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:

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

Electronic Control System Diagnostics Form

EGED-410 Diagnostic Form Example

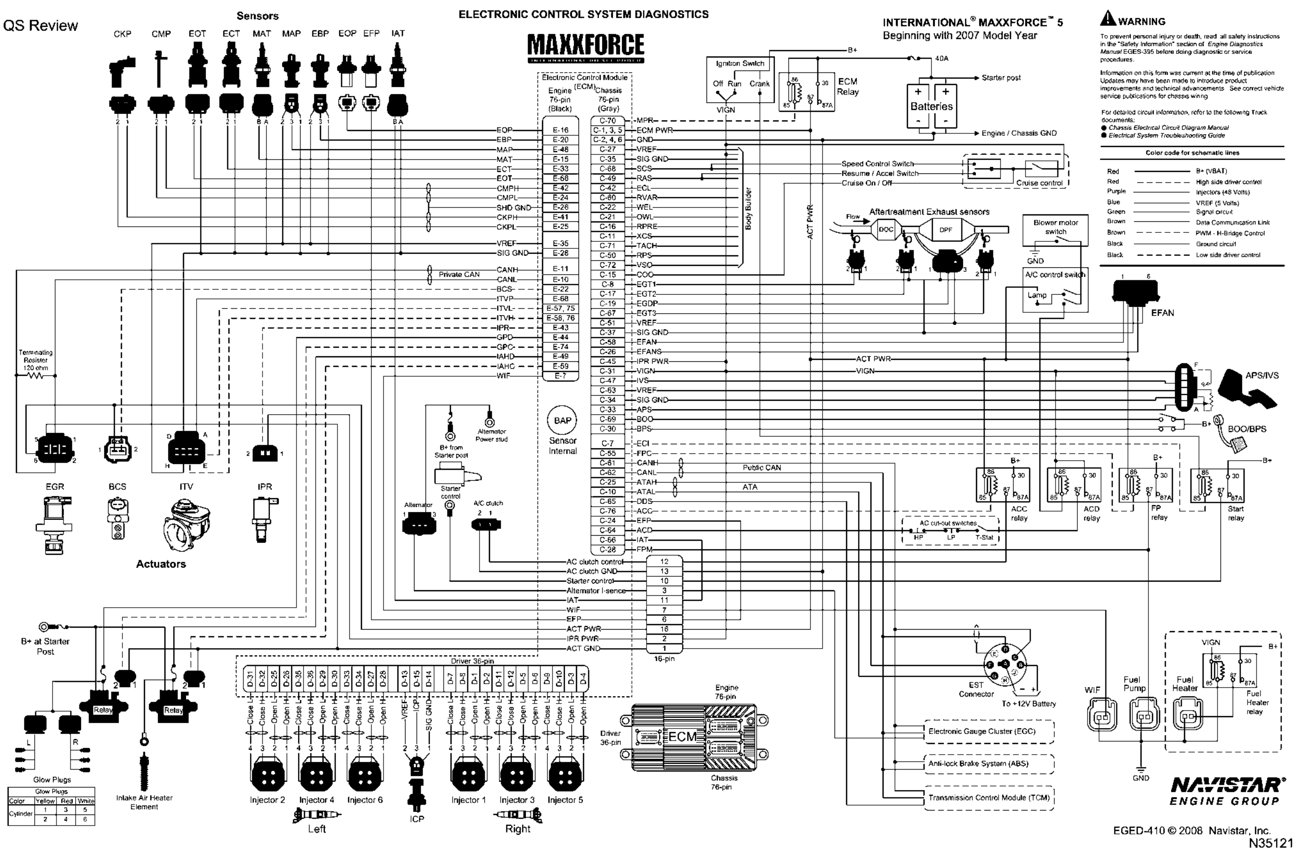

Figure 148 EGED-410 (Front Side)

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

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

Diagnostic Form EGED-410 is available in 50 sheet pads. To order technical service literature, contact your International dealer.

Sensor and Actuator Locations

Electronic Components – Top

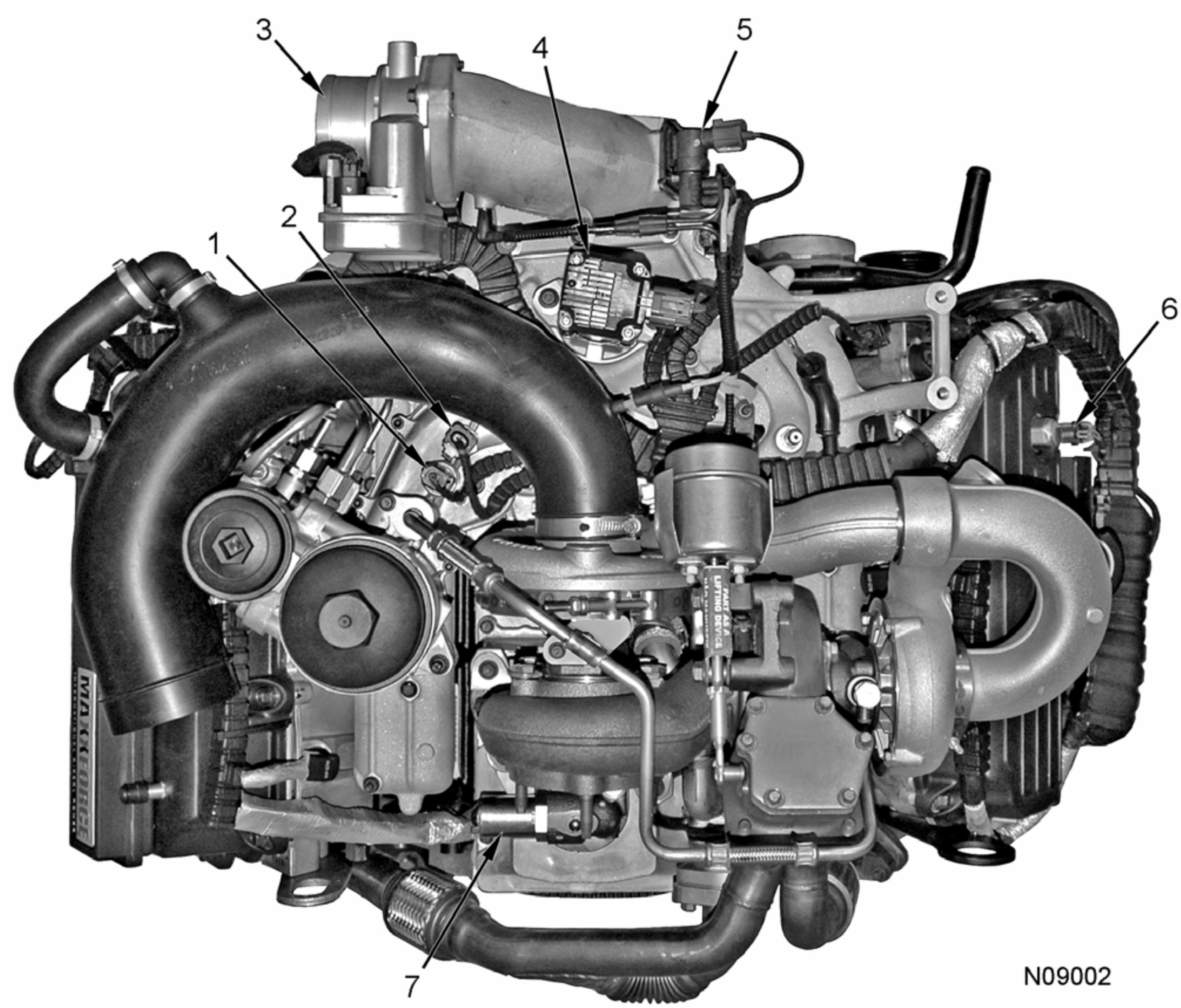

Figure 149 Sensor and switch locations – top (typical)

1. Engine Oil Pressure (EOP) switch
2. Engine Oil Temperature (EOT) sensor
3. Intake Throttle Valve (ITV) assembly
4. Exhaust Gas Recirculation (EGR) valve
5. Boost Control Solenoid (BCS) assembly
6. Injection Control Pressure (ICP) sensor
7. Injection Pressure Regulator (IPR) valve

