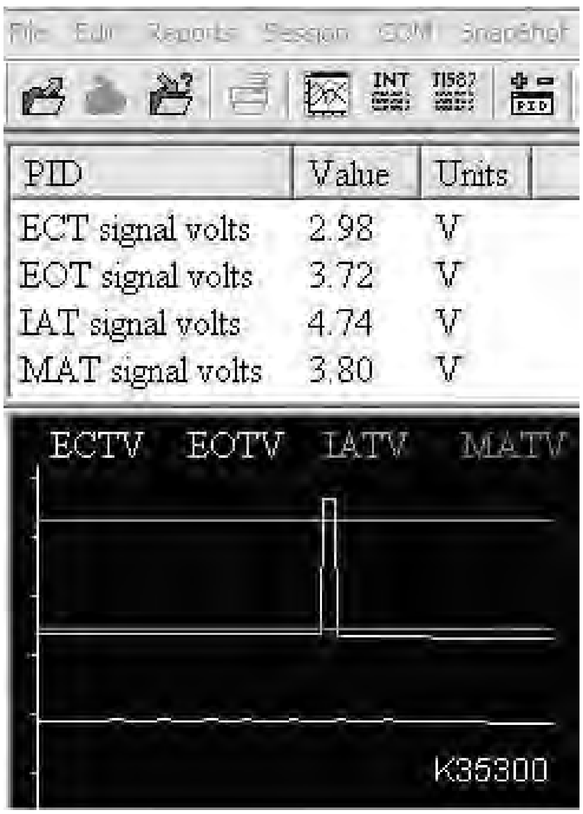

Figure 132 Sensor voltage

5. Monitor the sensor voltage and verify an active Diagnostic Trouble Code (DTC) is present.

   NOTE: If sensor signal circuit is shorted or open, the Parameter Identifier (PID) value reads NA or Error.

   - If the DTC is inactive, monitor the PID while wiggling the connector and all wires at suspected locations.

     If the circuit is interrupted, the signal spikes. Isolate the fault and repair.

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

6. Disconnect the sensor. Inspect the connector for damaged pins. Repair as necessary.

Example

Test Point	Spec	Comments
EST – Check DTC	DTC 1122	If DTC 1121 is active, check MAP signal for short to PWR

- If corresponding DTC does not go active, repair short to voltage on sensor signal circuit.
- If corresponding DTC goes active, continue to next test point.

7. Use a Digital Multimeter (DMM) to measure voltage on the VREF circuit. 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	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 Checks.

- 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.

8. Short a 3-banana plug harness across VREF and sensor signal circuit.
9. The corresponding DTC should go active, unless the signal circuit is open.

Example

Test Point	Spec	Comments
EST – Check DTC Short breakout harness across 2 and 3	DTC 1121	If DTC 1122 is active, check MAP signal for OPEN or short to GND. Do Harness Resistance Checks.

- If corresponding DTC does not go active, repair open in sensor signal circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If corresponding DTC goes active, continue to the next test point.

10. 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 Checks.

- 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.

11. Connect the sensor and clear the DTCs. If the active DTC remains, the sensor must be at fault. Replace the failed sensor.

Example

If checks are within specification, connect sensor and clear DTCs. If active DTC 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. Leave the engine off.
3. Use a Digital Multimeter (DMM) to measure voltage on each circuit to engine ground.

Example

Test Point	Spec	Comment
2 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.

- If the circuit is not within specification, the comment area lists possible cause 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 - Output State Test

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

1. Disconnect actuator. Inspect connector for damaged pins. Repair as necessary.
2. Connect breakout harness between engine harness and actuator.
3. Connect the Electronic Service Tool (EST) with MasterDiagnostics® software to the EST connector.
4. Turn the ignition switch to ON. Leave engine off.
5. Start MasterDiagnostics® software.
6. Open the Output State session. This session allows you to monitor the state of all engine actuators.
7. Run the Output State test (high or low) or Glow Plug/Intake Air Heater test.
8. Use a Digital Multimeter (DMM) to measure voltage on each circuit to engine ground.

Example

Test Point	Test	Spec	Comment
A to GND	KOEO	B+	If < B+, check for OPEN circuit or blown fuse
B to GND	Output State HIGH	B+	If < B+, check actuator control circuit for short to GND.
B to GND	Output State LOW	7.5 V	If > 7.5 V, check actuator control circuit for OPEN or short to PWR or failed actuator 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 circuit from voltage before continuing.

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

1. Turn the ignition switch to OFF or disconnect batteries.
2. Connect breakout box and breakout harness to chassis or engine harness. Leave Electronic Control Module (ECM) and sensor or actuator disconnected.
3. Use a Digital Multimeter (DMM) to measure resistance on each circuit from point-to-point, then to engine ground.

Example

Test Point	Spec	Comment
E-66 to 2	< 5 Ω	If > 5 Ω, check EOT circuit for OPEN.
E-66 to GND	> 1 k Ω	If < 1 k Ω, check EOT 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 Electronic Control Module (ECM) and the component being tested.
2. Turn the ignition switch to ON.
3. Connect the Electronic Service Tool (EST) with MasterDiagnostics® software to the EST connector.
4. Using MasterDiagnostics® software, open Continuous Monitor session or Output State test session (depending upon what is being tested).
5. Run the Continuous Monitor test.
6. 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

AFT System (Aftertreatment)

DTC	SPN	FMI	Condition
2687	8302	1	DPF, low flow resistance
2688	8302	0	DPF over temperature - possible filter damage
2782	8317	13	DPF servicing required
2783	8318	13	DPF load: above warning level
2784	8319	13	DPF load: above critical level 1 - engine de-rate
2785	8320	13	DPF load: above critical level 2 - further engine de-rate
3786	8326	2	DPF Test - test unsuccessful

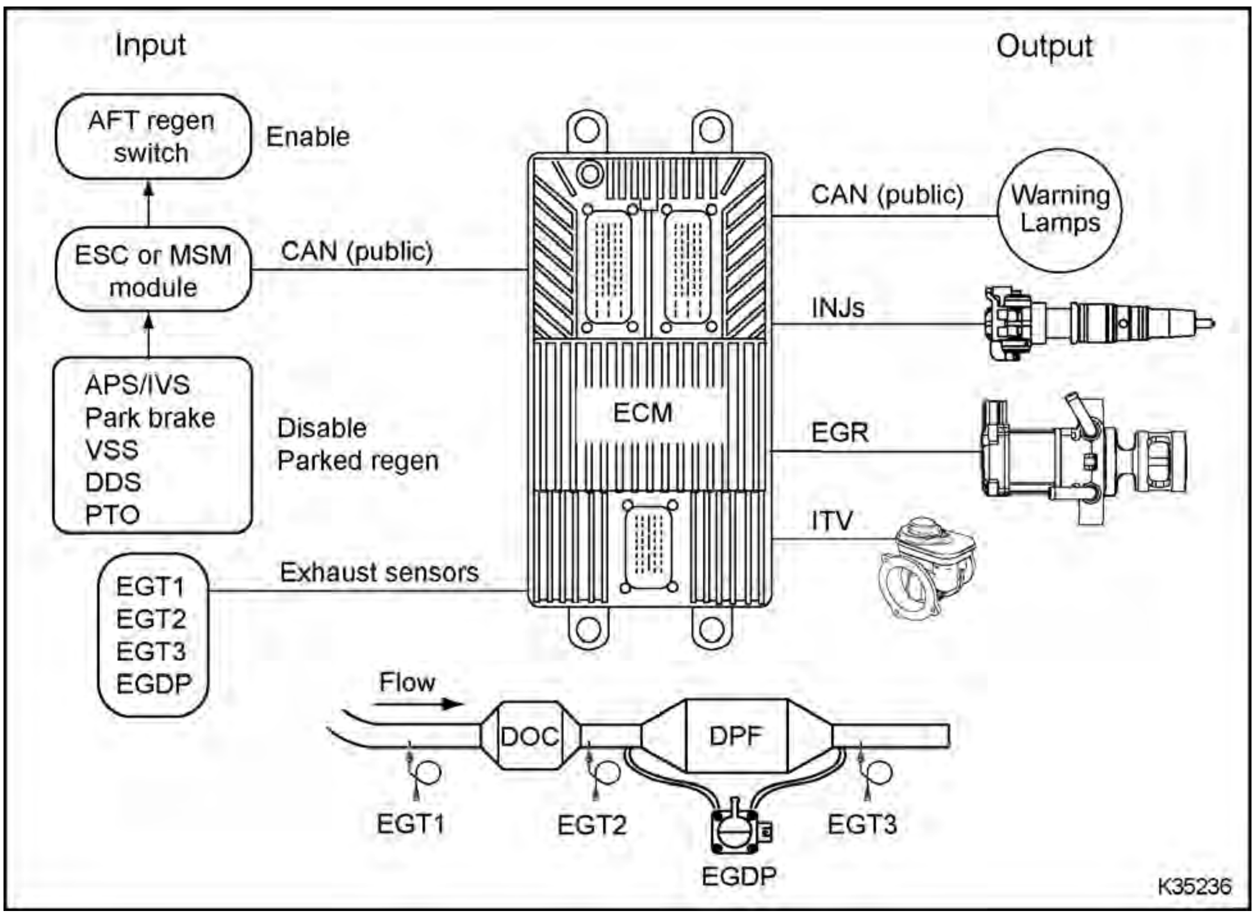

Figure 133 Function diagram for AFT system

The function diagram for the AFT system includes the following:

- 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
- Fuel Injectors (INJs)
- Exhaust Gas Recirculation (EGR)
- Intake Throttle Valve (ITV)
- Malfunction Indicator Lamp (MIL)
- Warn Engine Lamp (WEL)
- Oil/Water Lamp (OWL)
- Inhibit regeneration switch
- Electronic System Control (ESC) body module
- Multiplex System Module (MSM) body module
- 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 harmful exhaust emissions. The DPF captures particulate matter (soot) and ash from the exhaust. Soot builds up in the DPF and must occasionally be heated and turned into ash, this is the DPF regeneration process. Ash build-up is periodically removed from the DPF by a special cleaning machine.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit

AFT System Diagnostics

DTC	Condition	Possible Causes
2687	DPF, low flow resistance	• Biased EGDP sensor • Leaks in EGDP sensor hose • Reversed pressure lines on EGDP sensor • Exhaust leak before DPF • Damaged DPF
2688	DPF over temperature - possible filter damage	• Biased high EGT2 sensor • Restricted DPF • Restricted exhaust • Engine over-fueling
2782	DPF servicing required	• DPF needs to regenerate
2783	DPF load: above warning level	
2784	DPF load: above critical level 1 - engine de-rate	
2785	DPF load: above critical level 2 - further engine de-rate	• Replace or clean out DPF, beyond ability to regenerate.
3786	DPF Test - test unsuccessful	• Other active DTCs • Over full DPF - service required

Alert Levels of DPF Soot Loading

There are four levels indicating 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 auto-regenerate. OR Start a parked regeneration to prevent loss of power.
Regeneration lamp flashing	DPF is full	Pull vehicle safely off roadway and start a parked regeneration to prevent loss of power.
Regeneration lamp flashing WEL solid Audio alarm beeps five times every minute	DPF is full engine performance is limited	Pull vehicle safely off roadway 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 roadway 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 is above 400° C (750° F) and a regeneration could be in process.		

DTC 2687 – DPF, low flow resistance

DTC 2687 sets 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 (page 253) in this section of the manual.
3. Check for damaged DPF. Remove and inspect for cracks that could allow exhaust gas to bypass the filter.

DTC 2688 – DPF over temperature - possible filter damage

DTC 2688 sets when the temperature before or after the DPF is greater than the calibrated limit.

Pin-point AFT System Fault

1. Inspect EGT sensors for damage.
2. Inspect exhaust system for damage that could cause restriction.
3. Verify EGT sensors are within specification. See "Performance Specifications" section of this manual.
4. Check engine performance and verify engine is not over-fueling.
5. Check for damaged DPF. Remove and inspect for blockage.

DTC 2782 – DPF servicing required

DTC 2782 sets when Level 1 DPF soot loading is above 80% full and a DPF regeneration is required.

Pin-point AFT System Fault

1. Check for active DTCs that could prevent AFT system regeneration.
2. Drive vehicle at highway speeds for 20 to 30 minutes until the regeneration lamp is not illuminated or do a Manual Parked Regeneration Procedure (page 175).

DTC 2783 – DPF load: above warning level

DTC 2783 sets when Level 2 DPF soot loading is 100% full and a DPF regeneration is required.

Pin-point AFT System Fault

1. Check for active DTCs that could prevent AFT System regeneration.
2. Do a Manual Parked Regeneration Procedure (page 175).

DTC 2784 – DPF load: above critical level 1 - engine de-rate

DTC 2784 sets when Level 3 DPF soot loading is over 100% full and engine de-rate has been enabled. DPF regeneration is required.

Pin-point AFT System Fault

1. Check for active DTCs that could prevent AFT System from regenerating.
2. Do a Manual Parked Regeneration Procedure (page 175).

DTC 2785 – DPF load: above critical level 2 - further engine de-rate

DTC 2785 sets when level 4 DPF soot loading is overfull and engine shutdown is enabled.

Pin-point AFT System Fault

1. Remove DPF and service the filter.
2. Check for active DTCs that could prevent the AFT system from regenerating.
3. Do an Onboard Cleanliness Test to reset soot and ash monitors.

DTC 3786 – DPF Test - test unsuccessful

DTC 3786 sets when a Manual Parked Regeneration can not regenerate the DPF

Pin-point AFT System Fault

1. Check for the following active DTCs: 1114, 1115, 1141, 1142, 1299, 1311, 1312, 1397, 1398, 1742, 1741, 2159, 2544, 2545, 2673, 2674
2. If only DTC 3786 sets after doing a Manual Parked Regeneration, remove the DPF and service the filter.

AFT System Operation

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

When driving at lower speeds or lighter loads, the exhaust 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.

An automatic regeneration is not possible during frequent stops or low operating speeds. If a regeneration is required in these conditions, do a manual parked regeneration.

Active Rolling Regeneration

When the 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, 2673, 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, 1299, 1311, 1312, 1397, 1398, 1742, 1741, 2159, 2544, 2545, 2673, 2674)
- ECT above 65 °C (150 °F)
- Engine running
- Vehicle speed below 2 mph
- Parking brake must be set
- Brake pedal not pressed
- Accelerator pedal not pressed
- PTO not active
- Driveline disengaged
- Turn inhibit regeneration switch to OFF
- EGT2 and EGT3 below 500 °C (932 °F)

Manual Parked Regeneration Procedure

WARNING: To prevent personal injury or death, make certain the vehicle is safely off the roadway, away from people, and flammable materials or structures. The regeneration process creates an elevated exhaust temperature.

It is necessary to do a manual parked regeneration when the exhaust filter indication (level 2) is on or the engine will lose power and shut down.

To start manual 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 regeneration (using ON/PARKED 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 minimum 71 °C (160 °F)
   - Accelerator, foot brake, or clutch pedal (if equipped) must not be pressed
3. Press the ON position of the ON/PARKED REGEN switch to initiate the regeneration cycle.

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

   The regeneration cycle lasts approximately 20 minutes.
4. When the regeneration cycle is complete, the indicator 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.

Onboard Cleanliness Test (EST enabled)

The onboard cleanliness test performs a manual regeneration and measures DPF ash/soot levels before and after the test. This test is required after a DPF has been serviced or replaced to reset DPF monitors.

Parked Regeneration Switch

The parked regeneration 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 the need to regenerate the DPF. There are several DPF loading status levels. The lamp changes states from off, to solid on, to flashing. The lamp is used in combination with the Warn Engine Lamp (WEL) and Oil/Water Lamp (OWL).

High Exhaust System Temperature (HEST) Indicator

The HEST indicator 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
2351	7129	1	EBP below desired level
2352	7129	0	EBP above desired level
2388	2659	0	EGR flow excessive - possible leak to atmosphere
2389	2659	1	EGR flow insufficient - possible plugged system
3338	7129	17	KOER STD - EBP unable to build during test
3339	7129	15	KOER STD - EBP too high during test
3346	1209	0	AMT - EBP unable to build during EGR test
3348	1209	1	AMT - EBP too high during EGR test

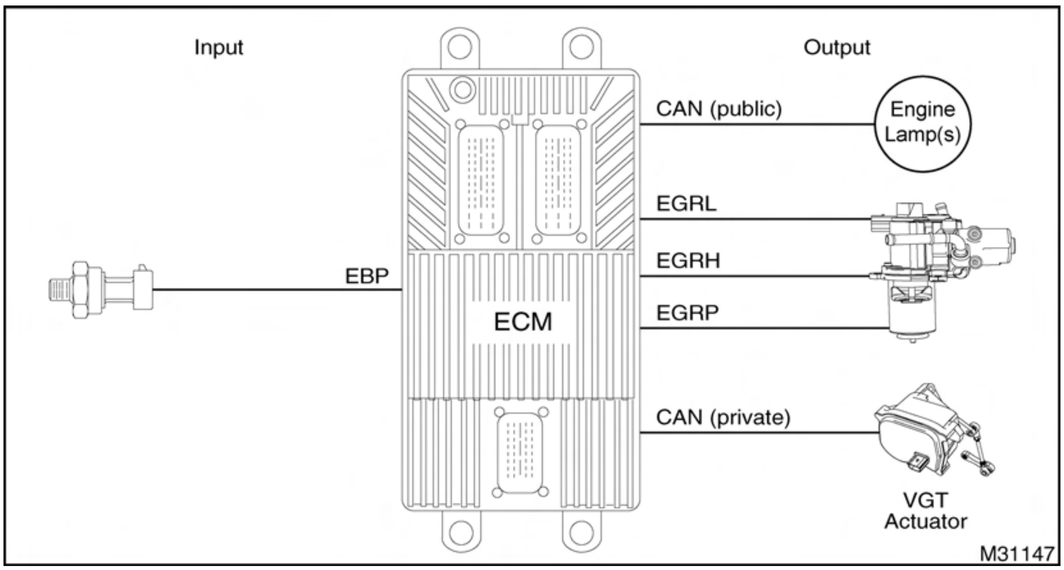

Figure 134 Function diagram for AMS

The Air Management System (AMS) includes the following:

- Electronic Control Module (ECM) with integrated Barometric Absolute Pressure (BAP) sensor
- Exhaust Back Pressure (EBP) sensor
- Variable Geometry Turbocharger (VGT) actuator
- Exhaust Gas Recirculation (EGR) actuator
- Malfunction Indicator Lamp (MIL)

Function

The Air Management system controls the intake air flow and pressure. The EGR recirculates exhaust gasses into the intake stream for cooler combustion which reduces the formation of NOx gasses. The VGT is used to increase the air pressure and density for increased performance. The VGT has actuated vanes in the turbine housing that modify air flow characteristics of the exhaust gasses through the turbine housing. The benefits of the VGT are the ability to control boost pressure for various engine speeds and loads while lowering emissions. The ECM uses the EBP sensor to monitor exhaust pressure and adjust VGT duty cycle.

Tools

- Electronic Service Tool (EST) with MasterDiagnostic® software
- EZ-Tech® Interface Kit

AMS Diagnostics

DTC	Condition	Possible Causes
2351 3338	EBP below desired level KOER STD - EBP unable to build during test	• Charge Air Cooler (CAC) system leaks • Exhaust or intake air system leaks • Biased EBP circuit or sensor • Turbocharger vanes sticking
2352 3339	EBP above desired level KOER STD - EBP too high during test	• Biased EBP circuit or sensor • Restricted exhaust system • Turbocharger vanes sticking
2388	EGR flow excessive - possible leak to atmosphere	• Restricted air flow (intake or exhaust) • CAC system leaks (hoses and cooler) • Biased EGR valve position sensor • Biased EBP circuit or sensor • Biased MAP circuit or sensor • EGR valve sticking or stuck
2389	EGR flow insufficient - possible plugged system	• Restricted air flow (intake or exhaust) • Restricted EGR cooler • Biased EGR valve position sensor • Biased EBP circuit or sensor • Biased MAP circuit or sensor • EGR valve sticking or stuck
3346	AMT - EBP unable to build during EGR test	• EGR valve inoperative or sticking • Biased EBP circuit or sensor • Restricted exhaust system • EBP sensor or tube plugged
3348	AMT - EBP too high during EGR test	• Biased EBP circuit or sensor • Exhaust or intake air system leaks • Inoperative EGR valve • Failed turbocharger

DTC 2351 - EBP below desired level

DTC 2351 sets when EBP is 10 psi below desired level.

3338 - KOER STD - EBP unable to build during test.

DTC 3338 sets when EBP is 6 psi below desired level during the KOER Standard test.

Pin-point AMS Fault

1. Check for other active or inactive EBP, MAP, VGT or EGR DTCs. Repair any electrical fault before continuing with this procedure.
2. Check for biased sensor. Verify BAP, MAP and EBP are within KOEO Specification. See Key-On Engine-Off for the applicable engine horsepower in the “Performance Specifications” section of this manual.
3. Check VGT operation. Run KOEO Standard test while visually inspecting VGT lever for full open and close movement.
4. Check EGR operation. Monitor EGRP PID and run KOEO Output State test HIGH and LOW. See EGR Actuator (page 258) in this section.
5. Check intake and exhaust system for leaks.

DTC 2352 - EBP above desired level

DTC 2352 sets when EBP is 10 psi above desired level.

3339 - KOER STD - EBP too high during test.

DTC 3339 sets when EBP is 3 psi above desired level during the KOER Standard test.

Pin-point AMS Fault

1. Check for other active or inactive EBP, MAP, VGT or EGR DTCs. Repair any electrical fault before continuing with this procedure.
2. Check for biased sensor. Verify BAP, MAP and EBP are within KOEO specification. See Key On Engine Off for the applicable engine horsepower in the “Performance Specifications” section of this manual.
3. Check VGT operation. Run KOEO Standard test while visually inspecting VGT lever for full open and close movement.
4. Check EGR operation. Monitor EGRP PID and run KOEO Output State test HIGH and LOW. See EGR Actuator (page 258) in this section.
5. Check for restricted exhaust. See Full Load Rated Speed for the applicable engine horsepower in the “Performance Specifications” section of this manual.

DTC 2388 - EGR flow excessive - possible leak to atmosphere

Estimated EGR percent is greater than the maximum limit for the operating conditions.

Pin-point AMS Fault

1. Check for other active or inactive EBP, MAP, VGT or EGR DTCs. Repair any electrical fault before continuing with this procedure.
2. Check for biased sensor. Verify BAP, MAP and EBP are within KOEO Specification. See Key-On Engine-Off for the applicable engine horsepower in the “Performance Specifications” section of this manual.
3. Check EGR operation. Monitor EGRP PID and run KOEO Output State test HIGH and LOW. See EGR Actuator (page 258) in this section.

DTC 2389 - EGR flow insufficient - possible plugged system

Estimated EGR percent is less than the minimum limit for the operating conditions.

Pin-point AMS Fault

1. Check for other active or inactive EBP, MAP, VGT or EGR DTCs. Repair any electrical fault before continuing with this procedure.
2. Check for biased sensor. Verify BAP, MAP and EBP are within KOEO Specification. See Key-On Engine-Off for the applicable engine horsepower in the “Performance Specifications” section of this manual.
3. Check for restricted EGR cooler, see EGR Cooler Inspection in “Engine Symptoms Diagnostics” section of this manual.
4. Check EGR operation. Monitor EGRP PID and run KOEO Output State test HIGH and LOW. See “EGR Actuator (page 258) in this section.
5. Check for restricted exhaust. See Full Load Rated Speed for the applicable engine horsepower in the “Performance Specifications” section of this manual.

DTC 3346 - AMT - EBP unable to build during EGR test

This code sets if EBP does not meet expected response during the AMS test.

Pin-point AMS Fault

1. Check for active or inactive EBP DTCs, see EBP Sensor (page 211) and check EBP KOEO specification.
2. Check for plugged EBP sensor or tubing.
3. Check for active or inactive DTCs, see appropriate pin-point test.
4. Check EGR valve, see EGR Pin-point test and run output high and low, while monitoring EGRP sensor.
5. Check for restricted exhaust system.

DTC 3348 - AMT - EBP too high during EGR test

DTC sets when EBP does not meet expected response during the EGR portion of the AMS test.

Pin-point AMS Fault

1. Check for other active or inactive EBP, MAP, VGT, or EGR DTCs. Repair any fault before continuing with this procedure.
2. Check for biased sensor. Verify BAP, MAP and EBP are within KOEO specification. See Key-On Engine-Off for the applicable engine horsepower in “Performance Specifications” section of this manual.
3. Check EGR operation. Monitor EGRP PID, Run KOEO Output State HIGH and LOW. See EGR Actuator (page 258) in this section.
4. Check intake and exhaust system for leaks.

AMS Operation

The AMS test checks the operation of the VGT and EGR by actuating each component open and closed while monitoring the effect it has on exhaust back pressure using the EBP sensor. The test sequence is carried out as follows.

The ECM monitors the BAP sensor as a baseline for zeroing the MAP and EBP signals.

VGT portion

The ECM commands the EGR valve to close, then increases engine idle speed to 950 rpm. The VGT vanes are commanded to open and EBP is allowed to stabilize (EBP is expected to drop). The VGT vanes are then commanded to close and EBP is allowed to stabilize (EBP is expected to increase). If pressure results do not match expected values for either condition, DTC 3345 sets, the engine returns to 700 rpm, and the test completes without running the EGR portion.

NOTE: Although commanding the EGR to close, it may be stuck partially open and cause EBP values to be lower than expected. This would cause the VGT portion of the test to fail. If this is suspected, the operation of the EGR valve should be visually inspected while doing the Output State tests.

If the VGT portion of the test completes without fault, no DTC sets, and the test continues for the EGR portion.

EGR portion

The EGR valve and VGT vanes are still closed, the ECM increases engine idle speed to 1200 rpm and EBP is allowed to stabilize (EBP is expected to increase). The EGR is then commanded open and EBP is allowed to stabilize (EBP is expected to drop). The EGR is then commanded closed and EBP is allowed to stabilize (EBP is expected to increase). If pressure results do not match expected values for either position, DTC 3346 sets, the engine returns to 700 rpm, and the test is complete.

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

DTC	SPN	FMI	Condition
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

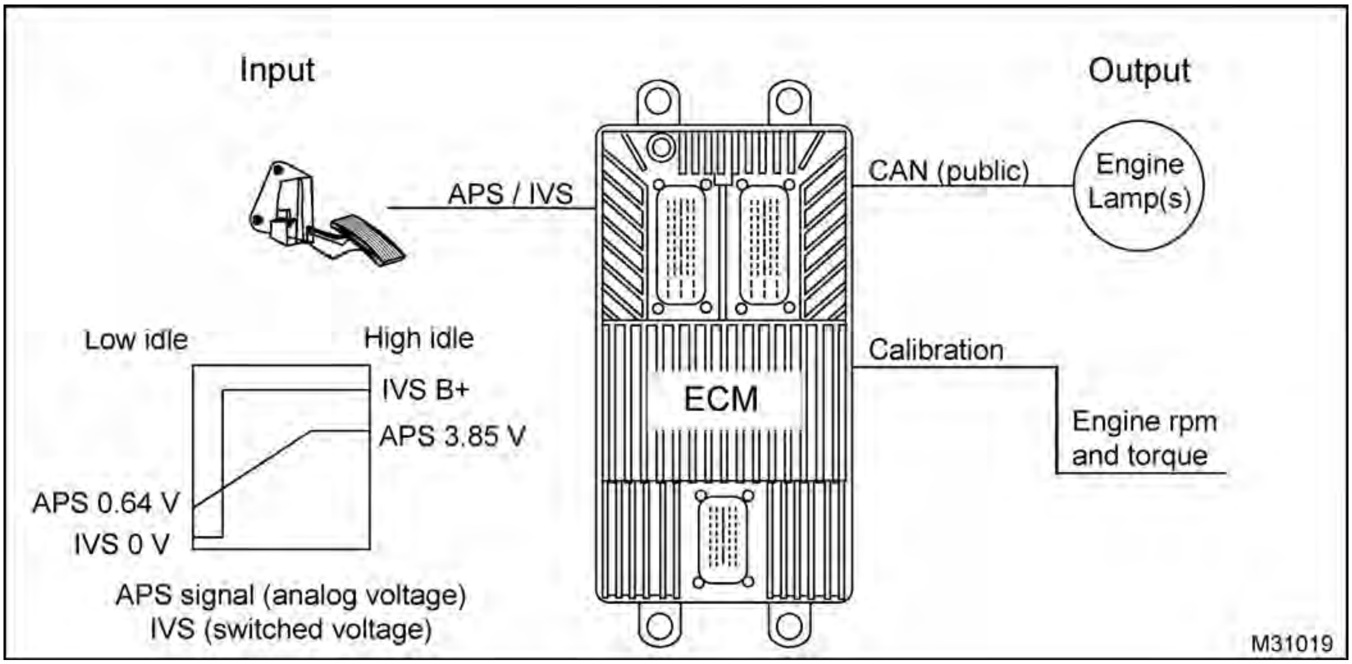

Figure 135 Function diagram for the APS/IVS

The APS/IVS function diagram includes the following:

- Accelerator Position Sensor/Idle Validation Switch (APS/IVS)
- Electronic Control Module (ECM)
- Warn Engine Lamp (WEL)

Function

The APS/IVS is controlled by the operator. The ECM uses APS/IVS input to control engine acceleration based on the operator’s demand for power.

Sensor Location

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

Tools

- Electronic Service Tool (EST) with MasterDiagnostic® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 180-Pin Breakout Box
- APS/IVS Breakout Harness
- Terminal Test Adapter Kit

APS/IVS Sensor End Diagnostics

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

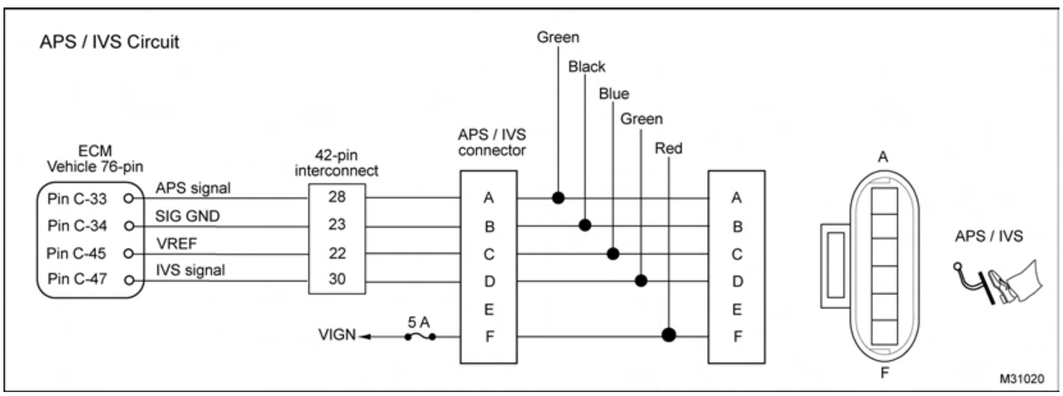

Figure 136 APS/IVS circuit diagram

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

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Verify sensor voltage is within KOEO specification. See “Performance Specifications” section of this manual.
3. 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 will spike and the DTC will go active.
   - If DTC is active, proceed to the next step.
4. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

5. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

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. Use DMM to measure circuits.

Test Point	Spec	Comments
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 Check (page 187).
EST – Check DTC Short breakout harness across A and C	DTC 1132	If DTC 1131 is active, check APS signal for OPEN. Do Harness Resistance Check (page 187).
DMM – Measure resistance B to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 187).
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 pedal a few times. If active DTC returns, replace sensor.		

APS/IVS Pin-point Diagnostics

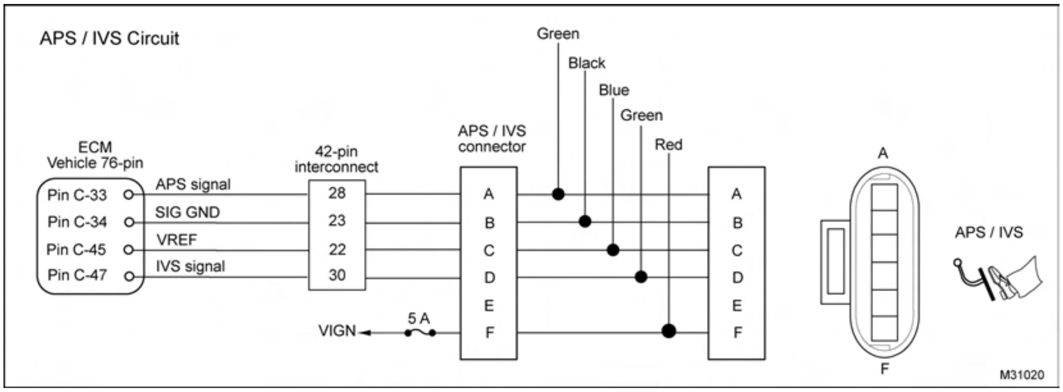

Figure 137 APS/IVS circuit diagram

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 Check (page 187).
D to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 187).
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. Disconnect both battery GND cables. Connect breakout box and breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

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

Test Point	Spec	Comment
A to C-33	< 5 Ω	If > 5 Ω, check APS signal circuit for OPEN.
B to C-34	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
C to C-63	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
D to C-47	< 5 Ω	If > 5 Ω, check IVS signal circuit for OPEN.
F to Fuse	< 5 Ω	If > 5 Ω, check PWR circuit for OPEN.

Operational Voltage Check

Connect breakout box or breakout harness between ECM 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 C-33 to GND	Pedal to floor	3.85 V ± 0.5 V	100%
IVS	Foot off pedal	0 V	Low Idle
D to GND or C-47 to GND	Pedal to floor	B+	Off Idle

APS/IVS Circuit Operation

The APS/IVS is integrated into one component and mounted on the accelerator pedal. The APS/IVS can be replaced separately.

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

Accelerator Position Switch (APS)

The APS is a potentiometer sensor supplied with a 5 volt reference voltage at Pin C from ECM Pin C-63. The sensor is grounded at Pin B from ECM Pin C-34. The sensor returns a variable voltage signal from Pin A to ECM Pin C-33.

Idle Validation Switch (IVS)

The IVS is an ON/OFF switch supplied B+ on Pin F from ACT PWR. The switch sends an ON or OFF idle voltage signal from Pin D to ECM Pin C-47.

APS Auto-Calibration

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

Fault Detection/Management

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

Any malfunction of the APS/IVS sensor circuit illuminates the WEL. If the ECM 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 and the ECM determines it is an IVS fault, the ECM only allows a maximum of 50% APS to be commanded. If the ECM cannot discern if it is an APS or IVS fault, the engine will operate at low idle only.

NOTE: If multiple APS/IVS DTCs are present, verify 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 Data Link (American Trucking Association)

DTC	SPN	FMI	Condition
None			No communication to EGC

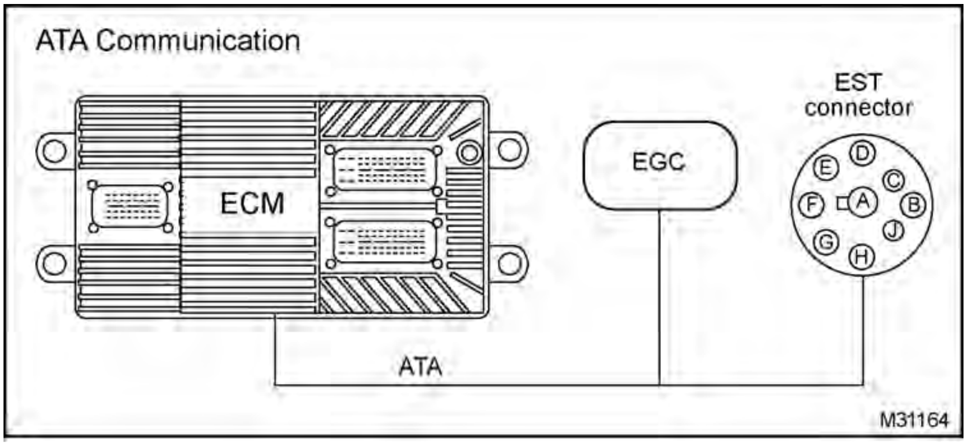

Figure 138 Function diagram for ATA

The function diagram for ATA includes the following:

- Electronic Control Module (ECM)
- Electronic Gauge Cluster (EGC)
- Electronic Service Tool (EST) connector

Function

The ATA data link provides communication between the ECM and an ATA compatible EGC module. The EST can access this data link at the EST connector.

Location

The ATA circuits are connected to the ECM, EGC and EST connector. The EST connector is located under the dash on the driver's side.

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- Terminal Test Adapter Kit

ATA Pin-point Diagnostics

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

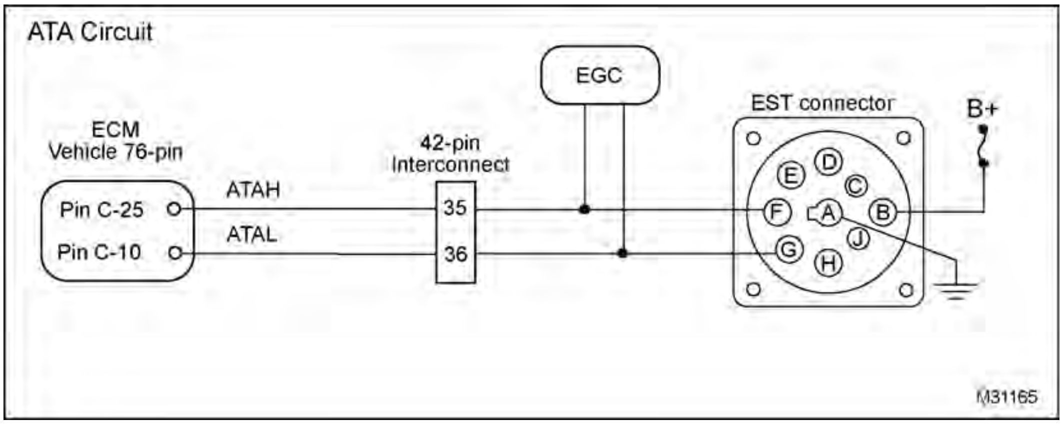

Figure 139 ATA circuit diagram

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 EST connector for OPEN or short to GND, or blown fuse.
B to A	B+	If < B+, check GND circuit to EST 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.

See *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for EGC diagnostic information.

Harness Resistance Check

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

Test Point	Spec	Comment
F to C-25	< 5 Ω	If > 5 Ω, check ATAH for OPEN in circuit
F to GND	> 1 kΩ	If < 1 kΩ, check ATAH for short to GND
G to C-10	< 5 Ω	If > 5 Ω, check ATAL for OPEN in circuit
G to GND	> 1 kΩ	If < 1 kΩ, check ATAL for short to GND
A to GND	< 5 Ω	If > 5 Ω, check GND for OPEN in circuit

ATA Operation

EST Connector

The fuse protected B+ signal is supplied to the EST connector through Pin B and ground is through Pin A. American Trucking Association High (ATAH) signal runs from ECM Pin C-25 and EST connector Pin F. American Trucking Association Low (ATAL) signal runs from ECM Pin C-10 and EST connector Pin G.

Electronic Gauge Cluster (EGC)

There are two types of EGC modules, one uses Controller Area Network (CAN) communication and the other uses ATA communication. The following information is sent through data communication:

- Warn Engine Lamp (WEL)
- Malfunction Indicator Lamp (MIL)
- Coolant level lamp
- Wait to start lamp
- Oil/Water Lamp (OWL)
- 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 DTCs for ATA communication faults. See *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 will disrupt communication.

Brake Switch Circuits

DTC	SPN	FMI	Condition
1222	597	2	Brake switch circuit fault

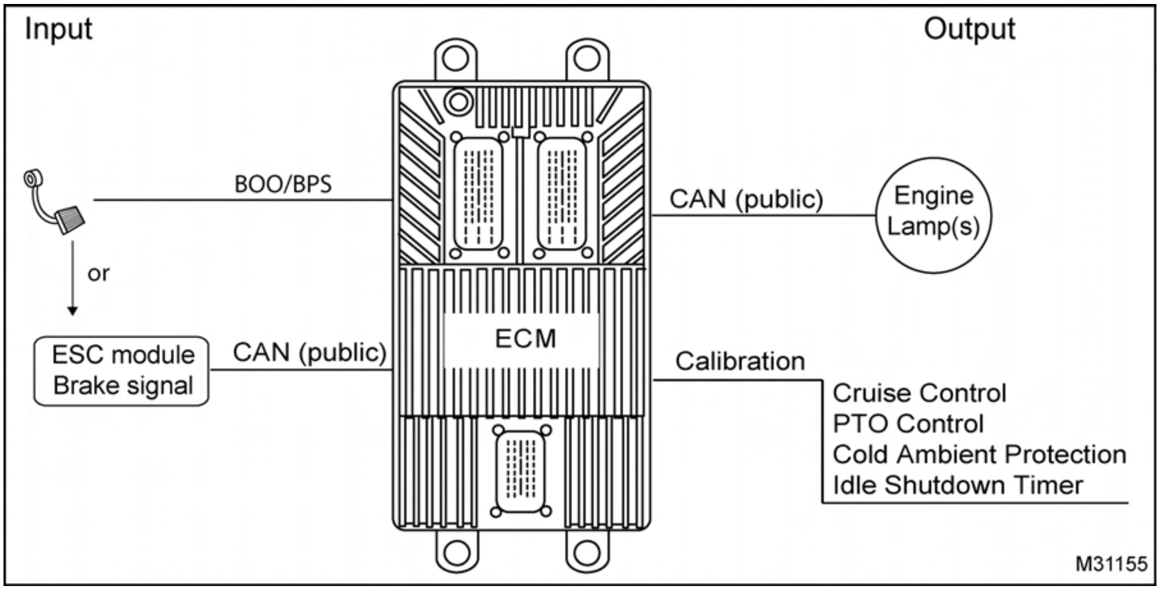

Figure 140 Function diagram for brake switch circuits

The brake switch circuit function diagram includes the following:

- Brake On/Off (BOO) switch
- Brake Pressure Switch (BPS)
- Electronic Control Module (ECM)
- Malfunction Indicator Lamp (MIL)
- Output - cancels cruise control
- Output - cancels Power Takeoff (PTO) control
- Output - cancels Cold Ambient Protection (CAP)
- Output - cancels Idle Shutdown Timer (IST)

Function

The brake switch circuit signals the ECM when the brakes are applied. The information is used to disengage the cruise control and PTO functions. The brake signal interrupts the CAP feature and resets the time interval for the IST feature.

Location

The BOO switch is located on the brake pedal lever. The BPS is located on the brake pressure line.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 180-Pin Breakout Box
- Terminal Test Adapter Kit

Brake Switch Circuits Pin-point Diagnostics

DTC	Condition	Possible Causes
1222	Brake Switch circuit fault	• OPEN in B+ circuit to the switches or blown fuse • BPS circuit OPEN or short to PWR or GND • Failed switch

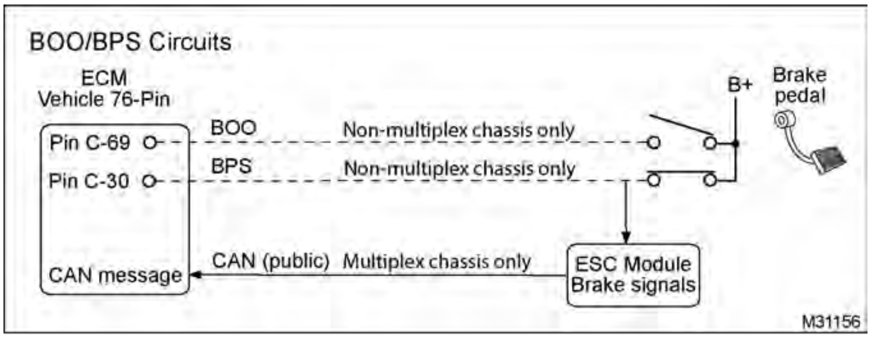

Figure 141 Brake switch circuit diagram

Brake Switch Circuits

Turn the ignition switch to ON. Connect EST to EST connector. Open Switch session to monitor BOO (BOO only applies to non-multiplex chassis) and BPS Parameter Identifiers (PIDs).

Test Point	Spec	Comments
BOO	Normal state = Released Pedal pressed = Applied	If not within specification, check for blown fuse, open circuit, short to ground, short to power, or failed switch.
BPS	Normal state = Released Pedal pressed = Applied	If not within specification, check for blown fuse, open circuit, short to ground, short to power, or failed switch.

See *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for circuit information. If the brake circuits are hard-wired to the ECM and do not go through the Electronic System Controller (ESC) module, do Voltage Check (page 194).

Voltage Check

Disconnect BOO (BOO only applies to non-multiplex chassis) and BPS switches. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comments
BOO		
B+ side	B+	If < B+, check for OPEN or short circuit, or blown fuse
Signal side	0 V	If > 0.5 V, check for short to PWR
BPS		
B+ side	B+	If < B+, check for OPEN or short circuit, or blown fuse
Signal side	0 V	If > 0.5 V, check for short to PWR

Harness Resistance Check

Turn ignition switch to OFF, Connect breakout box, Leave ECM, BOO (BOO only applies to non-multiplex chassis) and BPS disconnected. Use DMM to measure resistance.

Test Point	Spec	Comments
BOO		
C-69 to switch	< 5 Ω	If > 5 Ω, check for OPEN circuit
C-69 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND
BPS		
C-30 to switch	< 5 Ω	If > 5 Ω, check for OPEN circuit
C-30 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND

Brake Switch Circuit Operation

Fault Detection/Management

The ECM continuously monitors the state of the brake switch or switches. If a fault is detected on the brake switch circuit a Diagnostic Trouble Code (DTC) sets.

On multiplex vehicles, the BPS circuit is wired directly to the ESC module and the state of the switch is communicated to the ECM through the public CAN network.