Electronic Components – Front

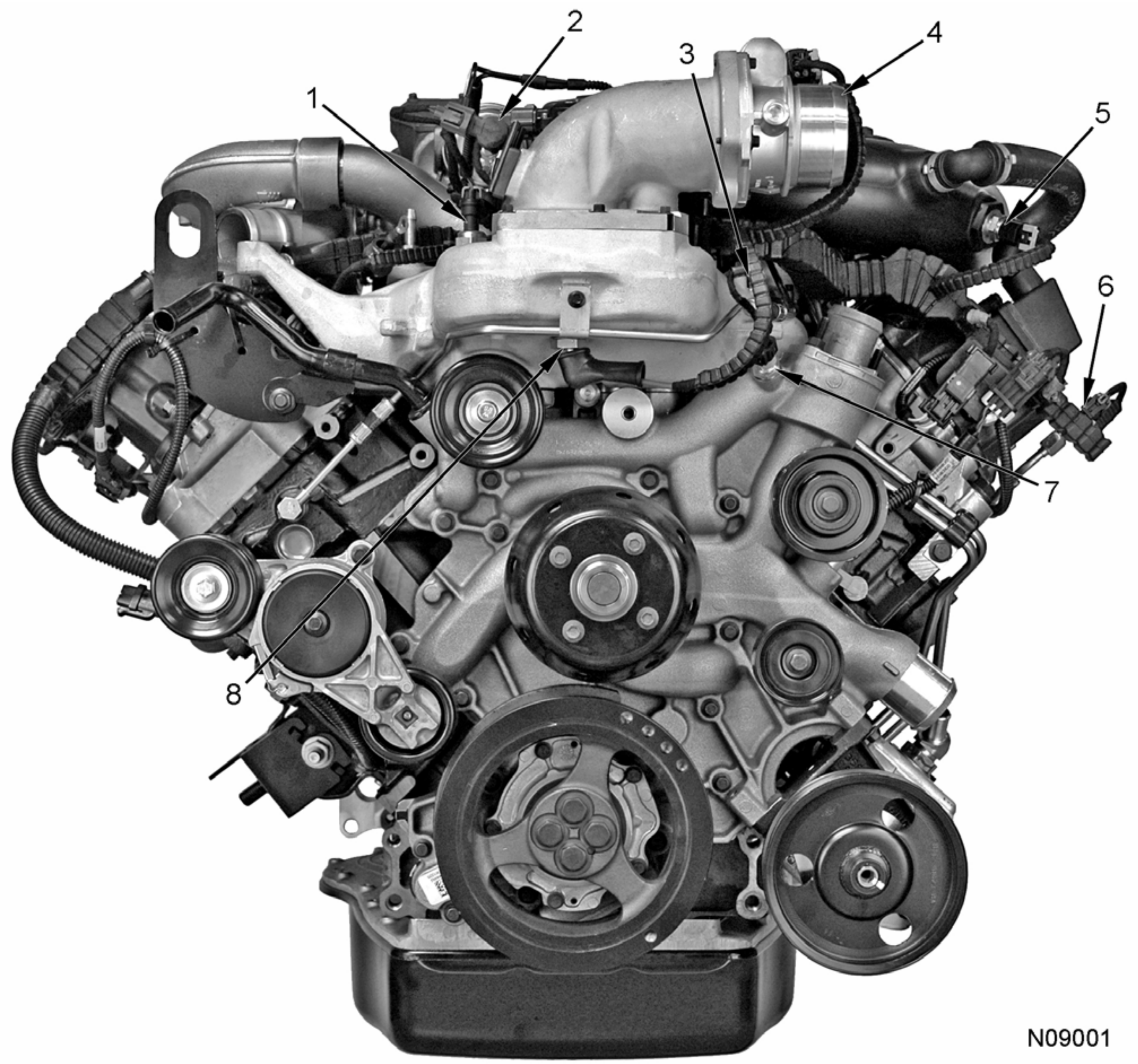

Figure 150 Sensor locations – front (typical)

1. Manifold Absolute Pressure (MAP) sensor
2. Boost Control Solenoid (BCS) assembly
3. Manifold Air Temperature (MAT) sensor
4. Intake Throttle Valve (ITV) Assembly
5. Intake Air Temperature (IAT) sensor
6. Exhaust Back Pressure (EBP) sensor
7. Engine Coolant Temperature (ECT) sensor
8. Intake Air Heater (IAH) element

Electronic Components – Right

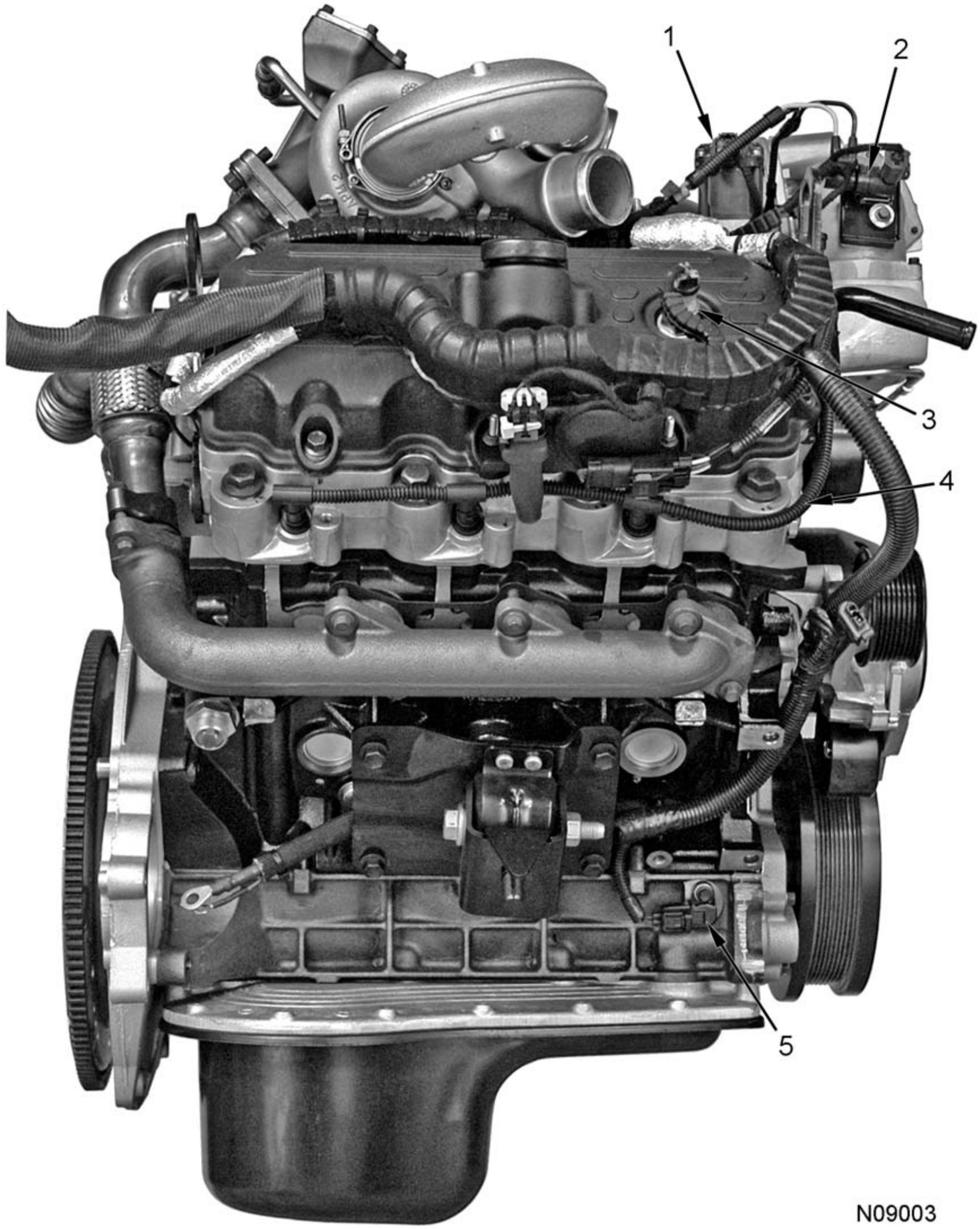

Figure 151 Sensor locations – right (typical)

1. Exhaust Gas Recirculation (EGR) valve
2. Boost Control Solenoid (BCS) assembly
3. Injection Control Pressure (ICP) sensor
4. Glow plug harness (right)
5. Crankshaft Position (CKP) sensor