CAN Communications (Controller Area Network)

DTC	SPN	FMI	Condition
2232	8331	7	Resume normal speed control due to momentary CAN loss
2545	8330	7	ECM not receiving body controller CAN messages
2544	8329	7	ECM unable to send CAN messages

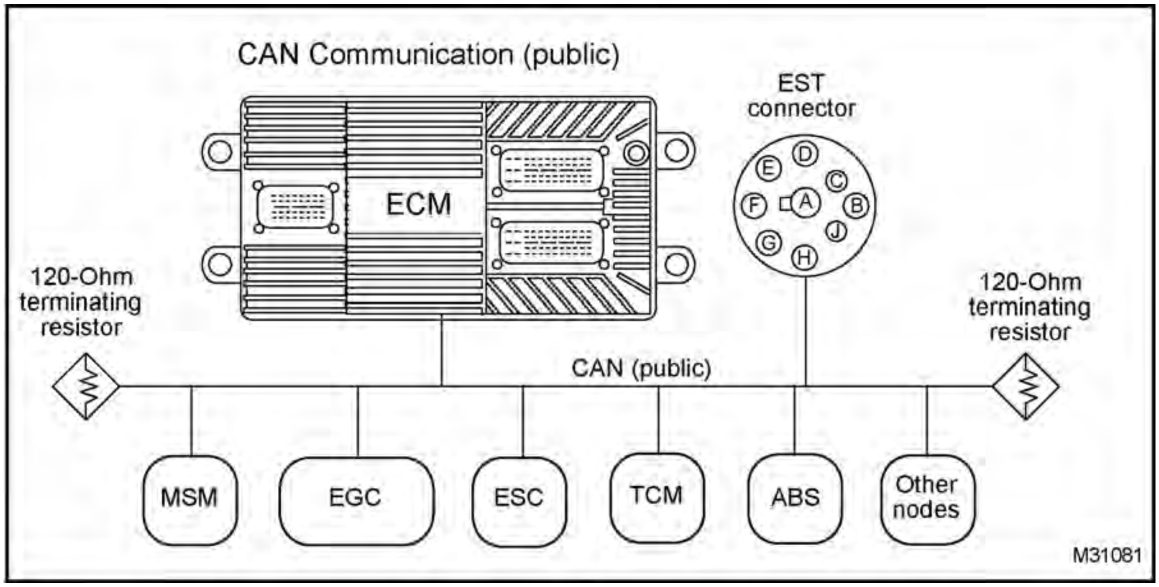

Figure 142 Function diagram for the CAN

The CAN function diagram includes the following:

- Electronic Control Module (ECM)
- Transmission Control Module (TCM)
- Electronic System Control (ESC) module
- Multiplex System Module (MSM)
- Antilock Brake System (ABS)
- Electronic Gauge Cluster (EGC)
- Electronic Service Tool (EST) connector
- 120-Ohm terminating resistors
- Other nodes (modules)

Function

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

Location

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

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- Terminal Test Adapter Kit

CAN (Public) Pin-point Diagnostics

DTC	Condition	Possible Causes
2232	Resume normal speed control due to momentary CAN loss	• CAN circuits OPEN or short to PWR or GND • ECM not powering up or failed module
2545	ECM not receiving body controller CAN messages	• CAN circuits OPEN or short to PWR or GND • Body controller not powering up or failed module
2544	ECM unable to send CAN messages	• CAN circuit OPEN • ECM not powering up or failed module
None	No communication with EST	• B+ circuit OPEN or short to GND • GND circuit OPEN • CAN circuits OPEN to EST connector

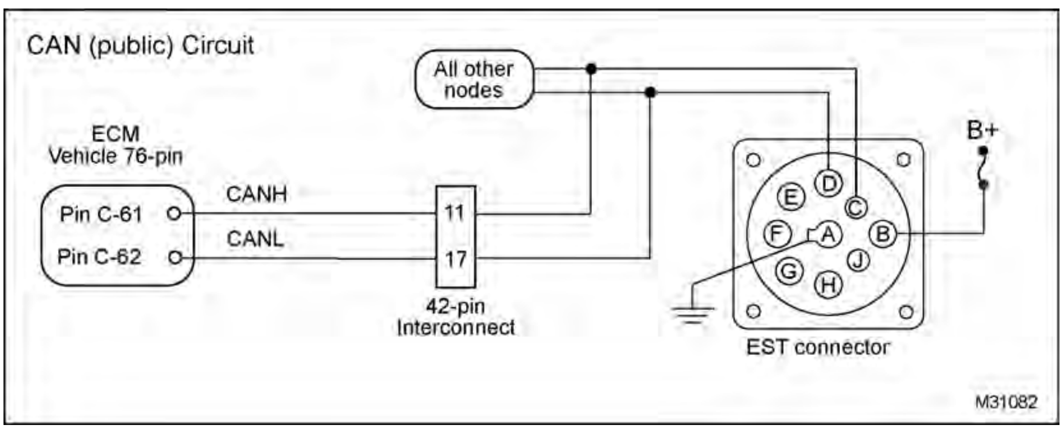

Figure 143 CAN communication circuit diagram

Connector Voltage Check

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

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

EST Communication Check

Turn ignition switch to ON. Connect EST to EST connector. If the EST is unable to communicate with the ECM, disconnect each module individually until communication can be established.

NOTE:

- If communication to ECM is established, check CAN circuits to disconnected module for correct wiring. See *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.
- If communication to ECM is not established, go to next test point.

Test Point	Comment
Disconnect TCM	See above note
Disconnect ABS	See above note
Disconnect ESC	See above note
Disconnect MSM	See above note
Disconnect EGC	See above note
Disconnect other nodes	See above note

Harness Resistance Check

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

Test Point	Spec	Comment
C to C-61	< 5 Ω	If > 5 Ω, check CANH for OPEN in circuit
C to GND	> 1 kΩ	If < 1 kΩ, check CANH for short to GND
D to C-62	< 5 Ω	If > 5 Ω, check CANL for OPEN in circuit
D to GND	> 1 kΩ	If < 1 kΩ, check CANL for short to GND
A to GND	< 5 Ω	If > 5 Ω, check GND for OPEN in circuit

CAN (Public) Circuit Operation

Controller Area Network (CAN) J1939 is a broadcast serial network standard. The public CAN network provides a communication link between all connecting modules, sending and receiving digital messages.

The EST with MasterDiagnostics® software communicates with the ECM through the EST 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 ECM.

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 ECM

Public CAN versus Private CAN

The public CAN network is set up to communicate with many different modules. The network branches 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 ECM and specific engine controls.

EST Connector

The EST connector provides an interface for the EST. The EST with MasterDiagnostics® software communicates with the joining modules through the CAN network for diagnostics and module programming. The EST connector is supplied with fused B+ at Pin B and GND at Pin A. Public CANH runs between ECM Pin C-61 and EST connector Pin C. Public CANL between C-62 and EST connector Pin D.

Electronic Gauge Cluster (EGC)

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

- Warn Engine Lamp (WEL)
- Malfunction Indicator Lamp (MIL)
- Coolant Level lamp
- Wait to Start lamp
- Oil/Water Lamp (OWL)
- Speedometer
- Tachometer
- Odometer/hourmeter
- Change oil message
- Oil pressure gauge
- Engine oil temperature gauge
- Engine coolant temperature gauge

ESC or MSM

Many EGC lamps and driver operated switches are wired to one of these modules, then communicated through public CAN to the ECM or EGC. Some of these control circuits include the following:

- Wait to Start lamp
- Fuel Pressure lamp
- OWL
- Aftertreatment Regeneration lamp
- Cruise control
- Self-test input (cruise switches)
- Driveline Disengagement Switch (DDS)
- Brake pedal (ESC only) hardwired to the ECM on vehicles using the MSM
- AC Demand (ACD)
- Remote Accelerator Pedal
- In-Cab PTO/throttle switch
- Aftertreatment regeneration switch

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.

CCS (Cruise Control System)

DTC	SPN	FMI	Condition
None			

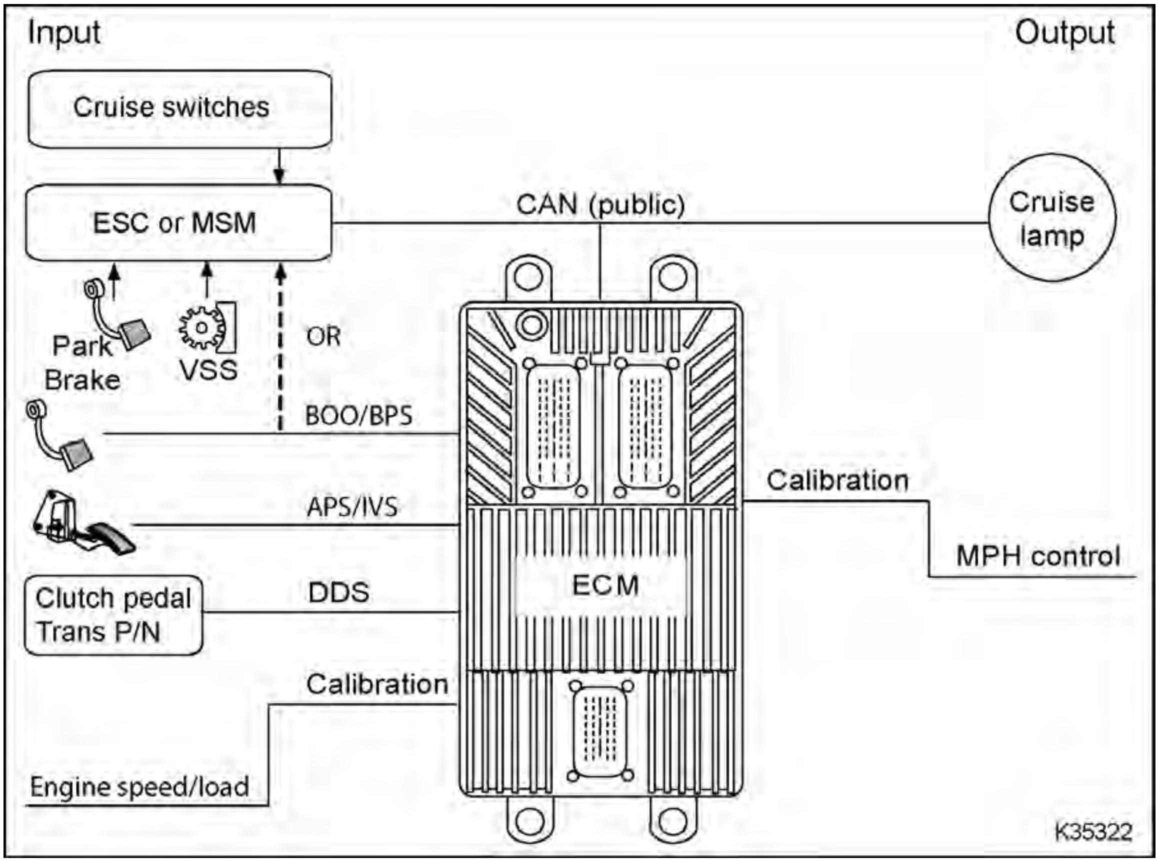

Figure 144 Function diagram for cruise control system

The cruise control system function diagram includes the following:

- Electronic System Control (ESC)
- Multiplex System Module (MSM)
- Cruise control switches
- Driveline Disconnect Switch (DDS)
- Electronic Control Module (ECM)
- Accelerator Position Sensor and Idle Validation Switch (APS/IVS)
- Brake On/Off (BOO) switch
- Brake Pressure Switch (BPS)
- Park brake switch
- Vehicle Speed Sensor (VSS)
- Cruise lamp

Function

Cruise control is a function of the ECM. Using the cruise control switches, the operator is able to set, resume, accelerate or coast to any desired vehicle speed within range of the system.

The ECM continuously monitors the clutch, brake and accelerator pedals before cruise control can be activated and to deactivate the cruise control after it has been set.

Location

The cruise control switches are wired to the body controller (ESC or MSM). The switch state is communicated to the ECM through the public CAN network.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit

Cruise Control System Pin-point Diagnostics

DTC	Condition	Possible Causes
None		

Switch Checks

Turn ignition switch to ON. Connect the EST to the EST connector. Open the cruise control session to monitor Parameter Identifiers (PIDs) (BOO only applies to non-multiplex chassis).

NOTE:

- If not within specification, diagnose switch interface with ESC or MSM. See *Chassis Electrical Circuit Diagnostic Manual* and *Electrical System Troubleshooting Guides*.
- If within specification, go to next test point.

Test Point	Spec	Comments
BOO	Normal state = Released Pressed = Applied	If not within specification, see Brake Switch Circuits Pin-point Diagnostics (page 193)
BPS	Normal state = Released Pressed = Applied	If not within specification, see Brake Switch Circuits Pin-point Diagnostics (page 193)
Park brake	Normal state = OFF Pressed = ON	See above note
Cruise On/Off	Unlatched = OFF Latched = ON	See above note
Cruise Set	Normal state = OFF Pressed = ON	See above note
Cruise Resume/Accel	Normal state = OFF Pressed = ON	See above note
If all switches are okay, go to Road Test.		

CKP Sensor (Crankshaft Position)

DTC	SPN	FMI	Condition
1144	8021	8	CKP signal noise detected
1146	8064	12	CKP signal inactive
1147	8064	2	CKP incorrect signal signature
4553	8022	12	CKP signal inactive
4554	8022	7	CKP loss of sync
4555	8064	8	CKP signal noise detected
4556	8022	8	CKP period too short
4611	8021	13	CKP signature one tooth off

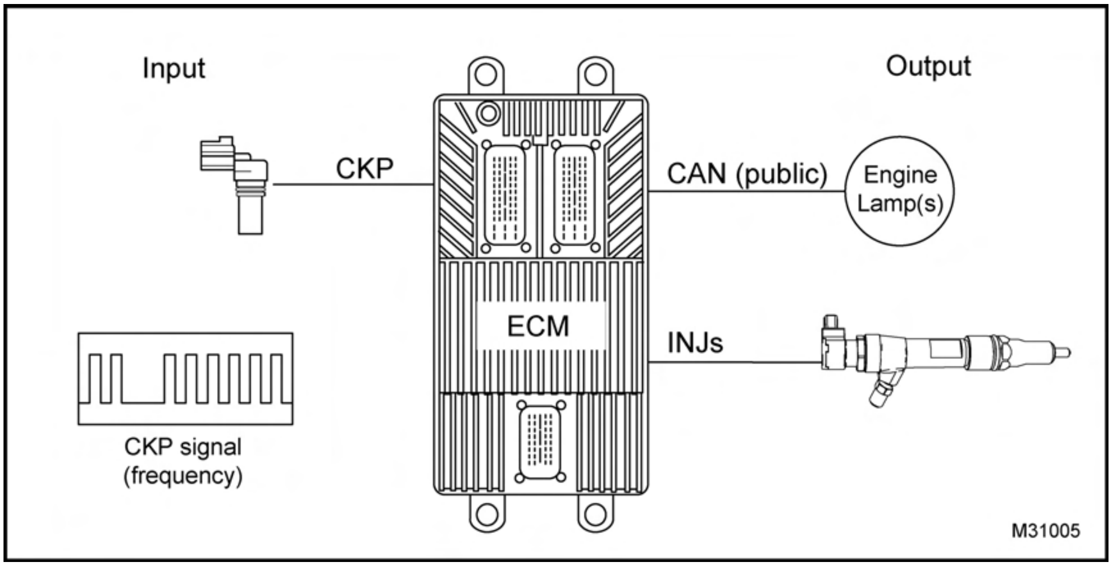

Figure 145 Function diagram for the CKP sensor

The CKP sensor function diagram includes the following:

- Crankshaft Position (CKP) sensor
- Electronic Control Module (ECM)
- Fuel injectors (INJ)
- Warn Engine Lamp (WEL)

Function

The CKP sensor provides the ECM with a crankshaft speed and position signals. The ECM uses this signal with the Camshaft Position (CMP) signal to calculate crankshaft speed and position.

Sensor Location

The CKP sensor is installed in the lower front right side of the crankcase.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 180-Pin Breakout Box
- Terminal Test Adapter Kit

CKP Pin-point Diagnostics

DTC	Condition	Possible Causes
1144	CKP signal noise detected	• OPEN or shorted CKP circuits
1146	CKP signal inactive	• Electrical noise detected on CKP signal
1147	CKP incorrect signal signature	• Failed sensor
4553	CKP signal inactive	• Failed harness
4554	CKP loss of sync	
4555	CKP signal noise detected	
4556	CKP period too short	
4611	CKP signature one tooth off	

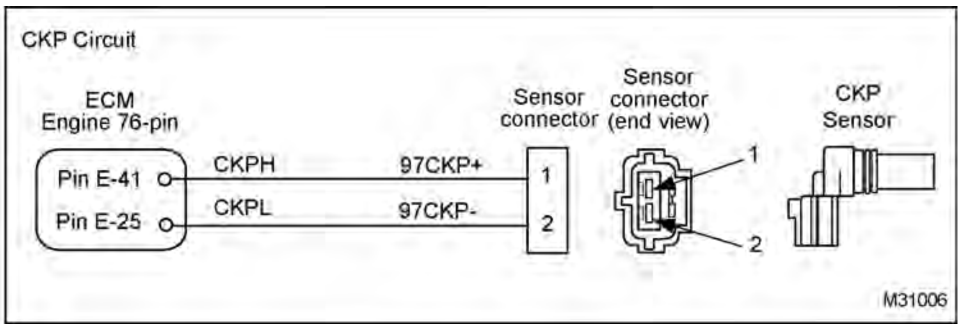

Figure 146 CKP circuit diagram

Sensor and Circuit Resistance Check

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

Test Point	Spec	Comment
E-25 to E-41	280 Ω to 560 Ω	If < 280 Ω, check for failed sensor. Do Harness Resistance Check (page 203). If > 560 Ω, check for OPEN circuit or failed sensor. Do Harness Resistance Check (page 203).

Harness Resistance Check

Turn ignition switch to OFF. Disconnect harness from sensor. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-25 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-25 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E-41 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-41 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

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

Operational Check

Connect breakout box between ECM and sensor. Use DMM set to AC Volts-Hz.

Test Point	Condition	Spec
E-41 to E-25	Engine crank	100 Hz to 250 Hz (100 rpm to 250 rpm)
	Low idle	650 Hz to 750 Hz (650 rpm to 700 rpm)
	High idle	2900 Hz to 3000 Hz (2950 rpm)

CKP 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 negative E-25 and CKP positive E-41.

As the crankshaft turns, the CKP sensor detects a 60 tooth timing disk on the crankshaft. Tooth 59 and tooth 60 are missing.

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

Diagnostic information on the CKP input signal is obtained by performing rationality and accuracy checks on duty cycle with software strategies.

NOTE: The engine will not operate without a CKP signal.

Fault/Detection Management

While the engine is cranking or running the ECM monitors the CMP signal to verify the engine is rotating. If a CKP fault is detected while engine is cranking, it causes a no start condition. If a fault is detected while the engine is running, it causes a stall condition.

CMP Sensor (Camshaft Position)

DTC	SPN	FMI	Condition
1143	8021	2	CMP signal incorrect for CKP sync
4551	8021	12	CMP signal inactive
4552	8022	2	CMP loss of sync
4612	8021	7	CMP to CKP incorrect reference

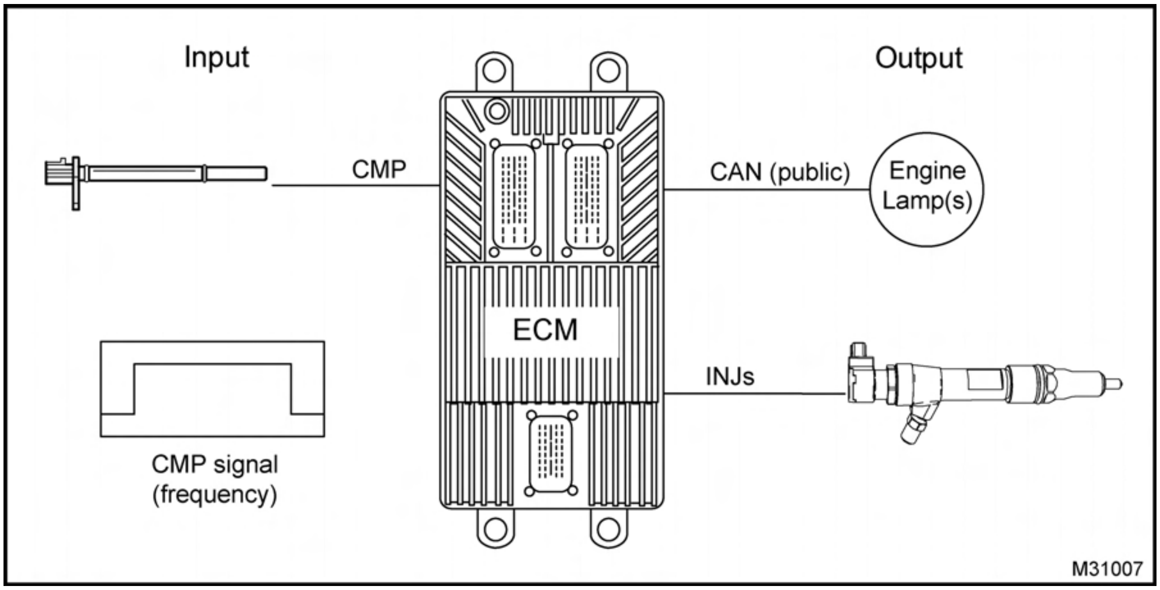

Figure 147 Function diagram for the CMP sensor

The CMP sensor function diagram includes the following:

- Camshaft Position (CMP) sensor
- Electronic Control Module (ECM)
- Fuel Injectors (INJ)
- Warn Engine Lamp (WEL)

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 crankshaft speed and position.

Sensor Location

The CMP sensor is installed in the lower front left side of the engine crankcase.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 180-Pin Breakout Box
- Terminal Test Adapter Kit

CMP Pin-point Diagnostics

DTC	Condition	Possible Causes
1143	CMP signal incorrect for CKP sync	• OPEN or shorted CMP circuits
4551	CMP signal inactive	• Electrical noise detected on CMP circuit
4552	CMP loss of sync	• Failed sensor
4612	CMP to CKP incorrect reference	• Failed harness

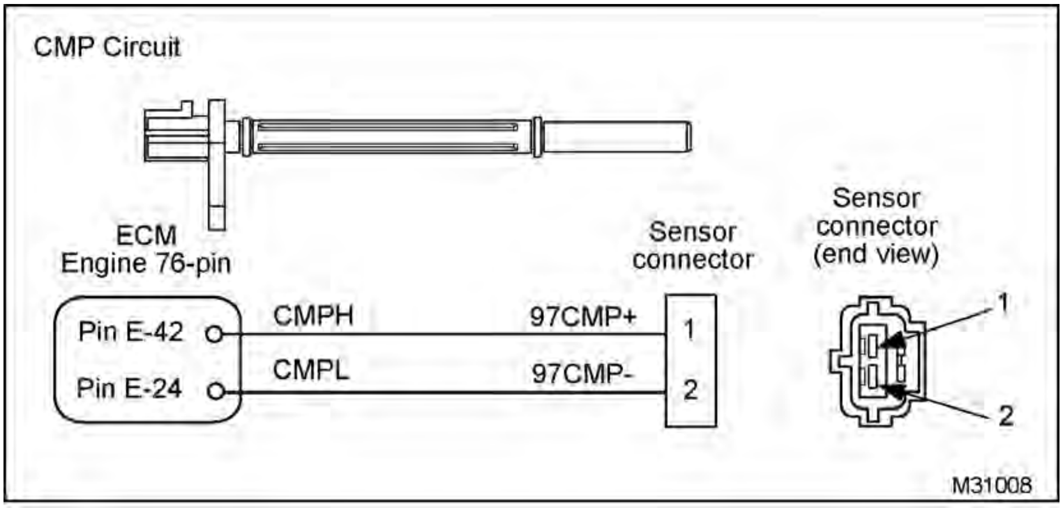

Figure 148 CMP circuit diagram

Sensor and Circuit Resistance Check

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

Test Point	Spec	Comment
E-24 to E-42	616 Ω to 1275 Ω	If < 616 Ω, check for failed sensor. Do Harness Resistance Check (page 206). If > 1275 Ω, check for OPEN circuit or failed sensor. Do Harness Resistance Check (page 206).

Harness Resistance Check

Turn ignition switch to OFF. Disconnect harness from sensor. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-24 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-24 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E-42 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-42 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

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

Operational Check

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

Test Point	Condition	Spec
E-42 to E-24	Engine crank	100 rpm to 250 rpm
	Low idle	650 rpm to 700 rpm
	High idle	3000 rpm

CMP Circuit Operation

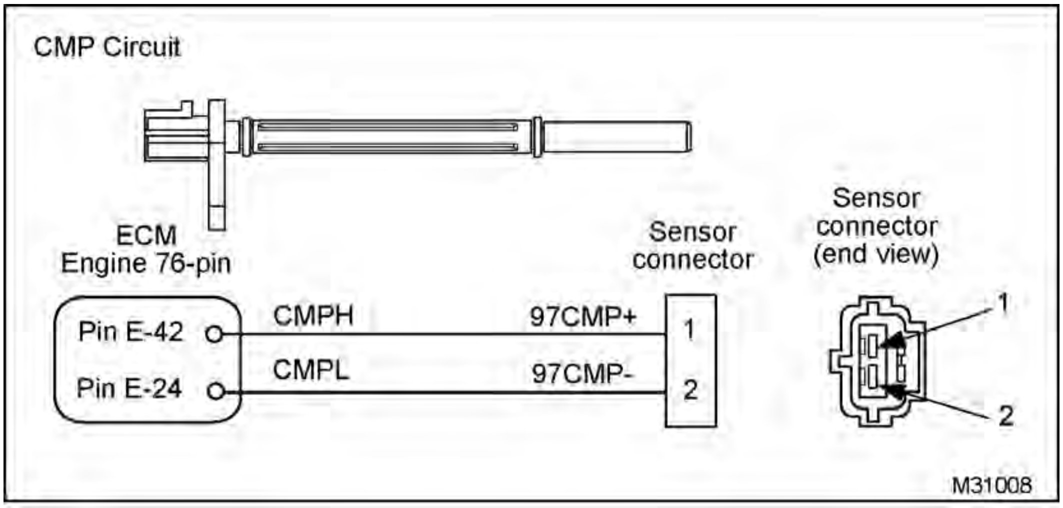

Figure 149 CMP circuit diagram

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, this identifies camshaft position. The ECM pins for the CMP sensor are CMP negative E-24 and CMP positive E-42.

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.

NOTE: The engine will not operate without a CMP signal.

Fault/Detection Management

During engine cranking, the ECM monitors the CMP signal to verify the camshaft is rotating. If the CMP signal is inactive during this time a Diagnostic Trouble Code (DTC) is set. Electrical noise can also be detected by the ECM, if the level is sufficient to effect engine operation a corresponding DTC is set. An inactive CMP signal will cause a no start condition.

Cylinder Balance

DTC	SPN	FMI	Condition
4561 - 4568	8001 - 8008	1	Cyl (#) balance below min limit
4571 - 4578	8001 - 8008	0	Cyl (#) balance max limit exceeded

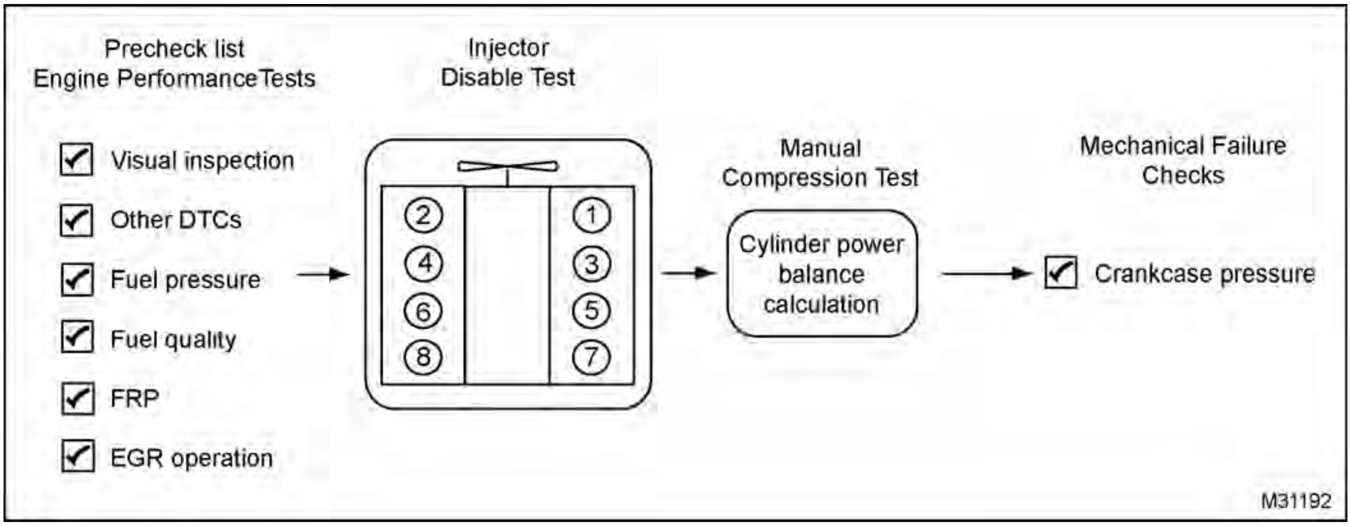

Figure 150 Function diagram for cylinder balance

Cylinder Balance Operation

Power cylinder sealing, valve train condition, and fuel delivery influence torque contributions from each power cylinder. 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.

The Electronic Control Module (ECM) uses a Cylinder Balance control strategy to even the power contribution of the cylinders, particularly at low idle. This strategy incorporates information from the crankshaft position 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 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
4561 - 4568	Cyl (#) balance below min limit	• Electrical fault
4571 - 4578	Cyl (#) balance max limit exceeded	• Low fuel pressure
		• Fuel quality
		• EGR valve stuck open
		• Fuel and injection control system
		• Failed injector
		• Base engine compression imbalance

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

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: These checks can be verified quickly by using the Fuel Pressure Test Gauge with shut-off valve. See Fuel Pressure test in the “Hard Start and No Start Diagnostics” section of this manual.
4. Check Fuel Rail Pressure and voltage.
   - Check FRP voltage at KOEO. Run KOEO Standard Test.

     See “Performance Specifications” section of this manual.
   - Check fuel rail pressure system pressure during KOER. Run KOER Standard Test.

     See “Performance Specifications” section of this manual.
5. Inspect Exhaust Gas Recirculation (EGR) valve. Verify valve is not stuck open.
   - Run KOEO Standard Test
   - Run KOER Air Management Test.

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

1. Run KOER Injector Disable Test to identify imbalanced cylinder. See Performance Diagnostics section.
2. Do Manual Compression Test to verify if cylinder imbalance is mechanical issue or injector issue. See Performance Diagnostics section.

   If the Manual Compression Test fails the same cylinder as indicated by Injector Disable Test, the fault is a mechanical failure.
   - Check crankcase pressure.
   - Check valve lash and brake lash (if equipped).

EBP Sensor (Exhaust Back Pressure)

DTC	SPN	FMI	Condition
3341	1209	4	EBP signal out-of-range LOW
3342	1209	3	EBP signal out-of-range HIGH

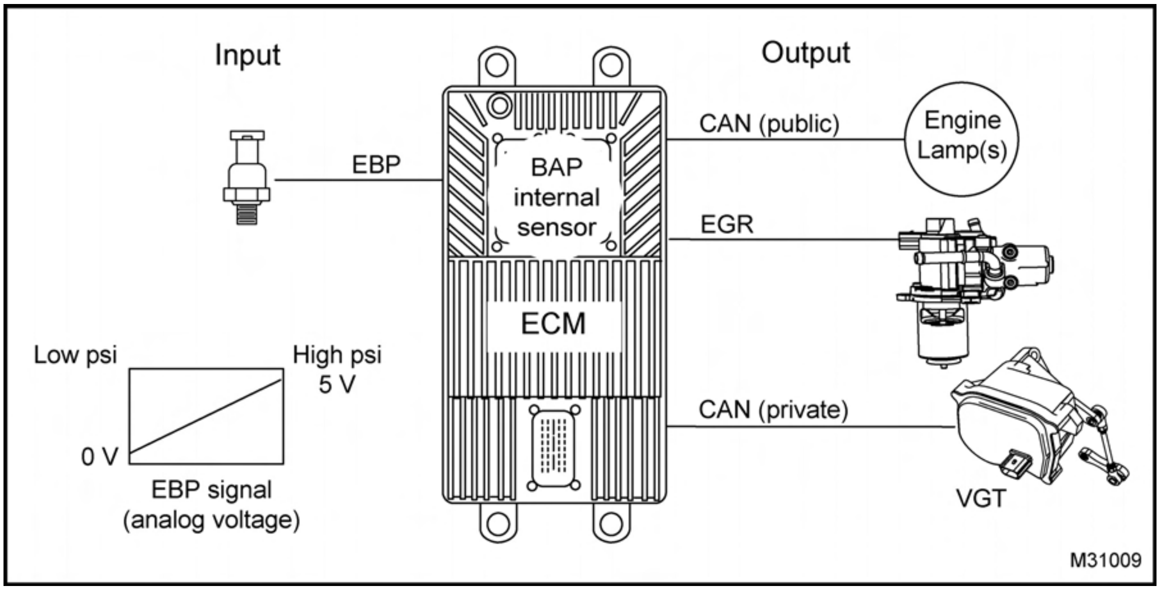

Figure 151 Function diagram for the EBP sensor

The EBP sensor function diagram includes the following:

- Exhaust Back Pressure (EBP) sensor
- Electronic Control Module (ECM) with integrated Barometric Absolute Pressure (BAP) sensor
- Variable Geometry Turbocharger (VGT)
- Exhaust Gas Recirculation (EGR) valve
- Malfunction Indicator Lamp (MIL)

Function

The EBP sensor measures exhaust back pressure. The ECM uses the EBP signals to control the VGT and EGR systems.

Sensor Location

The EBP sensor is installed in a bracket mounted above and behind the right valve cover.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 180-Pin Breakout Box
- Pressure Sensor Breakout Harness
- Terminal Test Adapter Kit

EBP Sensor End Diagnostics

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

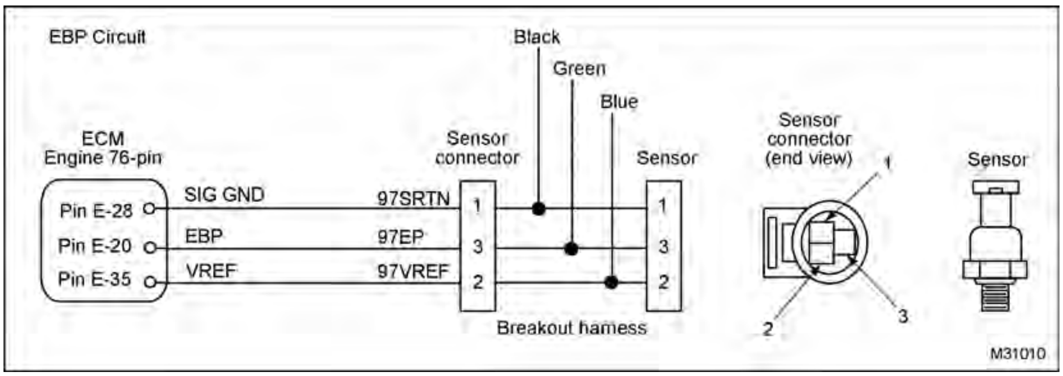

Figure 152 EBP circuit diagram

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

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Verify sensor voltage is within Key-On Engine-Off (KOEO) specifications. See “Performance Specifications” section of this manual.
3. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If code 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 will go active.
   - If code is active, proceed to the next step.
4. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

5. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

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. Use DMM to measure circuits.

Test Point	Spec	Comments
EST – Check DTC	DTC 3341	If DTC 3342 is active, check EBP signal for short to PWR
DMM – Measure volts 2 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 214).
EST – Check DTC Short breakout harness across 2 and 3	DTC 3342	If DTC 3341 is active, check EBP signal for OPEN. Do Harness Resistance Check (page 214).
DMM – Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 214).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

EBP Pin-point Diagnostics

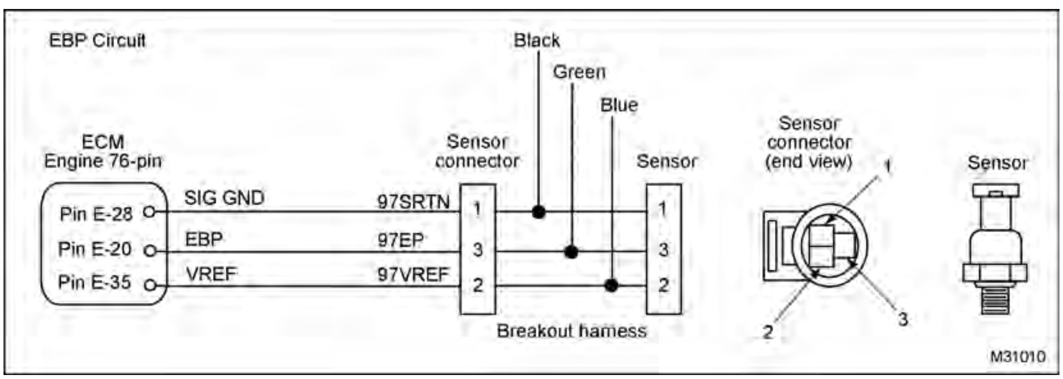

Figure 153 EBP circuit diagram

Connector Voltage Check

Connect sensor 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	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 214).
3 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 214).

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.
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 breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-28	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
2 to E-35	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
3 to E-20	< 5 Ω	If > 5 Ω, check EBP signal circuit for OPEN.

EBP Circuit Operation

The EBP sensor is a variable capacitance sensor supplied with a 5 volt reference voltage at Pin 2 from ECM Pin E-35. The sensor is grounded at Pin 1 from ECM Pin E-28. The sensor returns a variable voltage signal from Pin 3 to ECM Pin E-20.

Fault Detection/Management

The ECM monitors the internal BAP sensor as a baseline for zeroing the MAP and EBP signals.

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, turns on the MIL, and runs the engine in a default range. The EGR valve closes and the ECM relies on the VGT pre-programmed values.

ECI Circuit (Engine Crank Inhibit)

DTC	SPN	FMI	Condition
None			Engine starter motor will not engage

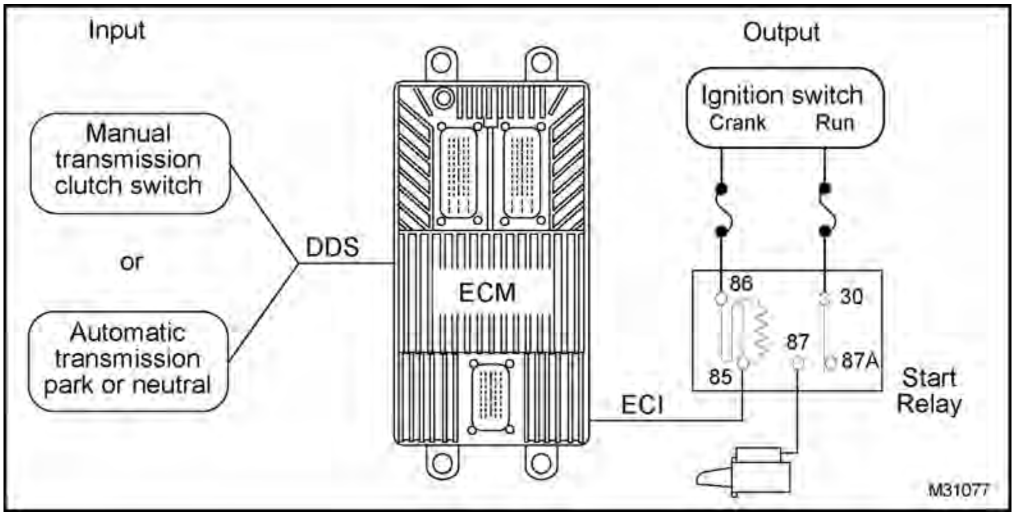

Figure 154 Function diagram for ECI circuit diagram

The ECI circuit function diagram includes the following:

- Electronic Control Module (ECM)
- Starter
- Start relay
- Engine Crank Inhibit (ECI) circuit
- Driveline Disengagement Switch (DDS)
- Thermal overcrank protection switch

Function

The ECI is a function of the ECM. It prevents starter engagement while the engine is running (above a set calibrated rpm), when the automatic transmission is in gear, or the manual transmission clutch pedal is not pressed. The start relay can also be disabled by an optional overcrank thermocouple.

Location

The relay and switches are chassis mounted parts. For additional supporting information, see truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.

Tools

- Digital Multimeter (DMM)
- 180-Pin Breakout Box
- Relay Breakout Harness

ECI Circuit Diagnostics

DTC	Condition	Possible Causes
None	No engine crank	• Transmission in gear • Clutch pedal not pressed • No power to automatic transmission module • No power to ECM • Blown fuse • Failed start relay • OPEN DDS circuit • OPEN ECI circuit • Failed ignition switch • Failed starter motor • Low battery state of charge. • High resistance or corroded cables to starter or battery.

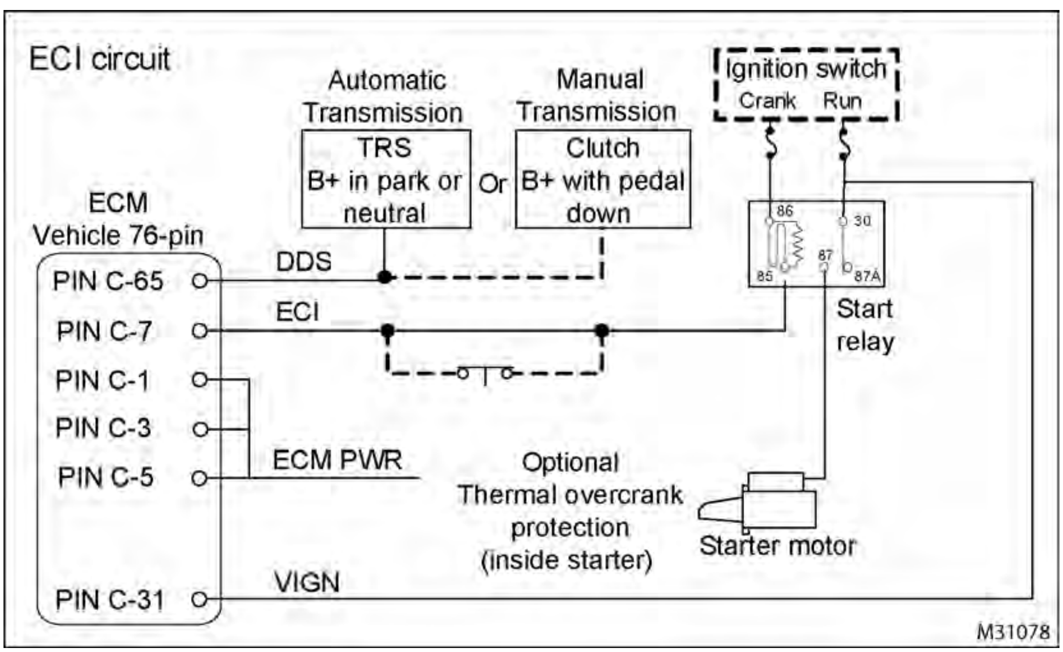

Figure 155 ECI circuit diagram

For additional circuit information see truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.

Voltage Check at Relay

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

Test Point	Spec	Comment
30 to GND	B+	If < B+, check power circuit to relay switch for OPEN or short to GND, or blown fuse.
Turn the ignition switch to CRANK. Use DMM to measure voltage.		
86 to GND	B+	If < B+, check power circuit to relay coil for OPEN or short to GND, blown fuse, or possible failed ignition switch.
85 to GND	< 2 V	If B+, check ECI control circuit for OPEN or failed thermal overcrank protection switch. If 4 V to 5 V, check DDS circuit to ECM and do Voltage Check at ECM (page 217).
87 to GND	B+	If < B+, replace relay. If B+, check voltage at starter solenoid.

Voltage Check at ECM

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

Test Point	Spec	Comment
C-31 to GND	B+	If < B+, check VIGN circuit for OPEN or short to GND, blown fuse, or possible failed ignition switch.
C-2 to GND C-4 to GND C-6 to GND	0 V	If voltage is present, check for OPEN ECM GND circuit. See ECM PWR Pin-point Diagnostics (page 224) in this section .
C-1 to GND C-3 to GND C-5 to GND	B+	If < B+, check for OPEN ECM PWR circuit. See ECM PWR Pin-point Diagnostics (page 224) in this section .
Place automatic transmission in park or neutral (manual transmission, press clutch). Use DMM to measure voltage.		
C-65 to GND	B+	If < B+, check DDS for OPEN circuit. • For automatic transmission, see transmission diagnostics. • For manual transmission, check PWR circuit to clutch pedal or blown fuse. A failed clutch pedal switch is possible.
C-7 to GND	< 2 V	If > 2 V, check ECM programming.

Harness Resistance Check - ECM to Relay

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

Test Point	Spec	Comment
85 to C-7	< 5 Ω	If > 5 Ω, check ECI control circuit for OPEN or possible failed thermal overcrank protection switch.
85 to GND	> 1 kΩ	If < 1 kΩ, check ECI control for short to GND.
87 to starter	< 5 Ω	If > 5 Ω, check ECI control for OPEN or possible failed thermal over crank protection switch.
87 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND.

Harness Resistance Check - Relay to Battery

Disconnect both battery GND cables. Disconnect start relay and remove VIGN fuse. Use DMM to measure resistance.

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

86 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
30 to B+ battery post	< 5 Ω	If > 5 Ω, check circuit for OPEN or blown fuse.
30 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
C-65 DDS circuit	See *Chassis Electrical Circuit Diagram Manual*. Check for OPEN or short to GND. Possible failed clutch switch or automatic transmission module circuit faults.	

Operational Voltage Check

Connect breakout box between ECM and chassis harness. Leave battery cables connected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Condition
DDS C-65 to GND	B+	ECM Input - Clutch pedal not pressed or automatic transmission in gear. Cranking is disabled.
	0 V	ECM Input - Clutch pedal to the floor or automatic transmission in park or neutral. Cranking is enabled.
Turn the ignition switch to the crank position. Use DMM to measure voltage.		
ECI C-7 to PWR	0 V	ECM Control - ECI enabled
	B+	ECM Control - ECI disabled

ECI Circuit Operation

The ECM controls the starting system. The clutch switch or transmission neutral switch provides input to the ECM. Both switches prevent the starter from being engaged unless the automatic transmission is in park or neutral or the manual transmission clutch is pressed.

DDS Circuit

The ECM monitors the DDS on Pin C-65. B+ indicates the drivetrain is disengaged and the engine is ready to start. Zero volts indicates the drivetrain is engaged and the engine is not ready to start. The source of this signal depends on the vehicle's hardware configuration. See appropriate electrical diagrams when diagnosing this circuit.

Ignition Switch

When the ignition switch is turned to CRANK, VIGN is supplied to the relay coil (Pin 86).

ECI Circuit

The ECM controls starter disable with the ECI circuit. Pin C-7 to relay coil Pin 85. Open or B+ will disable the relay. 0 volts (GND) will enable the relay.

ECM

When the ECM recognizes the engine is not running and the driveline is not engaged, the ECM grounds Pin C-7. This provides a current path for the start relay to close when the start switch is engaged or the starter button is pressed.

When the ECM recognizes the engine is running or the driveline is engaged, it opens Pin C-7. This prevents the start relay from closing and the starter motor from engaging.

Start Relay

The engine start relay controls voltage to the starter solenoid. Turning the ignition switch to CRANK, supplies current to energize the relay at Pin 86. If the engine is not running and the driveline is not engaged, ECM Pin C-7 enables the relay by supplying a ground to Pin 85. When the relay is closed, current passes through the relay to the starter solenoid.

Clutch Switch

Manual transmissions use the clutch switch to supply a signal to the ECM indicating the driveline is disengaged. A 12 volt signal on the DDS circuit indicates the clutch is disengaged. A 0 volt signal indicates the clutch is engaged.

Neutral Switch

Allison LCT transmissions use the neutral position switch to supply power to the start relay and a signal to the ECM that the driveline is disengaged. Vehicles programmed for Allison AT/MT transmissions receive a 12 volt signal on the DDS circuit indicating the transmission is out of gear. A 0 volt signal indicates the transmission is in gear. When the transmission is in gear no power is available to the start relay.

WTEC MD with Auto Neutral

Allison MD World Transmission Electronically Controlled (WTEC) transmissions (with optional Auto Neutral) have a crank inhibit system with an additional relay. The relay inhibits cranking when the transmission is in auto neutral. Pin 6 of the transmission module controls 12 volts to Pin 86 of the start relay. Pin C-65 of the ECM receives 12 volts from the WTEC auto neutral relay when the transmission is shifted to neutral or auto neutral.

Fault Detection/Management

There are no DTCs associated with the ECI system.