Electronic Components – Left

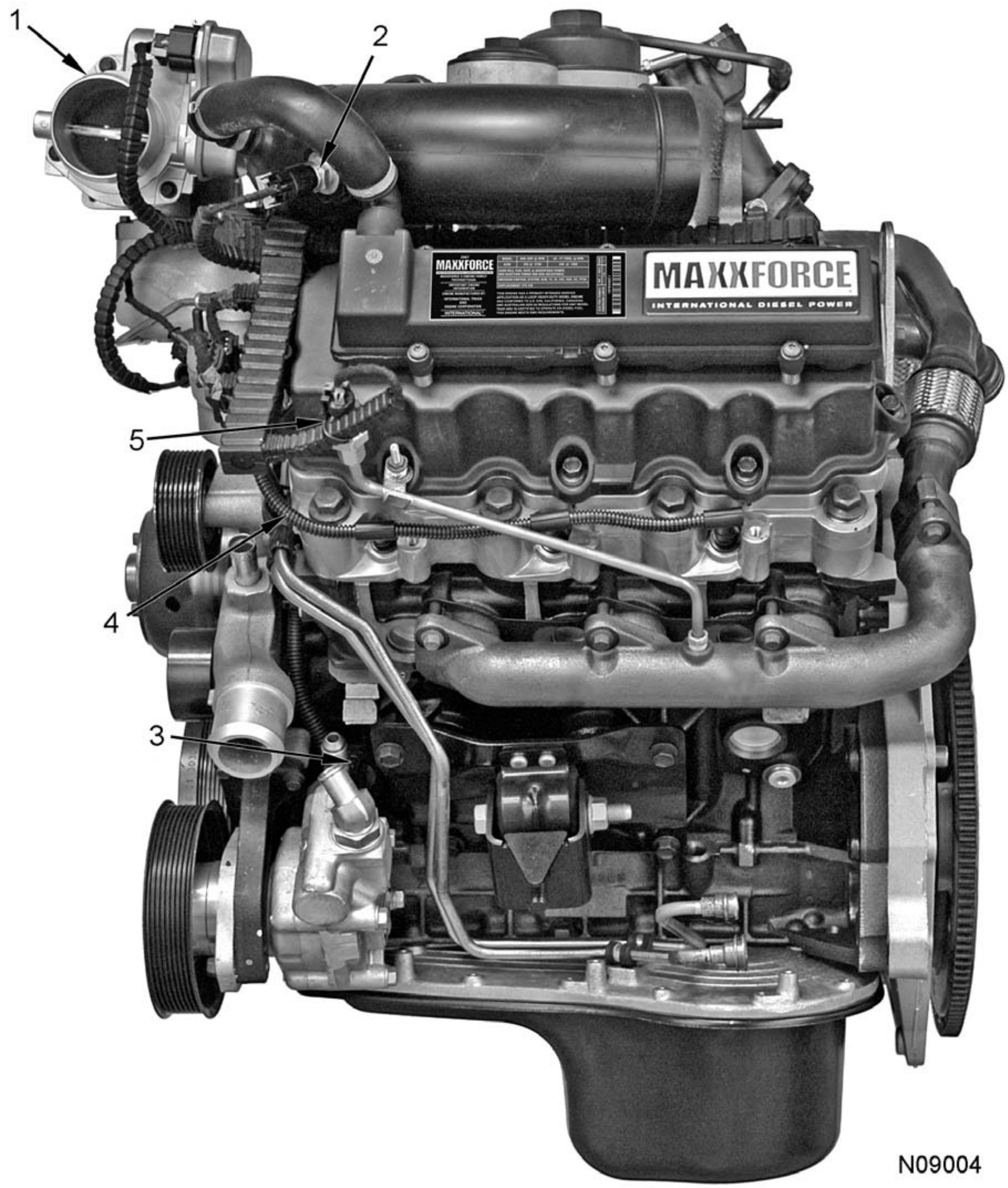

Figure 152 Sensor locations – left (typical)

1. Intake Throttle Valve (ITV) Assembly
2. Intake Air Temperature (IAT) sensor
3. Camshaft Position (CMP) sensor
4. Glow plug harness (left)
5. Exhaust Back Pressure (EBP) sensor

Vehicle Mounted Components

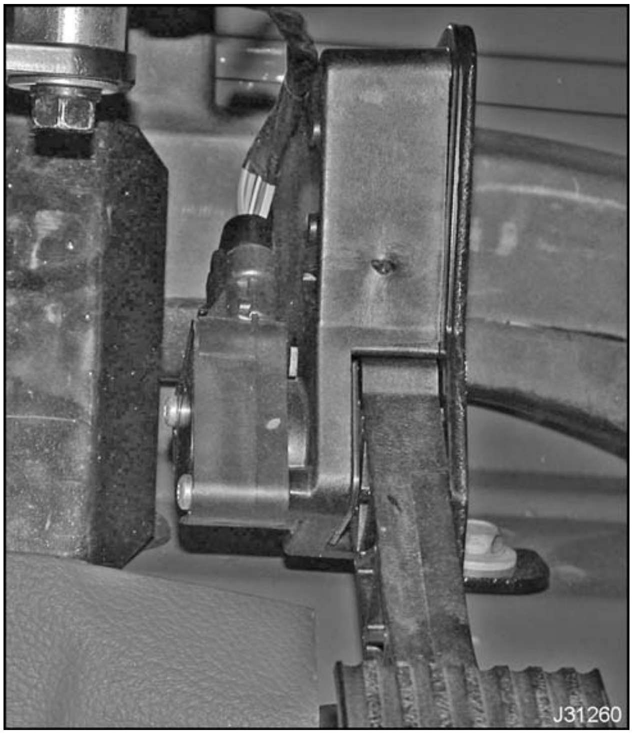

Figure 153 APS/IVS sensor (CityStar™)

The APS/IVS is installed in the accelerator pedal assembly.

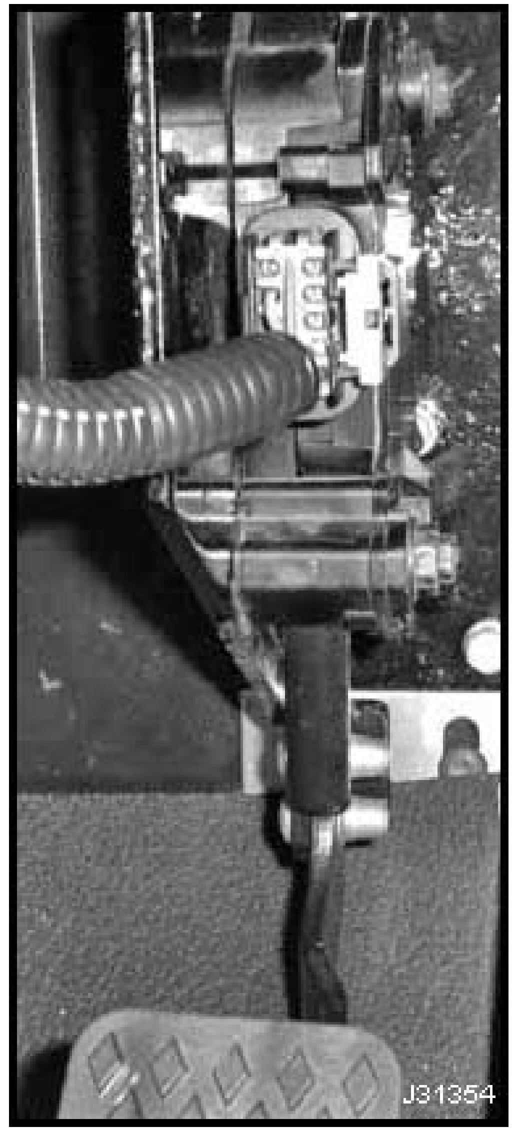

Figure 154 APS/IVS sensors (stripped chassis)

Diagnostic Procedure Process

Description

The test procedures in this section are 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 will direct 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

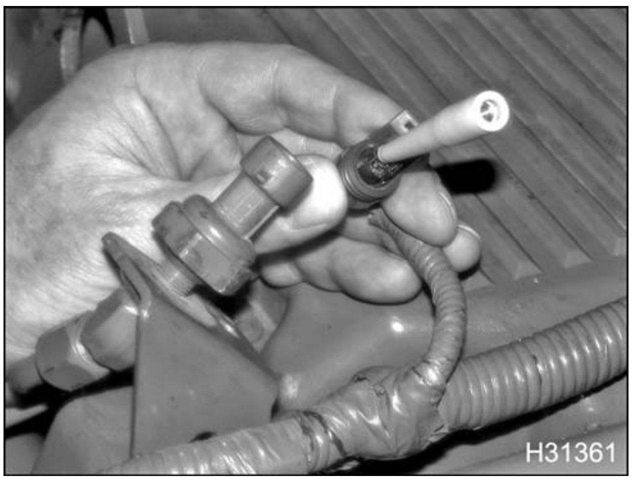

Figure 155 Pin grip check

1. Disconnect the harness connector from the sensor or actuator.
2. Inspect for corrosion, bent pins, spread pins, or conditions causing 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 EST (Electronic Service Tool)

Sensors can be diagnosed quickly using an EST with MasterDiagnostics® software. The tool monitors sensor signal back to the ECM (Electronic Control Module) 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 EST

Sensors can also be diagnosed by using 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 ignition switch to ON. Leave engine OFF.
3. Start MasterDiagnostics® software.

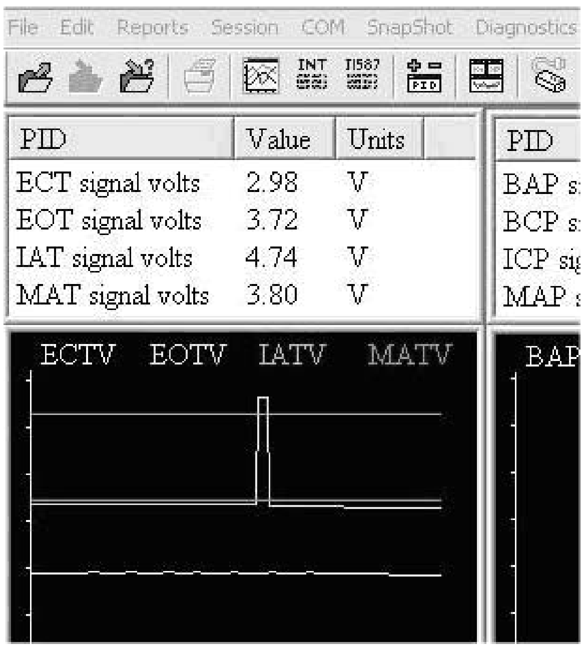

Figure 156 Continuous Monitor session

4. Open the Continuous Monitor session. This session lists all engine sensors.
5. Run KOEO (Key On Engine Off) Standard Test.