ECL Switch (Engine Coolant Level)

DTC	SPN	FMI	Condition
1236	111	2	ECL in-range circuit fault

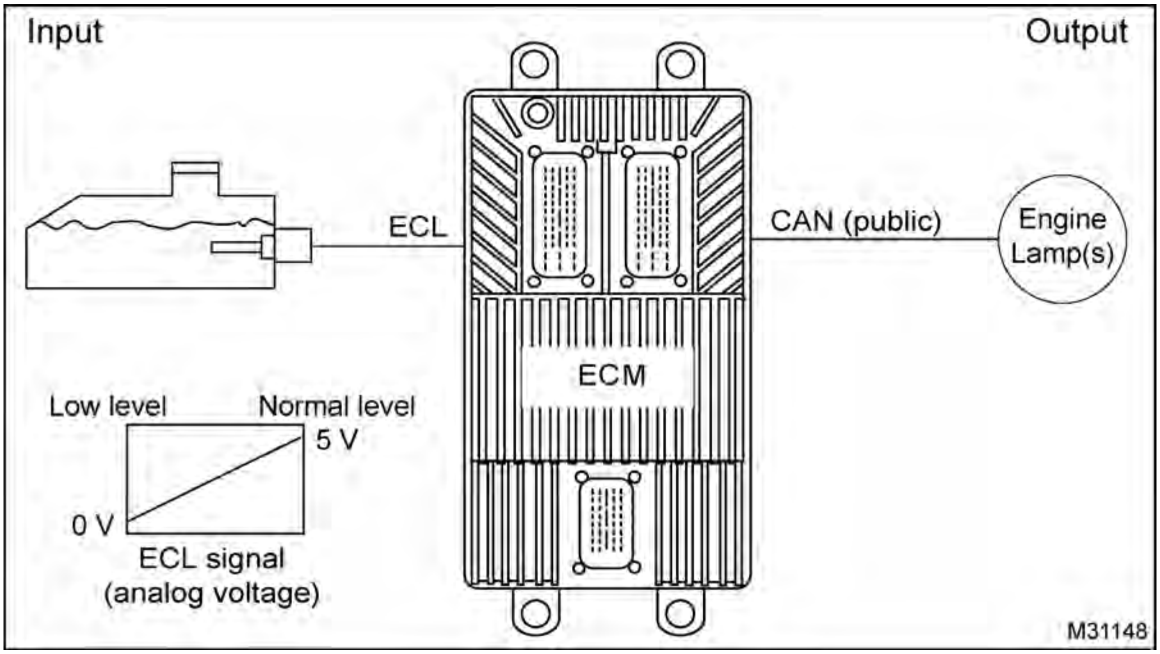

Figure 156 Function diagram for the ECL system

The ECL switch function diagram includes the following:

- Engine Coolant Level (ECL) switch
- Electronic Control Module (ECM)
- Oil/Water Lamp (OWL)

Function

The ECM 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 programmable feature that can be programmed using the Electronic Service Tool (EST) with MasterDiagnostics® software. The coolant level feature is operational if programmed for 3-way warning or 3-way protection.

Location

The ECL switch is installed in the plastic deaeration tank.

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 180-Pin Breakout Box

ECL Pin-point Diagnostics

DTC	Condition	Possible Causes
1236	ECL in-range circuit fault	• ECL circuit OPEN or short to GND or PWR • Failed switch

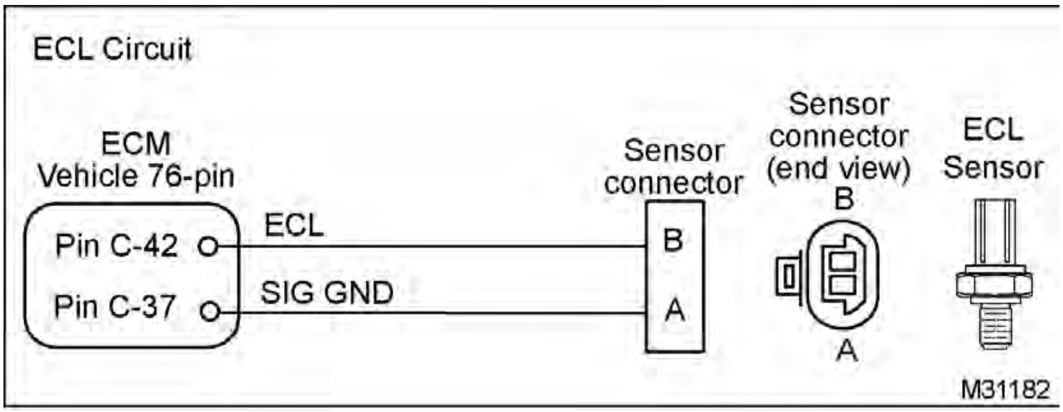

Figure 157 ECL circuit diagram

Connector Voltage Check

Disconnect ECL switch. 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	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 222).

Connector Resistance Check to GND

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

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

Switch Resistance Check

Disconnect ECL connector and measure across switch.

Test Point	Spec	Comment
A to B	> 1 kΩ (full)	If < 1 kΩ, replace switch
A to B	< 5 Ω (empty)	If > 5 Ω, replace switch

Harness Resistance Check

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

Test Point	Spec	Comment
A to C-37	< 5 Ω	If > 5 Ω, check for OPEN circuit.
B to C-42	< 5 Ω	If > 5 Ω, check for OPEN circuit.

ECL Circuit Operation

The ECL switch uses a floating ball with a magnetic switch. When the coolant level is full, the float will rise and the magnet pulls the level switch open. This allows a 5 volt signal at ECM Pin C-42. When the level is low, the switch closes and ECM Pin C-42 is 0 volts.

Fault Detection/Management

The ECM continuously monitors the ECL circuit for in-range faults. The ECM does not detect open or short circuits in the ECL system. When the ECM detects an in-range fault, a DTC is set.

ECM PWR (Electronic Control Module Power)

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

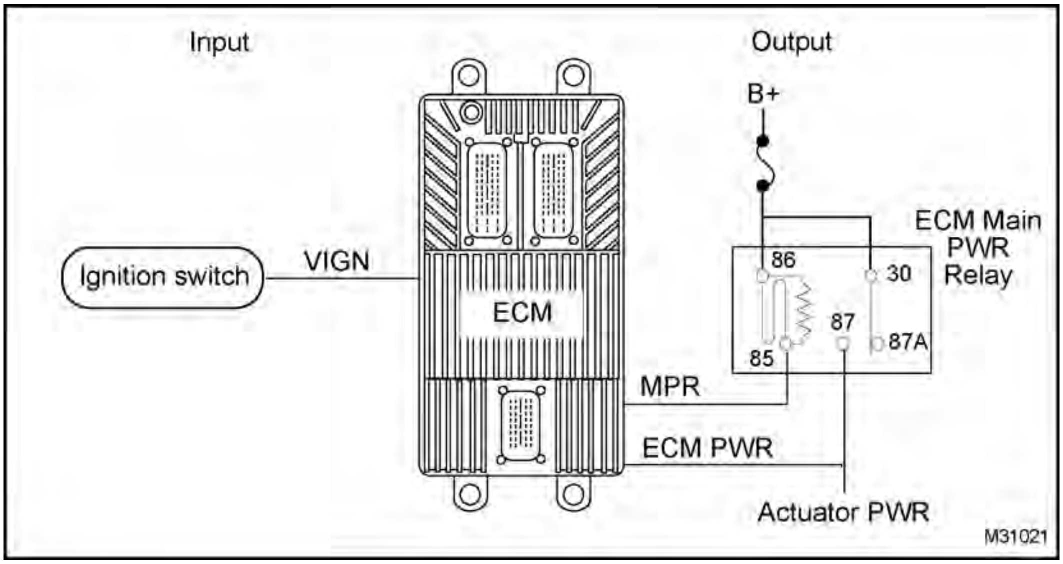

Figure 158 Function diagram for the ECM PWR

The ECM PWR function diagram includes the following:

- Electronic Control Module (ECM)
- ECM main power relay
- Ignition switch or power relay
- Battery
- Fuses

Function

The ECM requires battery power to operate the electronic control system and perform maintenance after turning the ignition switch to OFF. To do this, the ECM must control its own power supply. When the ECM receives the VIGN signal from the ignition switch, the ECM enables the relay to power-up. When turning the ignition switch to OFF, the ECM performs internal maintenance, then disables the ECM relay.

ECM Location

The ECM is installed on the left side of the engine, above the valve cover.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 180-Pin Breakout Box
- Relay Breakout Harness
- Terminal Test Adapter Kit

ECM PWR Pin-point Diagnostics

DTC	Condition	Possible Causes
1112	B+ out-of-range HIGH	• Jump starting using more than system voltage • Batteries wired incorrectly • Charging system fault
1113	B+ out-of-range LOW	• Low discharged batteries • Inoperative alternator/charging system fault • High resistance in ECM powering circuits (ECM PWR, ECM GND, or VIGN)

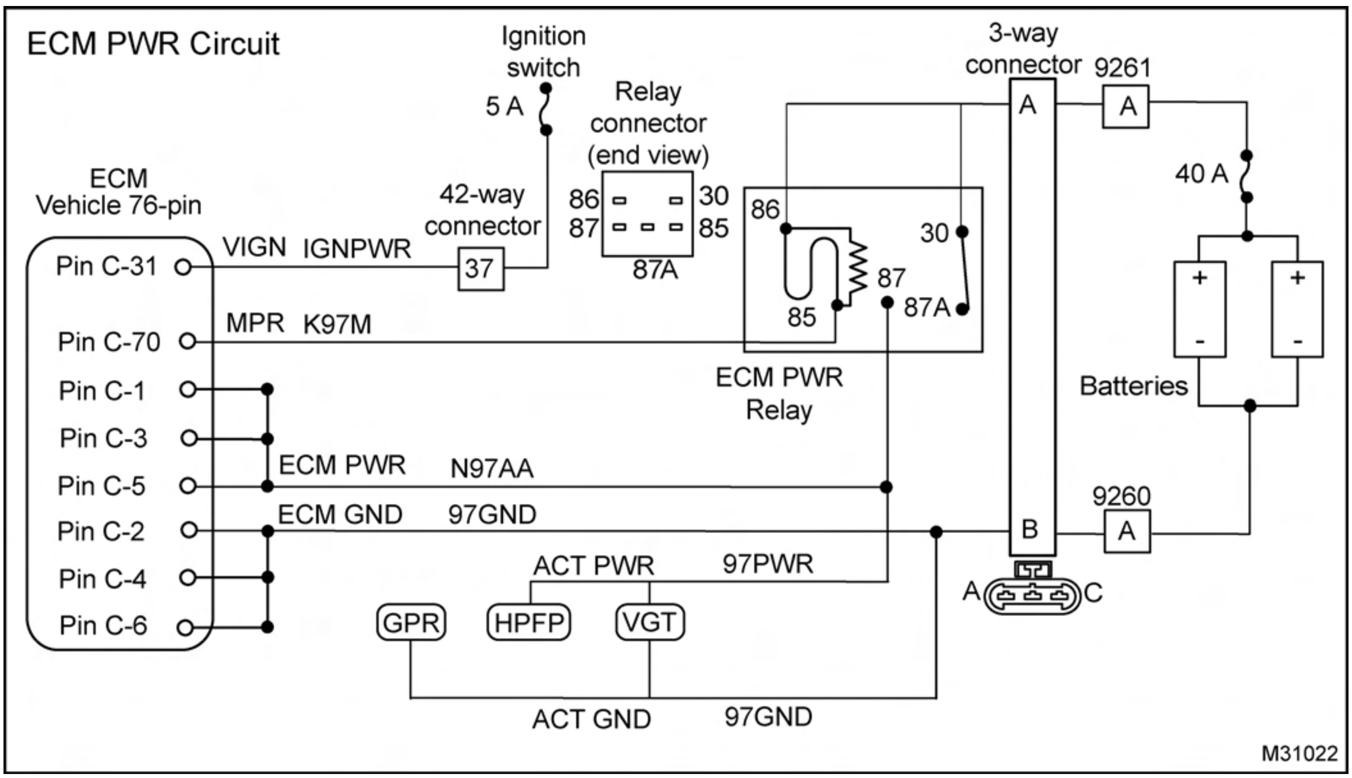

Figure 159 ECM PWR circuit diagram

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

Voltage Check at Relay

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

CAUTION: To avoid engine damage, turn the ignition switch to OFF before removing main power relay or any ECM connector supplying power to the ECM. Failure to turn the ignition switch to OFF will cause 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 Harness Resistance Check (page 226).
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 Harness Resistance Check (page 226).
85 to GND	0 V to 2 V	If > 2 V, check Main Power Relay (MPR) control circuit for OPEN or short to PWR. Do Harness Resistance Check (page 226).
87 to GND	B+	If < B+ but > 0 V, replace relay. If B+, check ECM PWR and ECM GND circuits at the ECM. Do Voltage Check at ECM (page 225).

Voltage Check at ECM

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

Test Point	Spec	Comment
C-31 to GND	B+	If < B+, check VIGN circuit for OPEN or short to GND, or blown fuse.
C-2 to GND C-4 to GND C-6 to GND	0 V 0 V 0 V	If voltage is present, check for OPEN circuit. Do Harness Resistance Check (page 226).
C-70 to GND	0 V to 2 V	If > 2 V, check MPR control circuit for OPEN or short to PWR. Do Harness Resistance Check (page 226).
C-1 to GND C-3 to GND C-5 to GND	B+ B+ B+	If < B+, check for OPEN circuit, failed relay, or blown fuse. Do Harness Resistance Check (page 226).

Harness Resistance Check

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

Test Point	Spec	Comment
C-70 to 85	< 5 Ω	If > 5 Ω, check MPR control circuit for OPEN.
C-70 to GND	> 1 kΩ	If < 1 kΩ, check MPR control circuit for short to GND.
C-1 to 87	< 5 Ω	If > 5 Ω, check ECM PWR circuit for OPEN.
C-1 to GND	> 1 kΩ	If < 1 kΩ, check ECM PWR circuit for short to GND.
C-3 to 87	< 5 Ω	If > 5 Ω, check ECM PWR circuit for OPEN.
C-3 to GND	> 1 kΩ	If < 1 kΩ, check ECM PWR circuit for short to GND.
C-5 to 87	< 5 Ω	If > 5 Ω, check ECM PWR circuit for OPEN.
C-5 to GND	> 1 kΩ	If < 1 kΩ, check ECM PWR circuit for short to GND.
C-2 to GND	< 5 Ω	If > 5 Ω, check ECM GND circuit for OPEN.
C-4 to GND	< 5 Ω	If > 5 Ω, check ECM GND circuit for OPEN.
C-6 to GND	< 5 Ω	If > 5 Ω, check ECM GND circuit for OPEN.

Harness Resistance Check 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

ECM PWR Circuit Operation

The ECM receives VIGN power at Pin C-31. This signals the ECM to provide a ground path from Pin C-70 to 85 to switch the ECM MPR. Switching the relay provides power from the battery positive terminal through a 40A fuse and relay contacts 30 and 87 to Pins C-1, C-3, and C-5.

The ECM is grounded to the battery negative terminal at ECM Pin C-2, C-4, and C-6.

Fault Detection/Management

The ECM internally monitors battery voltage. When the ECM continuously receives less than 7 volts or more than 17.5 volts, a Diagnostic Trouble Code (DTC) is set.

ECM Self Diagnostics (Electronic Control Module)

DTC	SPN	FMI	Condition
1151	108	3	BAP signal Out of Range HIGH
1152	108	4	BAP signal Out of Range LOW
1377	1136	3	ECM Temp above maximum
1378	1136	4	ECM Temp below minimum
1379	1136	10	ECM Temp intermittent
4518	8152	4	Fuel Injector Driver Initialization Circuit Performance Bank B
4519	8152	10	Fuel Injector Driver Circuit Performance Bank B
5382	1136	0	ECM Error - over temperature
5618	8334	2	ECM Error - SPI-BUS error1
5619	8334	12	ECM Error - SPI-BUS error2
5627	8333	12	ECM Error - Checksum program
5628	8333	2	ECM Error - Checksum Dataset
5633	8254	0	ECM Error - CPU load above maximum
5634	8336	12	ECM Error - MQPS daisy chain failure
5635	8337	12	ECM Error - OCT daisy chain failure
5636	8338	12	ECM Error - QPS daisy chain failure
5641	86	14	ECM Error - CC monitoring
5642	94	14	ECM Error - Fuel Cut Off monitoring
5643	183	14	ECM Error - Post Inj: monitoring
5644	190	2	ECM Error - Engine Speed limitation
5645	7253	7	ECM Error - EEPROM failure
5646	190	14	ECM Error - Engine Speed: monitoring
5647	558	14	ECM Error - PVS monitoring
5648	976	14	ECM Error - PTO monitoring
5649	1136	14	ECM Error - A/D conversion monitoring
5651	7132	14	ECM Error - MFMA monitoring
5652	8240	14	ECM Error - NVMY channel
5653	8300	14	ECM Error - PPS monitoring
5654	8329	14	ECM Error - CAN monitoring
5655	8332	14	ECM Error - Service Tool monitoring
5656	8335	14	ECM Error - Processor monitoring

5701	8476	3	ECM Error - DCDC voltage too high
5702	8476	4	ECM Error - DCDC voltage too low

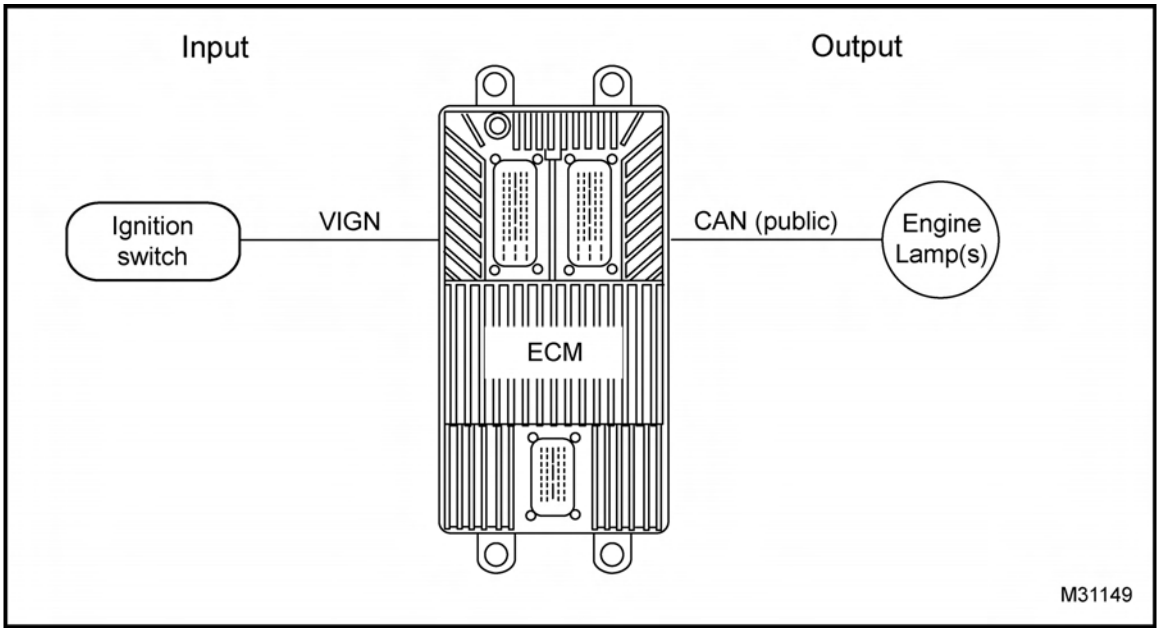

Figure 160 Function diagram for the ECM

The ECM does the following:

- Monitors and controls engine operation and performance
- Enables Power Takeoff (PTO) and cruise control
- Communicates engine and vehicle information to the instrument cluster
- Enables electronically controlled transmission (if equipped)
- Enables diagnostic programming tools

Fault Detection/Management

The ECM automatically performs diagnostic self-checks. The ECM self-test includes memory, programming, and internal power supply checks. The ECM detects internal 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.

When DTCs 1151, 1152, 1377, 1378, 1379, 5656, and 5644 are set by the ECM, the Warn Engine Lamp (WEL) is illuminated.

ECM Self Diagnostic Trouble Codes (DTCs)

DTC 1151 - 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 1377 - Internal ECM temp signal out-of-range HIGH

Checks whether the internal temperature 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 1378 - Internal ECM temp signal out-of-range LOW

Checks whether the internal temperature 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 1379 - Internal ECM temp, abnormal rate-of-change

Checks if ECM power is > 19 V.

Pin-point ECM Self-Diagnostic Fault

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

DTC 4518 - Fuel Injector Driver Initialization Circuit Performance Bank B

Pin-point ECM Self-Diagnostic Fault

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

DTC 4519 - Fuel Injector Driver Circuit Performance Bank B

Pin-point ECM Self-Diagnostic Fault

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

DTC 5382 - ECM over temperature

Pin-point ECM Self-Diagnostic Fault

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

DTC 5618 - SPI-BUS error 1

Pin-point ECM Self-Diagnostic Fault

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

DTC 5619 - SPI-BUS error 2

Pin-point ECM Self-Diagnostic Fault

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

DTC 5627 - Checksum program

Pin-point ECM Self-Diagnostic Fault

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

DTC 5628 - Checksum dataset

Pin-point ECM Self-Diagnostic Fault

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

DTC 5633 - CPU Load above maximum

Pin-point ECM Self-Diagnostic Fault

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

DTC 5634 - MQPS daisy chain failure

Indicates an error occurred in the ECM.

Pin-point ECM Self-Diagnostic Fault

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

DTC 5635 - OCT daisy chain failure

Indicates an error occurred in the ECM.

Pin-point ECM Self-Diagnostic Fault

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

DTC 5636 - QPS daisy chain failure

Indicates an error occurred in the ECM.

Pin-point ECM Self-Diagnostic Fault

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

DTC 5641 - ECM Error - CC monitoring

Pin-point ECM Self-Diagnostic Fault

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

DTC 5642 - ECM Error - Fuel Cut Off monitoring

Pin-point ECM Self-Diagnostic Fault

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

DTC 5643 - ECM Error - Post Inj: monitoring

Pin-point ECM Self-Diagnostic Fault

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

DTC 5644 - ECM Error - Engine Speed limitation

Pin-point ECM Self-Diagnostic Fault

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

DTC 5645 - ECM internal EEPROM failure

Pin-point ECM Self-Diagnostic Fault

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

DTC 5656 - Processor monitoring error detected

Indicates the ECM software is corrupted.

Pin-point ECM Self-Diagnostic Fault

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

DTC 5701 - ECM Error - DCDC voltage too high

Pin-point ECM Self-Diagnostic Fault

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

DTC 5702 - ECM Error - DCDC voltage too low

Pin-point ECM Self-Diagnostic Fault

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

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

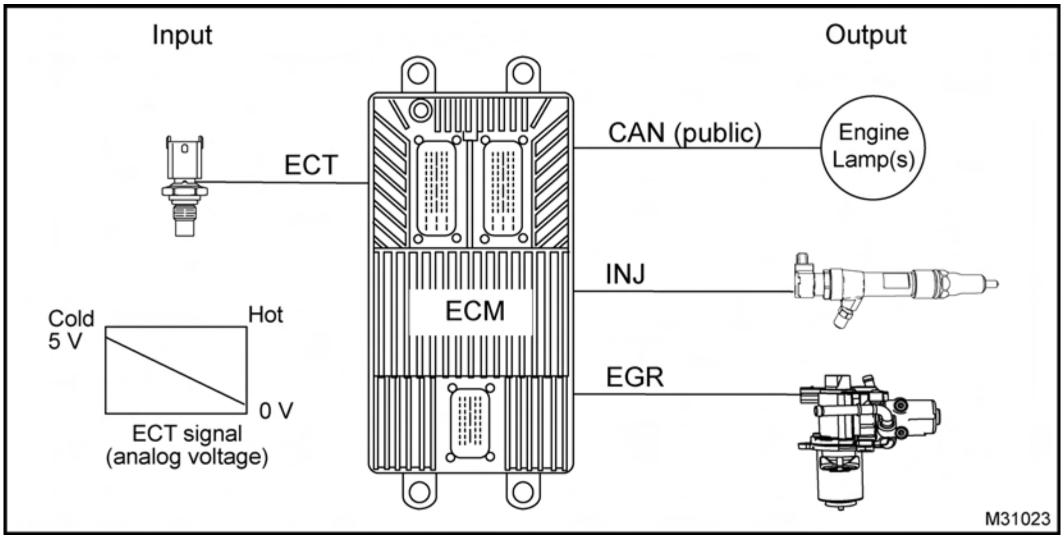

Figure 161 Function diagram for the ECT sensor

The ECT sensor function diagram includes the following:

- Engine Coolant Temperature (ECT) sensor
- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR) valve
- Fuel injector (INJ)
- Warn Engine Lamp (WEL)
- Oil/Water Lamp (OWL)

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:

- Engine Warning Protection System (EWPS)
- Cold Ambient Protection (CAP)
- Idle Shutdown Timer (IST)
- Cold idle advance
- Coolant compensation

The EWPS has standard and optional features. 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 front cover, just to the left of the water pump pulley.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 180-Pin Breakout Box
- Temperature Sensor Breakout Harness
- Terminal Test Adapter Kit

ECT Sensor 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 • SIG GND circuit OPEN • Failed sensor

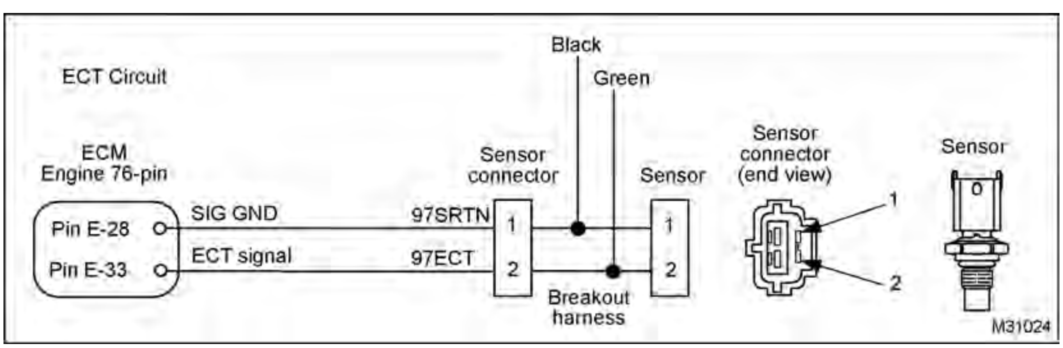

Figure 162 ECT circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating part (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 code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the Parameter Identifier (PID) spikes and the DTC will go active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

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

Test Point	Spec	Comments
EST – Check DTC	DTC 1115	If DTC 1114 is active, check ECT signal for short to GND. Do Harness Resistance Check (page 237).
EST – Check DTC Short 3 banana plug harness across 2 and GND	DTC 1114	If DTC 1115 is active, check ECT signal for OPEN. Do Harness Resistance Check (page 237).
EST – Check DTC Short 3 banana plug harness across 1 and 2	DTC 1114	If DTC 1115 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 237).
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.		

ECT Pin-point Diagnostics

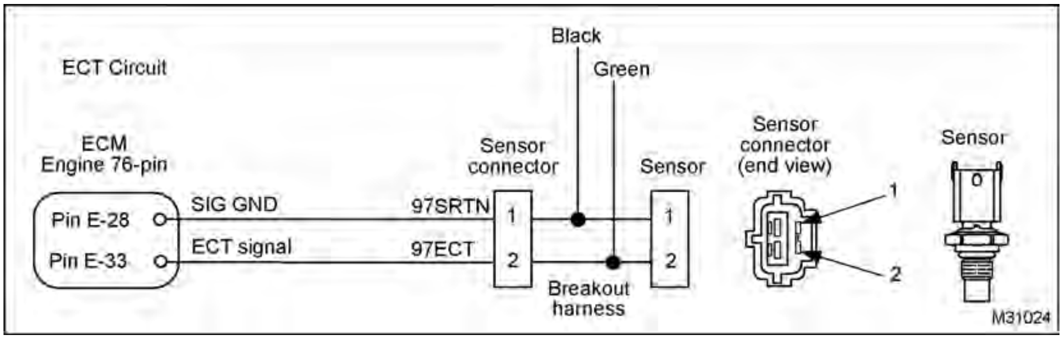

Figure 163 ECT circuit diagram

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	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 237).

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.
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 breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-28	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to E-33	< 5 Ω	If > 5 Ω, check for OPEN circuit.

ECT Circuit Operation

The ECT is a thermistor sensor supplied with a 5 volt reference voltage at Pin 2 from ECM Pin E-33. The sensor is grounded at Pin 1 from ECM Pin E-28. As the coolant temperature increases, the resistance of the thermistor decreases. This causes the signal voltage to decrease.

Coolant Temperature Compensation

Coolant temperature compensation reduces fuel delivery if ECT is above cooling system specifications.

The reduction in fuel delivery begins when ECT reaches approximately 107 °C (225 °F). A reduction of 15% is achieved as the ECT reaches approximately 110 °C (230 °F).

Fuel reduction is calibrated to a maximum of 30% before standard engine warning or optional warning/protection is engaged. If warning or shutdown occurs, a DTC is stored in ECM memory.

NOTE: Coolant temperature compensation may be disabled in emergency vehicles that require 100% power on demand.

Engine Warning Protection System (EWPS)

EWPS has standard and optional features. Optional features can be enabled or disabled. When enabled, the EWPS warns the operator of an overheat condition and can be programmed to shut down the engine.

The OWL illuminates when ECT reaches approximately 109 °C (228 °F). A warning buzzer sounds when ECT reaches approximately 112 °C (234 °F). The engine will shut down when the ECT reaches approximately 112 °C (234 °F), if 3-way protection is enabled.

Fault Detection/Management

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM disregards the signal and uses a calibrated default value. The ECM sets a DTC, turns on the WEL, 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.

EFAN Control (Engine Fan Control)

DTC	SPN	FMI	Condition
None			

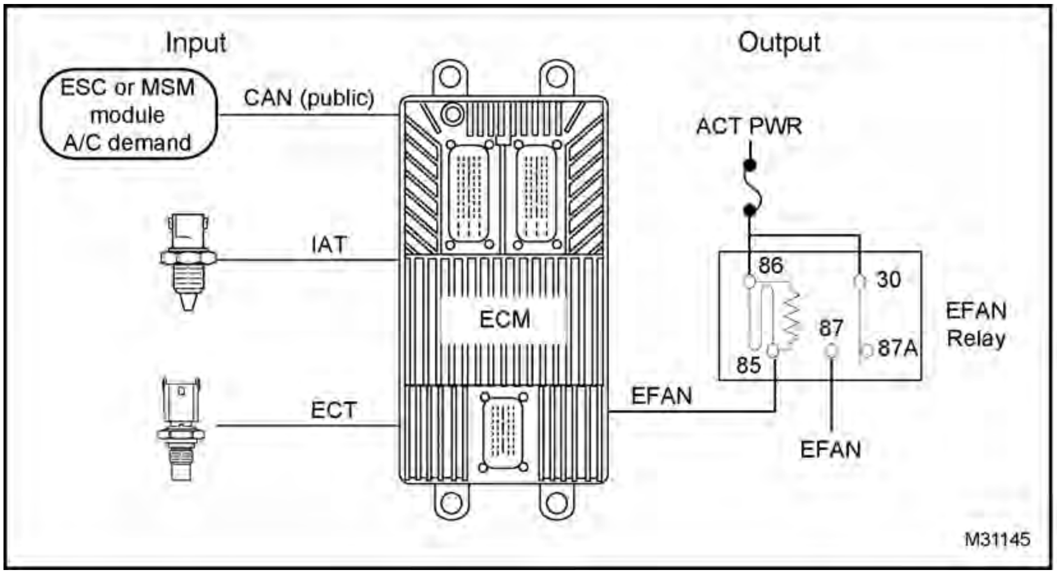

Figure 164 Function diagram for EFAN

The EFAN function diagram includes the following:

- Engine Fan (EFAN) control
- Electronic Control Module (ECM)
- Electronic System Control (ESC) module
- Multiplex System Module (MSM)
- Engine Coolant Temperature (ECT) sensor
- Intake Air Temperature (IAT) sensor
- Engine Fan (EFAN) relay

Function

The engine fan is to allows increased air flow through the radiator when the A/C is on or when ECT or IAT goes above a set temperature.

Location

The EFAN relay and switches are chassis mounted. For additional supporting information, see truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.

Tools

- Digital Multimeter (DMM)
- 180-Pin Breakout Box
- Relay Breakout Harness
- Terminal Test Adapter Kit

EFAN Circuit Diagnostics

DTC	Condition	Possible Causes
None	EFAN does not cycle on or off	• EFAN relay control circuit OPEN or shorted to GND • EFAN relay coil GND circuit OPEN • Blown fuse • Failed relay

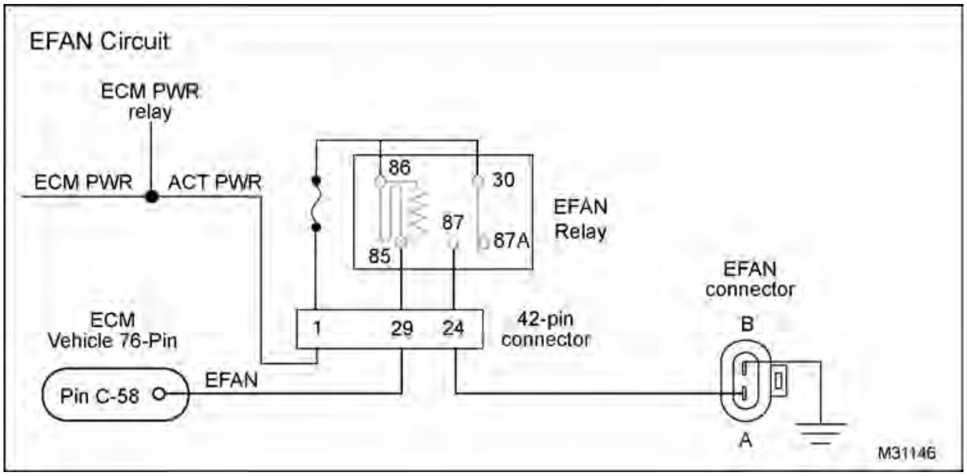

Figure 165 EFAN circuit diagram

Voltage Check at EFAN Connector - Output State Test

Disconnect EFAN 2-pin connector. Turn the ignition switch to ON. 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 or EFAN control circuit for short to GND, or failed EFAN relay.
B to GND	0 V to 0.25 V	If > 0.25 V, check for OPEN circuit.
Run Output State Test HIGH.		
A to GND	0 V to 0.25 V	If > 0.25 V, check for short to PWR, or EFAN control circuit for short to GND, or failed EFAN relay.
Run Output State Test LOW.		
A to GND	B+	If < B+, check for OPEN circuit between relay and EFAN, or EFAN control circuit for OPEN, or blown fuse, or failed relay. Do Harness Resistance Check (page 241).
A to B	B+	If < B+, check GND circuit for OPEN. Do Harness Resistance Check (page 241).

Voltage Check at Relay - Output State Test

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

Test Point	Spec	Comment
30 to GND	B+	If < B+, check power circuit to relay switch for OPEN or short to GND, or blown fuse.
86 to GND	B+	If < B+, check power circuit to relay coil for OPEN or short to GND, or blown fuse.
Run Output State Test HIGH.		
85 to GND	B+	If < B+, check EFAN control circuit for short to GND. Do Harness Resistance Check (page 241).
Run Output State Test LOW.		
85 to GND	0.06 V to 2 V	If > 2 V, check EFAN control circuit for OPEN. Do Harness Resistance Check (page 241).
87 to GND	B+	If < B+, replace relay.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and relay harness. Leave ECM and relay disconnected.

Test Point	Spec	Comment
C-58 to 85	< 5 Ω	If > 5 Ω, check for OPEN circuit between ECM and relay terminal.
87 to A (fan)	< 5 Ω	If > 5 Ω, check for OPEN circuit between relay terminal and A (fan).
30 to C-1, 3 and 5	< 5 Ω	If > 5 Ω, check ACT PWR for OPEN in circuit.
30 to GND	> 1 kΩ	If < 1 kΩ, check ACT PWR for short to GND.
86 to C-1, 3 and 5	< 5 Ω	If > 5 Ω, check ACT PWR for OPEN in circuit.
86 to GND	> 1 kΩ	If < 1 kΩ, check ACT PWR for short to GND.
See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for fuse information.		

EFAN Circuit Operation

The default state of the EFAN is ON. B+ is needed to turn the fan off.

ECM Pin C-58 controls the EFAN to shut off by supplying a ground path to the EFAN relay coil Pin 85. ACT PWR powers the other side of the relay coil, Pin 86. ACT PWR is sent through the relay switch, which deactivates the EFAN.

EFAN Programmable Parameters

By using an Electronic Service Tool (EST) with MasterDiagnostics® software, an authorized service technician can program the ECM to turn the EFAN on for any desired temperature.

- Engine fan control - indicates to the on-board electronics whether or not the vehicle has the electronic engine fan control feature.
- A/C fan activation - allows fan activation through the ECM when requested from the ESC during A/C operation.
- Disable - enables or disables the EFAN feature.
- Fan on temperature - indicates at what coolant temperature the fan is electronically activated.
- Fan off temperature - indicates at what coolant temperature the fan is electronically deactivated.

Fault Detection/Management

An open or short to ground in the EFAN can be detected by the ECM during an on-demand engine standard test. The IAT and ECT are continuously monitored. If a Diagnostic Trouble Code (DTC) is detected in the IAT or ECT circuit, the EFAN control is disabled and the engine fan remains on.

NOTE: Before diagnosing, verify the vehicle has an electronic fan and the ECM is programmed correctly.

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

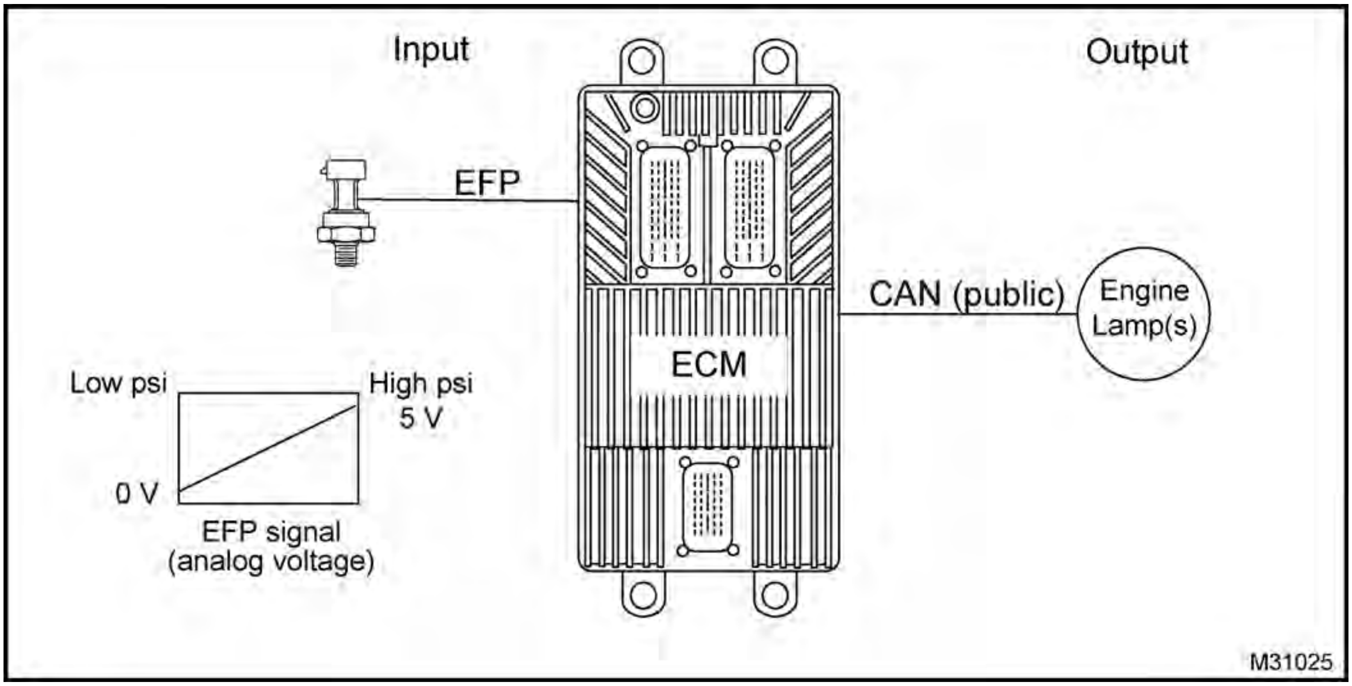

Figure 166 Function diagram for the EFP sensor

The EFP sensor function diagram includes the following:

- Engine Fuel Pressure (EFP) sensor
- Electronic Control Module (ECM)
- Warn Engine Lamp (WEL)
- Fuel filter lamp (amber)

Function

The EFP sensor provides a feedback signal to the ECM indicating engine fuel supply pressure. During engine operation, if pressure is low, 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 in the secondary fuel filter housing on the top front of the engine.

Tools

- Electronic Service Tool (EST) with MasterDiagnostic® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 180-Pin Breakout Box
- Pressure Sensor Breakout Harness
- Terminal Test Adapter Kit

EFP Sensor End Diagnostics

DTC	Condition	Possible Causes
1136	EFP signal out-of-range LOW	• EFP signal circuit OPEN or short to GND • VREF circuit OPEN or short to GND • Failed sensor
1137	EFP signal out-of-range HIGH	• EFP signal circuit short to PWR • Failed sensor
2371	Fuel pressure above normal	• SIG GND circuit OPEN • VREF short to PWR • Debris in fuel regulator • Biased circuit/sensor • Restricted fuel return line
2372	Fuel pressure below normal	• Dirty fuel filter • Fuel inlet restriction • Debris in fuel regulator • Failed fuel pump • Bias circuit/sensor

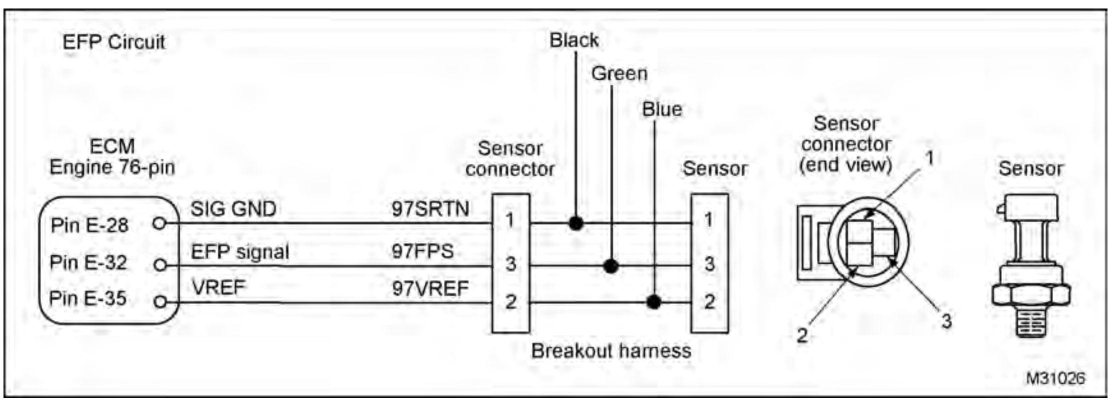

Figure 167 EFP circuit diagram

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

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Verify sensor voltage is within Key-On Engine-Off (KOEO) specification. See “Performance Specifications” section of this manual.
3. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If code 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.

4. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

5. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

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. Use DMM to measure circuits.

Test Point	Spec	Comments
EST – Check DTC	DTC 1136	If DTC 1137 is active, check EFP signal for short to PWR
DMM – Measure volts 2 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 247).
EST – Check DTC Short breakout harness across 2 and 3	DTC 1137	If DTC 1136 is active, check EFP signal for OPEN. Do Harness Resistance Check (page 247).
DMM – Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 247).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

EFP Pin-point Diagnostics

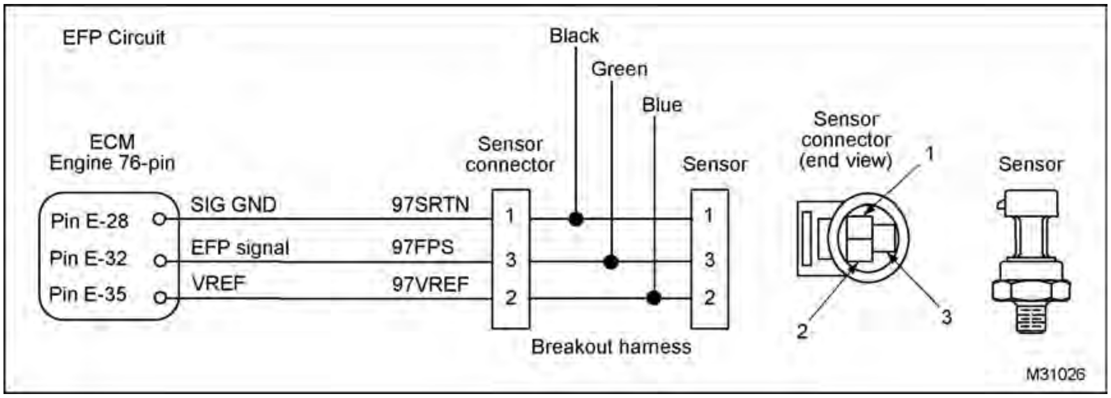

Figure 168 EFP circuit diagram

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	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 247).
3 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 247).

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.
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 breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-28	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
2 to E-35	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
3 to E-32	< 5 Ω	If > 5 Ω, check EFP signal circuit for OPEN.

EFP Circuit Operation

The EFP sensor is a variable capacitance sensor supplied with a 5 volt reference voltage at Pin 2 from ECM Pin E-35. The sensor is grounded at Pin 1 from ECM Pin E-28. The sensor returns a variable voltage signal from Pin 3 to ECM Pin E-32.

Fault Detection/Management

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

EFT Sensor (Engine Fuel Temperature)

DTC	SPN	FMI	Condition
1281	174	4	EFT signal out-of-range LOW
1282	174	3	EFT signal out-of-range HIGH
1283	174	2	Fuel temp sensor gradient not plausible
2284	174	0	Fuel temp above maximum - torque limited
2285	174	10	Fuel temp signal not plausible

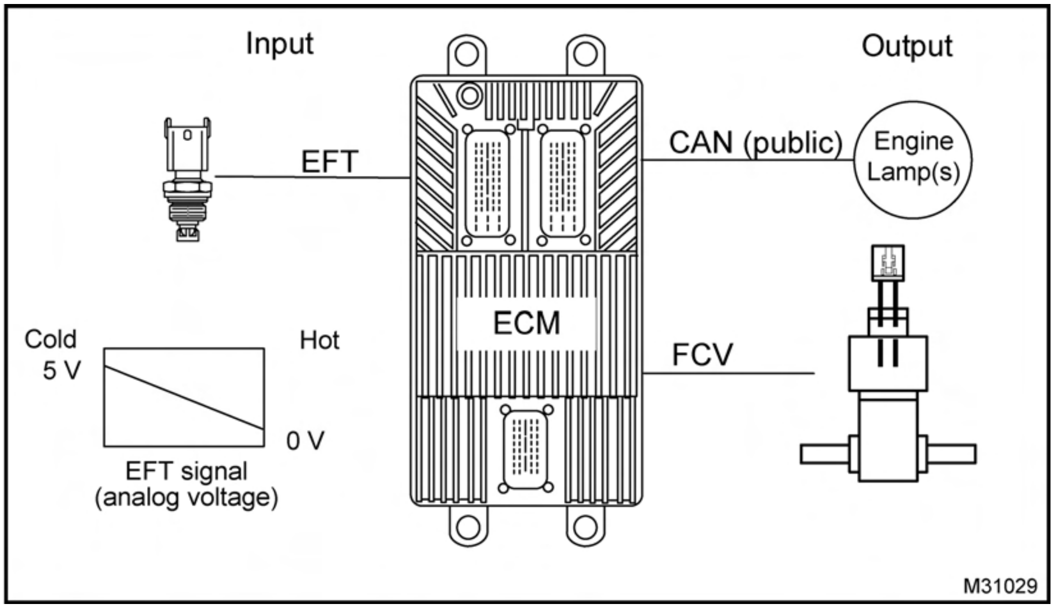

Figure 169 Function diagram for the EFT sensor

The EFT sensor function diagram includes the following:

- Engine Fuel Temperature (EFT) sensor
- Fuel Coolant Valve (FCV)
- Electronic Control Module (ECM)
- Malfunction Indicator Lamp (MIL)
- Warn Engine Lamp (WEL)

Function

The EFT sensor provides a feedback signal to the ECM indicating fuel temperature out of the secondary fuel filter. The ECM monitors this sensor and controls the FCV to maintain desired fuel temperature.

Sensor Location

The EFT sensor is installed under the secondary fuel filter housing, next to the EFP sensor.

Tools

- Electronic Service Tool (EST) with MasterDiagnotics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 180-Pin Breakout Box
- Temperature Sensor Breakout Harness
- Terminal Test Adapter Kit

EFT Sensor End Diagnostics

DTC	Condition	Possible Causes
1281	Fuel temp signal out-of-range LOW	• EFT signal circuit short to GND • Failed sensor
1282	Fuel temp signal out-of-range HIGH	• EFT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor
1283	Fuel temp sensor gradient not plausible	• More than 10 °C (50 °F) change within 0.1 second • EFT sensor or circuit fault
2284	Fuel temp above maximum - torque limited	• EFT biased sensor or circuit. • FCV fault • Low fuel level • Restricted fuel lines
2285	Fuel temp signal not plausible	• EFT biased sensor or circuit fault • Failed sensor

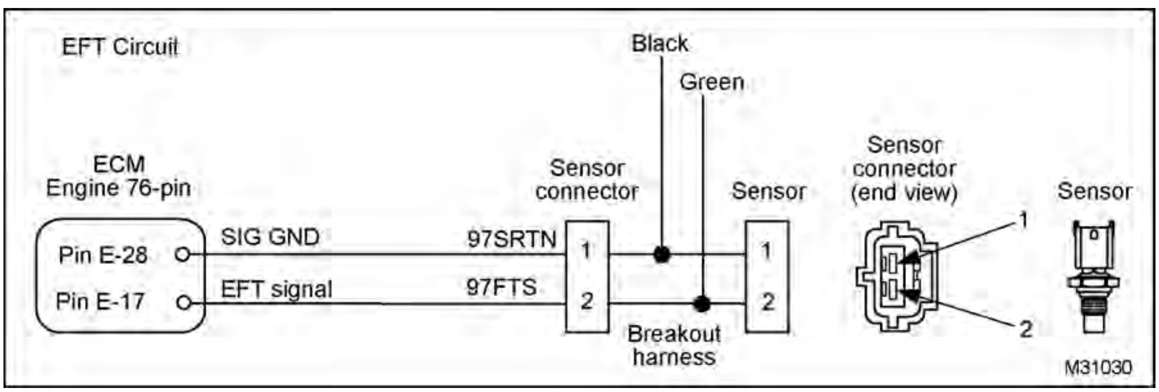

Figure 170 EFT circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating part (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 code 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.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

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

Test Point	Spec	Comments
EST - Check DTC	DTC 1282	If DTC 1281 is active, check EFT signal for short to GND. Do Harness Resistance Check (page 251).
EST - Check DTC Short 3-banana plug harness across 2 and GND	DTC 1281	If DTC 1282 is active, check EFT signal for OPEN. Do Harness Resistance Check (page 251).
EST - Check DTC Short 3-banana plug harness across 1 and 2	DTC 1281	If DTC 1282 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 251).
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.		

EFT Pin-point Diagnostics

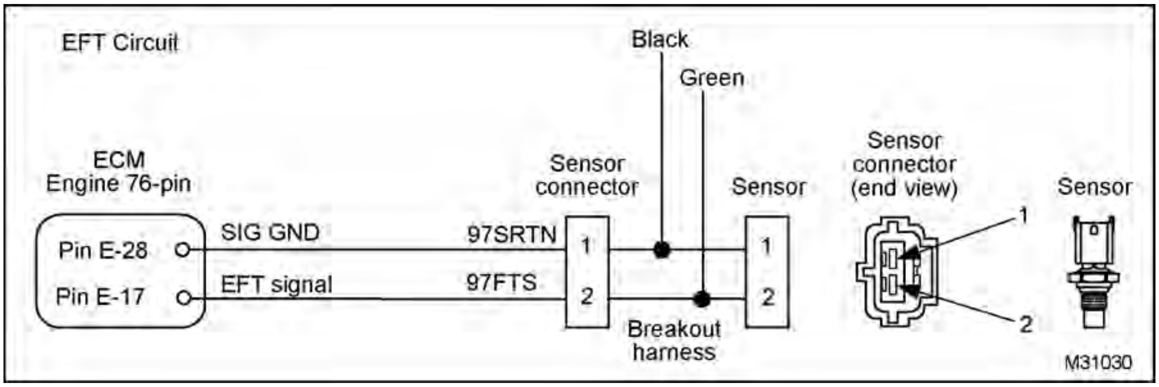

Figure 171 EFT circuit diagram

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	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 251).

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.
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 breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-28	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to E-17	< 5 Ω	If > 5 Ω, check for OPEN circuit.

EFT Circuit Operation

The EFT is a thermistor sensor supplied with a 5 volt reference voltage at Pin 2 from ECM Pin E-17. The sensor is grounded at Pin 1 from ECM Pin E-28. As temperature increases, the resistance of the thermistor decreases. This causes 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 signal and uses a calibrated default value. The ECM sets a DTC, turns on the MIL, and runs the engine in a default range.

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
2699	3251	1	EGDP below desired level
2732	3251	2	EGDP stuck in-range fault
2733	3251	10	EGDP mismatch between key-on/off

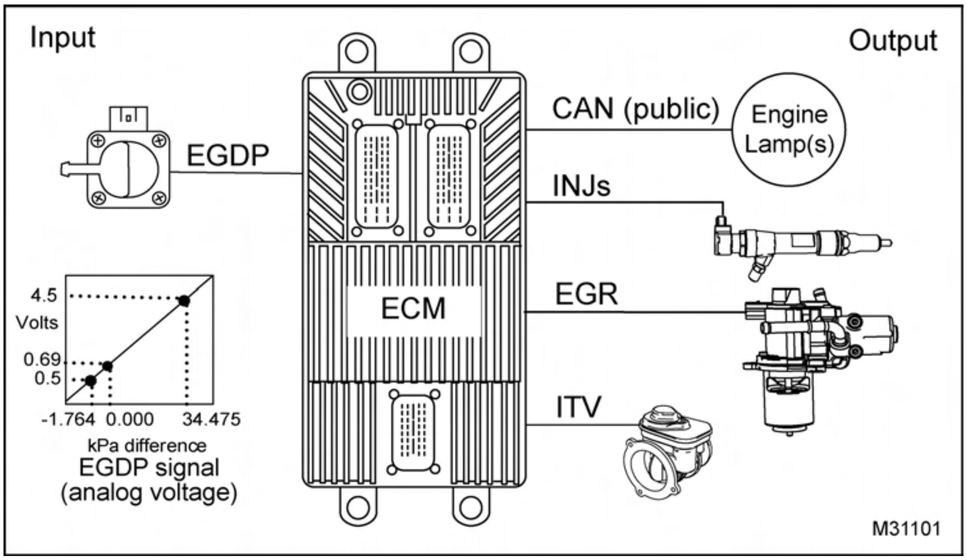

Figure 172 Function diagram for the EGDP sensor

The EGDP sensor function diagram includes the following:

- Exhaust Gas Differential Pressure (EGDP) sensor
- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR)
- Intake Throttle Valve (ITV)
- Fuel injectors (INJ)
- Malfunction Indicator Lamp (MIL)
- Regeneration lamp

Function

The EGDP sensor provides a feedback signal to the ECM indicating pressure difference between the inlet and outlet of the Diesel Particulate Filter (DPF). Before and during a catalyst regeneration, the ECM monitors this sensor along with EGT1, EGT2, EGT3, EGRP, and ITVP.

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
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- Breakout Box
- Breakout Harness
- Terminal Test Adapter Kit

EGDP Sensor End Diagnostics

DTC	Condition	Possible Causes
1729	EGDP signal out-of-range LOW	• EGDP signal OPEN or short to GND • Failed sensor • Damaged or missing DPF
1731	EGDP signal out-of-range HIGH	• EGDP signal short to power • SIG GND circuit OPEN • Failed sensor
2699	EGDP below desired level	• EGDP sensor tubes restricted, open, or assembled incorrectly • Biased circuit or sensor • Damaged or missing DPF
2732	EGDP stuck in-range fault	• EGDP sensor tubes restricted or open
2733	EGDP mismatch between key-on/off	• Biased circuit or sensor

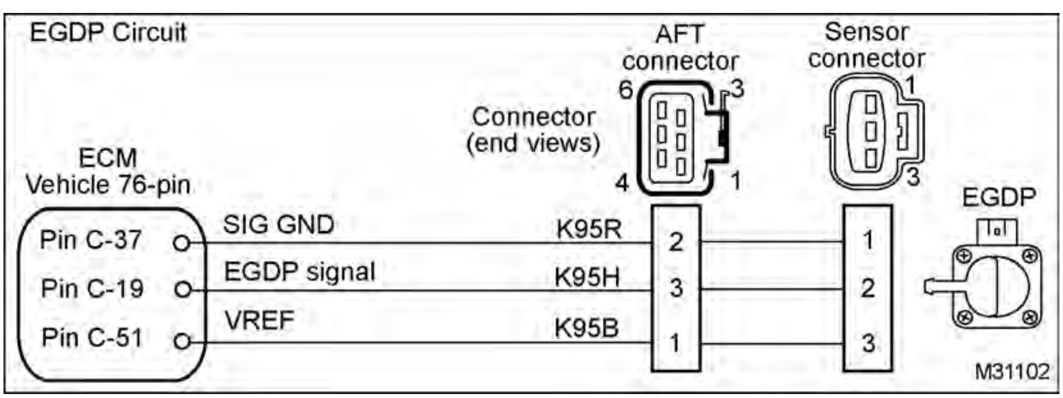

Figure 173 EGDP circuit diagram

WARNING: To prevent personal injury or death, be careful to avoid rotating parts (belts and fan) and hot engine surfaces.

1. Inspect EGDP sensor and tubes for damage or incorrect assembly.
2. Using EST, open the D_ContinuousMonitor.ssn.
3. Verify sensor voltage is within Key-On Engine Off (KOEO) specification. See "Performance Specifications" section of this manual.
4. 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.
5. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

6. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

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. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	DTC 1729	If DTC 1731 is active, check EGDP signal for short to PWR.
DMM - Measure volts 3 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 257).
EST - Check DTC Short breakout harness across 2 and 3	DTC 1731	If DTC 1729 is active, check EGDP signal for OPEN. Do Harness Resistance Check (page 257).
DMM - Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 257).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

EGDP Pin-point Diagnostics

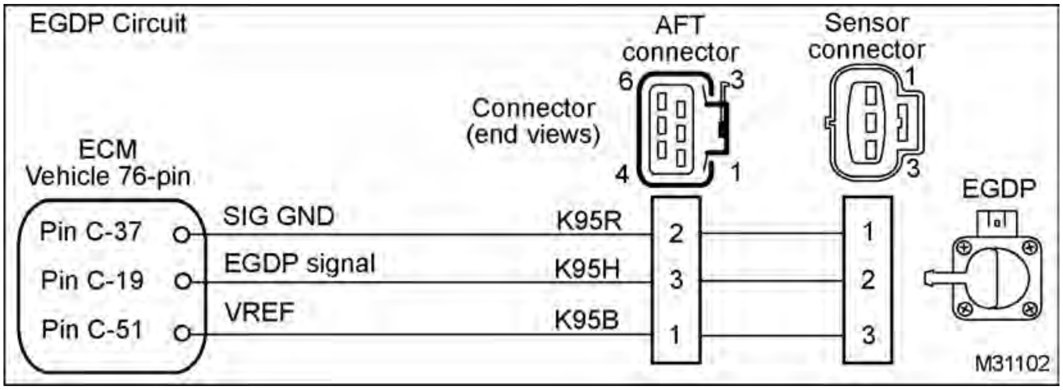

Figure 174 EGDP circuit diagram

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.
3 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 257).
2 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 257).

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.
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 breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to C-37	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN
2 to C-19	< 5 Ω	If > 5 Ω, check EGDP signal circuit for OPEN
3 to C-51	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN

EGDP Circuit Operation

The EGDP is a differential pressure sensor supplied with a 5 V reference voltage at Pin 3 from ECM Pin C-51. The sensor is grounded at Pin 1 from ECM Pin C-37. The sensor returns a variable voltage signal from Pin 2 to ECM Pin C-19.

EGR Actuator (Exhaust Gas Recirculation)

DTC	SPN	FMI	Condition
1163	7137	10	EGR Position Sensor/circuit fault
1396	8327	4	EGR control stuck CLOSED
1397	8327	12	EGR control stuck OPEN
1398	8327	7	EGR unable to achieve desired position
2391	2791	11	EGR control circuit fault
2392	7138	6	EGR Position Sensor Min/Max stop performance
2393	7137	2	EGR Position Sensor/circuit fault

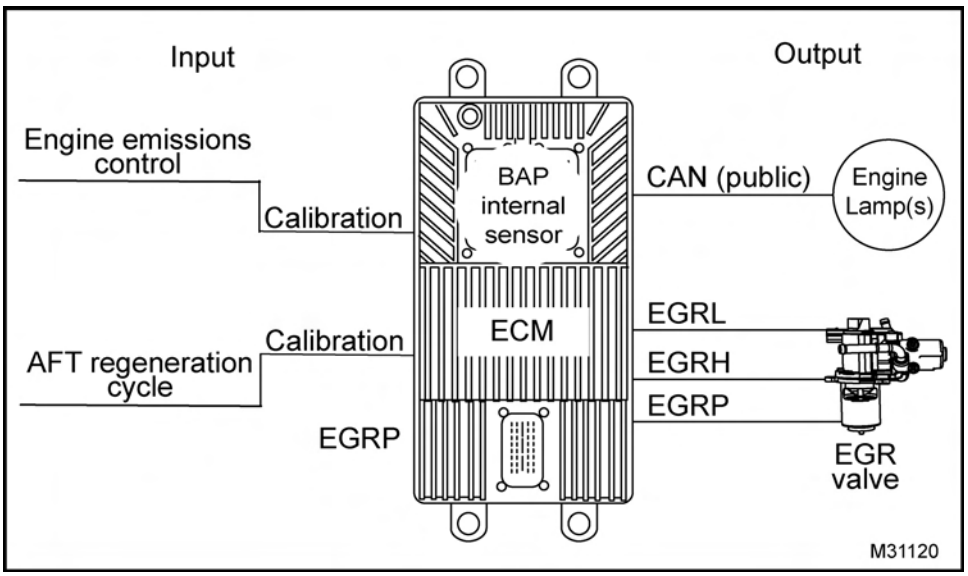

Figure 175 Function diagram for the EGR system

The EGR system function diagram includes the following:

- Exhaust Gas Recirculation (EGR) valve assembly with integrated EGR Position (EGRP) sensor
- Electronic Control Module (ECM) with integrated Barometric Absolute Pressure (BAP) sensor
- Malfunction Indicator Lamp (MIL)
- Warn Engine Lamp (WEL)

Function

Oxides of nitrogen (NO_X) in the atmosphere contributes to the production of smog. NO_X are 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. Exhaust gases that have already burned do not have oxygen. The EGR valve recirculates exhaust back into the intake stream. This cools the combustion process and reduces the formation of NO_X.

Component Location

The EGR valve is installed in the EGR valve elbow housing between the Intake Throttle Valve (ITV) and the intake manifold.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 180-Pin Breakout Box
- EGR Valve Breakout Harness
- Terminal Test Adapter Kit

EGR Actuator End Diagnostics

DTC	Condition	Possible Causes

1163	EGR Position Sensor/circuit fault	• EGRP Out-of-Range High
		  • EGRP signal circuit short to PWR
		  • Failed EGR valve assembly
		• EGRP Out-of-Range Low
		  • EGRP signal circuit OPEN or short to GND
		  • VREF circuit OPEN
		  • Failed EGR valve assembly

1396	EGR control stuck CLOSED	• EGR closed-loop error deviation is not within specified limits • EGRP circuit fault • Failed EGR valve assembly
1397	EGR control stuck OPEN	• EGR closed-loop error deviation is not within specified limits • EGRP circuit fault • Failed EGR valve assembly

1398	EGR unable to achieve desired position	• EGR closed-loop error deviation is not within specified limits • EGRP signal circuit short to PWR • EGRP signal circuit OPEN or short to GND • VREF circuit OPEN or short to GND • Failed EGR valve assembly

2391	EGR control circuit fault	• Failed H-bridge circuit due to
		  • Undervoltage
		  • Overcurrent
		  • Overtemperature

2392	EGR Position Sensor Min/Max stop performance	• EGRP sensor voltage when driven to close position, adaptation value not within tolerable limits • Failed EGR valve assembly • Possible EGRP sensor drift overtime

2393	EGR Position Sensor/circuit fault	• EGRP Out-of-Range High (ORH)
		  • EGRP signal circuit short to PWR
		  • Failed EGR valve assembly
		• EGRP Out-of-Range Low (ORL)
		  • EGRP signal circuit OPEN or short to GND
		  • VREF circuit OPEN
		  • Failed EGR valve assembly

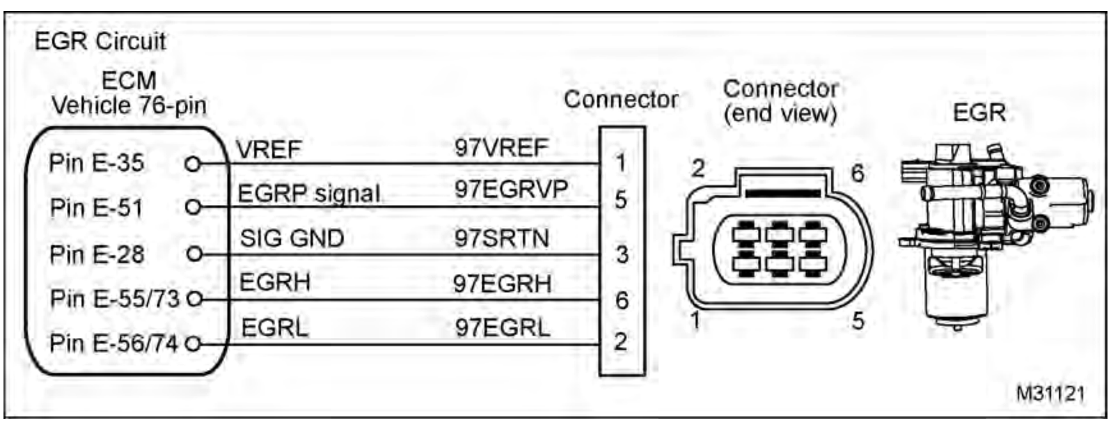

Figure 176 EGR actuator circuit diagram

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. Verify sensor voltage is within Key-On Engine Off (KOEO) specification. See “Performance Specifications” section of this manual.

3. 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.
4. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

5. Connect breakout harness to engine harness. Leave sensor disconnected.

EGR Actuator Circuit Check

Connect breakout harness. Leave EGR actuator disconnected. Turn the ignition switch to ON. Use EST to monitor PID and DMM to measure voltage during Continuous Monitor test.

NOTE: Clear DTC after each test step and watch voltage value before it changes to error.

Test Point	Spec	Comments
EST - Monitor EGRP	0 V	If > 0.039 V, check EGRP signal for short to PWR
DMM - Measure volts 1 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 264).
EST - Monitor EGRP Short 500-ohm resistor harness across 1 and 5	5 V	If < 4.5 V, check EGRP signal for OPEN or short to GND. Do Harness Resistance Check (page 264).
DMM - Measure resistance 3 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 264).
If checks are within specification, do EGR Actuator - Standard and Output State Test (page 262).		

EGR Actuator - Standard and Output State Test

Connect breakout harness between ECM and EGR actuator. Run KOEO Standard Test and KOEO Output State Test. Use EST to monitor EGRP volts.

Test	Spec	Comment
Standard Test/Output Circuit Check	3.55 V to 4.5 V	If < 3.55 V, check for OPEN or short in EGR control circuits. Do Harness Resistance Check (page 264).
Output State HIGH	3.55 V to 4.5 V	If < 3.55 V, check for OPEN or short in EGR control circuits. Do Harness Resistance Check (page 264).
Output State LOW	0.6 V to 1.5 volts	If > 1.5 volts, check for OPEN or short in EGR control circuits. Do Harness Resistance Check (page 264).

EGR Actuator Pin-point Diagnostics

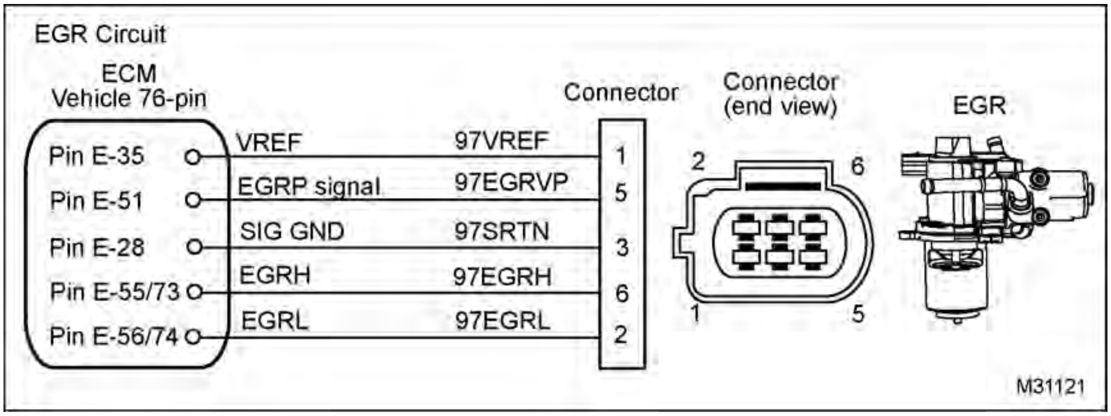

Figure 177 EGR actuator circuit diagram

Connector Voltage Check

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

Test Point	Spec	Comment
3 to GND	0 V	If > 0.25 V, check SIG GND for short to PWR.
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 Check (page 264).
2 to GND	B+	If < B+, check EGRL for OPEN or short to GND. Do Harness Resistance Check (page 264).
6 to GND	B+	If < B+, check EGRH for OPEN or short to GND. Do Harness Resistance Check (page 264).
5 to GND	0 V	If > 0.25 V, check EGRP for short to PWR. Do Harness Resistance Check (page 264).
If checks are within specification, do EGR Actuator - Output State Test (page 262).		

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave actuator 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.
5 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
6 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Disconnect battery GND and 9260 GND connector. Connect breakout box and breakout harness. Leave ECM and actuator disconnected. Use DMM to measure resistance.

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

Test Point	Spec	Comment
1 to E-35	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN
3 to E-28	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN
5 to E-51	< 5 Ω	If > 5 Ω, check EGRP signal circuit for OPEN
2 to E-56	< 5 Ω	If > 5 Ω, check EGRL circuit for OPEN
2 to E-74	< 5 Ω	If > 5 Ω, check EGRL circuit for OPEN
6 to E-55	< 5 Ω	If > 5 Ω, check EGRH circuit for OPEN
6 to E-73	< 5 Ω	If > 5 Ω, check EGRH circuit for OPEN

EGR Actuator Circuit Operation

EGR Position (EGRP) sensor

NOTE: The EGR valve is integrated with an EGRP sensor.

The EGRP is a potentiometer sensor supplied with a 5 volt reference voltage at Pin 1 from ECM Pin E-35. The sensor is grounded at Pin 3 from ECM Pin E-28. The sensor returns a variable voltage signal from Pin 5 to ECM Pin E-51.

EGR Actuator

The ECM controls the EGR valve with a Pulse Width Modulation (PWM) signal through H-bridge circuitry.

Pulse Width Modulation - Voltage is supplied by a series of pulses. To control motor speed, it varies (modulates) the width of the pulses.

H-bridge is a bipolar circuit. The ECM controls the EGR valve to close by driving the EGRH circuit high and EGRL circuit low. The opposite occurs then the valve is commanded open.

Variable voltage is needed to move the valve. Minimal voltage is needed to maintain its position.

Fault Detection/Management

The ECM monitors the internal BAP sensor as a base line for zeroing the MAP and EBP signals.

The ECM continuously monitors the EGRP sensor. If the sensor signal is higher or lower than expected, the ECM sets a DTC and turns on the MIL.

An open or short on the EGR controlling circuits can only be detected by an on demand output circuit check during KOEO Standard Test. If there is a circuit fault detected, a DTC sets.

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 temp not increasing with engine temp
2676	3241	1	EGT1 reading off compared to EGT2 and EGT3

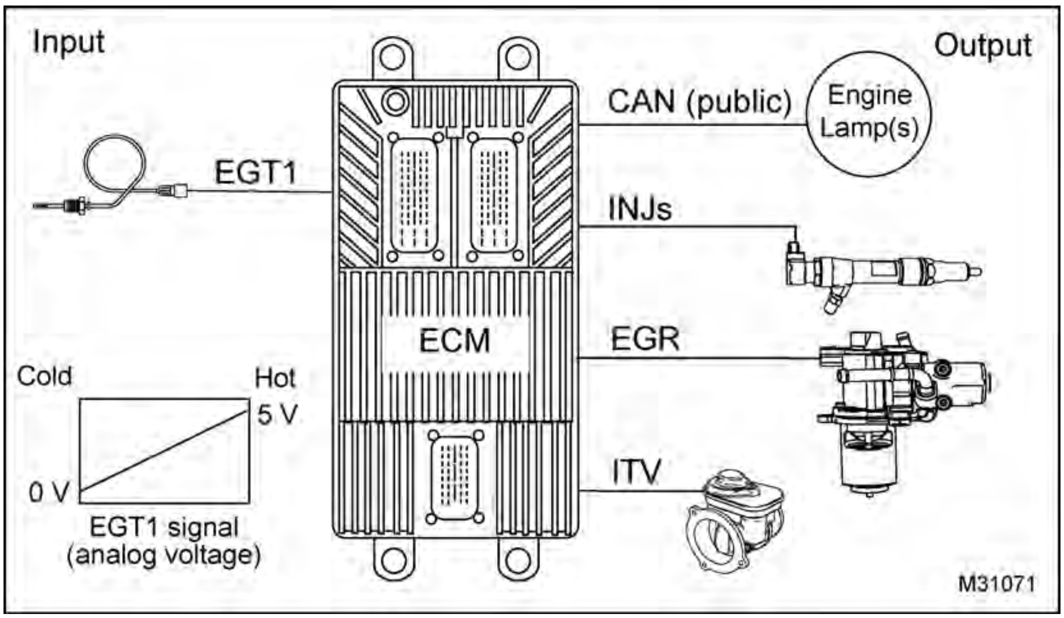

Figure 178 Function diagram for the EGT1 sensor

The EGT1 sensor function diagram includes the following:

- Exhaust Gas Temperature 1 (EGT1) sensor
- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR)
- Intake Throttle Valve (ITV)
- Fuel Injectors (INJ)
- Malfunction Indicator Lamp (MIL)
- Regeneration lamp

Function

The EGT1 sensor provides a feedback signal to the ECM indicating Diesel Oxidation Catalyst (DOC) inlet temperature. During catalyst regeneration, the ECM monitors this sensor along with EGT2, EGT3, EGDP, EGRP, and ITVP.

Sensor Location

The EGT1 sensor is the first exhaust temperature sensor installed downstream of the turbocharger and just before the DOC.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness

- 180-Pin Breakout Box
- Exhaust Temperature Breakout Harness
- Terminal Test Adapter Kit

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 circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor
2675	EGT1 temp not increasing with engine temp	• EGT1 biased sensor or circuit • EGT1 sensor outside of exhaust system
2676	EGT1 reading off compared to EGT2 and EGT3	• EGT1 biased sensor or circuit • EGT1 sensor outside of exhaust system • Engine over-fueling

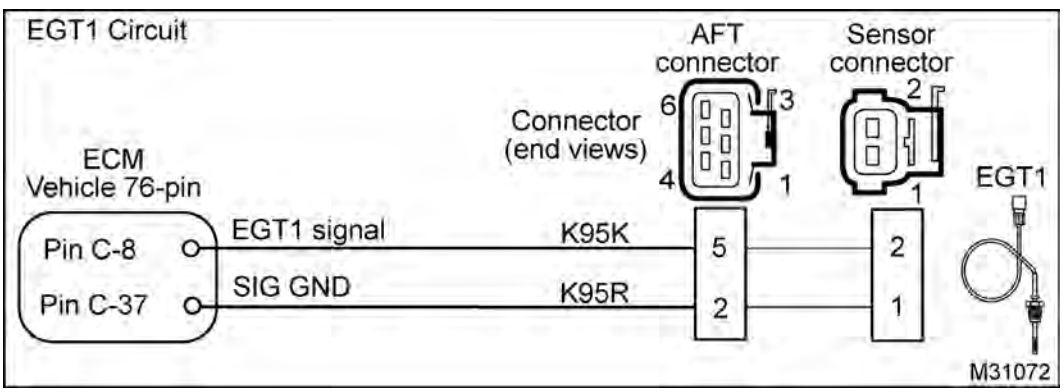

Figure 179 EGT1 circuit diagram

WARNING: To prevent personal injury or death, be careful to avoid 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.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

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. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	DTC 1738	If DTC 1737 is active, check EGT1 signal for short to GND. Do Harness Resistance Check (page 269).
EST - Check DTC Short 3-Banana plug harness across 1 and GND	DTC 1737	If DTC 1738 is active, check EGT1 signal for OPEN. Do Harness Resistance Check (page 269).
EST - Check DTC Short 3-Banana plug harness across 1 and 2	DTC 1737	If DTC 1738 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 269).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

EGT1 Pin-point Diagnostics

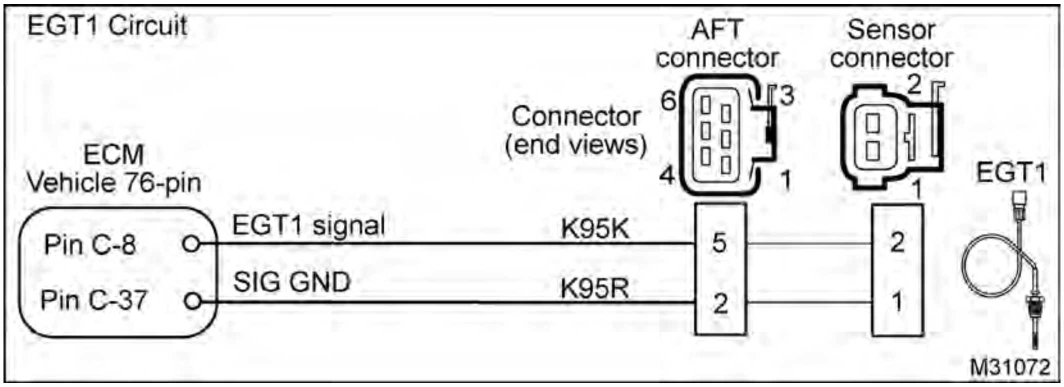

Figure 180 EGT1 circuit diagram

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	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 269).

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.
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 exhaust temperature breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to C-37	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to C-8	< 5 Ω	If > 5 Ω, check for OPEN circuit.

EGT1 Circuit Operation

EGT1 is a resistance temperature detector sensor supplied with a 5 volt reference voltage at Pin 2 from ECM Pin C-8. The sensor is grounded at Pin 1 from ECM Pin C-37. As temperature increases, resistance of the sensor increases. This causes the signal voltage to increase.

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
2673	3242	10	EGT2 not warming along with engine
2674	3242	2	EGT2 reading off compared to EGT1 and EGT3
2681	3242	1	EGT2 reading off compared to EGT1 and EGT3

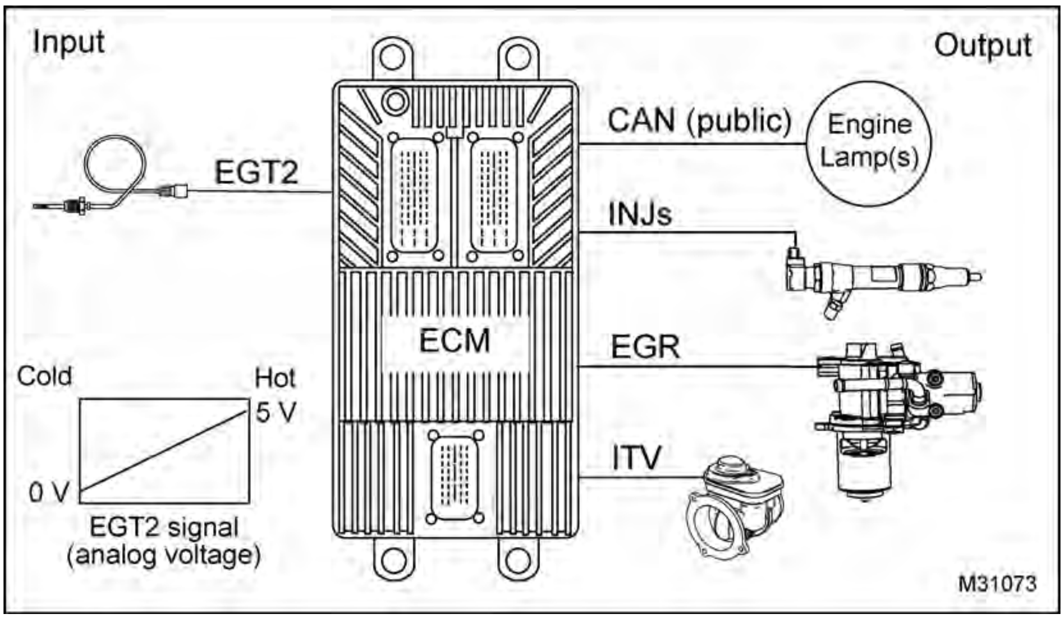

Figure 181 Function diagram for the EGT2 sensor

The EGT2 sensor function diagram includes the following:

- Exhaust Gas Temperature 2 (EGT2) sensor
- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR)
- Intake Throttle Valve (ITV)
- Fuel Injectors (INJ)
- Malfunction Indicator Lamp (MIL)
- Regeneration lamp

Function

The EGT2 sensor provides a feedback signal to the ECM indicating Diesel Particulate Filter (DPF) inlet temperature. During a catalyst regeneration, the ECM monitors this sensor along with EGT1, EGT3, EGDP, EGRP, and ITVP.

Sensor Location

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

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 180-Pin Breakout Box
- Exhaust Temperature Breakout Harness
- Terminal Test Adapter Kit

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
2673	EGT2 not warming along with engine	• EGT2 biased circuit or sensor • EGT2 sensor outside of exhaust system
2674	EGT2 reading off compared to EGT1 and EGT3	• EGT2 biased circuit or sensor • EGT2 sensor outside of exhaust system
2681	EGT2 reading off compared to EGT1 and EGT3	• EGT2 biased circuit or sensor • EGT2 sensor outside of exhaust system

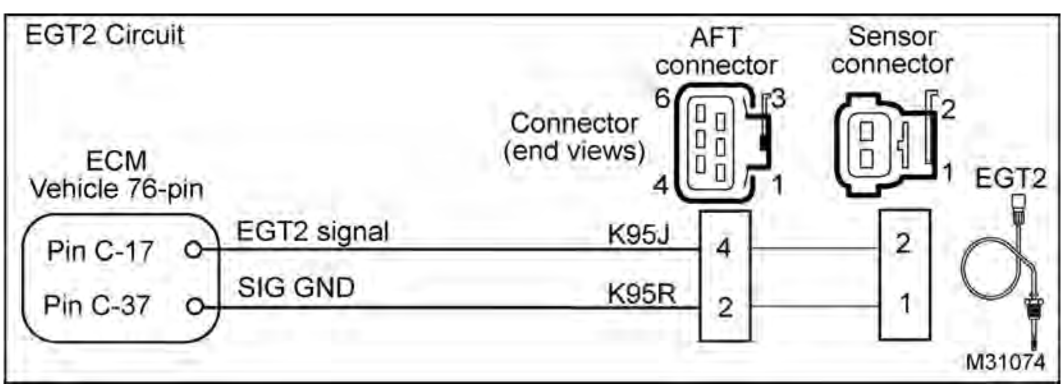

Figure 182 EGT2 circuit diagram

WARNING: To prevent personal injury or death, be careful to avoid 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.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

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. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	DTC 1742	If DTC 1741 is active, check EGT2 signal for short to GND. Do Harness Resistance Checks (page 274).
EST - Check DTC Short 3-Banana plug harness across 1 and GND	DTC 1741	If DTC 1742 is active, check EGT2 signal for OPEN. Do Harness Resistance Check (page 274).
EST - Check DTC Short 3-Banana plug harness across 1 and 2	DTC 1741	If DTC 1742 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 274).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

EGT2 Pin-point Diagnostics

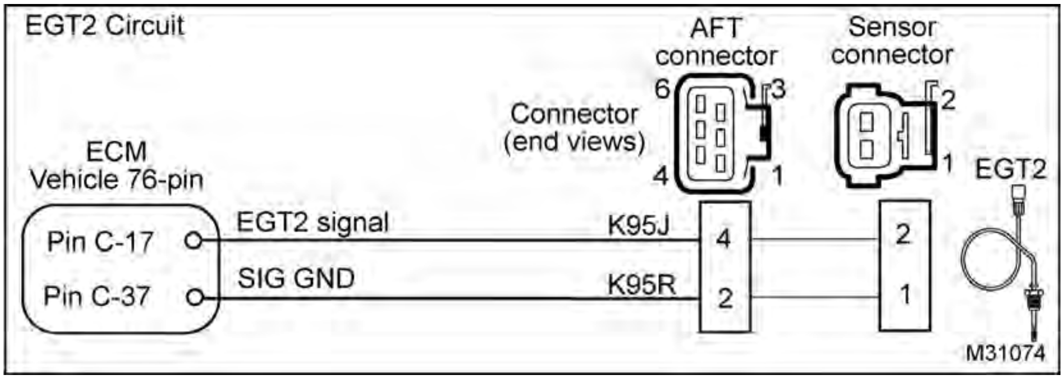

Figure 183 EGT2 circuit diagram

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	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 274).

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.
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 breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to C-37	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to C-17	< 5 Ω	If > 5 Ω, check for OPEN circuit.

EGT2 Circuit Operation

EGT2 is a resistance temperature detector sensor supplied with a 5 volt reference voltage at Pin 2 from ECM Pin C-17. The sensor is grounded at Pin 1 from ECM Pin C-37. As temperature increases, resistance of the sensor increases. This causes the signal voltage to increase.

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
2677	3245	2	EGT3 not warming along with engine
2678	3245	1	EGT3 reading off compared to EGT1 and EGT2

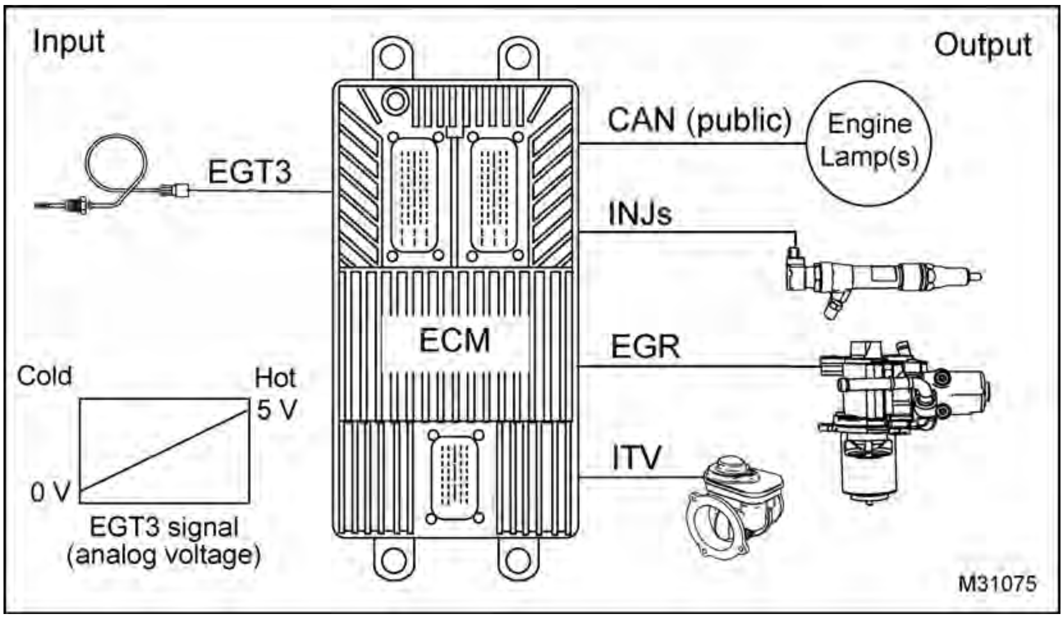

Figure 184 Function diagram for the EGT3 sensor

The EGT3 sensor function diagram includes the following:

- Exhaust Gas Temperature 3 (EGT3) sensor
- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR)
- Intake Throttle Valve (ITV)
- Fuel Injectors (INJ)
- Malfunction Indicator Lamp (MIL)
- Regeneration lamp

Function

EGT3 sensor provides a feedback signal to the ECM indicating Diesel Particulate Filter (DPF) outlet temperature. During catalyst regeneration, the ECM monitors this sensor along with EGT1, EGT2, EGDP, EGRP, and ITVP.

Sensor Location

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

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 180-Pin Breakout Box
- Exhaust Temperature Breakout Harness
- Terminal Test Adapter Kit

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
2677	EGT3 not warming along with engine	• EGT3 biased circuit or sensor • EGT3 sensor outside of exhaust system
2678	EGT3 reading off compared to EGT1 and EGT2	• EGT3 biased circuit or sensor • EGT3 sensor outside of exhaust system

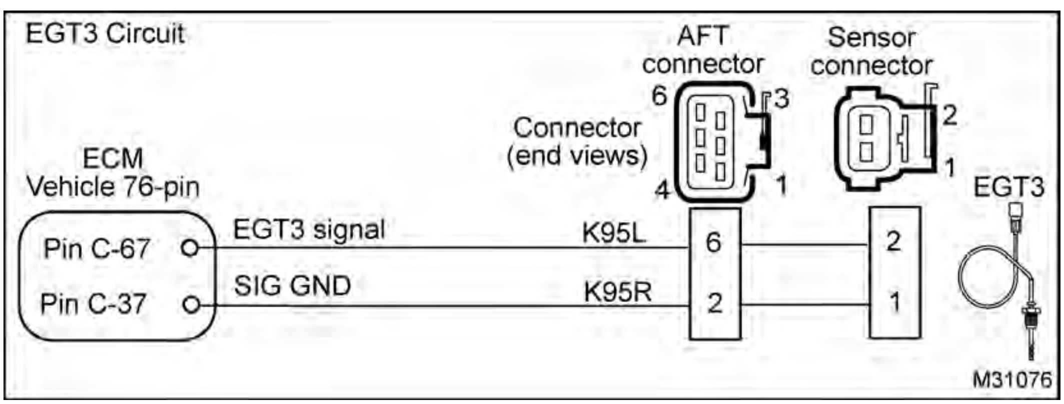

Figure 185 EGT3 circuit diagram

WARNING: To prevent personal injury or death, be careful to avoid 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.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

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. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	DTC 1745	If DTC 1744 is active, check EGT3 signal for short to GND. Do Harness Resistance Check (page 279).
EST - Check DTC Short 3-Banana plug harness across 1 and GND	DTC 1744	If DTC 1745 is active, check EGT3 signal for OPEN. Do Harness Resistance Check (page 279).
EST - Check DTC Short 3-Banana plug harness across 1 and 2	DTC 1744	If DTC 1745 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 279).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

EGT3 Pin-point Diagnostics

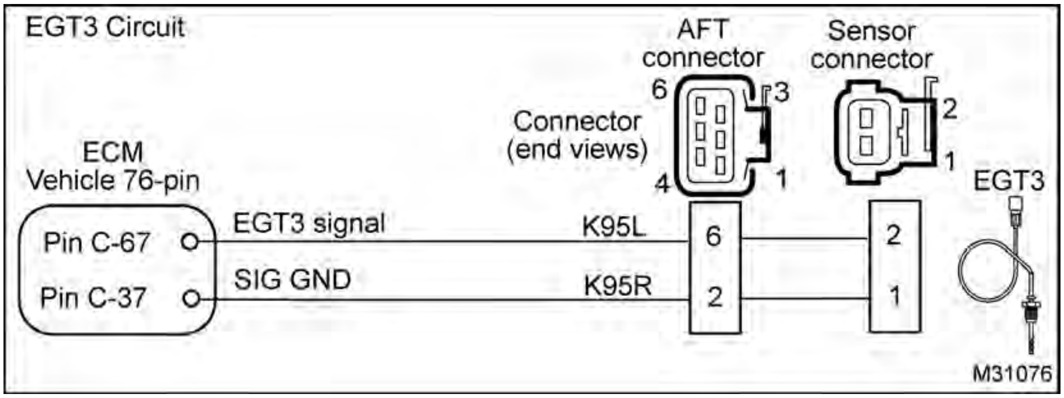

Figure 186 EGT3 circuit diagram

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	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 279).

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.
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 breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to C-37	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to C-67	< 5 Ω	If > 5 Ω, check for OPEN circuit.

EGT3 Circuit Operation

EGT3 is a resistance temperature detector sensor supplied with a 5 volt reference voltage at Pin 2 from ECM Pin C-67. The sensor is grounded at Pin 1 from ECM Pin C-37. As temperature increases, the resistance of the sensor increases. This causes the signal voltage to increase.