   NOTE: The KOEO Standard Test must be run before the Continuous Monitor test.
6. Run the Continuous Monitor test. This will allow the EST to read actual values from the sensors.
7. Monitor sensor voltage and verify an active Diagnostic Trouble Code (DTC) is present.
   - If the DTC is inactive, monitor the Parameter Identifier (PID) while wiggling the connector and all wires at suspected locations.

     If the circuit is interrupted, the signal will spike. Isolate the fault and repair.
   - If the DTC is active, continue to the next step.
8. Disconnect sensor. Inspect the connector for damaged pins. Repair as necessary.
9. Connect breakout harness to the wiring harness. Leave the sensor disconnected.
10. Monitor the sensor signal voltage with the EST. Voltage should be greater than 4.87 volts with the sensor disconnected, unless the circuit is shorted to ground.

Example

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

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

11. Short 3-banana Plug Harness across the sensor signal circuit and engine ground.
12. Monitor the sensor signal voltage with the EST. Voltage should be 0 volts, unless the sensor signal circuit is OPEN.

Example

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

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

13. Short 3-banana Plug Harness across the sensor signal circuit and SIG GND circuit.
14. Monitor the sensor signal voltage with the EST. Voltage should be 0 volts, unless the SIG GND circuit is OPEN.

Example

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

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

15. Short 500 Ohm Resistor Harness across the sensor signal circuit and SIG GND circuit.
16. Monitor the sensor signal voltage with the EST. Voltage should be less than 1.0 volts, unless the sensor signal circuit is shorted to voltage.

Example

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

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

17. 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.

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 ignition switch to ON. Leave engine OFF.
3. Start MasterDiagnostics® software.

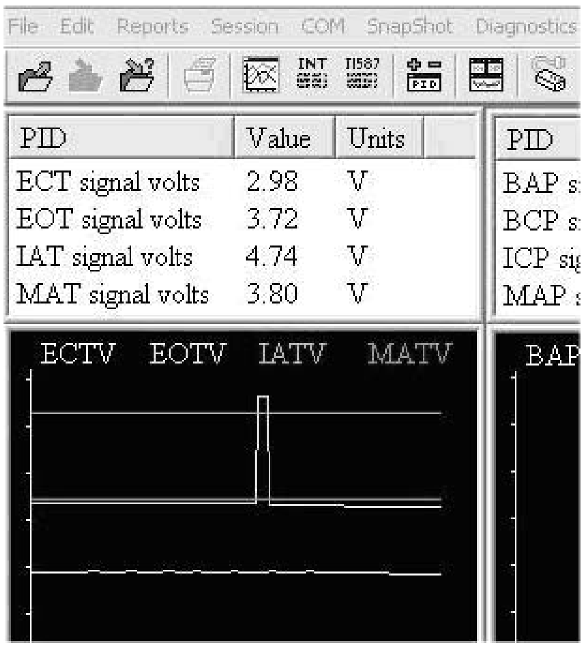

Figure 157 Continuous Monitor session

4. Run Continuous Monitor session. (This session lists all engine sensors.)
5. Run KOEO (Key On Engine Off) Standard Test.

   NOTE: The KOEO Standard Test must be run before the Continuous Monitor test.
6. Run the Continuous Monitor test. This will allow the EST to read actual values from the sensors.
7. Monitor sensor voltage and verify an active DTC (Diagnostic Trouble Code) is present.
   - If the DTC is inactive, monitor the PID (Parameter Identifier) while wiggling the connector and all wires at suspected locations.

     If the circuit is interrupted, the signal will spike. Isolate the fault and repair.
   - If the DTC is active, continue to the next step.
8. Disconnect the sensor. Inspect the connector for damaged pins. Repair as necessary.
9. Connect breakout harness to the wiring harness. Leave the sensor disconnected.
10. Monitor sensor signal voltage with EST. Voltage should read near 0 volts with the sensor disconnected, unless the sensor signal circuit is shorted to power.

Example

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

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

11. 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 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 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.

12. Short breakout harness across VREF and the sensor signal circuit.
13. Monitor the sensor signal voltage with the EST. Voltage should read 5 volts, unless the sensor signal circuit is OPEN.

Example

Test Point	Spec	Comments
EST - Monitor MAPV Short 500 Ohm Resistor Harness across 2 and 3	5 V	If < 4.5 V, check MAP signal for OPEN. Do Harness Resistance Checks.

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

14. Use a DMM to measure resistance on the SIG GND circuit to ground. Resistance should read less than 5 ohm, unless the 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.

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

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

Pin-point Diagnostics (without MasterDiagnostics® software)

1. Connect breakout harness to the engine harness. Leave sensor disconnected.
2. Turn 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
C to GND	5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Checks.

- If the circuit is not within specification, the comment area will list possible cause or direct 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 will allow 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) to the EST connector.
4. Turn 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 DMM (Digital Multimeter) 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
B to GND	KOEO	B+	If < B+, check actuator coil for OPEN.
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 across coil.

- If any circuit is not within specification, the comment area will list possible cause or direct 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.

1. Turn ignition switch OFF or disconnect batteries.

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

2. Connect breakout box and breakout harness to chassis or engine harness. Leave ECM (Electronic Control Module) 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 control circuit for OPEN.
E-66 to GND	> 1K Ω	If < 1 kΩ, check EOT control circuit for short to GND.

- If the circuit is not within specification, the comment area will list 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 ignition switch to ON.
3. Open Continuous Monitor session or Output State test session (dependent upon what is being tested) using the Electronic Service Tool (EST) with MasterDiagnostics® software.
4. Run the Continuous Monitor test.
5. 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
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

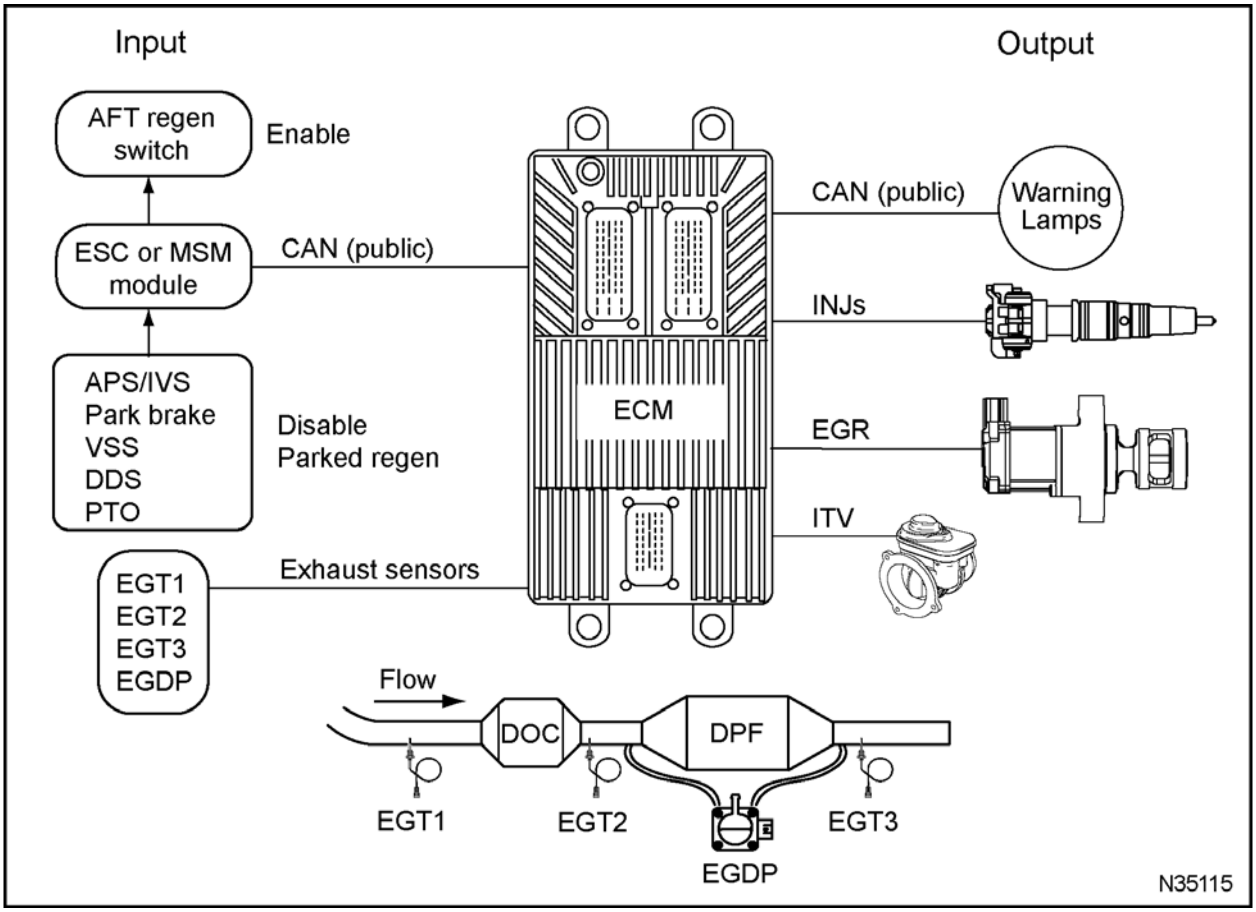

Figure 158 Function diagram for AFT System

The AFT function diagram includes the following:

- Electronic 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) valve

- Intake Throttle Valve (ITV)
- Warning lamps
- Inhibit regeneration switch
- Electronic System Control (ESC) body module
- Multiplex System Module (MSM) body module
- Driveline Disconnect Switch (DDS)
- Power Takeoff (PTO)

Function

The Aftertreatment 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 to ash, this is the DPF regeneration process. Ash build-up must periodically be removed from the DPF with a special cleaning machine.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)

Diesel Oxidation Catalyst (DOC)

The DOC oxidizes hydrocarbons, carbon monoxide and oxides of nitrogen. The DOC also converts fuel to heat for DPF regeneration.

Diesel Particulate Filter (DPF)

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

Regeneration

Process of converting particulate matter trapped in the DPF from soot to ash.

Passive Rolling Regeneration

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

DPF Status Lamp

The DPF status lamp provides information on the need to regenerate the DPF. Several DPF load levels are used. The lamp will change states from OFF, to solid-ON, to flashing. The lamp is used in combination with the Check Engine and Stop Engine lamps.

High Exhaust System Temperature Indicator (HEST)

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

AFT System Diagnostics

DTC	Condition	Possible Causes
2688	DPF over temperature - possible filter damage	• Biased high EGT2 sensor or circuit • 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	DPF soot loading over 100%, clean out or replace DPF.

Alert Levels of DPF Soot Loading

There are four levels to indicate the DPF is accumulating 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 Warn Engine lamp on solid Audio alarm beeps 5 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 2688 – DPF over temperature - possible filter damage

DTC 2688 is set 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” (page 427).
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 is set 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 Parked Regeneration. See Manual Parked Regeneration procedure in this section.

DTC 2783 – DPF load: above warning level

DTC 2783 is set 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 Parked Regeneration. See Manual Parked Regeneration procedure in this section.

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

DTC 2784 is set 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 Parked Regeneration. See Manual Parked Regeneration procedure in this section.

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

DTC 2785 is set 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. See Onboard Cleanliness Test procedure.

AFT System Operation

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

When driving at lower speeds or lighter loads, the exhaust is sometimes not hot enough to convert soot to ash. In these situations, the engine control system will increase exhaust temperature to convert soot 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, a manual parked regeneration must be done.

Active Rolling Regeneration

When the ECM determines the DPF needs to be regenerated, the aftertreatment lamp illuminates. The ECM will control engine operation to increase exhaust temperature. This enables the DPF to convert accumulated soot to ash.

The following entry conditions are required for active rolling regeneration:

- No disabling DTCs (1741, 1742, or 2673)
- 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 soot 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, 1299, 1311, 1312, 1397, 1398, 1741, 1742, 2544, 2673)
- ECT above 65 °C (150 °F)
- Engine running
- Vehicle speed below 2 mph
- Parking brake must be set
- Brake pedal not depressed
- Accelerator pedal not depressed
- PTO not active
- Driveline disengaged
- Inhibit regeneration switch in OFF position
- EGT2 and EGT3 below 500 °C (932 °F)

Manual Parked Regeneration Procedure

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

To start Parked Regeneration (cleaning) of exhaust DPF, do the following steps:

1. Park the vehicle safely off the road and away from flammable materials and vapors.
2. Before starting parked regeneration (using ON/PARKED REGEN switch), the following conditions must be true:
   - Set parking brake
   - Shift transmission to park or neutral
   - Engine Coolant Temperature (ECT) minimum 71 °C (160 °F)
   - Accelerator, foot brake, or clutch pedal (if equipped) must not be depressed
3. Press ON of the ON/PARKD REGEN switch to initiate the regeneration cycle.

   Engine speed will automatically ramp up to a preset rpm. The switch indicator will illuminate 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 will last approximately 20 minutes.
4. When the regeneration cycle is complete, the indicator switch will turn off. The engine rpm will return to normal idle and all exhaust filter indicators will turn off. The vehicle is now ready for normal driving operation.

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

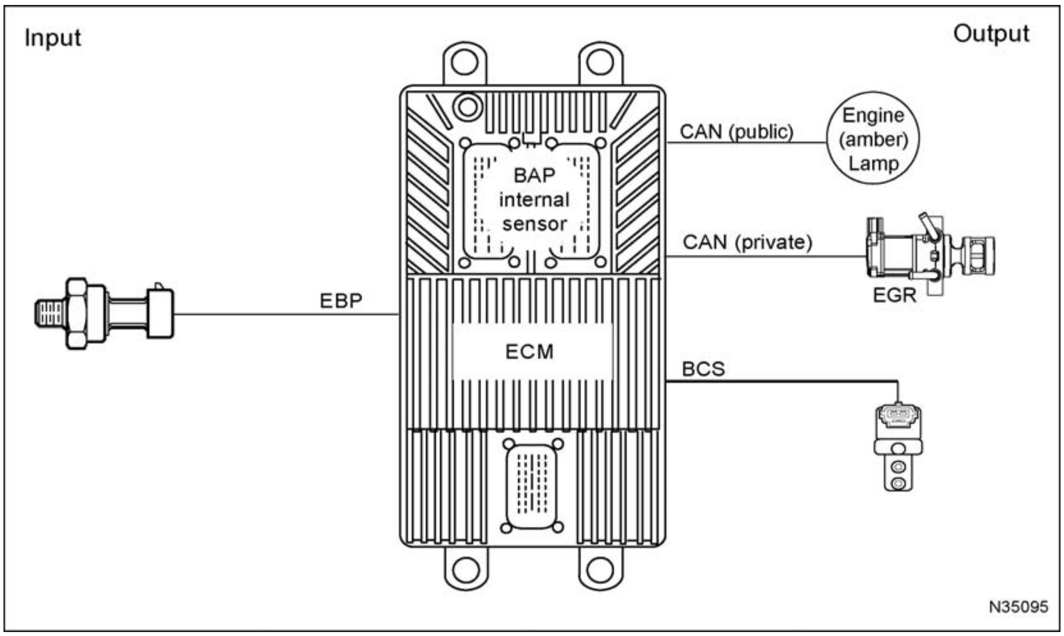

Figure 159 Function diagram for the AMS

The Air Management System (AMS) includes the following:

- Electronic Control Module (ECM)
- Barometric Absolute Pressure (BAP) sensor (internal to ECM)
- Exhaust Back Pressure (EBP) sensor
- Turbocharger Boost Control Solenoid (BCS)
- Exhaust Gas Recirculation (EGR) valve
- Engine lamp (amber)

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 dual stage turbocharger provides faster turbo response and quicker acceleration with less lag.

Tools

- EZ-Tech® Electronic Service Tool (EST) with MasterDiagnostics® Software (page 389)
- IC4–USB Interface Cable (page 390)

AMS System Diagnostics

DTC	Condition	Possible Causes
2351	EBP below desired level	• CAC system leaks • Exhaust or intake air system leaks • Failed turbocharger • Biased EBP circuit or sensor
2352	EBP above desired level	• Biased EBP circuit or sensor • Restricted exhaust system
2388	EGR flow excessive - possible leak to atm	• Restricted air flow (intake or exhaust) • Charge Air Cooler (CAC) system leaks (hoses and cooler) • Turbocharger or BCS problems • Biased EGRP, EBP, or MAP sensor or circuit biased • EGR valve sticking open
2389	EGR flow insufficient - possible plugged system	• Restricted air flow (intake or exhaust) • Turbocharger or BCS problems • Restricted EGR cooler or tubing • Biased EGRP, EBP, or MAP sensor or circuit • EGR valve sticking closed

DTC 2351 - EBP below desired level

Indicates boost pressure is not achieving calibrated goal by more than a calibrated threshold.

Pin-point AMS System Fault

1. Check for other active or inactive EBP, MAP, 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 KOEO in “Appendix A: Performance Specifications” (page 427).
3. Check EGR operation. Monitor EGRP PID and run KOEO Output State test HIGH and LOW. See EGR (Exhaust Gas Recirculation) Valve (page 279).
4. Check intake and exhaust system for leaks.
5. See “Performance Diagnostics” section for low engine performance concerns.

DTC 2352 - EBP above desired level

Indicates boost pressure is not achieving calibrated goal by more than a calibrated threshold.

Pin-point AMS System Fault

1. Check for other active or inactive EBP, MAP 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 KOEO in “Appendix A: Performance Specifications” (page 427).
3. Check EGR operation. Monitor EGRP PID and run KOEO Output State test HIGH and LOW. See EGR (Exhaust Gas Recirculation) Valve (page 279).
4. Check for restricted exhaust. See AFT System (Aftertreatment) (page 200).
5. See “Performance Diagnostics” section for Boost Control diagnostics.