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

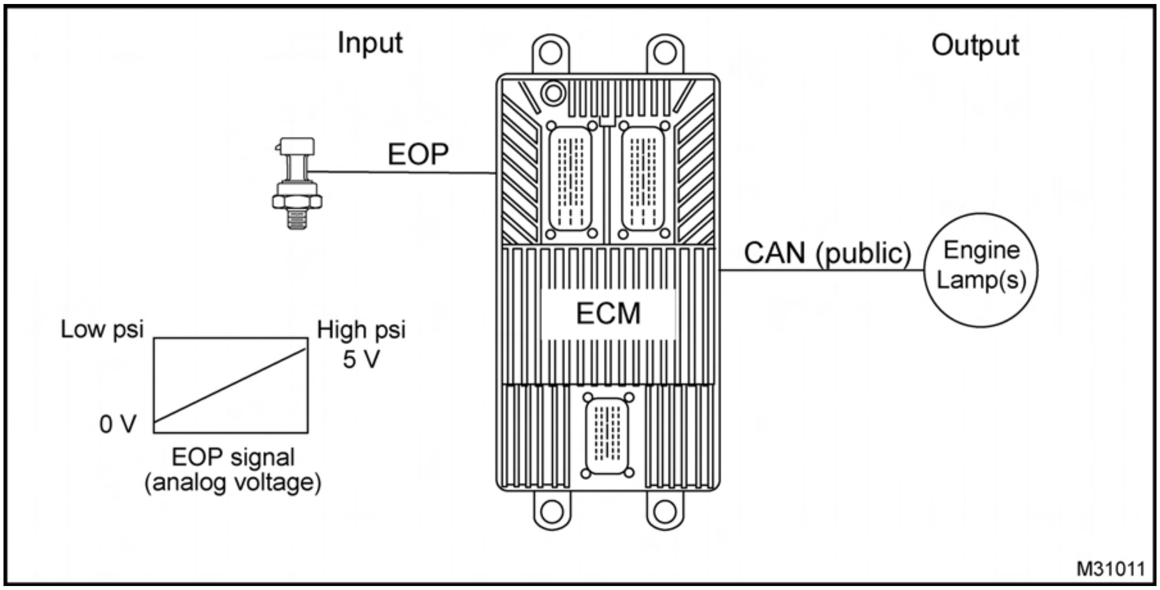

Figure 187 Function diagram for the EOP sensor

The EOP sensor function diagram includes the following:

- Engine Oil Pressure (EOP) sensor
- Electronic Control Module (ECM)
- Warn Engine Lamp (WEL)

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 oil pressure is satisfactory. If oil pressure is below required pressure, the ECM turns on the WEL.

The Engine Warning Protection System (EWPS), can be enabled to warn the engine operator and shut the engine down when a low engine oil pressure occurs.

Sensor Location

The EOP sensor is installed in the oil filter base assembly on the top of the engine.

Tools

- Electronic Service Tool with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 180-Pin Breakout Box
- Pressure Sensor Breakout Harness
- Terminal Test Adapter Kit

EOP Sensor End Diagnostics

DTC	Condition	Possible Causes
1211	EOP signal out-of-range LOW	• EOP signal circuit OPEN or short to GND • VREF circuit OPEN • Failed sensor
1212	EOP signal out-of-range HIGH	• EOP signal circuit short to PWR • Failed sensor

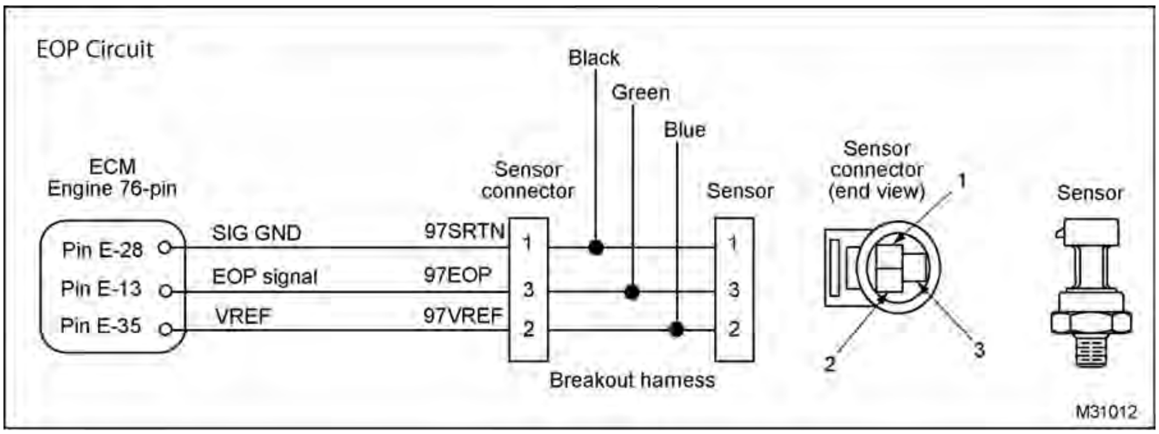

Figure 188 EOP circuit diagram

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

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Verify sensor voltage is within Key-On Engine Off (KOEO) specification. See “Performance Specifications” section of this manual.
3. 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.
4. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

5. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

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. Use DMM to measure circuits.

Test Point	Spec	Comments
EST – Check DTC	DTC 1211	If DTC 1212 is active, check EOP signal for short to PWR.
DMM – Measure volts 2 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 284).
EST – Check DTC Short 500 breakout harness across 2 and 3	DTC 1212	If DTC 1211 is active, check EOP signal for OPEN. Do Harness Resistance Check (page 284).
DMM – Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 284).
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.		

EOP Pin-point Diagnostics

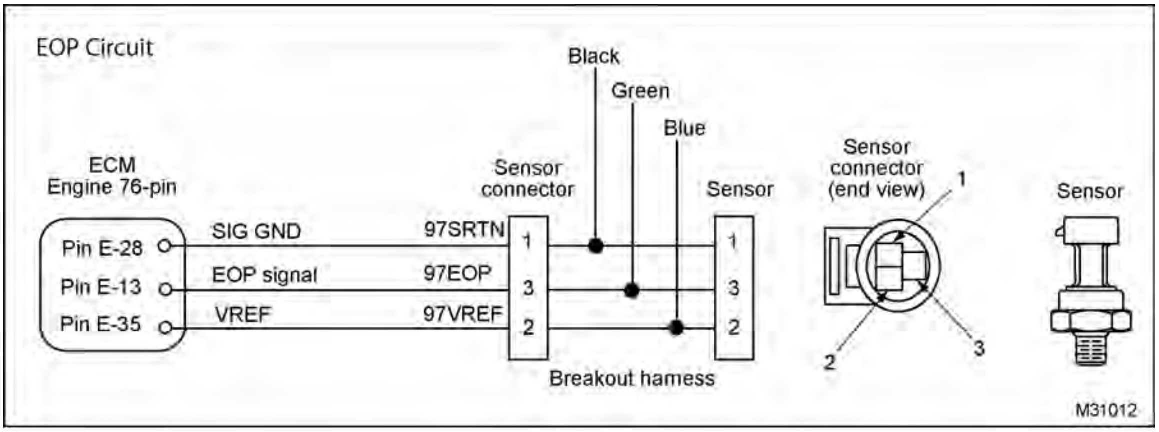

Figure 189 EOP circuit diagram

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	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 284).
3 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 284).

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.
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 breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-28	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
2 to E-35	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
3 to E-13	< 5 Ω	If > 5 Ω, check EOP signal circuit for OPEN.

EOP Circuit Operation

The EOP sensor is a variable capacitance sensor supplied with a 5 volt reference voltage at Pin 2 from ECM Pin E-35. The sensor is grounded at Pin 1 from ECM Pin E-28. The sensor returns a variable voltage signal from Pin 3 to ECM Pin E-13.

Fault Detection/Management

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM will disable the EWPS, sets a DTC, and turns on the WEL.

EOT Sensor (Engine Oil Temperature)

DTC	SPN	FMI	Condition
1299	175	10	EOT in-range fault
1311	175	4	EOT signal out-of-range LOW
1312	175	3	EOT signal out-of-range HIGH

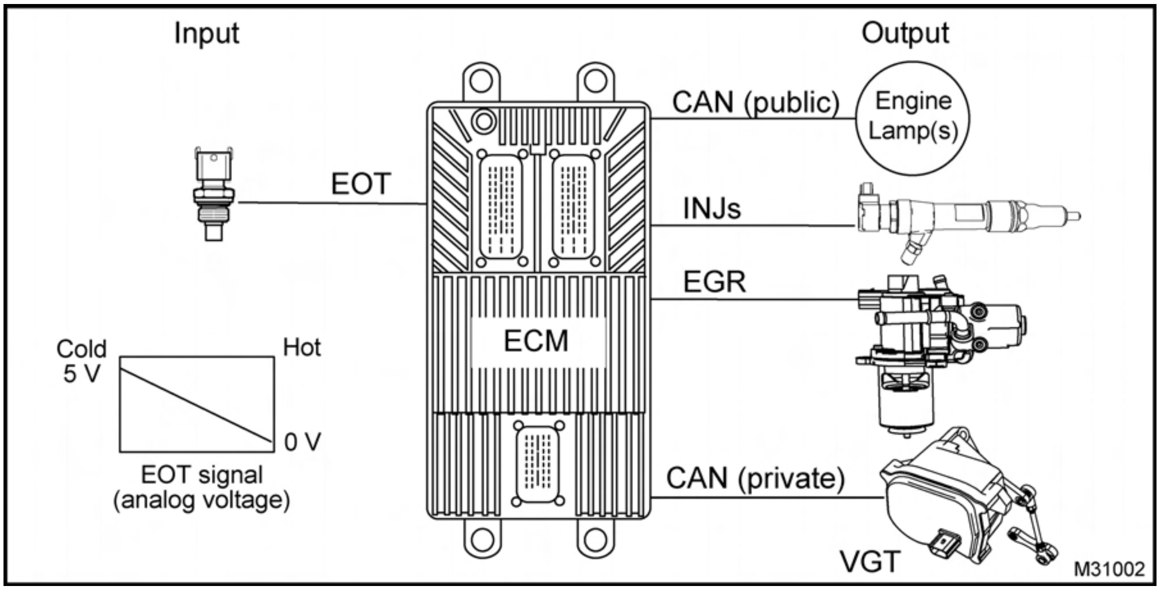

Figure 190 Function diagram for the EOT sensor

The EOT sensor function diagram includes the following:

- Engine Oil Temperature (EOT) sensor
- Electronic Control Module (ECM)
- Fuel Injectors (INJ)
- Exhaust Gas Recirculation Position (EGR)
- Variable Geometry Turbocharger (VGT)
- Warn Engine Lamp (WEL)

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 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 700 rpm) for faster warm-up to operating temperature. The ECM monitors the EOT sensor input and adjusts the fuel injector operation accordingly.

Low idle speed is increased proportionally with engine oil temperature between 15 °C (59 °F) at 700 rpm to below -10 °C (14 °F) at 750 rpm.

Sensor Location

The EOT sensor is installed in the base of the oil filter housing assembly located on top of the engine next to the EOP sensor.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 180-Pin Breakout Box
- Temperature Sensor Breakout Harness
- Terminal Test Adapter Kit

EOT Sensor End Diagnostics

DTC	Condition	Possible Causes
1299	EOT in-range fault	• Biased EOT circuit or sensor
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 • SIG GND circuit OPEN • Failed sensor

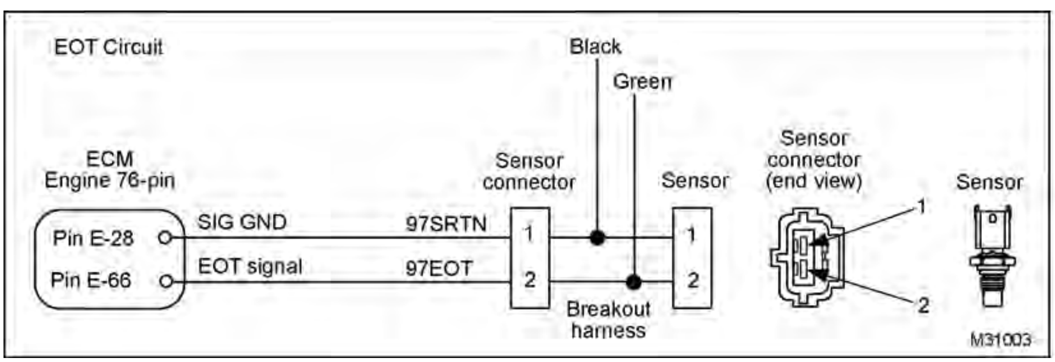

Figure 191 EOT circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating part (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.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

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. Use DMM to measure circuits.

Test Point	Spec	Comments
EST – Check DTC	DTC 1312	If DTC 1311 is active, check EOT signal for short to GND. Do Harness Resistance Check (page 288).
EST – Check DTC Short 3-banana plug harness across 2 and GND	DTC 1311	If DTC 1312 is active, check EOT signal for OPEN. Do Harness Resistance Check (page 288).
EST – Check DTC Short 3-banana plug harness across 1 and 2	DTC 1311	If DTC 1312 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 288).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

EOT Pin-point Diagnostics

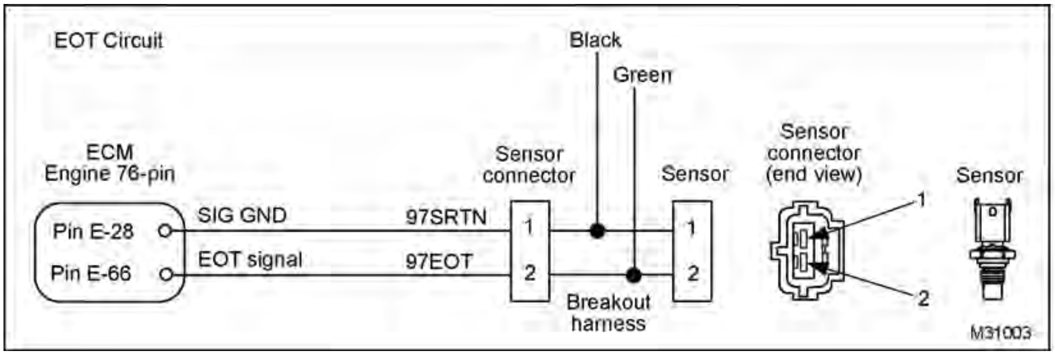

Figure 192 EOT circuit diagram

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	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 288).

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.
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 breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-28	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to E-66	< 5 Ω	If > 5 Ω, check for OPEN circuit.

EOT Circuit Operation

The EOT is a thermistor sensor supplied with a 5 volt reference voltage at Pin 2 from ECM Pin E-66. The sensor is grounded at Pin 1 from ECM Pin E-28. As temperature increases, resistance of the thermistor decreases. This causes 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, turns on the WEL, 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
2313	100	1	EOP below Warning level
2314	100	7	EOP below Critical level
2315	190	0	Engine speed above Warning level
2319	518	2	Torque limited to control engine overheat
2321	110	0	ECT above Warning level
2322	110	7	ECT above Critical level
2323	111	1	ECL below Warning/Critical level

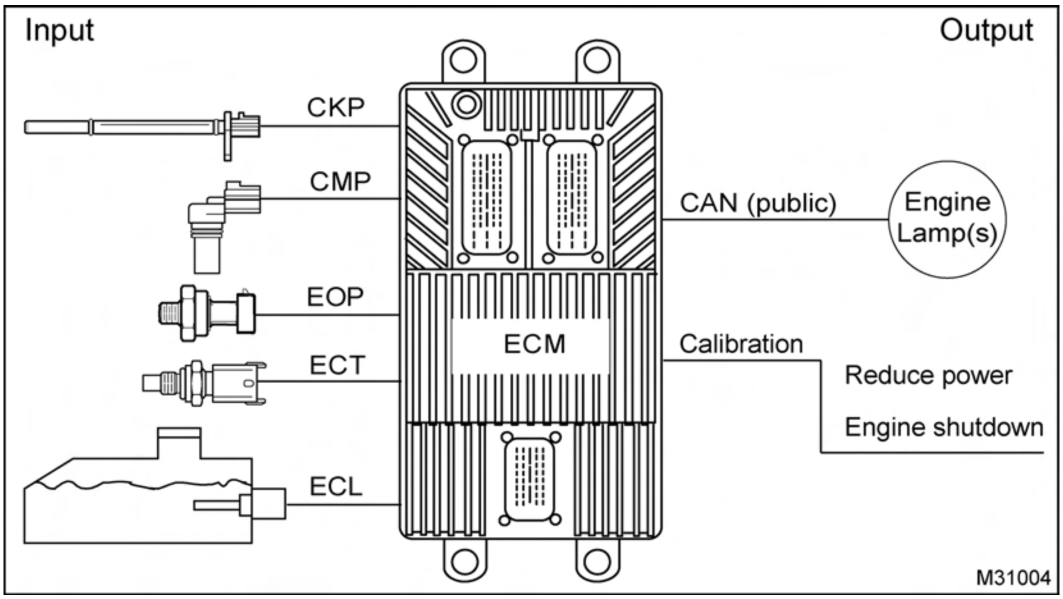

Figure 193 Function diagram for the EWPS

The EWPS function diagram includes the following:

- Electronic Control Module (ECM)
- Crankshaft Position (CKP) sensor
- Camshaft Position (CMP) sensor
- Engine Oil Pressure (EOP) sensor
- Engine Coolant Temperature (ECT) sensor
- Engine Coolant Level (ECL) switch
- Oil/Water Lamp (OWL)
- Warn Engine Lamp (WEL)

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 OWL 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 shut down available.

- ECT - Engine overheat warning
- EOP - Low engine oil pressure warning

3-way Warning – No engine shut down available.

- ECT - Engine overheat warning
- EOP - Low engine oil pressure warning
- ECL - Low engine coolant level warning

3-way Protection – Engine shut down 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 will sound a buzzer, illuminate the OWL and set 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 OWL and warning buzzer turns on.

ECT-CRITICAL – Specifies temperature threshold where an engine shut down 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 OWL 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 setpoint turns on the OWL 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 setpoint turns on the OWL and warning buzzer.

OIL-PRES-CRIT-SPD1 – Specifies the minimum oil pressure with engine speed greater than (PROT-ENG-SPD1). Failure to meet setpoint 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 setpoint commands an engine shut down.

OIL-PRES-CRIT-SPD3 – Specifies the minimum oil pressure with engine speed greater then (PROT-ENG-SPD2) but less then (PROT-ENG-SPD3). Failure to meet set point will command an engine shut down.

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. The specifications for the warning are:
  - 34 kPa (5 psi) @ 700 rpm
  - 69 kPa (10 psi) @ 1400 rpm
  - 138 kPa (20 psi) @ 2000 rpm
- For diagnostics, see Low Oil Pressure Diagnostics in the “Engine Symptoms Diagnostics” section of 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 OWL 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. The specifications are:
  - 14 kPa (2 psi) @ 700 rpm
  - 83 kPa (12 psi) @ 1400 rpm
  - 152 kPa (22 psi) @ 2000 rpm
- For diagnostics, see Low Oil Pressure Diagnostics in the “Engine Symptoms Diagnostics” section of 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 OWL flashes and sounds an audible signal.

DTC 2315
Engine Speed above Warning Level

- DTC 2315 is set by the ECM when the engine rpm has exceeded 3900 rpm.
- DTC 2315 can be set due to 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 WEL is illuminated. The engine hours and miles of the last two over speed occurrences will be recorded in the engine event log.

DTC 2319
Torque limited to control engine overheat

- DTC 2319 is set by the ECM when cooling system temperature exceeds 111 °C (232 °F). At this temperature the ECM reduces fuel delivered to the engine. When the temperature drops below 111 °C (232 °F) the DTC becomes inactive and the engine returns to normal operation. The WEL is not illuminated.
- For each Celsius degree of temperature fuel will be reduced by six percent. This reduces heat produced by the engine and the burden on the cooling system. Vehicle speed is also reduced and allows the operator to downshift. This increases cooling system efficiency. As temperature is reduced, the compensation level is reduced, until the temperature drops below 111 °C (232 °F) and normal operation is resumed.

DTC 2321
ECT above Warning level

- DTC 2321 is set by the ECM when engine coolant temperature is above 113 °C (228 °F). The ECM illuminates the OWL. When temperature drops below 113 °C (228 °F) the DTC becomes inactive. For diagnostics, see Coolant Over-Temperature in the “Engine Symptoms Diagnostics” section of this manual.
- For high altitude applications (103 kPa [15 psi] radiator cap), DTC 2321 is set by the ECM when the engine coolant temperature is above 116 °C (240 °F). When the temperature drops below 116 °C (240 °F) the DTC becomes inactive.

DTC 2322
ECT above Critical level

- DTC 2322 is set by the ECM when engine coolant temperature is above 116 °C (240 °F). The ECM illuminates the OWL. When temperature drops below 116 °C (240 °F) the DTC becomes inactive. For diagnostics, see Coolant Over-Temperature in the “Engine Symptoms Diagnostics” section of this manual.
- For high altitude applications (103 kPa [15 psi] radiator cap), DTC 2322 is set by the ECM when engine coolant temperature is above 119 °C (246 °F). When temperature drops below 119 °C (246 °F) the DTC becomes inactive.

DTC 2323
ECL below Warning/Critical level

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 engine hours and odometer reading at the time of occurrence. After the shutdown, the engine can be restarted for thirty seconds while DTC 2323 is active. When coolant has returned to correct levels, DTC 2323 becomes active

NOTE: If the coolant level is correct, do ECL “Connector Voltage Test”(page 221) in this section. An ECL signal shorted to ground can cause DTC 2323.

FCV (Fuel Coolant Valve)

DTC	SPN	FMI	Condition
None			

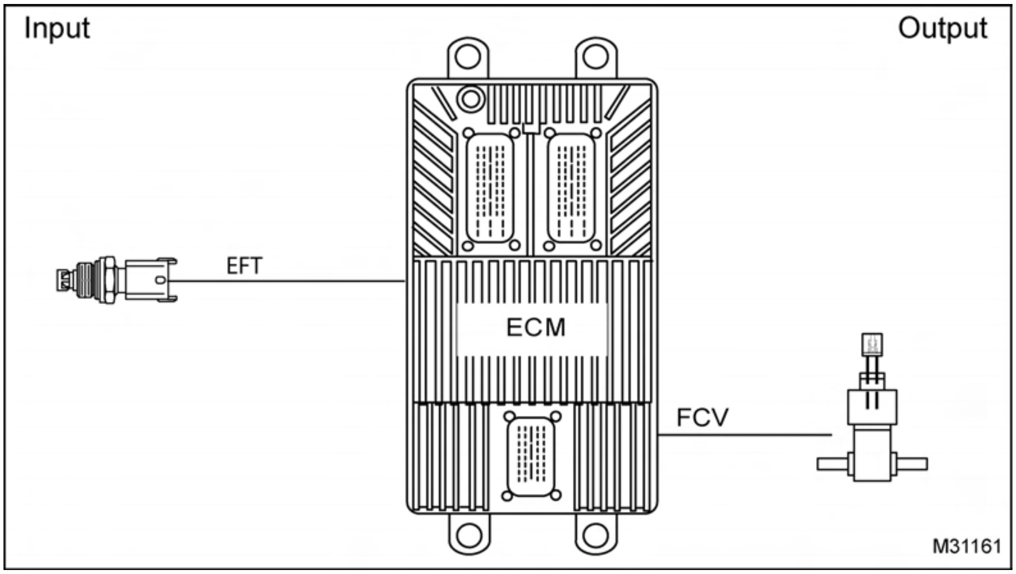

Figure 194 Function diagram for FCV

The FCV function diagram includes the following:

- Fuel Coolant Valve (FCV)
- Electronic Control Module (ECM)
- Engine Fuel Temperature (EFT) sensor

Function

The FCV is used to redirect coolant through the fuel cooler.

The ECM uses the EFT sensor to monitor fuel temperature and controls the FCV to maintain the desired fuel temperature.

Sensor Location

FCV is located on the left side radiator core support.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- Terminal Test Adapter Kit

FCV Circuit Diagnostics

DTC	Condition	Possible Causes
None	High fuel temperature	• FCV circuit OPEN or short to GND • ACT PWR circuit OPEN or short to GND, blown fuse • Failed FCV solenoid

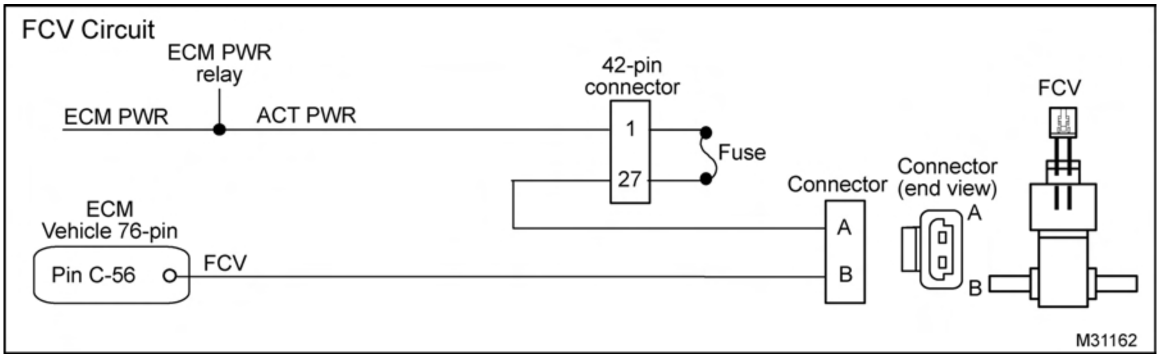

Figure 195 FCV circuit diagram

Voltage Check at FCV Connector - Output State Test

Disconnect FCV solenoid 2-pin connector. Turn the ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
A to GND	B+	If < B+, check ACT PWR circuit for OPEN or blown fuse.
B to GND	0 V to 0.25 V	If > 0.25 V, check FCV circuit for short to PWR.
Run Output State Test HIGH.		
B to B+	0 V to 0.25 V	If > 0.25 V, check FCV circuit for short to GND.
Run Output State Test LOW.		
B to B+	B+	If < B+, check FCV circuit for OPEN or short to PWR. Do Harness Resistance Check (page 295).
A to B	B+	If < B+, check ACT PWR circuit for OPEN. Do Harness Resistance Check (page 295).

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box. Leave ECM and FCV solenoid disconnected.

Test Point	Spec	Comment
C-56 to B	< 5 Ω	If > 5 Ω, check FCV for OPEN circuit.
C-56 to GND	> 1 kΩ	If < 1 kΩ, check FCV circuit for short to GND.

Harness Resistance Check (cont.)

A to C-1, 3 and 5	< 5 Ω	If > 5 Ω, check ACT PWR for OPEN in circuit.
A to GND	> 1 kΩ	If < 1 kΩ, check ACT PWR for short to GND.
See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for fuse information.		

FCV Circuit Operation

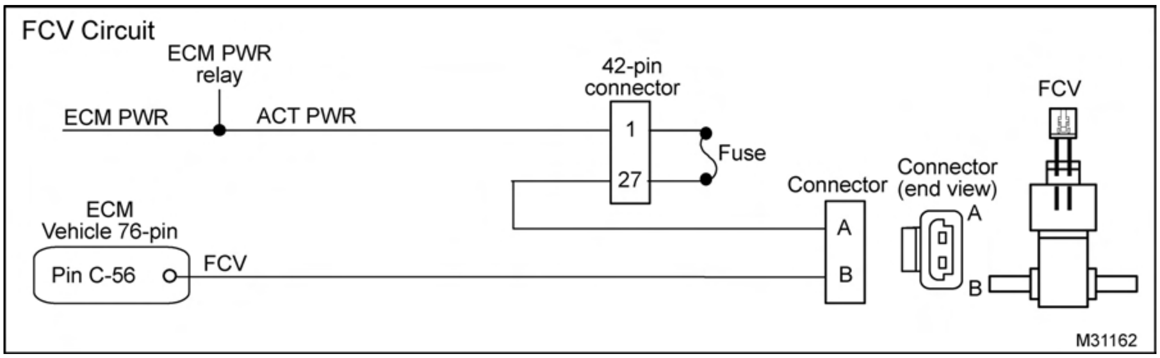

Figure 196 FCV circuit diagram

The FCV operates in a fail-safe manner. The valve opens automatically allowing coolant to pass through the fuel cooler. The ECM controls this valve in cold weather to warm the fuel and also controls the temperature from getting too hot.

The FCV solenoid is supplied ACT PWR at Pin A. The ECM Pin C-39 controls the solenoid by grounding Pin B.

FPCV (Fuel Pressure Control Valve)

DTC	SPN	FMI	Condition
1276	8366	3	FPCV short to B+, over temperature
1277	8366	4	FPCV short circuit
1278	8366	5	FPCV open circuit
1279	8366	6	FPCV current excesses maximum limit

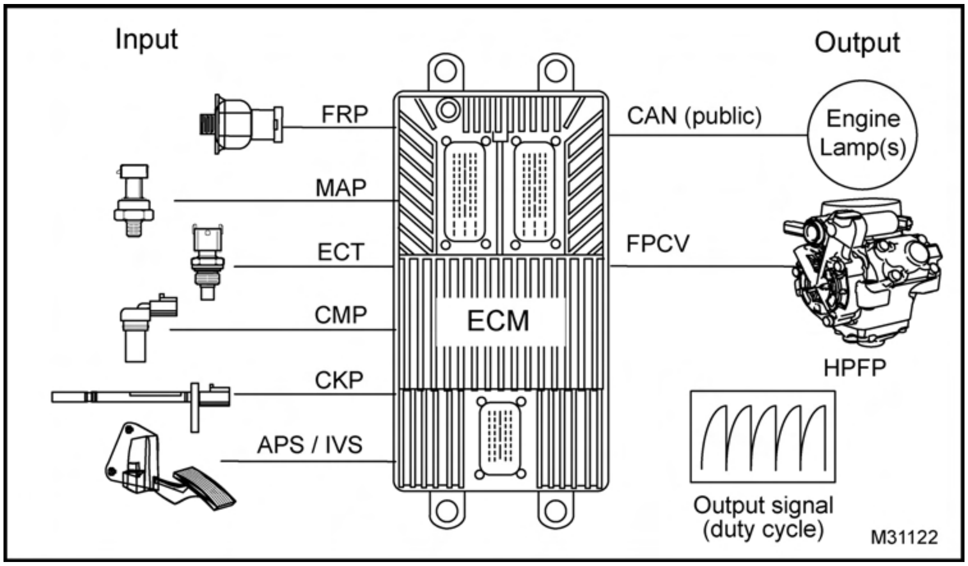

Figure 197 Function diagram for the FPCV

The FPCV function diagram includes the following:

- High-Pressure Fuel Pump (HPFP) with integrated Fuel Pressure Control Valve (FPCV)
- Engine Coolant Temperature (ECT) sensor
- Fuel Rail Pressure (FRP) sensor
- Manifold Absolute Pressure (MAP) sensor
- Camshaft Position (CMP) sensor
- Crankshaft Position (CKP) sensor
- Accelerator Position Sensor/Idle Validation Switch (APS/IVS)
- Electronic Control Module (ECM)
- Malfunction Indicator Lamp (MIL)

Function

The FPCV regulates fuel pressure from the HPFP that supplies the injectors. The ECM uses the FRP sensor to monitor system pressure and adjust the valve duty cycle to match engine requirements (starting, engine load, speed, and temperature).

NOTE: The engine may not operate with an FPCV fault, depending on the mode of failure.

FPCV Location

The FPCV is a non-serviceable part in the HPFP. If the FPCV fails, replace the HPFP.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 180-Pin Breakout Box
- 4-Pin Actuator Breakout Harness
- Terminal Test Adapter Kit

FPCV Pin-point Diagnostics

DTC	Condition	Possible Causes
1276	FPCV short to B+, over temperature	• FPCV circuit short to PWR • Failed valve
1277	FPCV short circuit	• FPCV circuit short to GND • Failed valve
1278	FPCV open circuit	• FPCV circuit OPEN • Failed valve
1279	FPCV current excesses maximum limit	• FPCV circuit short to PWR • Failed valve

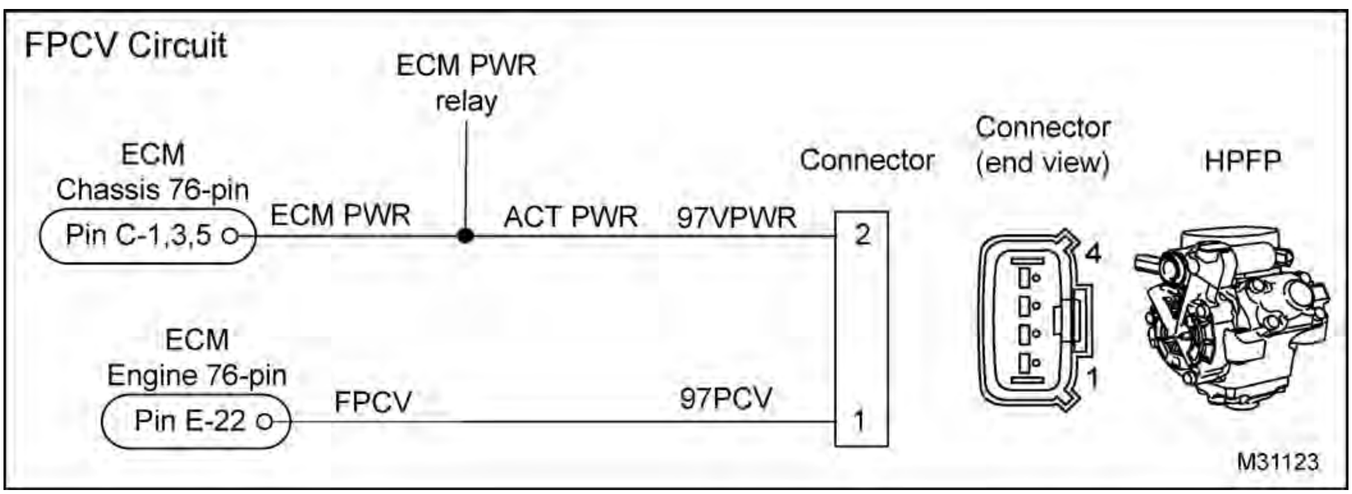

Figure 198 FPCV circuit diagram

Actuator/Harness Resistance Check

Connect breakout box to Engine and Chassis harness. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-22 to C-1, 3, and 5	3.5 +/- 1.5 Ω	If not within specification, check for OPEN or short circuit or failed FPCV valve.
E-22 to GND	> 1 k Ω	If < 1 k Ω, check for short to GND or failed FPCV valve.

Operational Voltage Check - Output Circuit Check

Connect breakout box between Engine and Chassis harness to ECM. Run KOEO Standard Test and Output Circuit Test HIGH and LOW. Use DMM to measure voltage. If unable to run KOEO Standard Test, see ECM PWR(page 223) in this section.

Test Point	Test	Spec	Comment
E-22 to GND	Output State LOW	B+	If < B+, check FPCV circuit for short to GRD or internal shorted FPCV valve.
E-22 to GND	Output State HIGH	5.5 V	If < 2.5 V, check FPCV circuit for OPEN or internal OPEN FPCV valve.

FPCV Circuit Operation

The HPFP is mechanically driven by the engine and electrically controlled by the ECM.

The HPFP consists of a high-pressure pump and two electric control valves, the FPCV and Fuel Volume Control Valve (FVCV). This is a non-serviceable unit. If the HPFP or either electric control valves fail, the HPFP must be replaced as a unit.

The FVCV governs the amount of fuel supplied to the HPFP. The FPCV regulates fuel pressure supplied to the injectors. The HPFP delivers fuel to the rail at about 165 MPa (1650 Bar) (24,300 psi).

The FPCV is supplied with ACT PWR at Pin 2. ECM Pin E-22 controls the valve by duty cycling a ground path to FPCV Pin 1. High duty cycle indicates high-pressure and low duty cycle indicates low-pressure.

Fault Detection / Management

An open or short in the FPCV circuit can be detected by an on demand output circuit check during KOEO Standard Test. If there is a circuit fault detected, a DTC is set.

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
1328	164	2	FRP signal constant
2327	164	10	FRP abnormal rate of change
2332	164	13	FRP above KOEO Spec

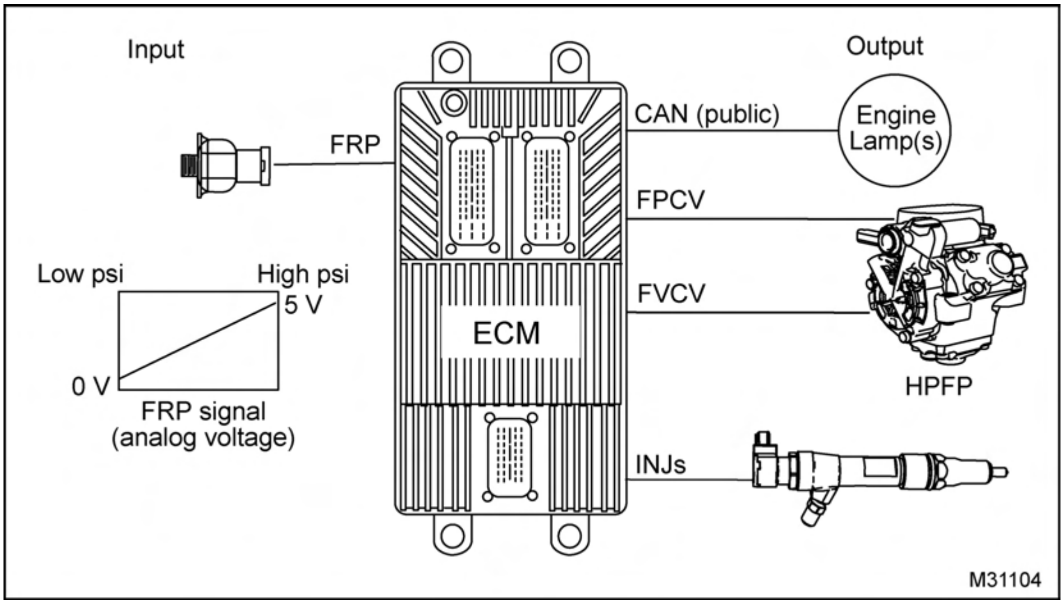

Figure 199 Function diagram for the FRP sensor

The FRP sensor function diagram includes the following:

- Fuel Rail Pressure (FRP) sensor
- Electronic Control Module (ECM)
- Fuel Injectors (INJ)
- High-Pressure Fuel Pump (HPFP) with integrated Fuel Pressure Control Valve (FPCV) and Fuel Volume Control Valve (FVCV)
- Malfunction Indicator Lamp (MIL)

Function

The FRP sensor provides a feedback signal to the ECM indicating fuel rail pressure. The ECM monitors FRP as the engine is operating to control the FPCV and FVCV. This is a closed loop function in which the ECM continuously monitors and adjusts for ideal FRP determined by conditions such as load, speed, and temperature.

Sensor Location

The FRP sensor is installed in the high-pressure fuel rail, under the right valve cover.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- FRP Breakout Harness
- 180-Pin Breakout Box
- Terminal Test Adapter Kit

FRP Sensor End Diagnostics

DTC	Condition	Possible Causes
1124	FRP signal out-of-range LOW	• FRP signal circuit short to GND • Failed sensor
1125	FRP signal out-of-range HIGH	• FRP signal circuit short to PWR • SIG GND circuit OPEN • Failed sensor
1328	FRP signal constant	• FRP signal too stable, should be fluctuating • FRP circuit fault, or failed sensor
2327	FRP abnormal rate of change	• Set when FRP changes more then 40 MPa (5800 psi) within 0.1 second • FRP sensor • FRP intermittent circuit fault
2332	FRP above KOEO Spec	• SIG GND circuit OPEN • Biased circuit/sensor • Failed sensor

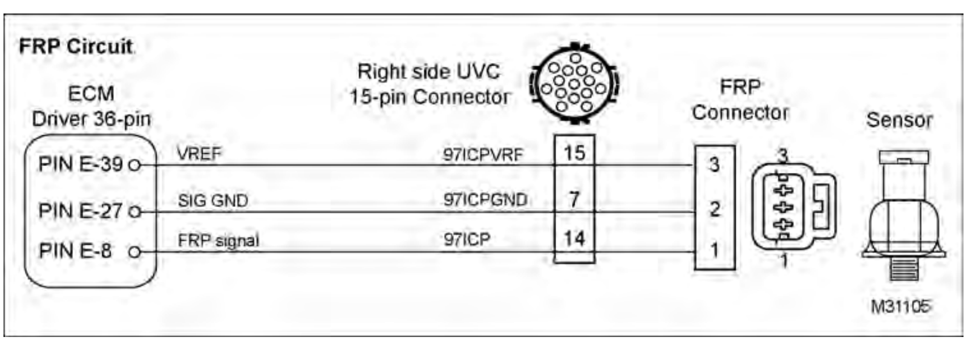

Figure 200 FRP circuit diagram

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. Verify sensor voltage is within Key-On Engine-Off (KOEO) specifications. See “Performance Specifications” section of this manual.
3. 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.
4. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

5. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Disconnect 15-pin UVC connector from right cylinder head. Turn the ignition switch to ON. Use EST to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	DTC 1125	If DTC 1124 is active, check FRP signal for short to GND.
DMM - Measure resistance 7 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 304)
EST - Check DTC Short breakout harness across 14 and 7	DTC 1124	If DTC 1125 is active, check FRP signal for OPEN. Do Harness Resistance Check (page 304).
DMM - Measure volts 15 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).

If checks are within specification, connect UVC connector and clear DTCs. If active DTC remains, check under valve cover harness for OPEN or shorts. If okay, replace sensor.

FRP Pin-point Diagnostics

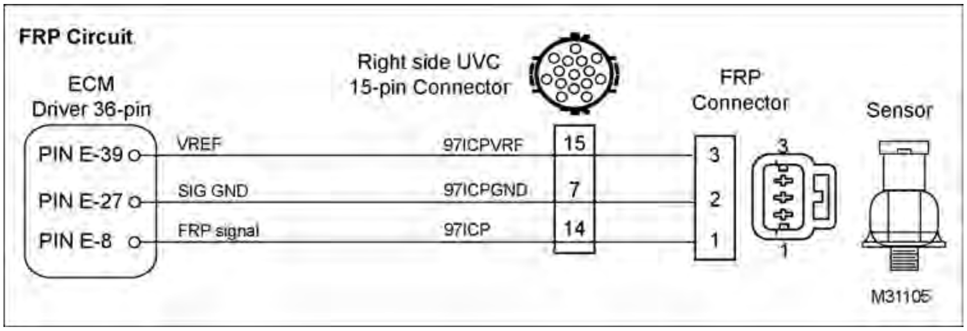

Figure 201 FRP circuit diagram

Connector Voltage Check

Connect breakout harness to 15-pin engine harness from right cylinder head. Leave UVC harness disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
7 to GND	0 V	If > 0.25 V, check for short to PWR.
14 to GND	5 V	If > 5.5 V, check FRP for short to PWR. If < 4.5 V, check FRP for OPEN or short to GND. Do Harness Resistance Check (page 304).
15 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 304).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect 15-pin engine harness from right cylinder head. Leave UVC harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
7 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
14 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
15 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Under Valve Cover Resistance Check to Engine GND

Connect breakout harness to UVC 15-pin connector (right side). Leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
7 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
14 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
15 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Remove right valve cover. Connect breakout box and ICP / FRP sensor breakout harness to engine. Leave ECM and FRP sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-27 to 2	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
E-27 to GND	> 1 k Ω	If < 1 k Ω, check for short to GND.
E-8 to 1	< 5 Ω	If > 5 Ω, check FRP signal circuit for OPEN.
E-8 to GND	> 1 k Ω	If < 1 k Ω, check for short to GND.
E-39 to 3	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
E-39 to GND	> 1 k Ω	If < 1 k Ω, check for short to GND.

FRP Circuit Operation

The FRP sensor is a micro-strain gauge sensor supplied with a 5 volt reference voltage at Pin 3 from ECM Pin E-39. The sensor is grounded at Pin 2 from ECM Pin E-27. The sensor returns a variable voltage signal from Pin 1 to ECM Pin E-8.

Fault Detection/Management

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

FRP System (Fuel Rail Pressure)

DTC	SPN	FMI	Condition
1268	8367	0	High Fuel Rail Pressure with Low FVCV command
1269	8367	7	Higher then normal FVCV to achieve desired FRP
1270	8367	1	Low Fuel Rail Pressure with High FVCV command
1271	8367	2	Excessive oscillation in FRP system
1284	8366	1	Low Fuel Rail Pressure with High FPCV command
2242	1442	2	FRP adaptation in-range fault
2335	164	1	FRP unable to build during engine cranking
3333	64	0	FRP above desired level
3334	8492	1	FRP below desired level
3373	164	15	FRP too high during test
3374	164	17	FRP unable to build during test

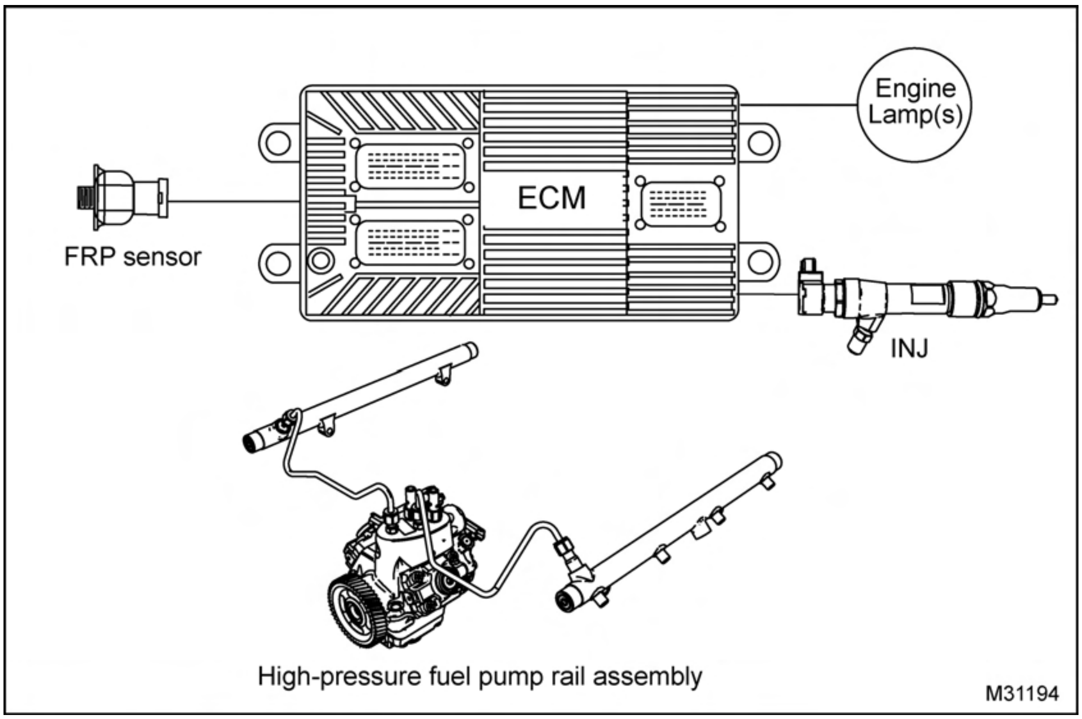

Figure 202 Function diagram for the FRP system

The FRP system includes the following:

- Electronic Control Module (ECM)
- Fuel Rail Pressure (FRP) sensor
- Fuel Injectors (INJ)
- High-pressure fuel pump rail assembly
- Malfunction Indicator Lamp (MIL)

Function

Filtered fuel is supplied to the high-pressure fuel pump from the gear driven fuel pump assembly and the fuel filter. The high-pressure pump pressurizes the fuel and routes the fuel to separate fuel rails for each engine bank. The fuel rails then supply fuel to each injector through individual supply tubes. The FRP sensor provides a feedback signal to the ECM indicating fuel rail pressure. The ECM continuously monitors and adjusts for ideal FRP determined by conditions such as load, speed, and temperature.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit

FRP System Diagnostics

DTC	Condition	Possible Causes
1268	High Fuel Rail Pressure with Low FVCV command	• Biased FRP sensor or circuit • Fuel Volume Control Valve (FVCV) circuit fault or failed valve • High-pressure fuel pump failure • High hydraulic resistance in the low-pressure return lines • Fuel contamination
1269	Higher then normal FVCV to achieve desired FRP	• FVCV circuit fault or sticking valve
1270	Low Fuel Rail Pressure with High FVCV command	• Biased FRP sensor or circuit • Fuel contamination • Dirty fuel filter • FVCV circuit fault or failed valve • FPCV circuit fault or failed valve • High-pressure fuel pump failure • High hydraulic resistance in the low-pressure return lines
1271	Excessive oscillation in FRP system	• Fuel aeration • FVCV circuit fault or sticking valve • FPCV circuit fault or sticking valve

1284	Low Fuel Rail Pressure with High FPCV command	• Biased FRP sensor or circuit • Fuel contamination • Dirty fuel filter • FVCV circuit fault or failed valve • FPCV circuit fault or failed valve • High-pressure fuel pump failure • High hydraulic resistance in the low-pressure return lines
2242	FRP adaptation in-range fault	• Fuel rail pressure command 10% higher then last learned command under same conditions • Possible FRP system leak
2335	FRP unable to build during engine cranking	• FRP below 20 MPa (2900 psi) during engine crank • Low fuel supply • FVCV circuit fault or failed valve • FPCV circuit fault or failed valve • High-pressure fuel pump failure
3333	FRP above desired level	• Sets when FRP is 3% higher than desired level for more the 2 seconds • Biased FRP sensor or circuit • FVCV circuit fault or failed valve • FPCV circuit fault or failed valve • High hydraulic resistance in the low-pressure return lines • Fuel contamination
3334	FRP below desired level	• Set when FRP is 3% lower than desired level for more the 2 seconds • Biased FRP sensor or circuit • FVCV circuit fault or failed valve • FPCV circuit fault or failed valve • High-pressure fuel pump failure • Fuel supply system faults • Fuel contamination

3373	FRP too high during test	• FRP sensor above 50 MPa (7,252 psi) during first part of KOER Standard test • Biased FRP sensor or circuit • FVCV circuit fault or failed valve • FPCV circuit fault or failed valve • Fuel supply system faults • Fuel contamination
3374	FRP unable to build during test	• FRP sensor below 85 MPa (12,328 psi) during second part of KOER Standard test • Biased FRP sensor or circuit • FVCV circuit fault or failed valve • FPCV circuit fault or failed valve • High-pressure fuel pump failure • Fuel supply system faults • Fuel contamination

Pin-point FRP System Fault

1. At KOEO, verify FRP sensor is within specification. See “Performance Specifications” section of this manual.
2. Check for Intermittent circuit faults. Open Continuous Monitor session and wiggle the engine harness while monitoring signals for spikes.
3. Check fuel system for faults. See Fuel System in the “Performance Diagnostics” section of this manual.
4. Run KOEO Output State Test to verify FPCV and FVCV are working without an electrical fault. See FPCV (page 297) and FVCV (page 310) sub-sections in this section of the manual to test these valves.
5. Check the FRP system for leaks. See “Hard Start and No Start Diagnostics” section in this manual.