DTC 2388 - EGR flow excessive - possible leak to atm

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

Pin-point AMS System Fault

1. Check for other active or inactive EBP, MAP, 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 KOEO in “Appendix A: Performance Specifications” (page 427).
3. Check EGR operation. Monitor EGRP PID and run KOEO Output State test HIGH and LOW. See EGR (Exhaust Gas Recirculation) Valve (page 279).
4. Check for CAC leaks.

DTC 2389 - EGR flow insufficient - possible plugged system

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

Pin-point AMS System Fault

1. Check for other active or inactive EBP, MAP 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 KOEO in “Appendix A: Performance Specifications” (page 427).
3. Check EGR operation. Monitor EGRP PID and run KOEO Output State test HIGH and LOW. See EGR (Exhaust Gas Recirculation) Valve (page 279).
4. Check for restricted exhaust. See AFT System (Aftertreatment) (page 200).

APS/IVS (Accelerator Pedal 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

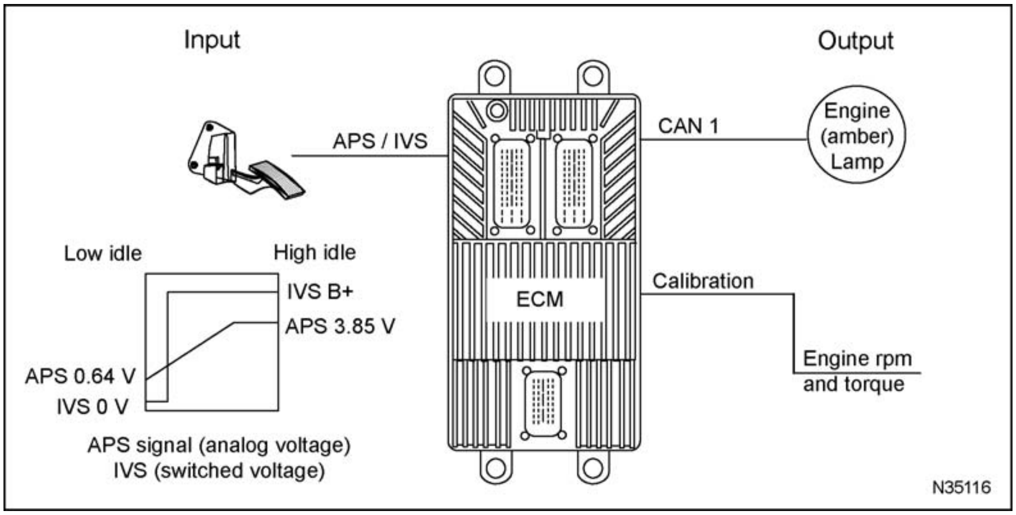

Figure 160 Function diagram for the APS/IVS

The APS/IVS function diagram includes the following:

- Accelerator Position Sensor and Idle Validation Switch (APS/IVS)
- Electronic Control Module (ECM)
- Engine lamp (amber)

Function

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

Sensor Location

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

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 3-banana Plug Harness (page 386)
- Breakout Box (page 385)
- APS/IVS Breakout Harness (page 388)
- Terminal Test Adapter Kit (page 392)

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 • 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 circuit fault	• IVS circuit OPEN or short to GND or PWR • Failed sensor

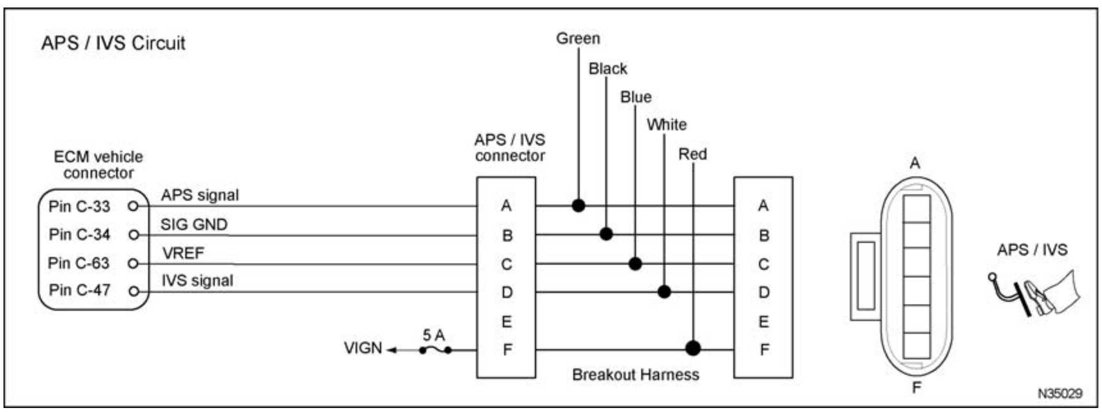

Figure 161 APS/IVS circuit diagram

WARNING: To prevent personal injury or death, avoid 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”.
3. Monitor sensor voltage. Verify an active DTC for the sensor.
   - 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 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 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 Checks (page 214).
EST - Check DTC Short breakout harness across A and C	DTC 1132	If DTC 1131 is active, check APS signal for OPEN or short to GND. Do Harness Resistance Checks (page 214).
DMM - Measure resistance B to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Checks (page 214).
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.
EST - Monitor IVSV Short 3-banana Plug Harness across D and F	B+	If < B+, check IVS circuit for OPEN or short to GND. Do Harness Resistance Checks (page 214).

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

APS/IVS Pin-point Diagnostics

Connector Voltage Check

Connect breakout harness. Leave APS/IVS 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 SIG GND. Do Harness Resistance Checks (page 214).
D to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Checks (page 214).
F to GND	B+	If < B+, check for OPEN or blown fuse.

Connector Resistance Check to Engine GND

Turn ignition switch OFF. Connect breakout harness. Leave APS/IVS 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.

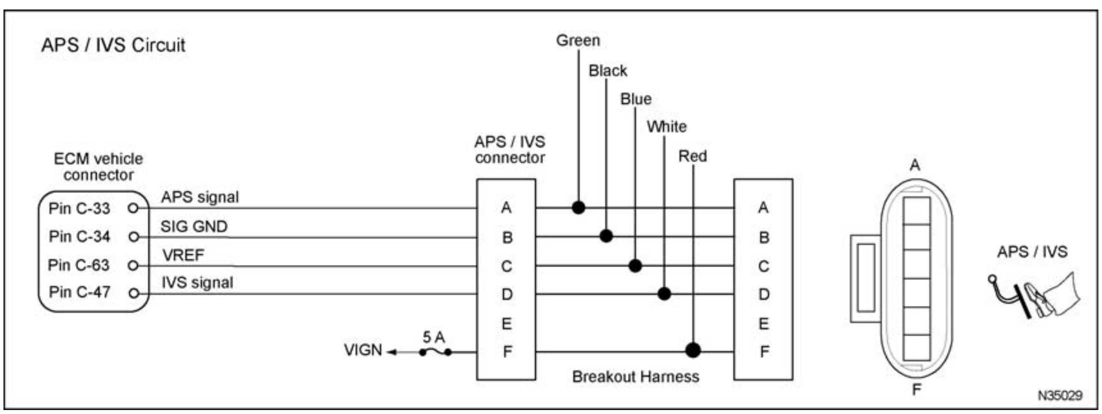

Figure 162 APS/IVS circuit diagram

Harness Resistance Check

Turn ignition switch OFF. Disconnect both battery GND cables. Connect breakout box and breakout harness. Leave ECM and APS/IVS disconnected. 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
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 APS/IVS. Turn ignition switch to 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 and IVS are integrated into one component and installed in the accelerator pedal assembly. The APS/IVS can be replaced without replacing the complete assembly.

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

APS

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

IVS

The IVS is an ON / OFF switch that is supplied B+ on Pin F from the ECM Pin C-31 VIGN. The switch sends and 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 key is turned off, this information is lost until the next key cycle where the process is repeated. No accelerator pedal adjustment is needed with this feature.

Fault Detection / Management

When the key is on, the 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 will set a Diagnostic Trouble Code (DTC).

Any malfunction of the APS/IVS sensor circuit will illuminate the amber engine lamp. If the ECM detects an APS signal Out of Range HIGH or LOW, the engine will ignore the APS signal and operate at low idle. If a disagreement in the state of IVS and APS is detected and the ECM determines the IVS is at fault, a maximum of 50% APS can be commanded. If the ECM can not discern if it is an APS or IVS fault, the engine will operate at low idle only.