FRP System Operation

The ECM uses a strategy to control fuel supply to the injectors using the FPCV and FVCV. The strategy maintains fuel pressure and quantity by using the FRP sensor to measure fuel rail pressure.

Fault Detection/Management

The Diagnostic Trouble Codes (DTCs) associated with this system may indicate an electrical or mechanical problem with the FRP system.

FVCV (Fuel Volume Control Valve)

DTC	SPN	FMI	Condition
1272	8367	3	FVCV short to B+, over temperature
1273	8367	4	FVCV short circuit
1274	8367	5	FVCV open circuit
1275	8367	6	FVCV current exceeds maximum limit

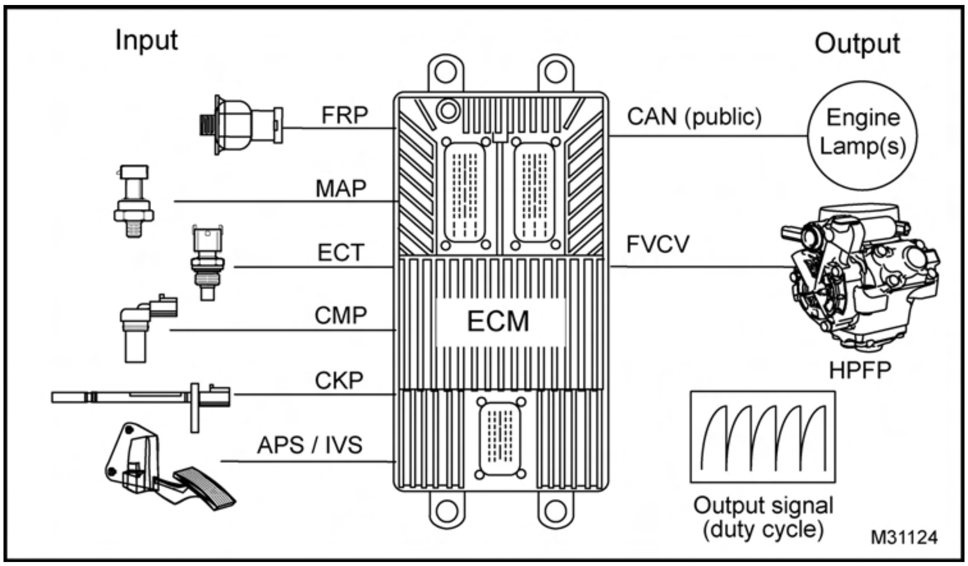

Figure 203 Function diagram for the FVCV

The FVCV function diagram includes the following:

- High-Pressure Fuel Pump (HPFP) with integrated Fuel Volume Control Valve (FVCV)
- Engine Coolant Temperature (ECT) sensor
- Fuel Rail Pressure (FRP) sensor
- Manifold Absolute Pressure (MAP) sensor
- Camshaft Position (CMP) sensor
- Crankshaft Position (CKP) sensor
- Accelerator Position Sensor / Idle Validation Switch (APS/IVS)
- Electronic Control Module (ECM)
- Malfunction Indicator Lamp (MIL)

Function

The FVCV regulates fuel volume through the HPFP to supply the injectors. The ECM uses the FRP sensor to monitor system pressure and adjusts FVCV duty cycle to match engine requirements (starting, engine load, speed, and temperature).

NOTE: The engine may not operate with an FVCV fault, depending on the mode of failure.

FVCV Location

The FVCV is a non-serviceable part in the HPFP. If the FVCV fails, replace the HPFP.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 180-Pin Breakout Box
- 4-Pin Actuator Breakout Harness
- Terminal Test Adapter Kit

FVCV Pin-point Diagnostics

DTC	Condition	Possible Causes
1272	FVCV short to B+, over temperature	• FVCV circuit short to PWR • Failed valve
1273	FVCV short circuit	• FVCV circuit short to GND • Failed valve
1274	FVCV open circuit	• FVCV circuit OPEN • Failed valve
1275	FVCV current exceeds maximum limit	• FVCV circuit short to PWR • Failed valve

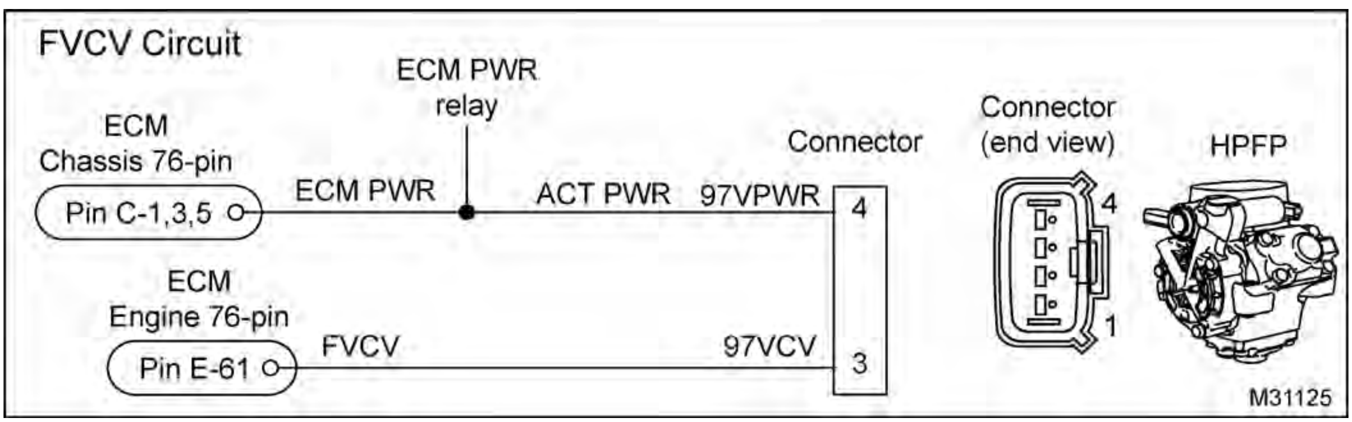

Figure 204 FVCV circuit diagram

Actuator/Harness Resistance Check

Connect breakout box to engine and chassis harness. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-61 to C-1, 3, and 5	3.5 +/- 1.5 Ω	If not within specification, check for OPEN or short circuit or failed FVCV valve.
E-61 to GND	> 1 k Ω	If < 1 k Ω, check for short to GND or failed FVCV valve.

Operational Voltage Check - Output Circuit Check

Connect breakout box between engine and chassis harness to ECM. Run KOEO Standard Test and Output Circuit Test HIGH and LOW. Use DMM to measure voltage. If unable to run KOEO Standard Test, see ECM PWR(page 223) in this section.

Test Point	Test	Spec	Comment
E-61 to GND	Output State LOW	B+	If < B+, check FVCV circuit for short to GRD or internal shorted FVCV valve.
E-61 to GND	Output State HIGH	5.5 V	If < 2.5 V, check FVCV circuit for OPEN or internal OPEN FVCV valve.

FVCV Circuit Operation

The HPFP is mechanically driven by the engine and electrically controlled by the ECM.

The HPFP consists of a high-pressure pump and two electric control valves, FPCV and FVCV. This is a non-serviceable unit. If the HPFP or either of the two electric control valves fail, the HPFP must be replaced as a unit.

The FVCV governs the amount of fuel supplied to the HPFP. The FPCV regulates fuel pressure supplied to the injectors. The HPFP delivers fuel to the rail at about 165 MPa. (24,000 psi)

The FVCV is supplied with ACT PWR at Pin 4. The ECM Pin E-61 controls the valve by duty cycling a ground path to FVCV Pin 1. High duty cycle indicates high-pressure and low duty cycle indicates low-pressure.

Fault Detection/Management

An open or short in the FVCV circuit can be detected by an on demand output circuit check during the KOEO Standard Test. If there is a circuit fault detected, a Diagnostic Trouble Code (DTC) is set.

GPC System (Glow Plug Control)

DTC	SPN	FMI	Condition
1375	7264	11	Glow plug relay circuit fault

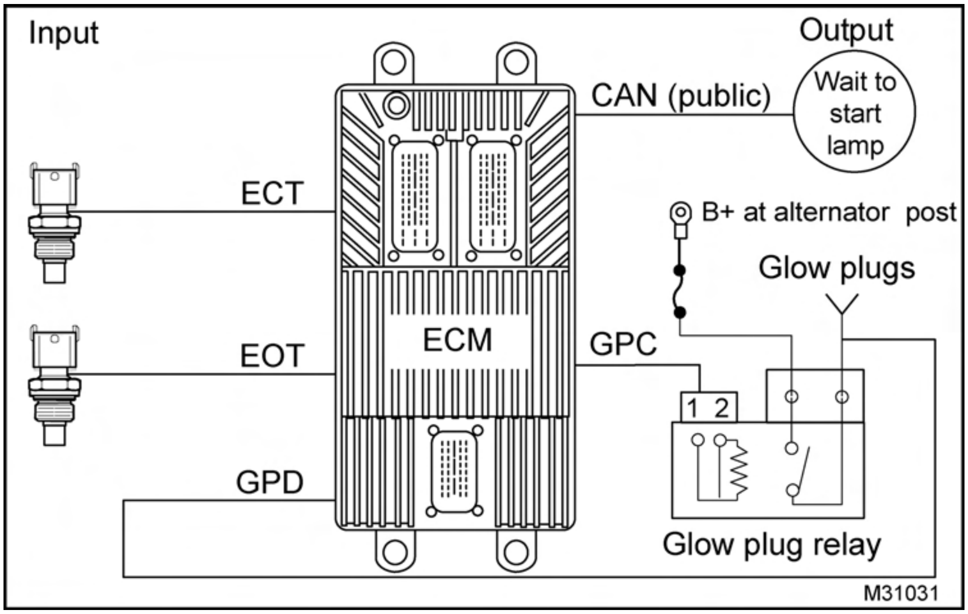

Figure 205 Function diagram for the GPC system

The GPC system function diagram includes the following:

- Glow plug relay
- Glow Plug Control (GPC) circuit
- Glow Plug Diagnostic (GPD) circuit
- Glow Plugs
- Electronic Control Module (ECM)
- Engine Coolant Temperature (ECT) sensor
- Engine Oil Temperature (EOT) sensor
- Battery
- Wait To Start lamp

Function

The GPC system heats the cylinders to aid cold engine starting and reduce white smoke during warm-up.

Component Location

The glow plug relay is installed on a bracket above the right valve cover. The glow plugs are installed through the valve cover into each cylinder head.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- Amp Clamp
- 180-Pin Breakout Box

GPC Pin-point Diagnostics

DTC	Condition	Possible Causes
1375	Glow plug relay circuit fault	• B+ supply circuit to relay switch OPEN • GPD circuit OPEN or connected to the wrong terminal • GPC relay control circuit OPEN or short to GND • GPC relay coil GND circuit OPEN • Failed relay

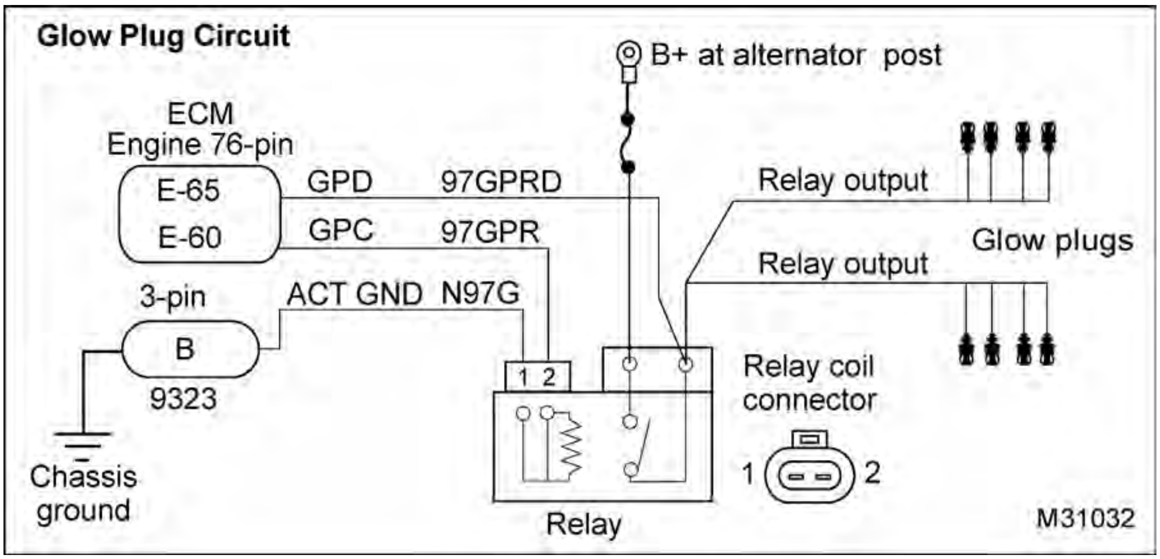

Figure 206 GPC circuit diagram

NOTE: For this procedure, run the KOEO Standard Test. Do not run the Glow Plug/Intake Air Heater Output State test.

The KOEO Standard Test will enable the relays for four seconds every time the test is run. The Glow Plug/Intake Air Heater Output State test only enables the relays twice for 30 seconds to prevent element overheating.

Voltage Check on Relay Switch - Output State Test

Turn the ignition switch to OFF. Use DMM to measure voltage on relay B+ side.		
Test Point	**Spec**	**Comment**
Measure voltage Relay B+ side to GND	B+	If < B+, check large power circuit to relay for OPEN, corroded terminal, or blown fuse link.
Turn the ignition switch to ON; 2 minutes after key On, the glow plugs are commanded off. Open the Output State test session to monitor GPD PID.		
Monitor GPD	Off after 2 minutes	If ON when output side of relay reads 0 V, verify the GPD circuit is wired to the output side of the relay and not the B+ side.

Run Glow Plug/Intake Air Heater Output State test. Monitor GPD PID. Use a DMM to measure voltage on relay output side.

Measure voltage Relay Output side to GND	B+	If 0 V, do Voltage Check - Relay Coil – Output State Test. If < B+, check for corroded terminal on relay or blown fuse link. Do Amperage Draw Check (page 317).
Monitor GPD	ON	If OFF when output side of relay reads B+, check GPD circuit for OPEN, corroded terminal or blown fuse link.

Voltage Check on Relay Coil - Output State Test

Disconnect relay 2-pin connector. Run KOEO Standard Test (GPC is commanded on for 4 seconds during this test). Use DMM to measure voltage when relay is commanded on.

Test Point	Spec	Comment
Pin 2 to GND	B+	If < B+, check GPC circuit for OPEN or short to GND. Do Harness Resistance Check - Relay Coil Circuit (page 317).
Pin 1 to 2	B+	If < B+, check PWR GND circuit for OPEN. Do Harness Resistance Check - Relay Coil Circuit (page 317).
If voltage checks at relay coil are okay, but voltage checks at relay switch failed, replace the relay.		

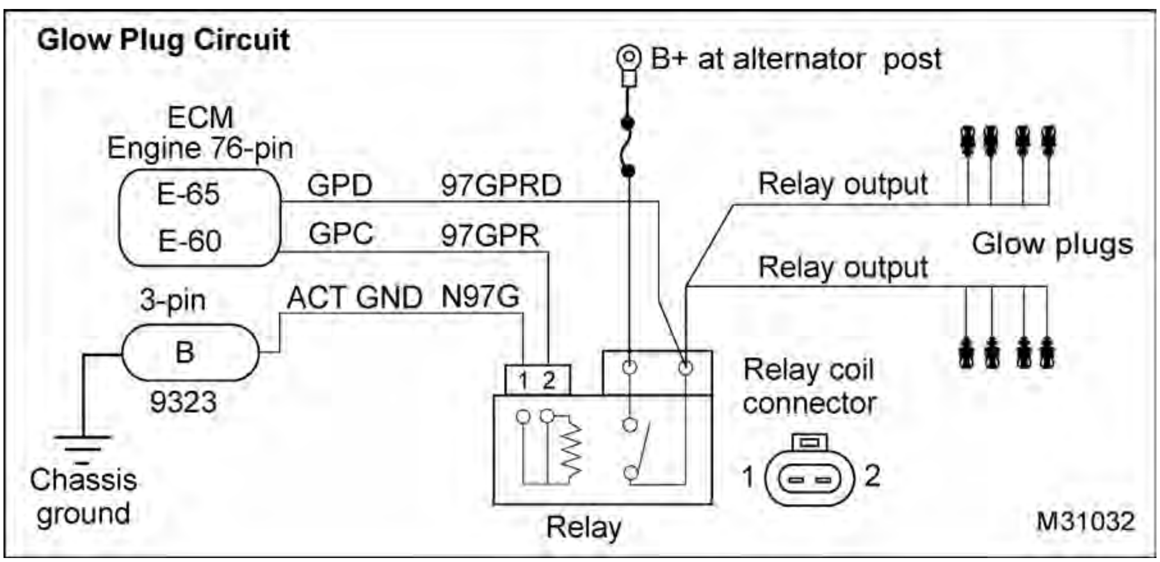

Figure 207 GPC circuit diagram

Amperage Draw Check

NOTE: Batteries must be fully charged before running this test.

Wait 9 seconds, measure the amperage going to each cylinder heads. Run the Glow Plug/Intake Air Heater Output State test. Use a DMM with an amp probe. Set DMM to DCmV and zero amp clamp.

Test Point	Spec	Comment
Left side	28 - 40 A	If 0 A, do Harness Resistance Check - Relay Coil Circuits (page 317). If > 0 A, but below specification, check for corroded terminals on relay, glow plugs, and power source. Do Glow Plug Resistance Check (page 317).
Right side	28 - 40 A	If 0 A, do Harness Resistance Check - Relay Coil Circuits (page 317). If > 0 A, but below specification, check for corroded terminals on relay, glow plugs, and power source. Do Glow Plug Resistance Check (page 317).
If > 0 A, but below specification, and glow plugs and wiring check out okay, replace the relay.		

Glow Plug Resistance Check

Turn ignition switch to OFF. Disconnect harnesses from glow plugs. Use a DMM to measure resistance of each glow plug to engine GND.

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

Harness Resistance Check - Relay Coil Circuits

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

Test Point	Spec	Comment
Pin 2 to E-60	< 5 Ω	If > 5 Ω, check GPC circuit for OPEN.
Pin 1 to GND	< 5 Ω	If > 5 Ω, check with 3-pin breakout harness.
Relay output side to E-65	< 5 Ω	If > 5 Ω, check GPD circuit for OPEN, corroded terminal, or blown fuse link.
E-60 to GND	> 1 kΩ	If < 1 kΩ, check GPC for short to GND.
Connect 3-pin breakout harnesses to engine harness. Leave relay and chassis harness disconnected.		
Pin 1 to 3-pin Pin B	< 5 Ω	If > 5 Ω, check for OPEN circuit on engine harness. If < 5 Ω, check for OPEN circuit on chassis harness.

Harness Resistance Check - Relay to Glow Plugs

Turn the ignition switch to OFF. Disconnect harness from glow plugs. Use DMM to measure resistance.

Test Point	Spec	Comment
Relay Output side to each glow plug connector	< 5 Ω	If > 5 Ω, check for OPEN circuit or corroded terminals.

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

Disconnect battery GND cables.

Relay B+ side to battery positive post	< 5 Ω	If > 5 Ω, check for OPEN circuit or corroded terminals.

NOTE: If circuits and glow plugs are okay, but failed amperage test, replace the relay.

GPC Circuit Operation

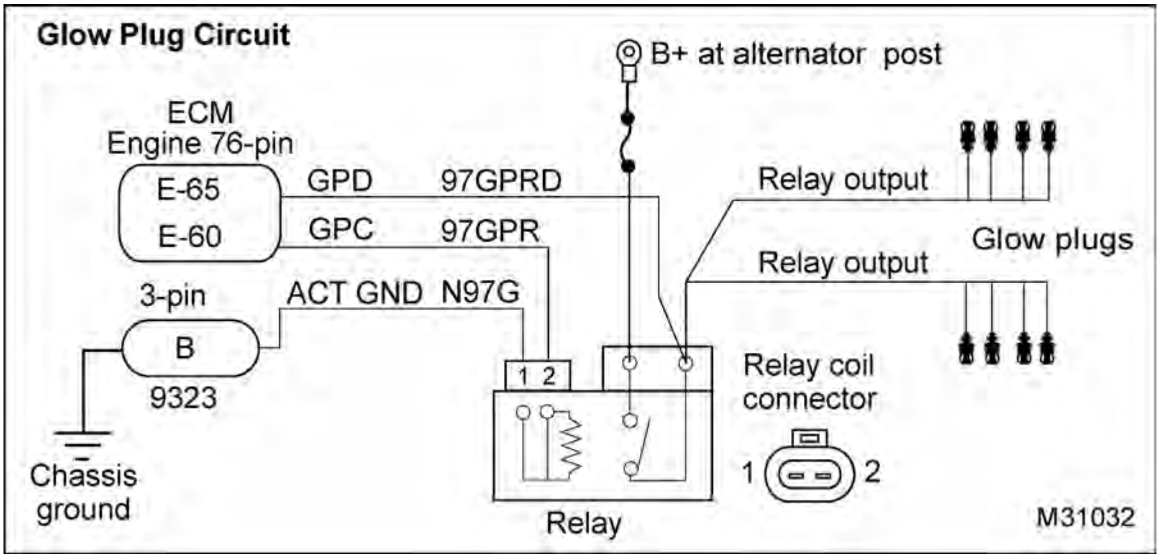

Figure 208 GPC circuit diagram

The ECM controls the WAIT TO START lamp and glow plugs based on ECT and EOT. The wait to start lamp (0 to 10 seconds) on time is independent from the glow plugs (0 to 120 seconds) on time.

The ECM controls the WAIT TO START lamp through public CAN communication to the Electronic Gauge Cluster (EGC).

The ECM uses a relay to control the glow plugs. The ECM energizes the relay by supplying power from Pin E-60 to Pin 2 on the relay coil. The relay coil is grounded at Pin 2 through the 3-pin connector Pin B from chassis harness ground. See *Chassis Electrical Circuit Diagram Manual*.

Power is supplied to the switch side of the glow plug relay from the starter motor through a fusible link. When the relay is energized, power is supplied to the glow plugs, which are grounded through the cylinder heads.

The ECM monitors the output side of the relay with the GPD circuit at ECM Pin E-65.

Fault Detection/Management

The ECM continuously monitors the output of the glow plug relay, when voltage is not as expected a Diagnostic Trouble Code (DTC) is set.

An open or short to ground in the glow plug relay control circuit can be detected by an on demand Output Circuit Check (OCC) performed during the KOEO Standard test. When a circuit fault is detected, a DTC is set. Glow plug and glow plug harness problems cannot be detected by the ECM.

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

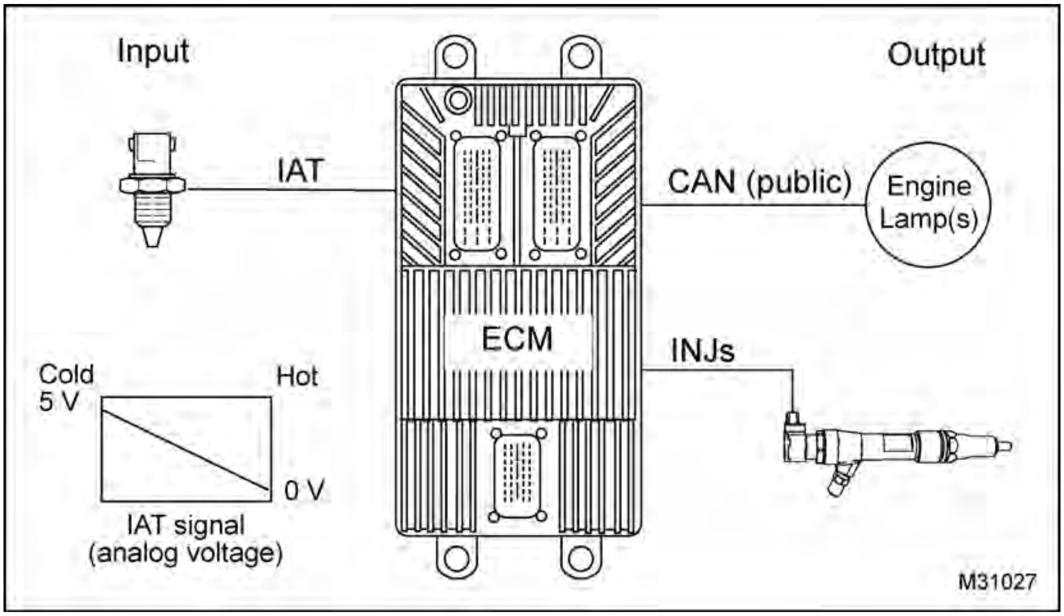

Figure 209 Function diagram for the IAT sensor

The IAT sensor function diagram includes the following:

- Intake Air Temperature (IAT) sensor
- Fuel Injectors (INJ)
- Electronic Control Module (ECM)
- Warn Engine Lamp (WEL)

Function

The IAT sensor provides a feedback signal to the ECM indicating intake air temperature. The ECM monitors the IAT signal to control timing and fuel rate for cold starting. The IAT is monitored while the engine is running to limit smoke and reduce exhaust emissions.

Sensor Location

The IAT sensor is installed in the air filter housing.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 180-Pin Breakout Box
- Temperature Sensor Breakout Harness
- Terminal Test Adapter Kit

IAT Sensor 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

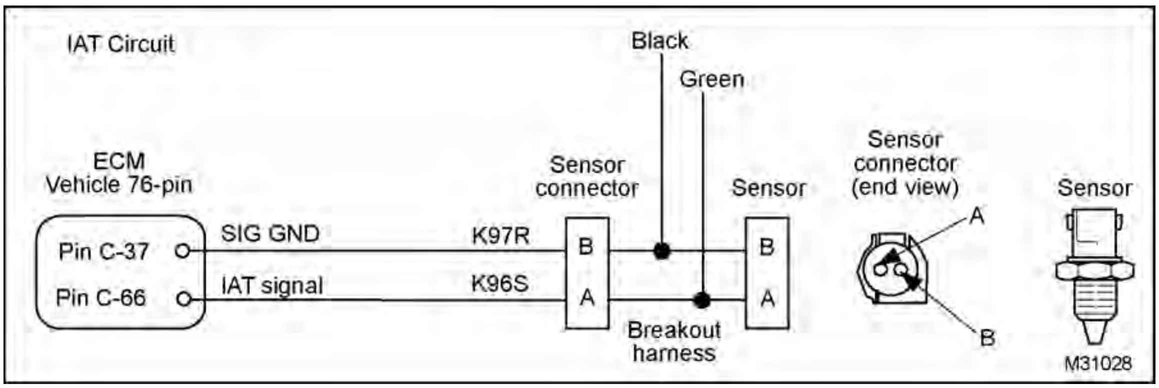

Figure 210 IAT circuit diagram

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.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

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. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC EST - Check PID	DTC 1155 4.68 V	If DTC 1154 is active, or < 4.5 V, check IAT signal for short to GND. Do Harness Resistance Check (page 324).
EST - Check DTC Short 3-Banana plug harness across A and GND	DTC 1154	If DTC 1155 is active, check IAT signal for OPEN. Do Harness Resistance Check (page 324).
EST - Check DTC Short 3-Banana plug harness across A and B	DTC 1154	If DTC 1155 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 324).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

IAT Pin-point Diagnostics

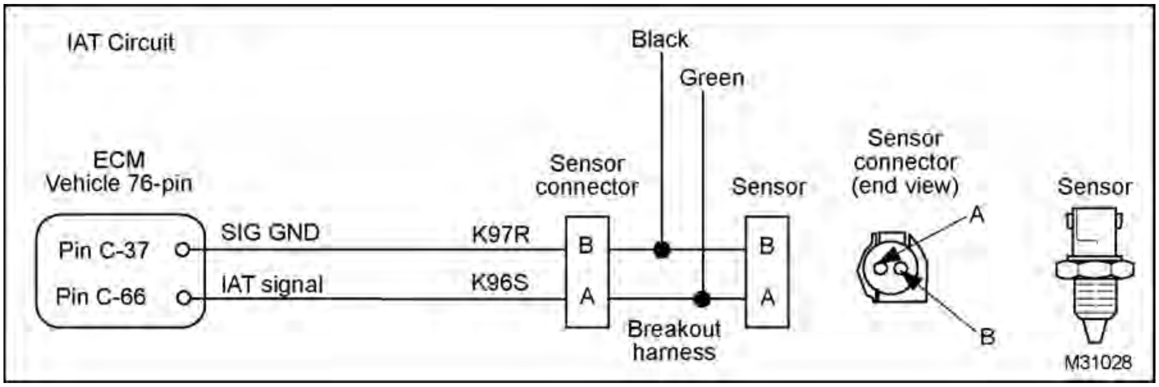

Figure 211 IAT circuit diagram

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	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 324).
B to GND	0 V	If > 0.25 V, check 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
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.

Harness Resistance Check

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

Test Point	Spec	Comment
A to C-66	< 5 Ω	If > 5 Ω, check for OPEN circuit.
B to C-37	< 5 Ω	If > 5 Ω, check for OPEN circuit.

IAT Circuit Operation

The IAT is a thermistor sensor supplied with a 5 volt reference voltage at Pin A from ECM Pin C-66. The sensor is grounded at Pin B from ECM Pin C-37. As the temperature increases, the resistance of the thermistor decreases. This causes 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 signal and uses a calibrated default value. The ECM sets a DTC, turns on the WEL, and runs the engine in a default range.

INJ (Injector Circuits)

DTC	SPN	FMI	Condition
4441-4448	8001-8008	3	Cyl (#) close coil: short circuit
4461-4468	8001-8008	7	Cyl (#) CCT failed (KOER Combustion Problems)
4471-4478	8001-8008	2	Cyl (#) INJ Open Circuit
4481-4488	8001-8008	8	Cyl (#) INJ charging time not plausible
4512	8151	11	Initialization of Fuel injector driver circuit failed Bank A
4513	8151	3	Bank A INJ driver short circuit
4514	8152	3	Bank B INJ driver short circuit
4517	8152	11	Initialization of Fuel injector driver circuit failed Bank B

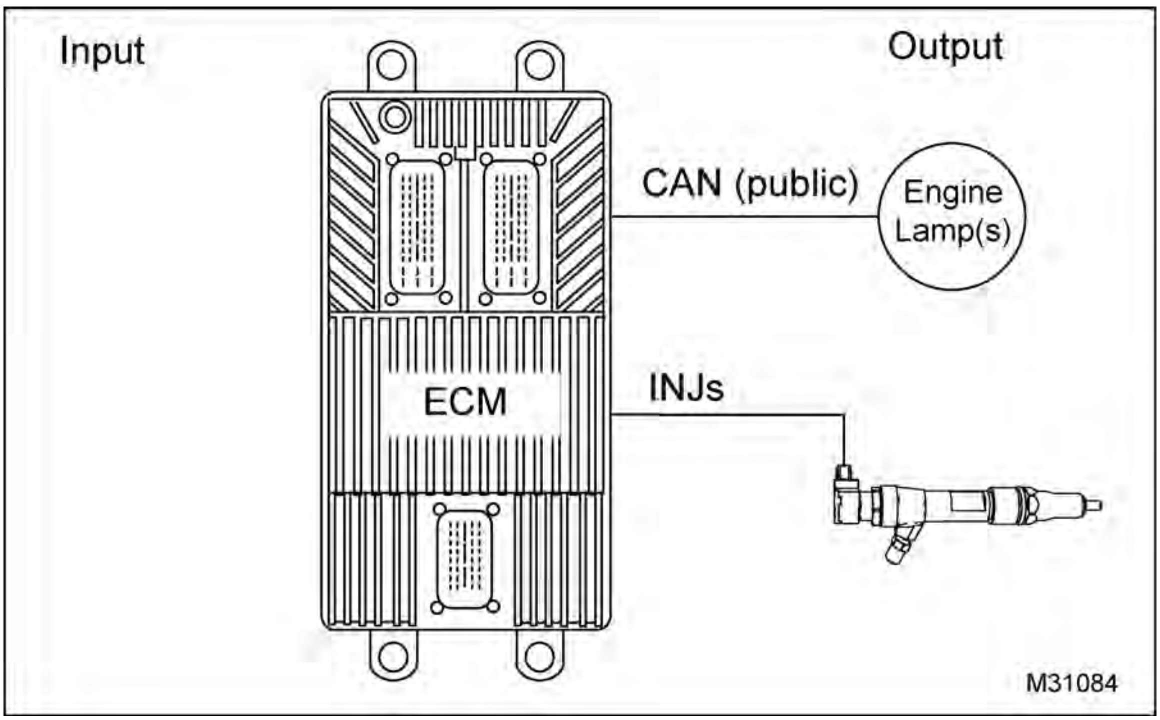

Figure 212 Function diagram for the INJ circuit

The INJ circuit function diagram includes the following:

- Fuel Injectors (INJ)
- Electronic Control Module (ECM)
- Warn Engine Lamp (WEL)

Function

The fuel injectors inject fuel into the cylinders. The ECM controls the timing and amount of fuel sprayed from each injector. The ECM also controls the high-pressure fuel system to regulate fuel pressure.

The injectors deliver several injections per ignition cycle including pre-injection, main-injection, and post-injection. Pre-injection reduces combustion noise, reduces mechanical load and exhaust emissions. when needed, post-injection adds fuel to the exhaust to regenerate the aftertreatment system.

Component Location

The injectors are installed in the cylinder head, under the valve covers and under the high-pressure fuel rail.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- Terminal Test Adapter Kit
- 180-Pin Breakout Box
- 36-Pin Jumper
- 15-Pin UVC Breakout Harness

Injector 1 Check

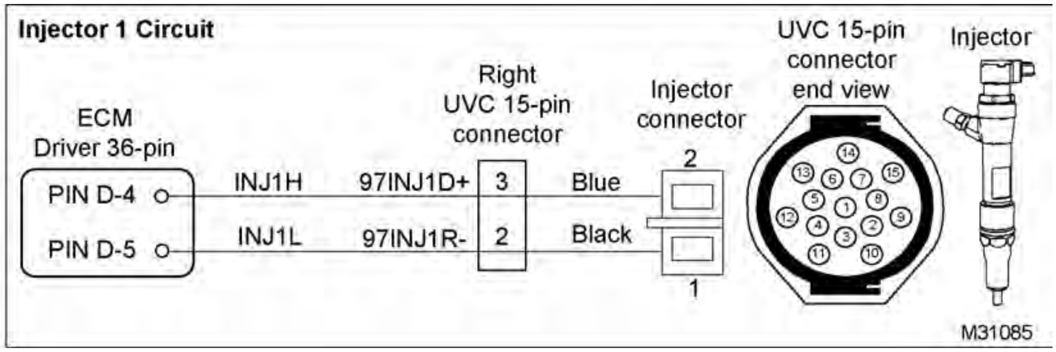

Figure 213 Injector 1 circuit diagram

Injector 1 - Resistance Checks Through Harness and Injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injectors. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To prevent engine damage, turn the ignition switch to OFF before disconnecting the connectors. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect breakout box to the ECM 36-pin 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-5 to GND	> 1 kΩ	
D-4 to D-5	195 kΩ to 205 kΩ	If not within specification, check for OPEN or short circuit or injector coil.

Injector 1 - Resistance UVC Checks

Turn ignition switch to OFF. Connect 15-pin breakout harness to UVC harness. Use DMM to measure resistance.

Test Point	Spec	Comment
2 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
3 to GND	> 1 kΩ	
2 to 3	195 kΩ to 205 kΩ	If not within specification, check for OPEN or short circuit or injector coil.

Injector 1 - Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box to the ECM 36-pin connector. Leave ECM and UVC disconnected. Use DMM to measure resistance.

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

Injector 2 Check

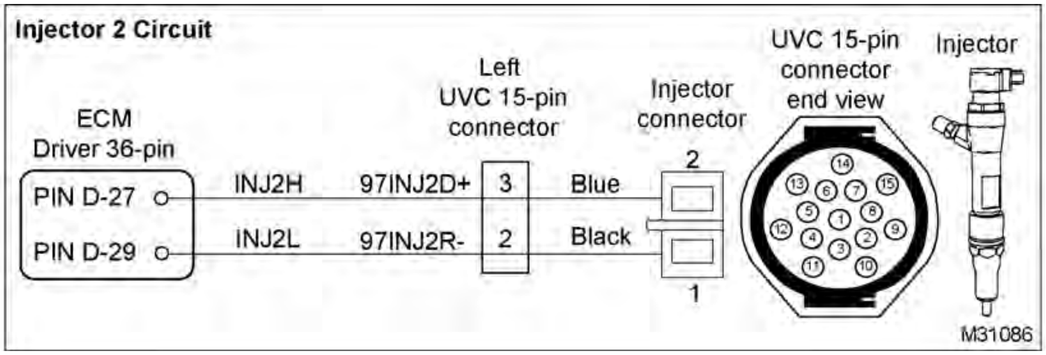

Figure 214 Injector 2 circuit diagram

Injector 2 - Resistance Through Valve Cover to Engine GND Check

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injectors. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To prevent engine damage, turn ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect breakout harness to the left UVC. Use DMM to measure resistance.

Test Point	Spec	Comment
2 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
3 to GND	> 1 kΩ	

Injector 2 - Coil Resistance Check

Turn ignition switch to OFF. Connect breakout harness to the left UVC. Use DMM to measure resistance.

Test Point	Spec	Comment
2 to 3	195 kΩ to 205 kΩ	If not within specification, check UVC harness for OPEN or short circuit. If harness is okay, replace injector.

Injector 2 - Harness Resistance Check

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

Test Point	Spec	Comment
D-27 to 3	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-27 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-29 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-29 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 3 Check

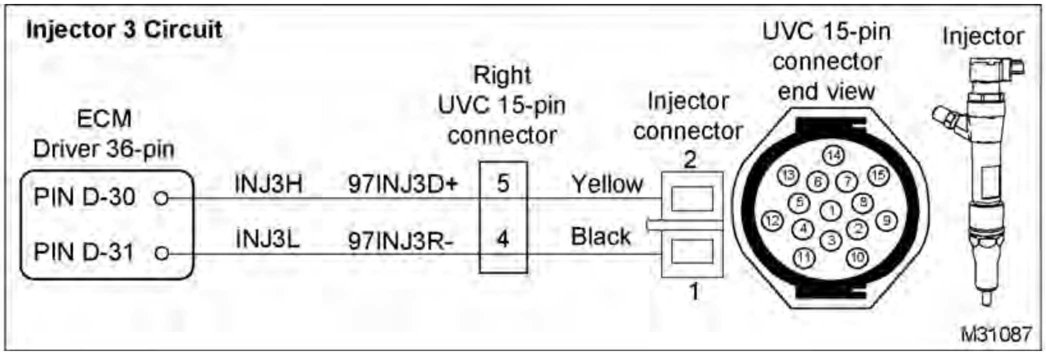

Figure 215 Injector 3 circuit diagram

Injector 3 - Resistance Through Valve Cover to Engine GND Check

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injectors. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To prevent engine damage, turn ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect breakout harness to the right UVC. Use DMM to measure resistance.

Test Point	Spec	Comment
4 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
5 to GND	> 1 kΩ	

Injector 3 - Coil Resistance Check

Turn ignition switch to OFF. Connect breakout harness to the right UVC. Use DMM to measure resistance.

Test Point	Spec	Comment
4 to 5	195 kΩ to 205 kΩ	If not within specification, check UVC harness for OPEN or short circuit. If harness is okay, replace injector.

Injector 3 - Harness Resistance Check

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

Test Point	Spec	Comment
D-30 to 5	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-30 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-31 to 4	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-31 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 4 Check

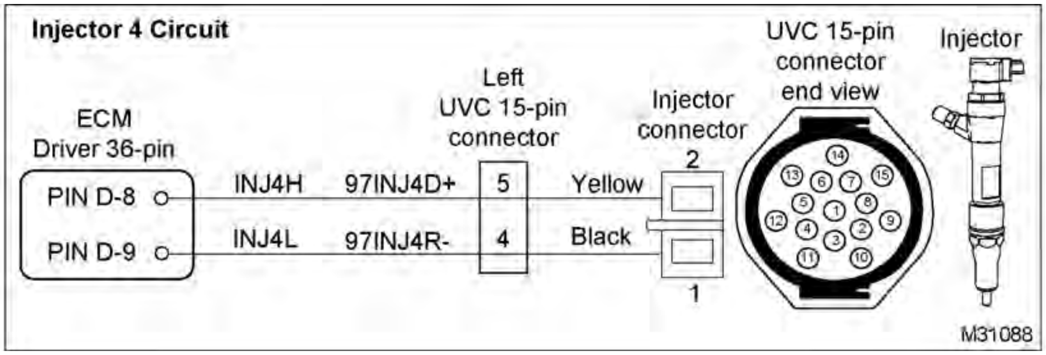

Figure 216 Injector 4 circuit diagram

Injector 4 - Resistance Through Valve Cover to Engine GND Check

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injectors. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To prevent engine damage, turn ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect breakout harness to the left UVC. Use DMM to measure resistance.

Test Point	Spec	Comment
4 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
5 to GND	> 1 kΩ	

Injector 4 - Coil Resistance Check

Turn ignition switch to OFF. Connect breakout harness to the left UVC. Use DMM to measure resistance.

Test Point	Spec	Comment
4 to 5	195 kΩ to 205 kΩ	If not within specification, check UVC harness for OPEN or short circuit. If harness is okay, replace injector.

Injector 4 - Harness Resistance Check

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

Test Point	Spec	Comment
D-8 to 5	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-8 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-9 to 4	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-9 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 5 Check

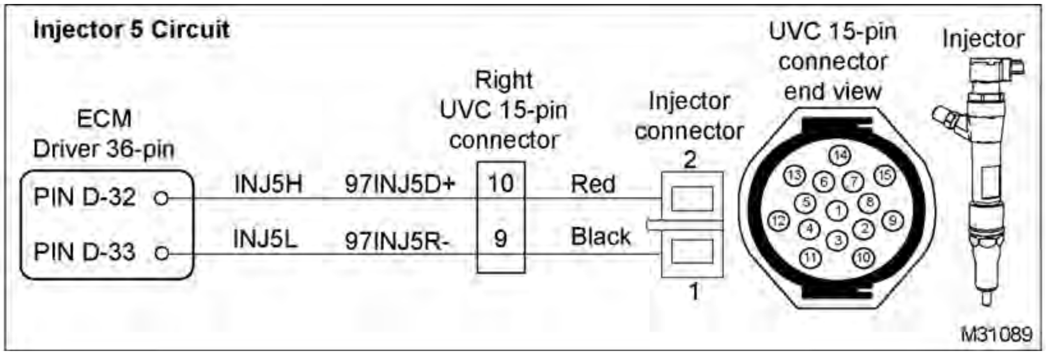

Figure 217 Injector 5 circuit diagram

Injector 5 - Resistance Through Valve Cover to Engine GND Check

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injectors. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To prevent engine damage, turn ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect breakout harness to the right UVC. Use DMM to measure resistance.

Test Point	Spec	Comment
9 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
10 to GND	> 1 kΩ	

Injector 5 - Coil Resistance Check

Turn ignition switch to OFF. Connect breakout harness to the right UVC. Use DMM to measure resistance.

Test Point	Spec	Comment
9 to 10	195 kΩ to 205 kΩ	If not within specification, check UVC harness for OPEN or short circuit. If harness is okay, replace injector.

Injector 5 - Harness Resistance Check

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

Test Point	Spec	Comment
D-32 to 10	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-32 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-33 to 9	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-33 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 6 Check

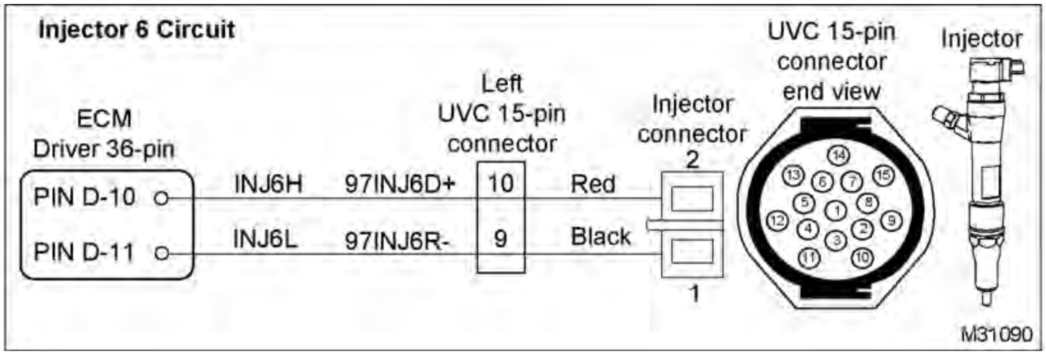

Figure 218 Injector 6 circuit diagram

Injector 6 - Resistance Through Valve Cover to Engine GND Check

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injectors. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To prevent engine damage, turn ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect breakout harness to the left UVC. Use DMM to measure resistance.

Test Point	Spec	Comment
9 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
10 to GND	> 1 kΩ	

Injector 6 - Coil Resistance Check

Turn ignition switch to OFF. Connect breakout harness to the left UVC. Use DMM to measure resistance.

Test Point	Spec	Comment
9 to 10	195 kΩ to 205 kΩ	If not within specification, check UVC harness for OPEN or short circuit. If harness is okay, replace injector.

Injector 6 - Harness Resistance Check

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

Test Point	Spec	Comment
D-10 to 10	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-10 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-11 to 9	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-11 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 7 Check

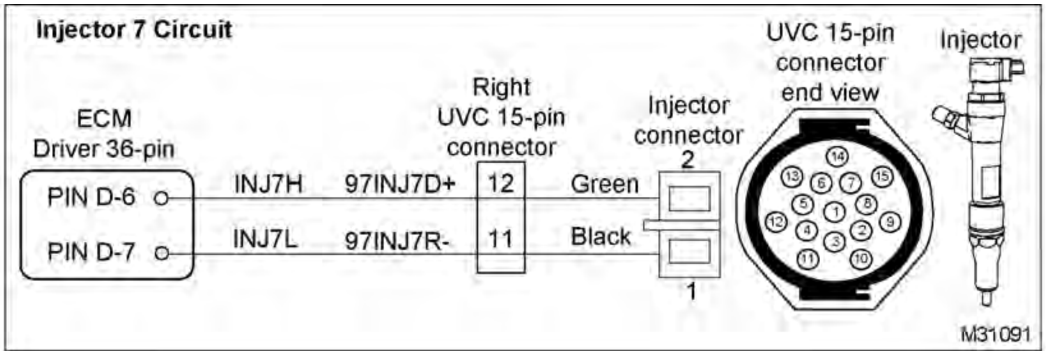

Figure 219 Injector 7 circuit diagram

Injector 7 - Resistance Through Valve Cover to Engine GND Check

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injectors. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To prevent engine damage, turn ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect breakout harness to the right UVC. Use DMM to measure resistance.

Test Point	Spec	Comment
11 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
12 to GND	> 1 kΩ	

Injector 7 - Coil Resistance Check

Turn ignition switch to OFF. Connect breakout harness to the right UVC. Use DMM to measure resistance.

Test Point	Spec	Comment
11 to 12	195 kΩ to 205 kΩ	If not within specification, check UVC harness for OPEN or short circuit. If harness is okay, replace injector.

Injector 7 - Harness Resistance Check

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

Test Point	Spec	Comment
D-6 to 12	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-6 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-7 to 11	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-7 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 8 Check

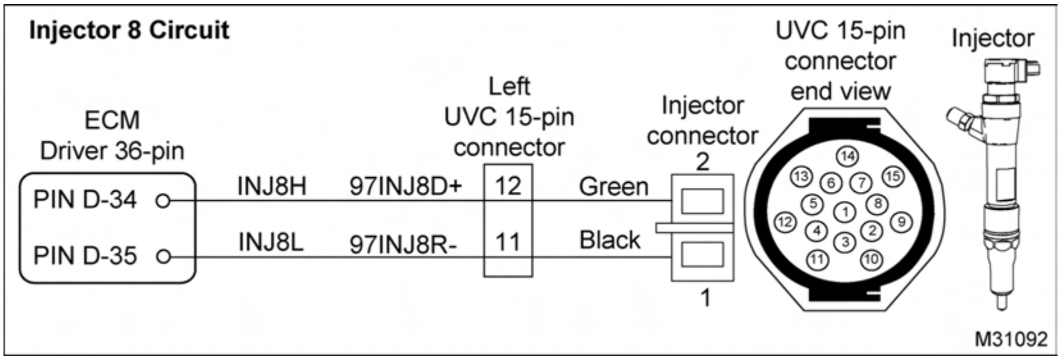

Figure 220 Injector 8 circuit diagram

Injector 8 - Resistance Through Valve Cover to Engine GND Check

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injectors. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To prevent engine damage, turn ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect breakout harness to the left UVC. Use DMM to measure resistance.

Test Point	Spec	Comment
11 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
12 to GND	> 1 kΩ	

Injector 8 - Coil Resistance Check

Turn ignition switch to OFF. Connect breakout harness to the left UVC. Use DMM to measure resistance.

Test Point	Spec	Comment
11 to 12	195 kΩ to 205 kΩ	If not within specification, check UVC harness for OPEN or short circuit. If harness is okay, replace injector.

Injector 8 - Harness Resistance Check

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

Test Point	Spec	Comment
D-34 to 12	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-34 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-35 to 11	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-35 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector Circuit Operation

Each injector has an actuator that indirectly opens or closes the injector nozzle. Charging the actuator opens the nozzle and discharging the actuator closes the nozzle. The ECM charges and discharges the actuators by switching on either the high side or low side output. The high side output supplies the actuator with a power supply of 220 V DC at 2.5 A rms. The low side output supplies a return circuit for each injector actuator.

High Side Drive Output

There is one high side switch circuit per cylinder side. It is common to all injector circuits on that cylinder side. High DC voltage is present on these circuits.

Low Side Drive Return

The injector actuators are grounded through the low side return switches, one per each injector.

Fault Detection/Management

The ECM can detect if the output is short to injector, short to ground / battery detection, or if output is open load.

IST System (Idle Shutdown Timer)

DTC	SPN	FMI	Condition
2324	593	14	Engine stopped by IST

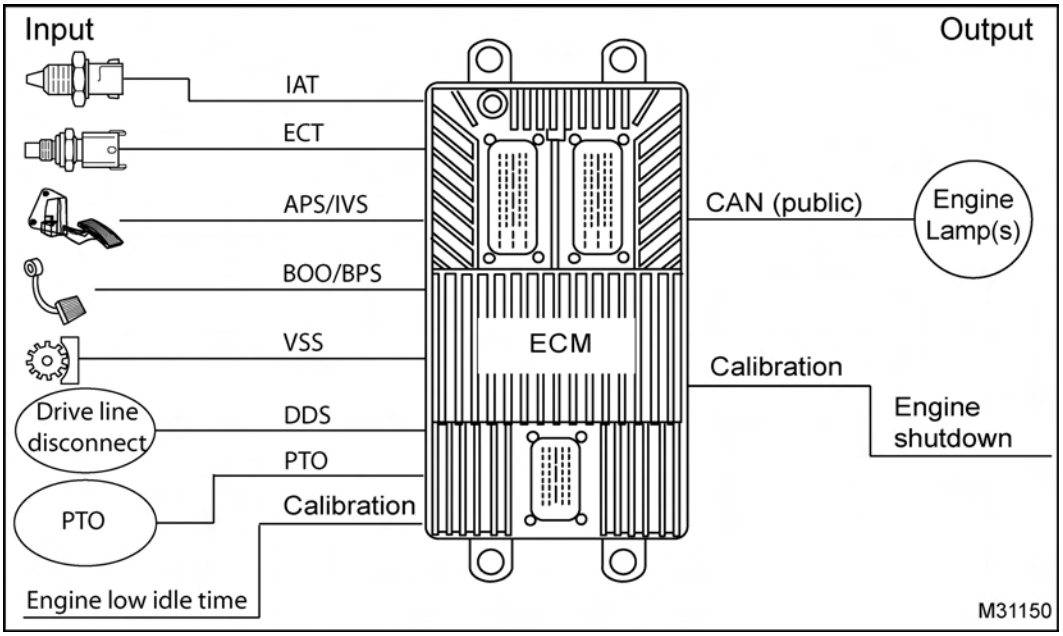

Figure 221 Function diagram for IST system

The IST system function diagram includes the following:

- Electronic Control Module (ECM)
- Intake Air Temperature (IAT) sensor
- Engine Coolant Temperature (ECT) sensor
- Accelerator Position Sensor and Idle Validation Switch (APS/IVS)
- Brake On/Off (BOO) switch and Brake Pressure Switch (BPS)
- Vehicle Speed Sensor (VSS)
- Driveline Disengagement Switch (DDS)
- Power Takeoff (PTO)
- Engine lamps

Function

The IST allows the ECM to shut down the engine during extended engine idle times.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit

GOVERNMENT REGULATION: State and local regulations may limit engine idle time. The vehicle owner or operator is responsible for compliance with those regulations.

IST Operation

Idle Shutdown Warning

Thirty seconds before IST-defined engine shutdown, a vehicle instrument panel indicator activates. There are two types of indicators:

- Amber flashing idle shutdown indicator for multiplex electrical systems.
- Red flashing indicator with audible alarm for non-multiplex electrical systems.

This continues until the engine shuts down or the low idle shutdown timer is reset.

Engine Idle Shutdown Timer for California ESS Compliant Engines

Beginning in 2008 MY, International® MaxxForce® engines certified for sale in the state of California (CA) will conform to mandatory California Air Resources Board (CARB) Engine Shutdown System (ESS) regulations. The prior function of the IST is available on CA ESS exempt and Federally certified engines (school buses, emergency, and military vehicles).

Engine idle duration is limited for ESS compliant engines as follows:

- When vehicle parking brake sets, the idle shutdown time is limited to the CARB requirement of 5 minutes.
- When vehicle parking brake is released, the idle shutdown time is limited to the CARB requirement of 15 minutes.

The duration of CARB mandated values can be reduced by programming the customer IST programmable parameter to a value lower than 15 minutes. Adjusting this parameter reduces overall system shutdown time as follows:

- Adjusting parameter value between 5 and 15 minutes reduces idle shutdown time with the vehicle parking brake released. The default value of 5 minutes for the vehicle parking brake “set” condition remains unaffected.
- Adjusting parameter value between 2 and 5 minutes reduces idle time for both the vehicle parking brake “released” and “set” conditions.

While the EST is installed, idle shutdown time is factory defaulted to 60 minutes and cannot be adjusted. If the IST is enabled, the Cold Ambient Protection (CAP) will not function.

NOTE: The CARB IST feature is factory programmed. Customers cannot turn IST off for ESS compliant engines.

CARB IST Conditions

The following conditions must be true for the IST to activate in all modes. Any change of the “true” state of one or more of these conditions resets or disables the IST.

- Manual Diesel Particulate Filter (DPF) regeneration is inactive (not enabled).
- Steady driveline state (no transition detected). No change in the state of the clutch switch (manual transmission) or transmission shifter between the in-gear position and neutral or park (automatic transmission).
- PTO Remote mode disabled.
- Engine coolant temperature greater than 15.6 ºC (60 ºF).
- No active coolant temperature sensor diagnostic faults.
- No active intake air temperature sensor diagnostic faults.
- Engine is operating in run mode or in active diagnostic tool mode.
- Vehicle speed is less than 1.25 miles/hr.
- No active vehicle speed diagnostic faults.
- PTO control is in off or standby mode.
- Engine speed less than 750 RPM.
- Steady accelerator pedal position (no transition detected from any preset position).
- Steady brake pedal state (no transition detected from any preset state).
- Steady parking brake state (CAN message) (no transition detected from any preset state).

Engine Idle Shutdown Timer (Federal-Optional)

Idle time can be programmed from 5 to 120 minutes. While the EST is installed, the IST function is active with the programmed shutdown time in effect. Parking brake transitions reset the idle timer. If the IST is enabled, the Cold Ambient Protection (CAP) will not function.

Federal IST Conditions

The following conditions must be true for the IST to activate. Any change to the “true” state of one or more of these conditions resets or disables the IST.

Common Enable Conditions for All Federal IST Options

- Manual Diesel Particulate Filter (DPF) regeneration is inactive (not enabled).
- Steady driveline state (no transition detected). No change in the state of the clutch switch (manual transmission) or transmission shifter between the in-gear position and neutral or park (automatic transmission).
- PTO Remote mode disabled.
- Intake air temperature greater than 15.6 ºC (60 ºF) (manufacturer’s default, customer adjustable parameter).
- Intake air temperature lower than 44 ºC (112 ºF) (manufacturer’s default, customer adjustable parameter).
- Engine coolant temperature greater than 60 ºC (140 ºF).
- No active coolant temperature sensor diagnostic faults.
- Engine is operating in run mode or in active diagnostic tool mode.
- Vehicle speed is less than 1.25 miles/hr.
- No active vehicle speed diagnostic faults.
- Steady parking brake state (CAN message). No transition detected from any preset state.

Additional operation enable conditions depending on selected Federal IST operation mode:

Federal IST Mode 1: PTO Operation Option Enable Conditions

- PTO control is in off or standby mode.
- Engine speed less than 750 RPM.
- Accelerator pedal position is less than 2%.
- No active accelerator pedal diagnostic faults.
- Steady brake pedal state (No transition detected).
- No active brake system diagnostic faults.

Federal IST Mode 2: No Load / Light Load Limit Option Enable Conditions

- Accelerator pedal position is less than 2%.
- No active accelerator pedal diagnostic faults.
- Steady brake pedal state (no transition detected).
- No active brake system diagnostic faults.
- Engine reported fuel usage (load) is less than ECM specified limit (factory calibrated, not customer adjustable).

Federal IST Mode 3: Tamper Proof Option Enable Conditions

- Engine reported fuel usage (load) is less than ECM specified limit (factory calibrated, not customer adjustable).
- Steady accelerator pedal position (no transition detected from any preset position).
- Steady brake pedal state (no transition detected from any preset state).

Fault Detection/Management

The IST DTC does not indicate a system fault. DTC 2324 sets by the ECM when the engine has been shut down due to exceeding the programmed idle time. The IST feature must be enabled for DTC 2324 to be displayed.

ITV (Intake Throttle Valve)

DTC	SPN	FMI	Condition
1287	3464	1	ITVL OCC self-test failed
1288	3464	0	ITVH OCC self-test failed
1292	7318	2	ITVP in-range fault
1293	7318	3	ITVP signal out-of-range HIGH
1294	7318	4	ITVP signal out-of-range LOW
1295	51	4	Intake Throttle Valve open circuit
1296	51	5	Intake Throttle Valve short circuit
1297	51	3	ITV no input signal
1298	51	2	ITV operation fault - under V, over amp, over temp

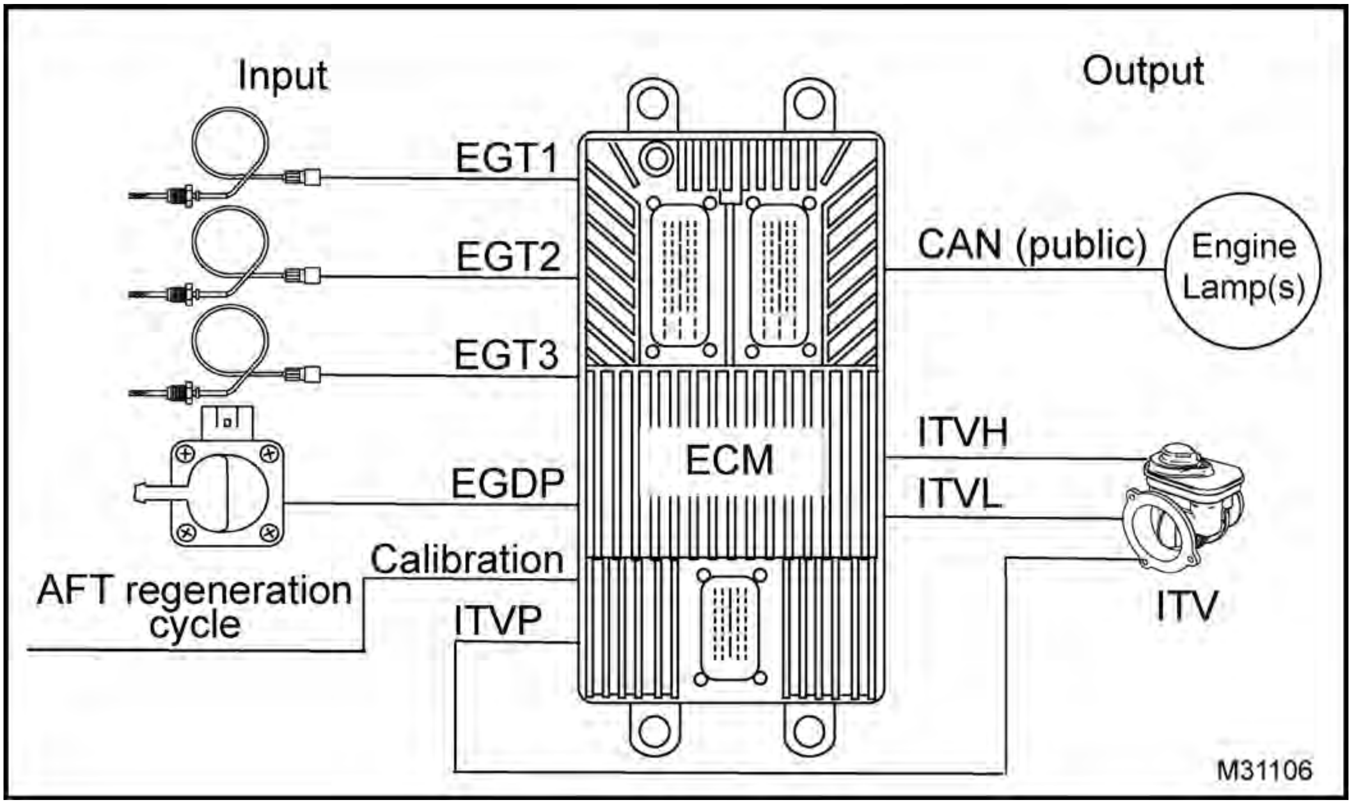

Figure 222 Function diagram for the ITV

The ITV function diagram includes the following:

- Intake Throttle Valve (ITV)
  - Intake Throttle Valve High (ITVH) circuit
  - Intake Throttle Valve Low (ITVL) circuit
  - Intake Throttle Valve Position (ITVP) sensor
- Electronic Control Module (ECM)
- Malfunction Indicator Lamp (MIL)
- Warn Engine Lamp (WEL)
- Exhaust Gas Differential Pressure (EGDP) sensor
- Exhaust Gas Temperature 1 (EGT1) sensor
- Exhaust Gas Temperature 2 (EGT2) sensor
- Exhaust Gas Temperature 3 (EGT3) sensor

Function

The ITV is a variable position actuator that restricts intake air flow to help heat the exhaust aftertreatment during regeneration.

Component Location

The ITV is mounted on the EGR valve elbow housing on the top front of the engine.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 180-Pin Breakout Box
- ITV Breakout Harness
- Terminal Test Adapter Kit

ITV Actuator End Diagnostics

DTC	Condition	Possible Causes
1287	ITVL OCC self-test failed	Valve is not opening as much as desired by 35% • ITVL circuit OPEN or shorted to PWR or GND • Failed ITV actuator
1288	ITVH OCC self-test failed	Valve is not closing as much as desired by 35% • ITVH circuit OPEN or shorted to PWR or GND • Failed ITV actuator
1292	ITVP in-range fault	ITV position does not agree with the commanded position • ITVP circuit fault • Failed ITV actuator
1293	ITVP signal out-of-range HIGH	• ITVP signal circuit short to PWR • Failed ITVP sensor
1294	ITVP signal out-of-range LOW	• ITVP signal circuit OPEN or short to GND • VREF circuit OPEN • Failed ITVP sensor

1295
1296
1297
1298
	Intake Throttle Valve open circuit
	Intake Throttle Valve short circuit
	ITV no input signal
	ITV operation fault - under V, over amp, over temp
		• ITVH control circuit fault
		• ITVL control circuit fault
		• Failed H-bridge circuit due to:
		  • under voltage
		  • over current
		  • over temperature
		• Failed ITV actuator

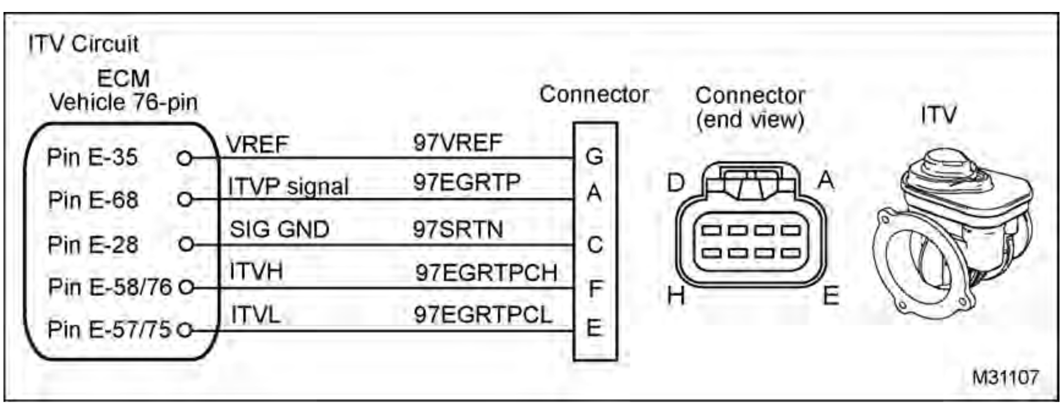

Figure 223 ITV actuator circuit diagram

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. Verify sensor voltage is within KOEO specification. See “Performance Specifications” section of this manual
3. 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.
4. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

5. Connect breakout harness to engine harness. Leave sensor disconnected.

ITV Actuator Circuit Check

Connect breakout harness. Leave ITV disconnected. Turn the ignition switch to ON. Use EST to monitor PID and DMM to measure voltage during Continuous Monitor test.

Test Point	Spec	Comments
EST - Check DTC	DTC 1294	If DTC 1293, check ITVP signal for short to PWR
DMM - Measure volts G 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 346).
EST - Check DTC Short breakout harness across A and G	DTC 1293	If DTC 1294, check ITVP signal for OPEN. Do Harness Resistance Check (page 346).
DMM - Measure resistance C to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 346).
DMM - Measure voltage E to GND	B+	If < B+, check ITVL for OPEN or short to GND. Do Harness Resistance Check (page 346).
DMM - Measure voltage F to GND	B+	If < B+, check ITVH for OPEN or short to GND. Do Harness Resistance Check (page 346).

ITV Actuator - Standard Test and Output State Test

Connect breakout harness between ECM and ITV actuator. Run KOEO Standard Test and Output State Test. Use EST to monitor ITVP volts.

Test	Spec	Comment
Standard Test	2.5 V to 3.0 V	If < 2.5 V, check for OPEN or short in ITV control circuits. Do Harness Resistance Check (page 346).
Output State HIGH	2.5 V to 3.0 V	If < 2.5 V, check for OPEN or short in ITV control circuits. Do Harness Resistance Check (page 346).
Output State LOW	0.6 V to 1.5 volts	If > 1.5 volts, check for OPEN or short in ITV control circuits. Do Harness Resistance Check (page 346).

ITV Actuator Pin-point Diagnostics

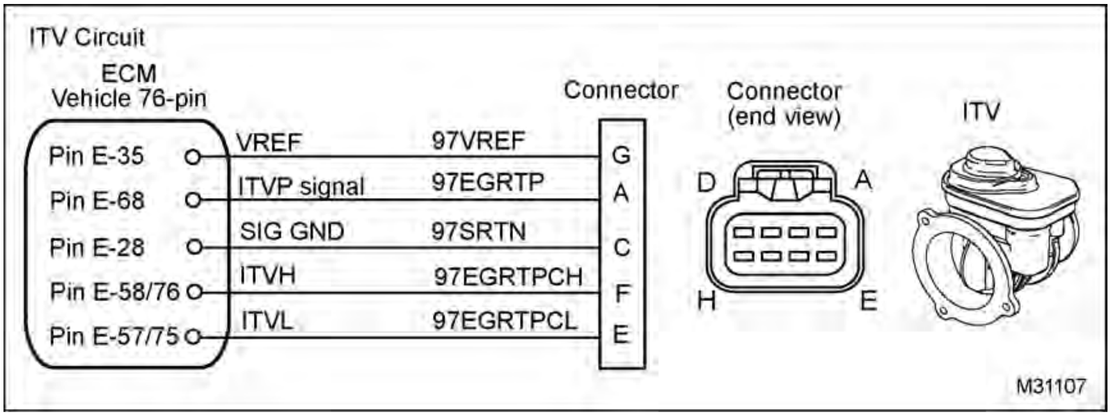

Figure 224 ITV actuator circuit diagram

Connector Voltage Check

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

Test Point	Spec	Comment
C to GND	0 V	If > 0.25 V, check SIG GND for short to PWR.
G 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 346).
A to GND	0 V	If > 0.25 V, check ITVP for short to PWR. Do Harness Resistance Check (page 346).
E to GND	B+	If < B+, check ITVL for OPEN or short to GND. Do Harness Resistance Check (page 346).
F to GND	B+	If < B+, check ITVH for OPEN or short to GND. Do Harness Resistance Check (page 346).
If checks are within specification, do ITV Actuator - Output State High and Low Test (page 344).		

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave actuator 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	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
F to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
G to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

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

Test Point	Spec	Comment
A to E-68	< 5 Ω	If > 5 Ω, check ITVP signal circuit for OPEN
C to E-28	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN
E to E-57	< 5 Ω	If > 5 Ω, check ITVL circuit for OPEN
E to E-75	< 5 Ω	If > 5 Ω, check ITVL circuit for OPEN
F to E-58	< 5 Ω	If > 5 Ω, check ITVH circuit for OPEN
F to E-76	< 5 Ω	If > 5 Ω, check ITVH circuit for OPEN
G to E-35	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN

ITV Actuator Circuit Operation

The ITV/ITVP is integrated into one component. ITV is the control valve actuator and ITVP is the valve position sensor.

ITVP sensor

The ITVP is a potentiometer sensor supplied with a 5 volt reference voltage at Pin G from ECM Pin E-35. The sensor is grounded at Pin C from ECM Pin E-28. The sensor returns a variable voltage signal from Pin A to ECM Pin E-68.

ITV actuator

The ECM controls the ITV with a Pulse Width Modulation (PWM) signal through H-bridge circuitry.

Pulse Width Modulation - Voltage is supplied by a series of pulses. To control motor speed, it varies (modulates) the width of the pulses.

H-bridge is a bipolar circuit. The ECM controls the ITV to close by driving the ITVH circuit high and the ITVL circuit low. The opposite occurs when the valve is commanded open.

Variable voltage is needed to move the valve. Minimal voltage is needed to maintain its position.

Fault Detection/Management

The ECM continuously monitors the ITVP sensor. If the sensor signal is higher or lower than expected, the ECM sets a DTC and turns on the MIL.

An open or short on the ITV controlling circuits can only be detected by on-demand output circuit check during KOEO Standard test. If there is a circuit fault detected, a DTC is set.

MAP Sensor (Manifold Absolute Pressure)

DTC	SPN	FMI	Condition
1121	102	3	MAP signal out-of-range HIGH
1122	102	4	MAP signal out-of-range LOW
1156	102	0	MAP in-range HIGH - MAP above BARO at start
1157	102	1	MAP in-range LOW - MAP below BARO at start

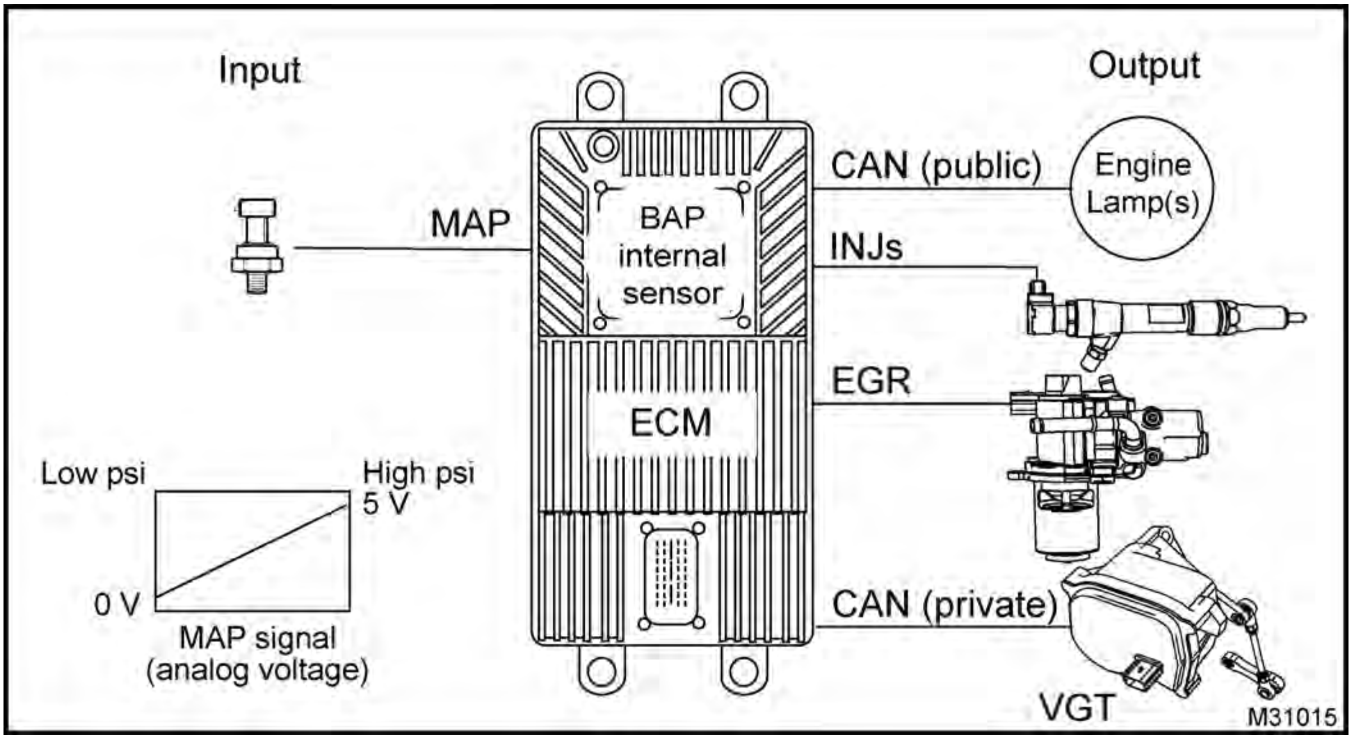

Figure 225 Function diagram for the MAP sensor

The MAP sensor function diagram includes the following:

- Manifold Absolute Pressure (MAP) sensor
- Electronic Control Module (ECM) with integrated Barometric Absolute Pressure (BAP) sensor
- Exhaust Gas Recirculation (EGR) valve
- Variable Geometry Turbocharger (VGT)
- Fuel Injectors (INJ)
- Malfunction Indicator Lamp (MIL)

Function

The ECM uses the MAP sensor signal to assist in the calculation of the EGR and VGT duty percentage. The ECM monitors the MAP signal to determine intake manifold (boost) pressure. From this information the ECM can optimize control of fuel rate and injection timing for all engine operating conditions.

Sensor Location

The EGR valve assembly is installed in the EGR valve elbow housing, on the top front of the engine.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 180-Pin Breakout Box
- Pressure Sensor Breakout Harness
- Terminal Test Adapter Kit

MAP Sensor End Diagnostics

DTC	Condition	Possible Causes
1121	MAP signal out-of-range HIGH	• MAP signal circuit short to PWR • Failed sensor
1122	MAP signal out-of-range LOW	• MAP signal circuit OPEN or short to GND • VREF circuit OPEN • Failed sensor
1156	MAP in-range HIGH - MAP above BARO at start	• SIG GND circuit OPEN • VREF circuit short to PWR • Biased MAP or BAP circuit/sensor • Failed sensor
1157	MAP in-range LOW - MAP below BARO at start	• VREF circuit OPEN • Biased MAP or BAP circuit/sensor • Failed sensor

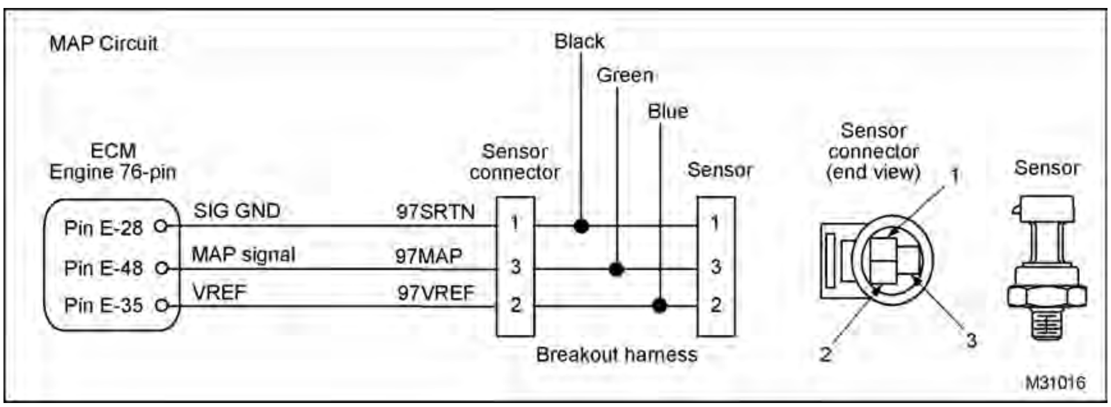

Figure 226 MAP circuit diagram

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

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Verify MAP and BAP are within specification. See “Performance Specifications” section of this manual.
3. 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.
4. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

5. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

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. Use DMM to measure circuits.

Test Point	Spec	Comments
EST – Check DTC	DTC 1122	If DTC 1121 is active, check MAP signal for short to PWR.
DMM – Measure volts 2 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 352).
EST – Check DTC Short breakout harness across 2 and 3	DTC 1121	If DTC 1122 is active, check MAP signal for OPEN. Do Harness Resistance Check (page 352).
DMM – Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 352).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

MAP Pin-point Diagnostics

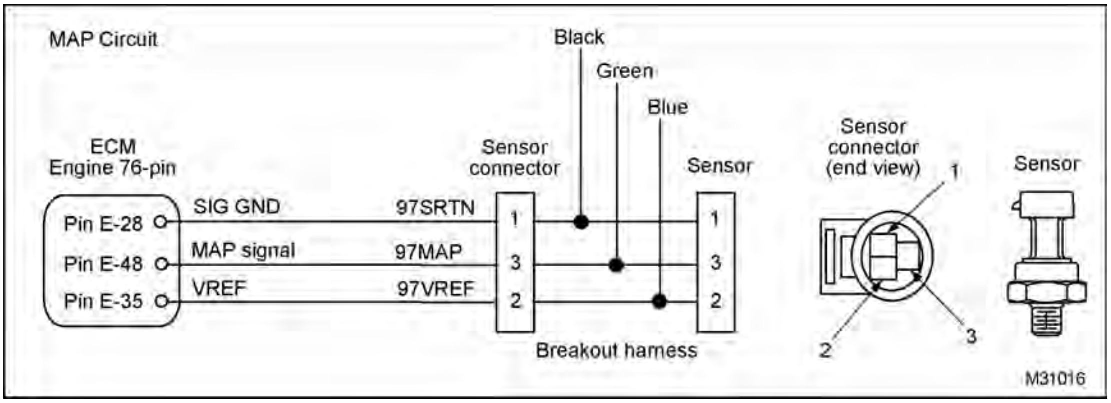

Figure 227 MAP circuit diagram

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	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 352).
3 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 352).

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.
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 breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-28	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
2 to E-35	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
3 to E-48	< 5 Ω	If > 5 Ω, check MAP signal circuit for OPEN.

MAP Circuit Operation

The MAP sensor is a variable capacitance sensor supplied with a 5 volt reference voltage at Pin 2 from ECM Pin E-35. The sensor is grounded at Pin 1 from ECM Pin E-28. The sensor returns a variable voltage signal from Pin 3 to ECM Pin E-48.

Fault Detection/Management

The ECM monitors the internal BAP sensor as a baseline for zeroing the MAP and EBP signals.

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM disregards the signal and uses a calibrated default value. The ECM sets a DTC, turns on the MIL, runs the engine in a default range, and disables the Engine Warning Protection System (EWPS).

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

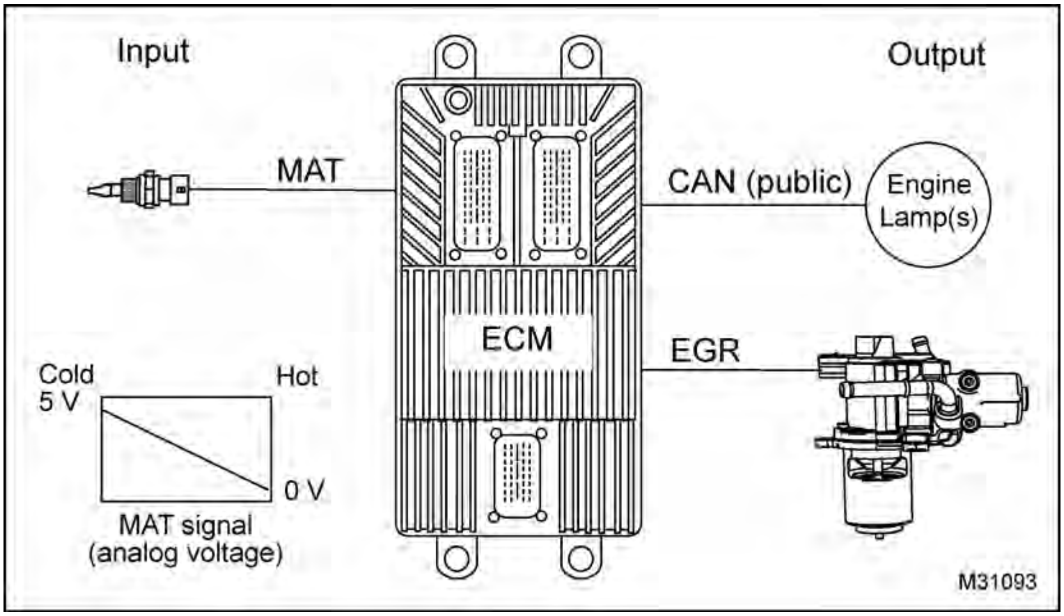

Figure 228 Function diagram for the MAT sensor

The MAT sensor function diagram includes the following:

- Manifold Air Temperature (MAT) sensor
- Exhaust Gas Recirculation (EGR) valve
- Electronic Control Module (ECM)
- Warn Engine Lamp (WEL)

Function

The MAT sensor provides a feedback signal to the ECM indicating intake manifold air temperature. The ECM controls the EGR system 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 installed in the left leg of the intake manifold, next to the Manifold Absolute Pressure (MAP) sensor, just behind the inlet to the turbocharger.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 180-Pin Breakout Box
- Temperature Sensor Breakout Harness
- Terminal Test Adapter Kit

MAT Sensor 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

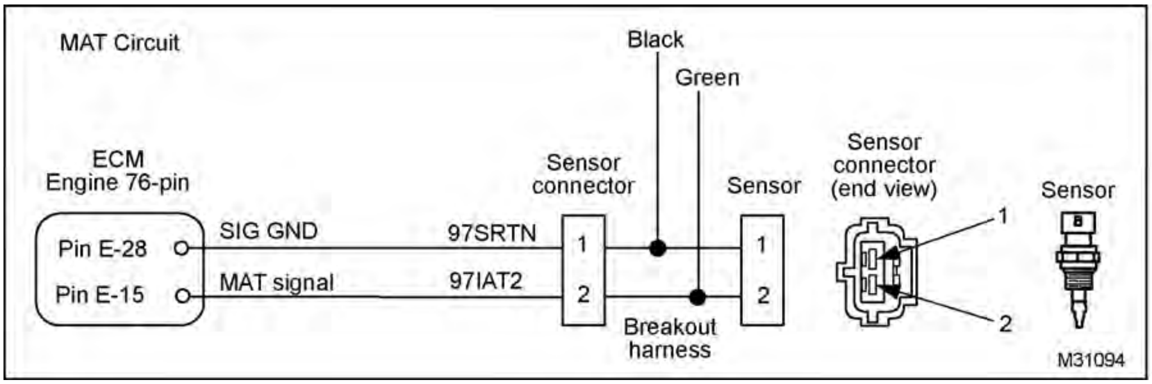

Figure 229 MAT circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating part (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.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

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. Use DMM to measure circuits.

Test Point	Spec	Comments
EST – Check DTC	DTC 1162	If DTC 1161 is active, check MAT signal for short to GND. Do Harness Resistance Check (page 356).
EST – Check DTC Short a 3-banana plug harness across 2 and GND	DTC 1161	If DTC 1162 is active, check MAT signal for OPEN. Do Harness Resistance Check (page 356).
EST – Check DTC Short a 3-banana plug harness across 1 and 2	DTC 1161	If DTC 1162 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 356).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

MAT Pin-point Diagnostics

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	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 356).

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.
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 breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-28	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to E-15	< 5 Ω	If > 5 Ω, check for OPEN circuit.

MAT Circuit Operation

The MAT is a thermistor sensor that is supplied with a 5 V reference voltage at Pin 2 from ECM Pin E-15. The sensor is grounded at Pin 1 from ECM Pin E-28. As the temperature increases, the resistance of the thermistor decreases. This causes 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, turns on the WEL, and runs the engine in a default range.

RSE (Radiator Shutter Enable)

DTC	SPN	FMI	Condition
None			

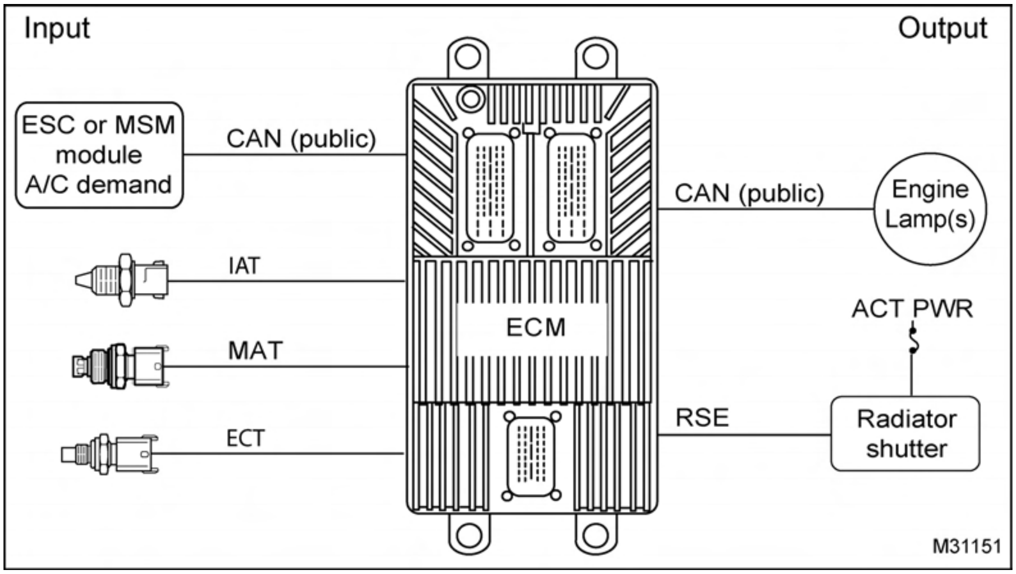

Figure 230 Function diagram for RSE

The RSE function diagram includes the following:

- Radiator Shutter Enable (RSE)
- Electronic Control Module (ECM)
- Intake Air Temperature (IAT)
- Manifold Air Temperature (MAT)
- Engine Coolant Temperature (ECT)
- Warn Engine Lamp (WEL)

Function

The Radiator Shutter Enable (RSE) feature provides signals to open or close radiator shutters (energize or de-energize the solenoid). Closing the shutters keeps the engine warm during cold weather operation. This provides faster warm up of the passenger cab and enables faster windshield defrosting.

Component Location

The radiator shutter solenoid is installed in the pressure line that feeds the shutters.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- Terminal Test Adapter Kit

RSE Circuit Diagnostics

DTC	Condition	Possible Causes
None	Inactive radiator shutter	• RSE circuit OPEN or short to GND • ACT PWR circuit OPEN or short to GND, blown fuse • Failed relay • Failed RSE solenoid

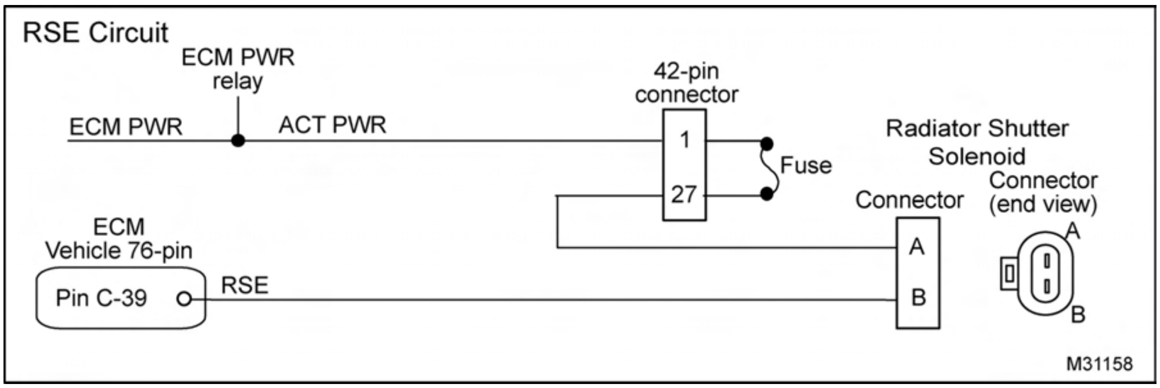

Figure 231 RSE circuit diagram

Voltage Check at RSE Connector - Output State Test

Disconnect radiator shutter solenoid 2-pin connector. Turn the ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
A to GND	B+	If < B+, check ACT PWR circuit for OPEN, blown fuse or failed relay
B to GND	0 V to 0.25 V	If > 0.25 V, check RSE circuit for short to PWR
Run Output State Test HIGH.		
B to B+	0 V to 0.25 V	If > 0.25 V, check RSE circuit for short to GND
Run Output State Test LOW.		
B to B+	B+	If < B+, check RSE circuit for OPEN or short to PWR. Do Harness Resistance Check (page 359)
A to B	B+	If < B+, check ACT PWR circuit for OPEN. Do Harness Resistance Check (page 359)

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box. Leave ECM and radiator shutter solenoid disconnected.

Test Point	Spec	Comment
C-39 to B	< 5 Ω	If > 5 Ω, check RSE for OPEN circuit
C-39 to GND	> 1 kΩ	If < 1 kΩ, check RSE circuit for short to GND
A to C-1, 3 and 5	< 5 Ω	If > 5 Ω, check ACT PWR for OPEN in circuit.
A to GND	> 1 kΩ	If < 1 kΩ, check ACT PWR for short to GND.

See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for fuse information.

RSE Circuit Operation

The control cylinder responds to air or hydraulic pressure from the shutter control valve, and actuates to hold the spring-loaded vanes closed. When pressure is relieved, the vanes open. The vanes open automatically when the vehicle is shut down.

The RSE solenoid is supplied ACT PWR at Pin A. The ECM Pin C-39 controls the solenoid by grounding Pin B.

The shutters close when all of the following conditions exist:

- MAT is less than 37 °C (99 °F)
- IAT is less than 7 °C (45 °F)
- ECT is less than 80 °C (176 °F)
- No transmission retarder request is present
- No engine fan request is present

The shutters will open when any of the following conditions exist:

- MAT is greater than 60 °C (140 °F)
- IAT is greater than 12 °C (54 °F)
- Transmission retarder request is present
- Engine fan request is present
- ECT is greater than 87 °C (189 °F)

NOTE: ECT is customer programmable

The shutters will not close again until all closed conditions exist.

Fault Detection/Management

An open or short to ground in the RSE can be detected by the ECM during an on-demand engine standard test. The IAT, MAT, and ECT are continuously monitored. If a DTC is detected in the IAT, MAT, or ECT circuit, the RSE control is disabled and the radiator shutters remain open.