ATA (American Trucking Association) Datalink

DTC	SPN	FMI	Condition
None			No communication to EGC

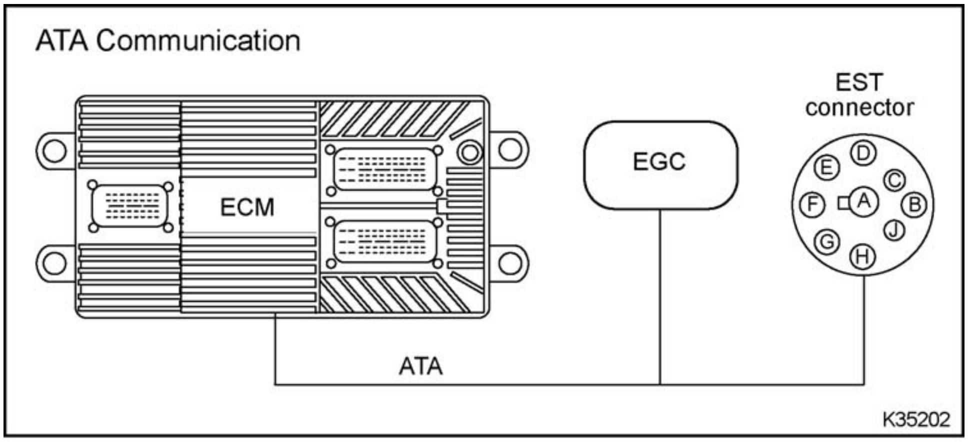

Figure 163 Function diagram for ATA

The ATA function diagram 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 tool 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

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- Terminal Test Adapter Kit (page 392)

ATA Pin-point Diagnostics

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

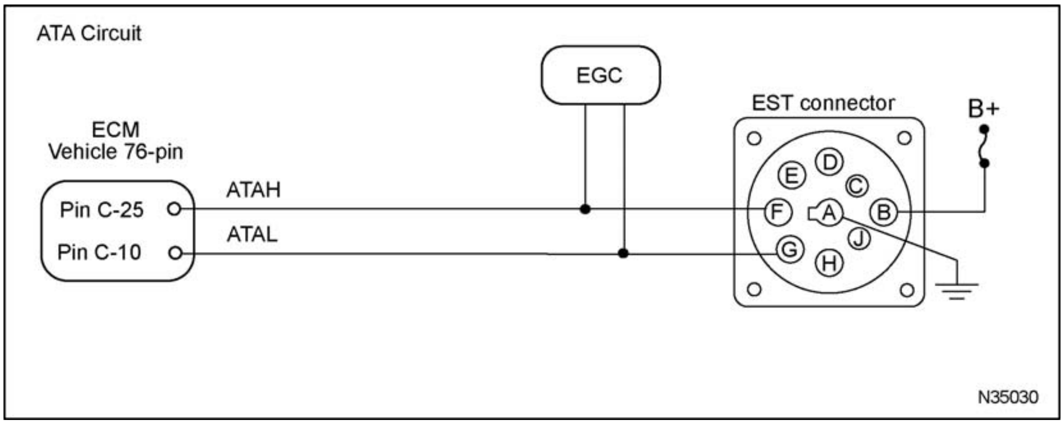

Figure 164 ATA circuit diagram

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 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 SIG 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.

EGC

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

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

Fault Detection / Management

There are no engine 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.

BCS (Boost Control Solenoid)

DTC	SPN	FMI	Condition
None			

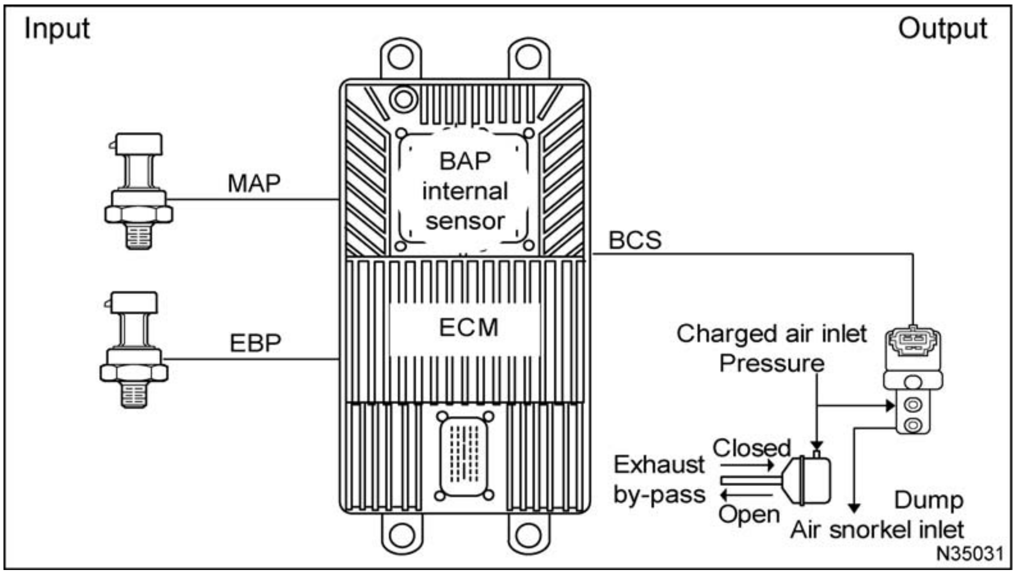

Figure 165 Function diagram for BCS

The BCS function diagram includes the following:

- Boost Control Solenoid (BCS)
- Electronic Control Module (ECM) with internal Barometric Absolute Pressure (BAP) sensor
- Manifold Air Pressure (MAP) sensor
- Exhaust Back Pressure (EBP) Sensor
- Engine lamp (amber)

Function

The ECM commands the BCS to control the turbocharger pneumatic actuator.

Location

The BCS is installed on the air inlet elbow.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- Terminal Test Adapter Kit (page 392)

BCS Circuit Diagnostics

DTC	Condition	Possible Causes
None		

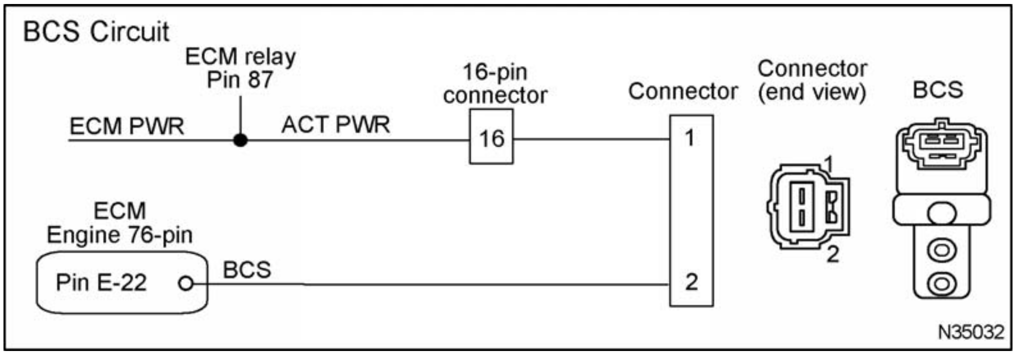

Figure 166 BCS circuit diagram

Voltage Check at BCS Connector - Output State Test

Disconnect BCS 2-pin connector. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	B+	If < B+, check ACT PWR for OPEN circuit
2 to GND	0 V to 0.25 V	If > 0.25 V, check BCS circuit for short to PWR
Run Output State Test HIGH.		
2 to B+	0 V to 0.25 V	If > 0.25 V, check BCS circuit for short to GND
Run Output State Test LOW.		
2 to B+	B+	If < B+, check BCS circuit for OPEN or short to PWR. Do Harness Resistance Checks (page 220)
1 to 2	B+	If < B+, check ACT PWR circuit for OPEN. Do Harness Resistance Checks (page 220)

Harness Resistance Check

Turn ignition switch OFF. Connect breakout box. Leave ECM and BCS disconnected.

Test Point	Spec	Comment
E-22 to 2	< 5 Ω	If > 5 Ω, check BCS for OPEN circuit
E-22 to GND	> 1 kΩ	If < 1 kΩ, check BCS circuit for short to GND
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.

BCS Circuit Operation

The BCS is supplied ACT PWR at Pin 1. The ECM grounds Pin E-22 to control the BCS at Pin 2.

Fault Detection / Management

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

An OPEN or short to ground in the BCS can be detected by the ECM during an on-demand engine standard test.

Brake Switch Circuits (BOO/BPS)

DTC	SPN	FMI	Condition
1222	597	2	Brake switch circuit fault

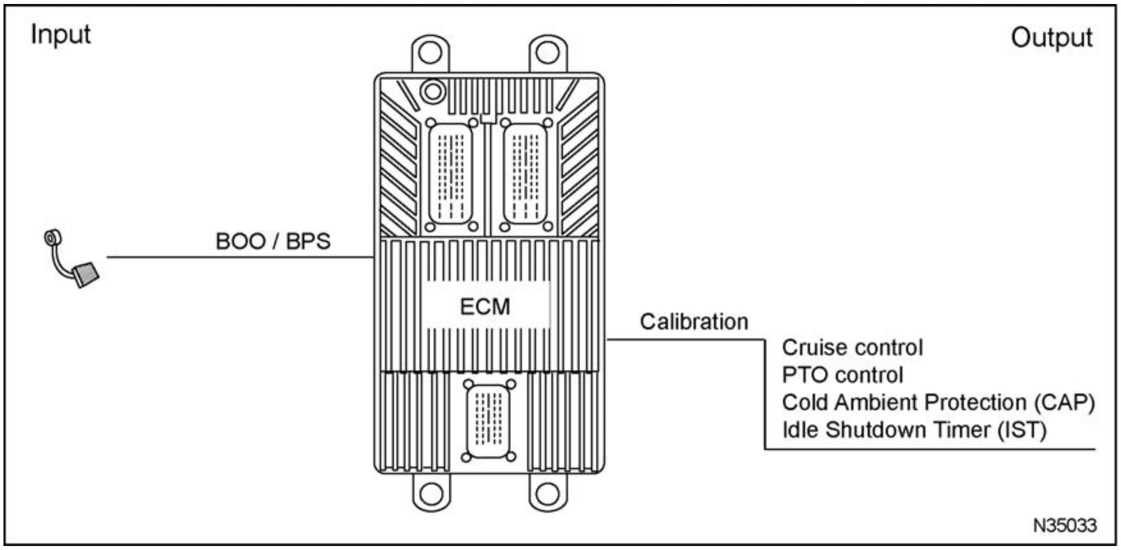

Figure 167 Function diagram for brake switch circuits

The brake switch circuits function diagram includes the following:

- Brake ON/OFF (BOO) switch
- Brake Pressure Switch (BPS)
- Electronic Control Module (ECM)
- 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 will interrupt the CAP feature and will reset the time interval for the IST feature.