TACH (Tachometer Output Circuit)

DTC	SPN	FMI	Condition
None			

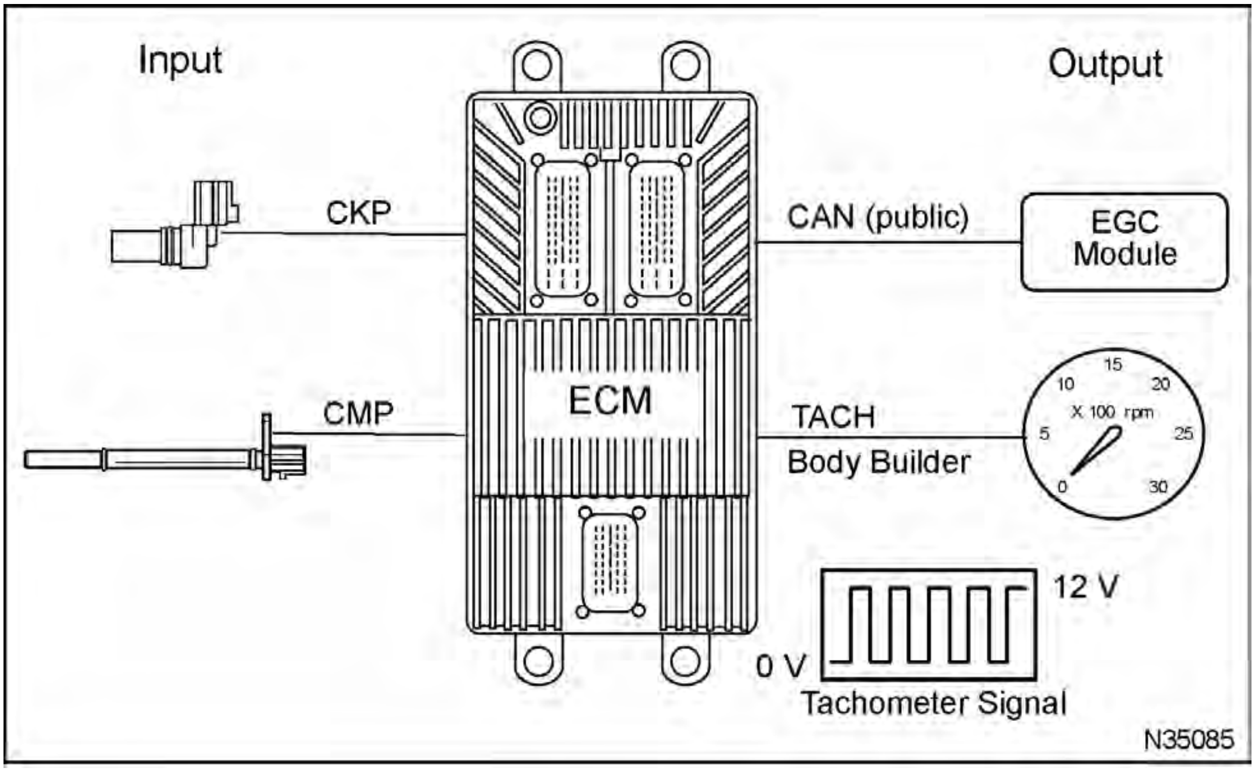

Figure 232 Function diagram for the tachometer output circuit

The tachometer output circuit function diagram includes the following:

- Remote tachometer
- Electronic Control Module (ECM)
- Electronic Gauge Cluster (EGC) Module
- Crankshaft Position (CKP) sensor
- Camshaft Position (CMP) sensor

The tachometer signal is sent to the EGC through the public CAN network. The TACH signal is also supplied on one circuit to the body builder blunt cut-off circuits.

Tachometer Pin-point Diagnostics

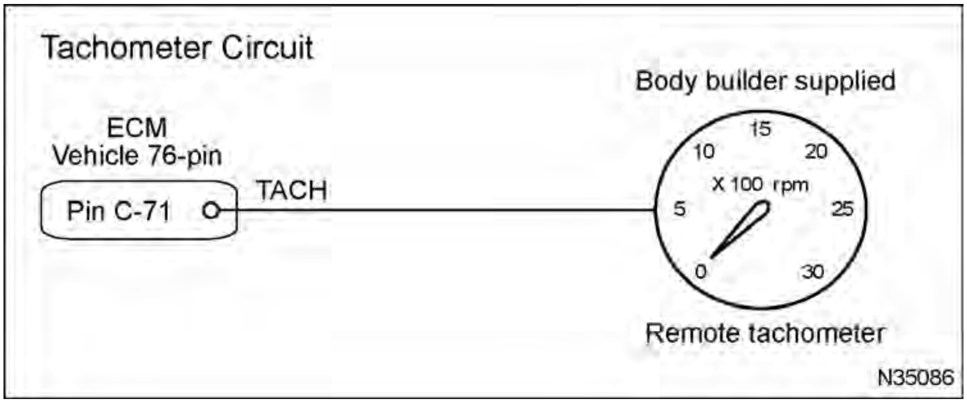

Figure 233 Tachometer circuit diagram

Circuit End Voltage Check

NOTE: If the tachometer is not working on the EGC, see truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.

Disconnect component from the body builder blunt cut off circuit. Turn the ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
TACH to GND	B+	If < B+, check for OPEN circuit
Start engine. Set DMM to ACV - RPM 2 to measure engine speed signal.		
TACH to GND	Low idle = 140 Hz at 700 RPM High idle = 590 Hz at 2950 RPM	If no signal, do Harness Resistance Check (page 361).

Harness Resistance Check

Connect breakout box, leave ECM and TACH component disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
C-71 to TACH	< 5 Ω	If > 5 Ω , check for OPEN circuit
C-71 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND

Tachometer Circuit Operation

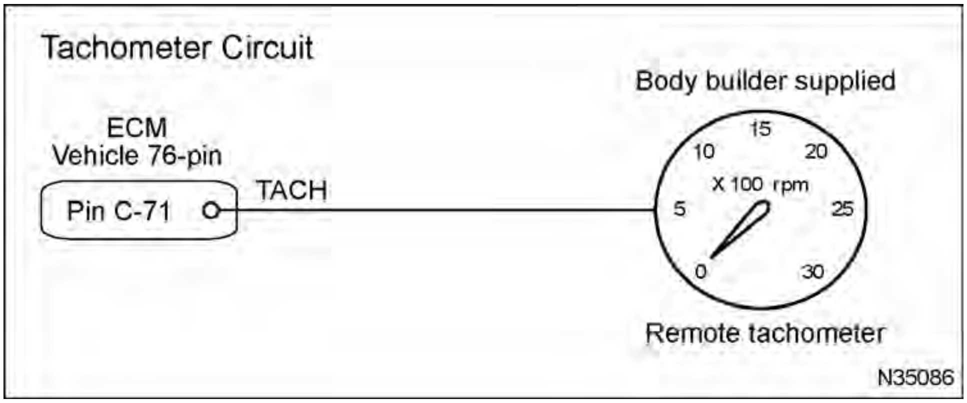

Figure 234 Tachometer circuit diagram

The ECM receives a signal from the CKP sensor and calculates engine speed (rpm). The ECM provides an output for a remote tachometer with a 0 to 12 volts digital signal that indicates engine speed. The frequency sent by the ECM is 1/5th of the actual engine rpm (12 pulses per engine revolution).

Diagnostic Trouble Codes (DTCs)

DTCs are not available for communication between the ECM and the remote tachometer.

VGT (Variable Geometry Turbocharger) Actuator

DTC	SPN	FMI	Condition
1178	7316	0	VGT actuator temp above high limit
2174	8321	2	VGT communication fault
2175	8321	7	VGT performance fault
2176	8321	0	VGT commanded position over a threshold
2177	8321	1	VGT commanded position below a threshold
2549	8321	12	ECM not receiving VGT CAN messages
3345	7136	0	VGT control over duty
3347	7136	1	VGT control under duty

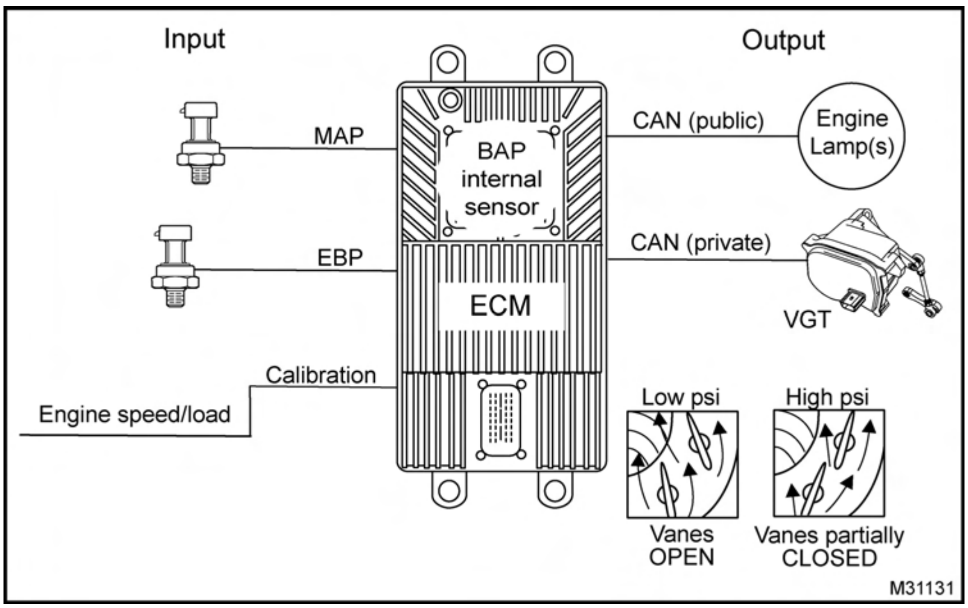

Figure 235 Function diagram for the VGT actuator

The VGT actuator function diagram includes the following:

- Variable Geometry Turbocharger (VGT) actuator
- Electronic Control Module (ECM) with integrated Barometric Absolute Pressure (BAP) sensor
- Manifold Absolute Pressure (MAP) sensor
- Exhaust Back Pressure (EBP) sensor
- Malfunction Indicator Lamp (MIL)
- Warn Engine Lamp (WEL)

Function

The VGT changes turbocharger flow to control boost pressure by moving actuated vanes mounted on a unison ring inside the turbine housing. The VGT is used for the following:

- Performance - The VGT provides faster turbocharger response and quicker acceleration with less lag.
- Emissions - The VGT controls the pressure difference between exhaust and inlet manifolds to ensure proper EGR operation.

Component Location

The VGT actuator is an electronic component mounted on the side of the turbocharger.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 4-Pin Actuator Breakout Harness
- 180-Pin Breakout Box
- Terminal Test Adapter Kit

VGT Actuator End Diagnostics

DTC	Condition	Possible Causes
1178	VGT actuator temp above high limit	• ACT PWR circuit OPEN
2174	VGT communication fault	• Battery GND circuit OPEN
2175	VGT performance fault	• CANH circuit OPEN or shorted
2176	VGT commanded position over a threshold	• CANL circuit OPEN or shorted
2177	VGT commanded position below a threshold	• Sticky or stuck VGT linkage
2549	ECM not receiving VGT CAN messages	• Failed VGT actuator
3345	VGT control over duty	
3347	VGT control under duty	

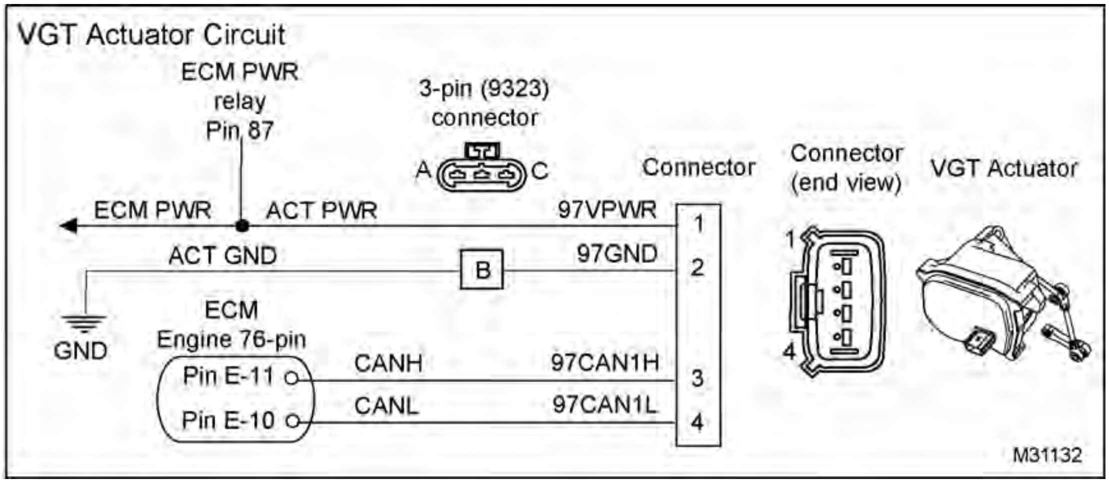

Figure 236 VGT actuator circuit diagram

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

NOTE: When the ignition switch is turned to ON, the VGT actuator cycles the vanes closed and then back open before starting.

Determine if there is a mechanical or electrical problem. Visually inspect VGT vane linkage assembly for anything restricting movement. Try moving the VGT linkage by hand. See VGT Actuator Linkage Test in the "Performance Diagnostics" section of this manual.

- If the linkage does not move freely through its full travel, the turbocharger assembly must be replaced. See *Engine Service Manual*.
- If the linkage moves freely through its full travel, do Connector Voltage Check.

Connector Voltage Check

Connect breakout harness between engine harness and VGT actuator. Turn ignition switch to ON. Use DMM to measure voltage.

Test	Spec	Comment
1 to GND	B+	If < B+, check ACT PWR circuit for OPEN or short to GND, or blown fuse. Do Harness Resistance Check (page 366).
1 to 2	B+	If < B+, check GND circuit for OPEN. Do Harness Resistance Check (page 366).
3 to GND	1 to 4 V	The sum of 3 to GND and 4 to GND should equal 4 to 5 V.
4 to GND	1 to 4 V	The sum of 4 to GND and 3 to GND should equal 4 to 5 V.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and breakout harness to VGT actuator. Leave ECM and VGT actuator disconnected.

Test Point	Spec	Comment
3 to E-11	< 5 Ω	If > 5 Ω, check CANH for OPEN in circuit
3 to GND	> 1 kΩ	If < 1 kΩ, check CANH for short to GND
4 to E-10	< 5 Ω	If > 5 Ω, check CANL for OPEN in circuit
4 to GND	> 1 kΩ	If < 1 kΩ, check CANL for short to GND
2 to GND	< 5 Ω	If > 5 Ω, check ACT PWR GND for OPEN in circuit
1 to C-1, 3 and 5	< 5 Ω	If > 5 Ω, check ACT PWR for OPEN in circuit
1 to GND	> 1 kΩ	If < 1 kΩ, check ACT PWR for short to GND

Operational Visual Inspection - Output State Test

Run KOEO Standard Test and Output State Test HIGH and LOW. Visually inspect actuator movement.

Test Point	Spec	Comment
Output State Test HIGH	OPEN	Run next test
Output State Test LOW	CLOSE	If VGT actuator does not cycle fully open and fully closed. Check for mechanical problem; sticking vanes or linkage

If the linkage moves freely and the circuit checks are okay, clear DTCs, and cycle the ignition switch.
If active DTC returns, replace the VGT actuator.

VGT Actuator Circuit Operation

The turbocharger has a set of movable vanes mounted on a unison ring in the turbine housing, they control boost by controlling exhaust turbine inlet pressure. At low engine speeds when exhaust flow is low, the vanes are partially closed. This increases the pressure of the exhaust pushing against the turbine blades, making the turbine spin faster and generating more boost. As engine speed increases, so does exhaust flow, so the vanes are opened to reduce turbine pressure and hold boost steady or reduce it as needed.

The ECM monitors the internal BAP sensor as a baseline for zeroing the MAP and EBP signals.

By monitoring the MAP and EBP sensors, the ECM can adjust turbine inlet pressure to control boost at any speed/load and to limit boost at full load. The ECM also controls the VGT actuator to ensure there is always enough exhaust pressure for sufficient EGR flow. The default position of the VGT vanes are normally open.

The VGT actuator receives power at Pin 1, from the ECM main power relay Pin 87. Ground for the VGT actuator is supplied at Pin 2, from ACT ground. The ECM controls the VGT actuator through the CAN (private) circuits, CANH, ECM E-11 to VGT Pin 3, and CANL, ECM E-10 to VGT Pin 4.

CAN (private) Circuit Operation

The private Controller Area Network (CAN) provides a communication link between the ECM and a specific engine controller, in this case, the VGT actuator. The VGT actuator can be controlled through the private CAN network. The VGT can communicate failures back to the ECM through the private CAN network.

CAN (private) versus CAN (public)

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 terminating resistors are used to reduce reflections.

The private CAN system is set up to only communicate between the ECM and specific engine controls.

CAN Repair Information

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.

VREF (Reference Voltage)

DTC	SPN	FMI	Condition
5666	8339	4	VREF engine voltage below min
5667	8339	3	VREF engine voltage above max
5668	8340	4	VREF chassis voltage below min
5669	8340	3	VREF chassis voltage above max
5671	8341	4	VREF body voltage below min
5672	8341	3	VREF body voltage above max

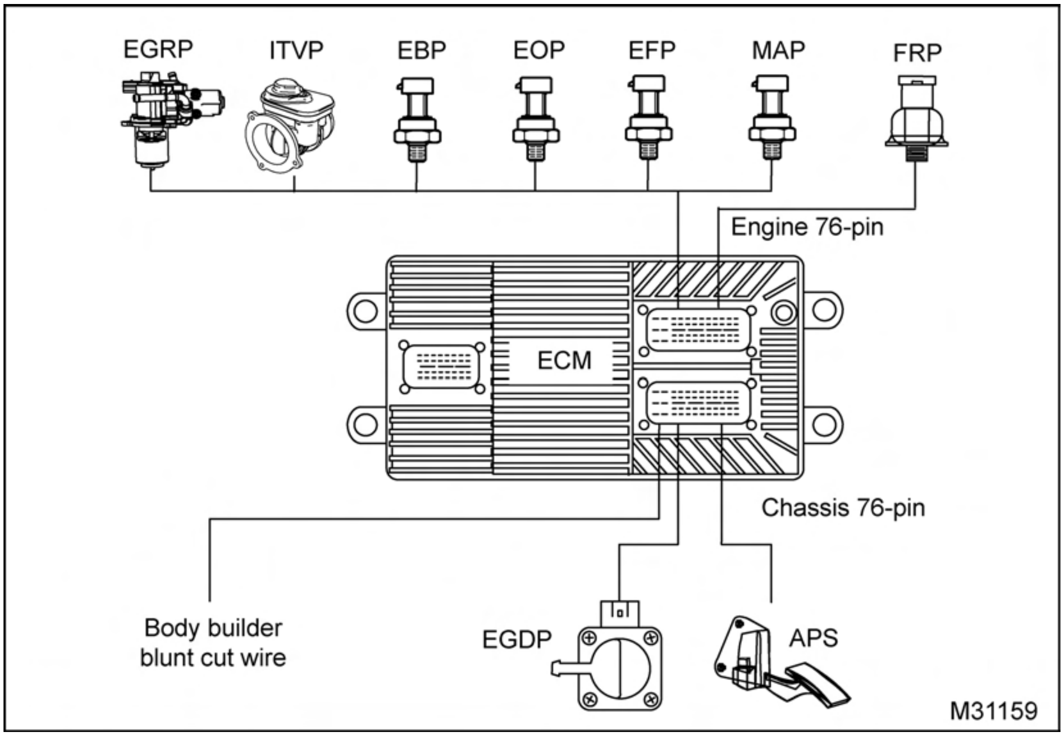

Figure 237 Function diagram for the VREF

The VREF function diagram includes the following:

- Electronic Control Module (ECM)
- Fuel Rail Pressure (FRP) sensor
- Exhaust Gas Recirculation Position (EGRP) sensor
- Intake Throttle Valve Position (ITVP) sensor
- Exhaust Back Pressure (EBP) sensor
- Engine Oil Pressure (EOP) sensor
- Engine Fuel Pressure (EFP) sensor
- Manifold Absolute Pressure (MAP) sensor
- Exhaust Gas Differential Pressure (EDGP) sensor
- Accelerator Position Sensor (APS)
- Body builder blunt cut wire

Function

The VREF circuit is a 5 volt reference supplied by the ECM and provides power to all 3-wire sensors.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)
- 180-Pin Breakout Box
- Terminal Test Adapter Kit

VREF Pin-point Diagnostics

DTC	Condition	Possible Causes
5666	VREF engine voltage below min	• VREF on engine connector short to GND
5667	VREF engine voltage above max	• VREF on engine connector short to VBAT
5668	VREF chassis voltage below min	• VREF on chassis connector short to GND
5669	VREF chassis voltage above max	• VREF on chassis connector short to VBAT
5671	VREF body voltage below min	• VREF on body connector short to GND
5672	VREF body voltage above max	• VREF on body connector short to VBAT

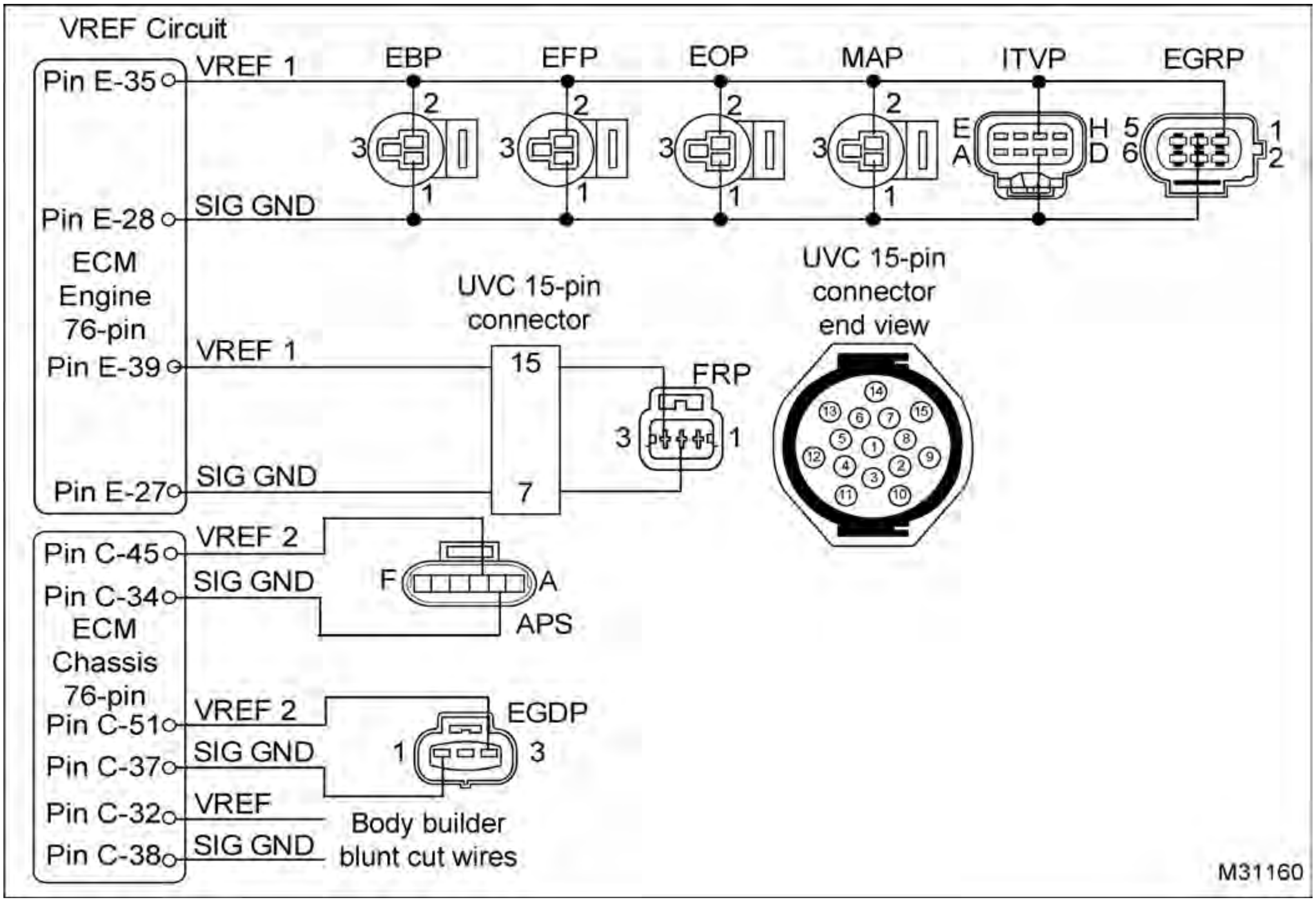

Figure 238 VREF circuit diagram

VREF Voltage Check

If multiple 3-wire sensor Diagnostic Trouble Codes (DTCs) are set, turn ignition switch to ON. Disconnect each sensor one at a time. Use DMM to measure voltage.

NOTE:

- If VREF is not present, but returns after disconnecting a sensor, inspect sensor for internal short to GND.
- If VREF is not present after all 3-wire sensors are disconnected, check for an OPEN circuit between the ECM and sensors.

Test Point	Spec	Comment
APS C to GND	5 V ± 0.5 V	See above note
EGDP 3 to GND	5 V ± 0.5 V	See above note
EBP 2 to GND	5 V ± 0.5 V	See above note

VREF Voltage Check (cont.)

EFP 2 to GND	5 V ± 0.5 V	See above note
EOP 2 to GND	5 V ± 0.5 V	See above note
MAP 2 to GND	5 V ± 0.5 V	See above note
ITVP G to GND	5 V ± 0.5 V	See above note
EGRP 1 to GND	5 V ± 0.5 V	See above note
FRP 15-pin 15 to GND	5 V ± 0.5 V	If this sensor caused VREF to go below specification, see above note. Check under valve cover harness for a short to GND or an internal shorted sensor.
Body builder blunt cut wire VREF to GND	5 V ± 0.5 V	See above note

Connector Resistance Check to GND

Turn ignition switch to OFF. Disconnect each sensor one at a time. Use DMM to measure resistance.

NOTE:

- If resistance is below 1 kΩ, but goes above 1 kΩ after disconnecting a sensor, inspect sensor for internal short to GND.
- If resistance is below 1 kΩ after all 3-wire sensors are disconnected, check for short to GND between ECM and sensors.

Test Point	Spec	Comment
APS C to GND	> 1 kΩ	See above note
EGDP 3 to GND	> 1 kΩ	See above note
EBP 2 to GND	> 1 kΩ	See above note
EFP 2 to GND	> 1 kΩ	See above note
EOP 2 to GND	> 1 kΩ	See above note
MAP 2 to GND	> 1 kΩ	See above note
ITVP G to GND	> 1 kΩ	See above note
EGRP 1 to GND	> 1 kΩ	See above note
FRP 15-pin 15 to GND	> 1 kΩ	If this sensor caused VREF to go below specification, see above note. Check under valve cover harness for a short to GND or an internal shorted sensor.
Body builder blunt cut wire VREF to GND	> 1 kΩ	See above note

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and breakout harness. Leave ECM and all 3-wire sensors disconnected. Use DMM to measure resistance.

Sensor	Test Point	Spec	Comment
APS			
VREF	C to C-45	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	B to C-34		
EGDP			
VREF	3 to C-51	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to C-37		
EBP			
VREF	2 to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to E-28		
EFP			
VREF	2 to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to E-28		
EOP			
VREF	2 to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to E-28		
MAP			
VREF	2 to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to E-28		
ITVP			
VREF	G to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	C to E-28		
EGRP			
VREF	1 to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	3 to E-28		
FRP 15-pin			
VREF	15 to E-39	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	7 to E-27		
Body builder blunt cut wires			
VREF	VREF to C-32	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	SIG GND to C-38		

VREF Circuit Operation

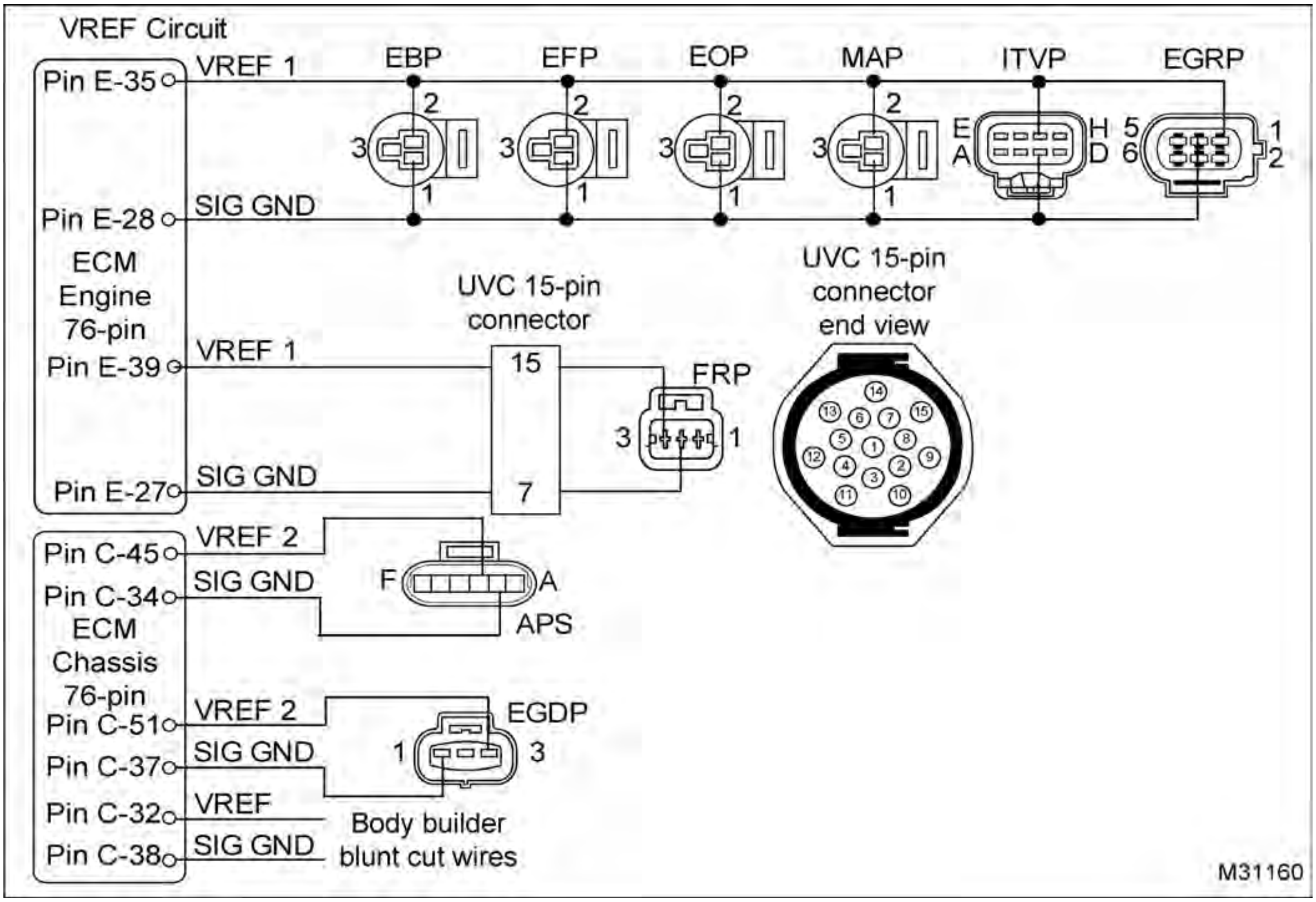

Figure 239 VREF circuit diagram

NOTE: See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for APS and EGDP sensor circuit diagrams.

The ECM supplies VREF at Pin E-35 and E-39 (engine connector) and C-32, C-45, and C-51 (chassis connector) when the ignition switch is on.

VREF provides power to all 3-wire sensors on the engine and the chassis mounted APS/IVS. The ECM also provides these sensors with a ground through the SIG GND circuit. Sensor signal voltage is between these two reference points based on the pressure or position the sensor is designed to measure.

Fault Detection/Management

There are no DTCs for VREF. When a VREF circuit fault occurs in a sensor, the ECM may set an out-of-range high or low code.

When the ECM sets multiple sensor high or low DTCs, the VREF circuit could be open or shorted, or the SIG GND circuit could be open. When a VREF signal is shorted to ground, the ECM resets and causes a stumble. To determine if the VREF circuits are the cause, complete the Pin-point diagnostics check.

NOTE: After removing connector, inspect for damaged pins, corrosion, or loose pins. Repair as required.

VSS (Vehicle Speed Sensor)

DTC	SPN	FMI	Condition
1141	84	4	VSS signal out-of-range LOW
1142	84	3	VSS signal out-of-range HIGH

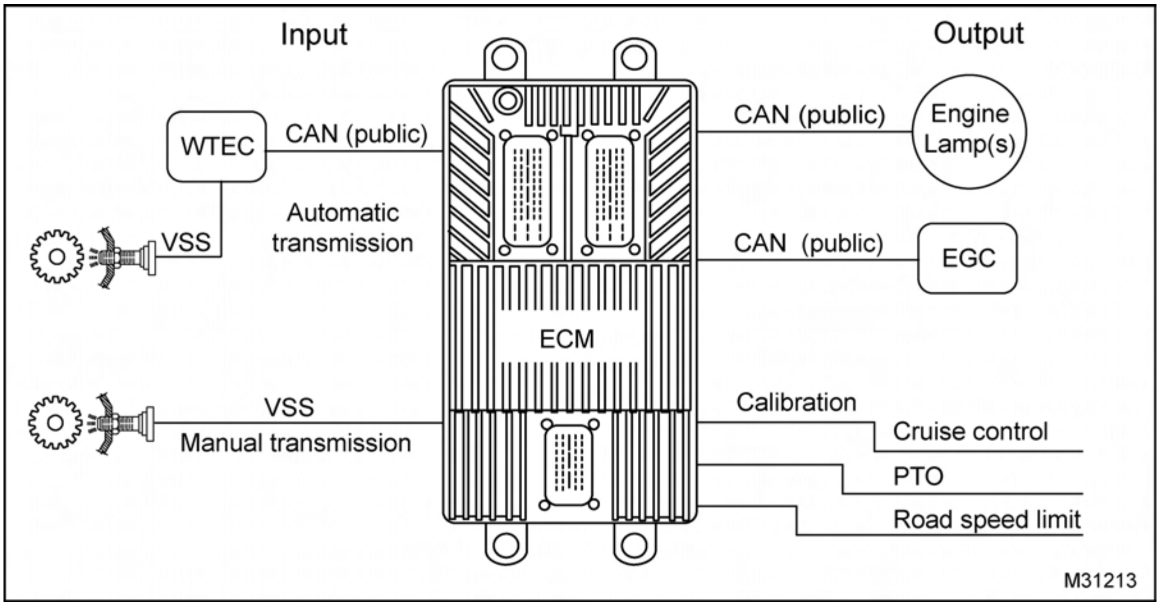

Figure 240 Function diagram for the VSS

The function diagram for the VSS includes the following:

- Vehicle Speed Sensor (VSS)
- Electronic Control Module (ECM)
- World Transmission Electronic Control (WTEC) ECM
- Cruise control
- Road Speed Limit
- Power Takeoff (PTO)
- Electronic Gauge Cluster (EGC)
- Warn Engine Lamp (WEL)

Function

The VSS is used by the ECM to monitor the vehicle's speed. The ECM uses this signal to control PTO, road speed limiting, and cruise control. Automatic transmissions use this signal for shift scheduling.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit
- *Electrical System Troubleshooting Guide* (truck manual)
- Electrical circuit diagrams (truck manual)

VSS Pin-point Diagnostics (Manual Transmissions)

DTC	Condition	Possible Causes
1141	VSS signal out-of-range LOW	• VSS circuits short to GND • VSS frequency below 0.25 Hz • Failed VSS
1142	VSS signal out-of-range HIGH	• VSS circuits OPEN or short to PWR • VSS frequency above 4365 Hz • Failed VSS

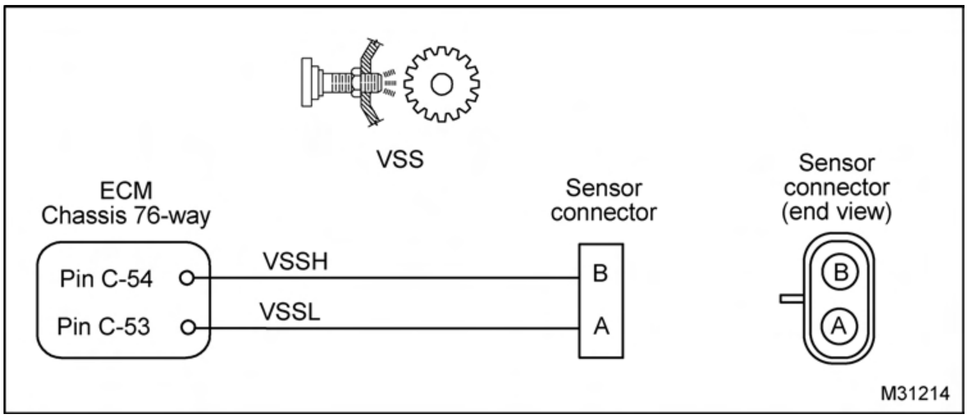

Figure 241 VSS circuit diagram (manual transmissions)

VSS circuit diagnostics require the use of vehicle circuit diagrams. See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for circuit numbers, connector and fuse locations.

Connector Voltage Checks

Disconnect VSS. Turn the ignition switch to ON. Use a DMM to measure voltage.

Test Point	Spec	Comment
B to GND	2.5 V ± 0.5 V	If < 2 V, check for OPEN or short to GND.
A to GND	2.5 V ± 0.5 V	If > 3 V, check for short to PWR.

Sensor Resistance Check

Disconnect VSS. Use a DMM to measure resistance through sensor.

Test Point	Spec	Comment
A to B	700 Ω ± 100 Ω	If not within specification, replace VSS.

Harness Resistance Check

Connect breakout box. Leave VSS and ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
C-53 to A	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C-54 to B	< 5 Ω	If > 5 Ω, check for OPEN circuit.

VSS Pin-point Diagnostics (Allison Transmissions)

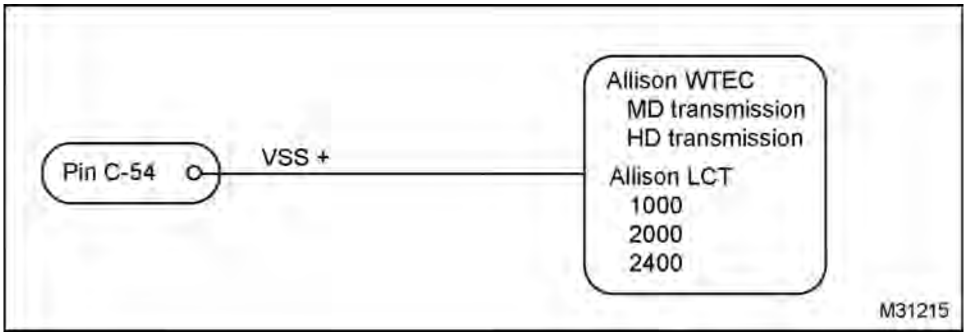

Figure 242 VSS circuit diagram (Allison transmissions)

VSS circuit diagnostics require the use of vehicle circuit diagrams. See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for circuit numbers, connector and fuse locations.

Resistance Checks

Connect breakout box. Leave ECM and TCM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
C-54 to TCM	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C-54 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
If within specification, see transmission diagnostics.		

Operational Check

Connect terminal probes between the C-72 Vehicle Speed Output (VSO) circuit and GND. Use DMM to measure Hz

Test Point	Spec	Comment
Vehicle moving at 15 mph	125 Hz	If not within specification, check for circuit fault or failed sensor.
Vehicle moving at 25 mph	204 Hz	

VSS Circuit Operation (Manual and Allison Transmissions)

The VSS produces a pulsating AC voltage. The voltage level and number of pulses increase with vehicle speed.

Allison WTEC MD, HD, and 2000 series transmissions use an internal VSS that sends a signal to the transmission module. The transmission module processes the signal and sends a square wave signal to the engine ECM.

Fault Detection/Management

The ECM performs diagnostic checks on the VSS circuit when the engine is operating at 0 mph. The ECM transmits a voltage signal on the VSS circuit and determines if the return voltage is out of range high or low. When a fault is detected, the ECM disables the cruise control and power takeoff. If the road speed limiting option is enabled, the ECM limits engine rpm for all gears.

NOTE: See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for circuit numbers, connector and fuse locations. To diagnose Allison transmission VSS problems, use Allison maintenance and diagnostic manuals.

WIF Sensor (Water In Fuel)

DTC	SPN	FMI	Condition
1253	97	3	WIF signal out-of-range LOW
1254	97	4	WIF signal out-of-range HIGH
1255	97	5	WIF signal open circuit fault
2179	97	2	Water In fuel detected

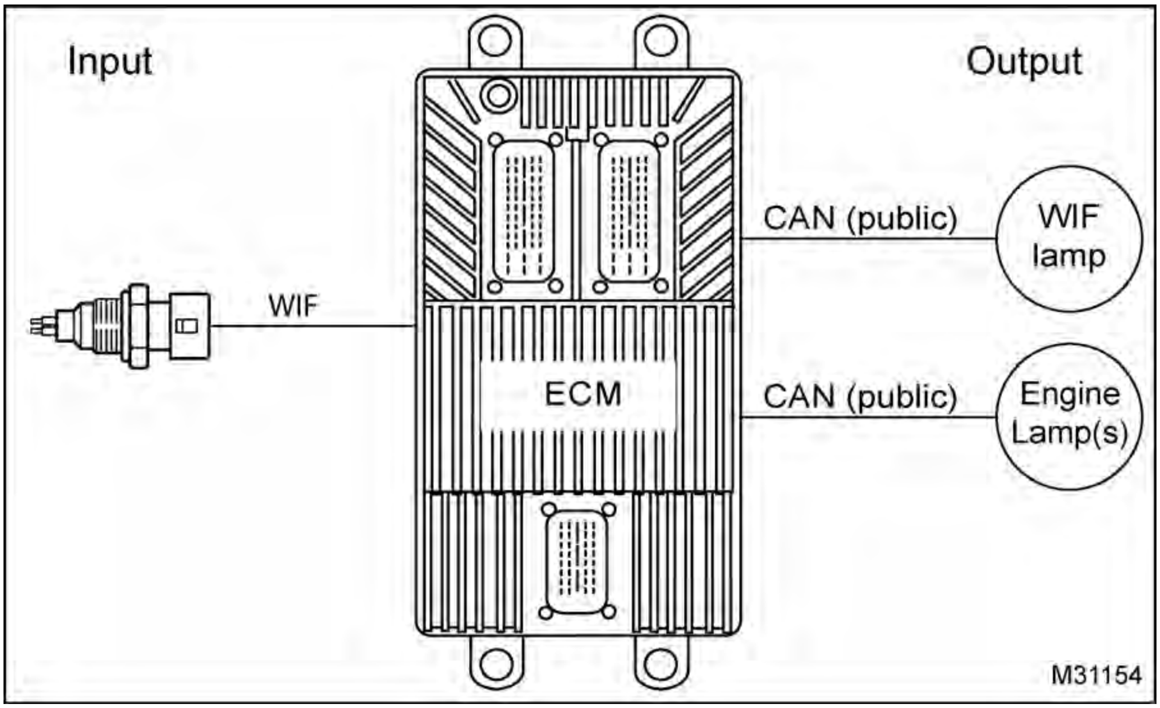

Figure 243 Function diagram for the WIF

The WIF function diagram includes the following:

- Water In Fuel (WIF) sensor
- Electronic Control Module (ECM)
- Warn Engine Lamp (WEL)
- Water In Fuel (WIF) lamp

Function

The WIF sensor provides a feedback signal to the ECM when water is detected in the fuel supply. If water is detected, the ECM alerts the operator by illuminating the WIF lamp. If a circuit fault is detected, a Diagnostic Trouble Code (DTC) sets and the WEL illuminates.

Sensor Location

The WIF sensor is installed in the primary fuel filter housing.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software
- EZ-Tech® Interface Kit

WIF Pin-point Diagnostics

DTC	Condition	Possible Causes
1253	WIF signal out-of-range LOW	• WIF signal circuit short to GND • Failed sensor
1254	WIF signal out-of-range HIGH	• WIF signal circuit short to PWR • Failed sensor
1255	WIF signal open/circuit fault	• WIF signal circuit OPEN or short to PWR or GND • SIG GND circuit OPEN • Failed sensor
2179	Water In fuel detected	• Water detected in primary fuel filter housing

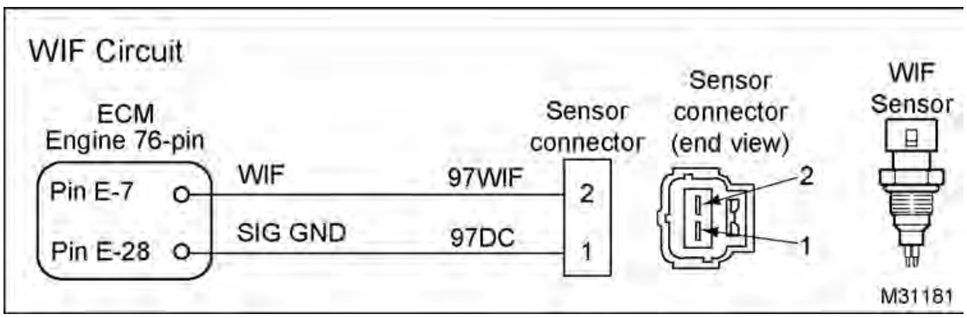

Figure 244 WIF circuit diagram

1. Drain a fuel sample from the water drain valve on the primary fuel filter housing. See Drain Water from Primary Fuel Filter in the “Engine Symptoms Diagnostics" section of this manual.
   - If water is present, drain all water out of the system.
   - If no water is present in the fuel sample, continue to next step.
2. Using EST with MasterDiagnostics® Software, open the D_SwitchMonitor.ssn

   NOTE: The WIF Parameter Identifier (PID) will read YES if there is water in the fuel filter housing or if the WIF signal circuit is shorted high.
   - If DTC is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will change from No to Yes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect breakout harness to engine harness. Leave sensor disconnected.

Voltage Check

Disconnect WIF sensor connector. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comments
1 to B+	B+	If < B+, check SIG GND circuit for OPEN
2 to GND	4.6 V	If > 5.5 V, check WIF circuit for short to PWR
		If < 4.5 V, check WIF circuit for short to GND

Connector Resistance Checks to GND

Turn ignition switch to OFF, disconnect harness from WIF sensor, use DMM to measure resistance.

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

Harness Resistance Check

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

Test Point	Spec	Comments
1 to E-28	< 5 Ω	If > 5 Ω, check for OPEN circuit
2 to E-7	< 5 Ω	If > 5 Ω, check for OPEN circuit

WIF Circuit Operation

The WIF sensor is supplied with a 5 volt reference voltage at Pin 2 from the ECM Pin E-7. The sensor is grounded at Pin 1 from ECM Pin E-28. The WIF signal is 4.6 volts at normal state and below 4.0 volts when water is detected.

Fault Detection/Management

The ECM continuously monitors the WIF sensor. If voltage drops below 4.0 V, DTC 2179 sets and the WIF lamp is illuminated. Three other DTCs can be set if there is a fault with the circuit or sensor.