Location

The Brake On/Off (BOO) switch is installed on the brake pedal assembly. The Brake Pressure Switch (BPS) is installed on the brake pressure line.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- Breakout Box (page 385)
- Terminal Test Adapter Kit (page 392)

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 sensor

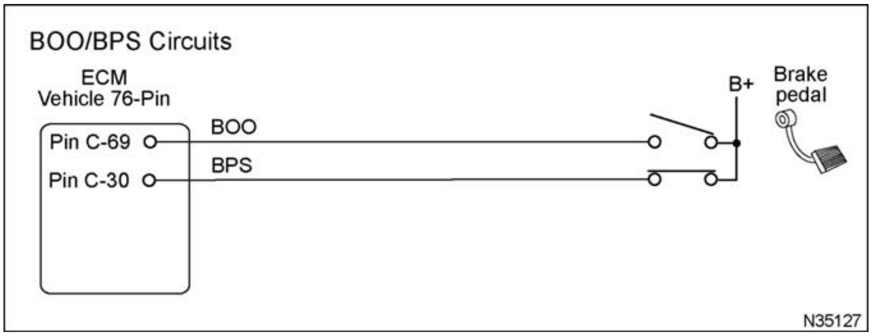

Figure 168 Brake switch circuit diagram

Brake Switch Circuits

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

Test Point	Spec	Comments
BOO	Normal state = Released Pedal depressed = 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 depressed = 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 ESC module, do Voltage Check (page 224).

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 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 BOO circuit at Pin C-69 and BPS at Pin C-30. If the ECM receives a mismatch signal such as an OPEN BPS or an OPEN BOO a Diagnostic Trouble Code (DTC) will be set.

CAN Communications (Controller Area Network) (Public)

DTC	SPN	FMI	Condition
2543	1136	2	CAN error present, missing messages from TCM
2544	8329	7	ECM unable to send CAN messages

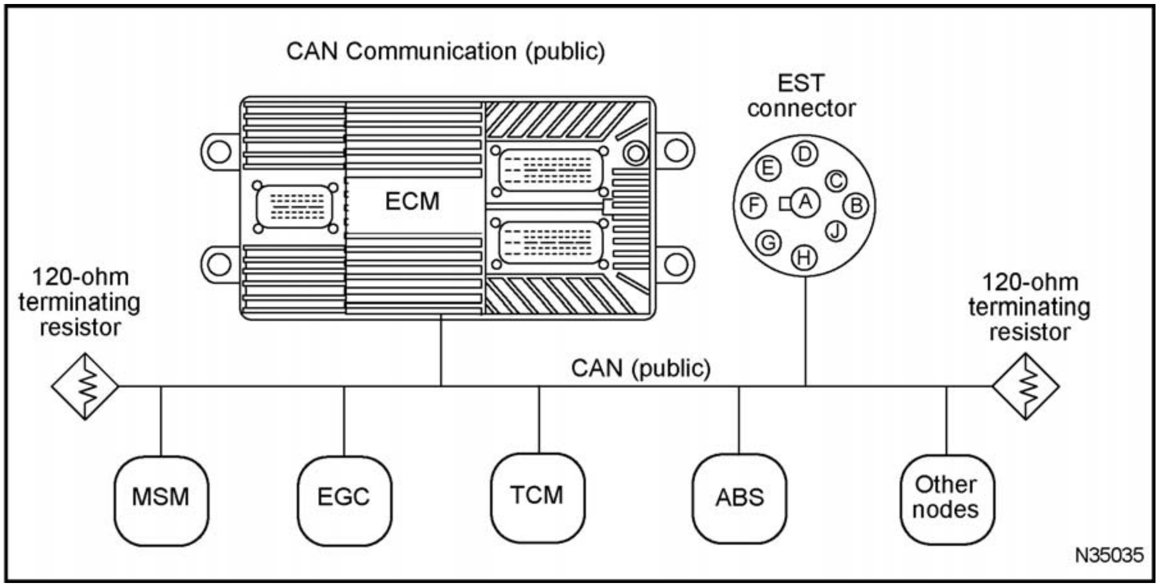

Figure 169 Function diagram for CAN

The CAN function diagram includes the following:

- Electronic Control Module (ECM)
- Transmission Control Module (TCM)
- Multiplex System Module (MSM) body
- 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 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

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- Terminal Test Adapter Kit (page 392)

CAN (Public) Pin-point Diagnostics

DTC	Condition	Possible Causes
2543	CAN error present, missing messages from TCM	• TCM not powering up or failed module • CAN circuits OPEN on TCM
2544	ECM unable to send CAN messages	• ECM not powering up or failed module • CAN circuits OPEN on ECM
None	No communication with EST	• B+ circuit OPEN or short to GND • GND circuit OPEN • CAN circuits OPEN to EST connector

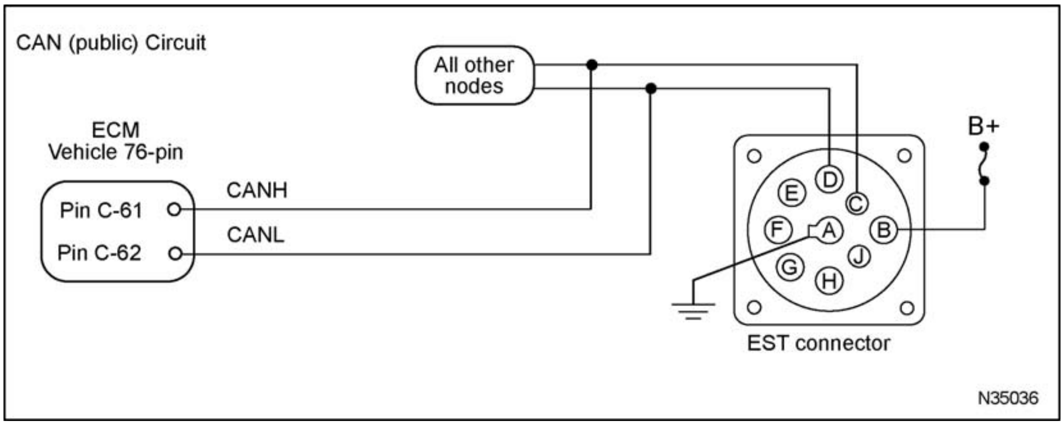

Figure 170 CAN communication circuit diagram

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 SIG 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 is established.

NOTE:

- If communication to the 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 the ECM is not established, go to next test point.

Test Point	Comment
Disconnect TCM	See above note
Disconnect ABS	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 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 CANL 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 CANH 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 communication between the ECM and all connecting modules, sending and receiving digital messages.

The EST communicates with the ECM through the EST connector. The EST is able to retrieve DTCs, run diagnostic tests, and view PIDs from all inputs and outputs of the ECM, through the public CAN network.

CAN public supports the following functions:

- Transfer of engine parameter data
- Accessing and clearing Diagnostic Trouble Codes (DTCs)
- Diagnostics and troubleshooting
- Programming performance parameter values
- Programming engine and chassis features
- Programming calibrations and strategies in the ECM

Public CAN versus Private CAN

The public CAN network is setup 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 reduce reflections.

The private CAN system is setup to only communicate between the ECM and specific engine controls.

Electronic Service Tool (EST) Connector

The EST connector provides an interface for the EST with other nodes. The EST 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 CAN + runs between ECM Pin C-61 and EST connector Pin C. Public CAN - between C-62 and EST connector Pin D.

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:

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

ESC or MSM Body Module

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
- Water in fuel lamp
- Aftertreatment regeneration lamp
- Cruise control
- Driveline Disengagement Switch (DDS)
- Brake pedal (ESC only) hard wired to the ECM on vehicles using the MSM module
- A/C Demand (ACD)
- Remote Accelerator Pedal (RPS)
- 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 will disrupt communications.

Fault Detection / Management

See *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.

CCS (Cruise Control System)

DTC	SPN	FMI	Condition
1221	536	2	SCCS switch circuit fault

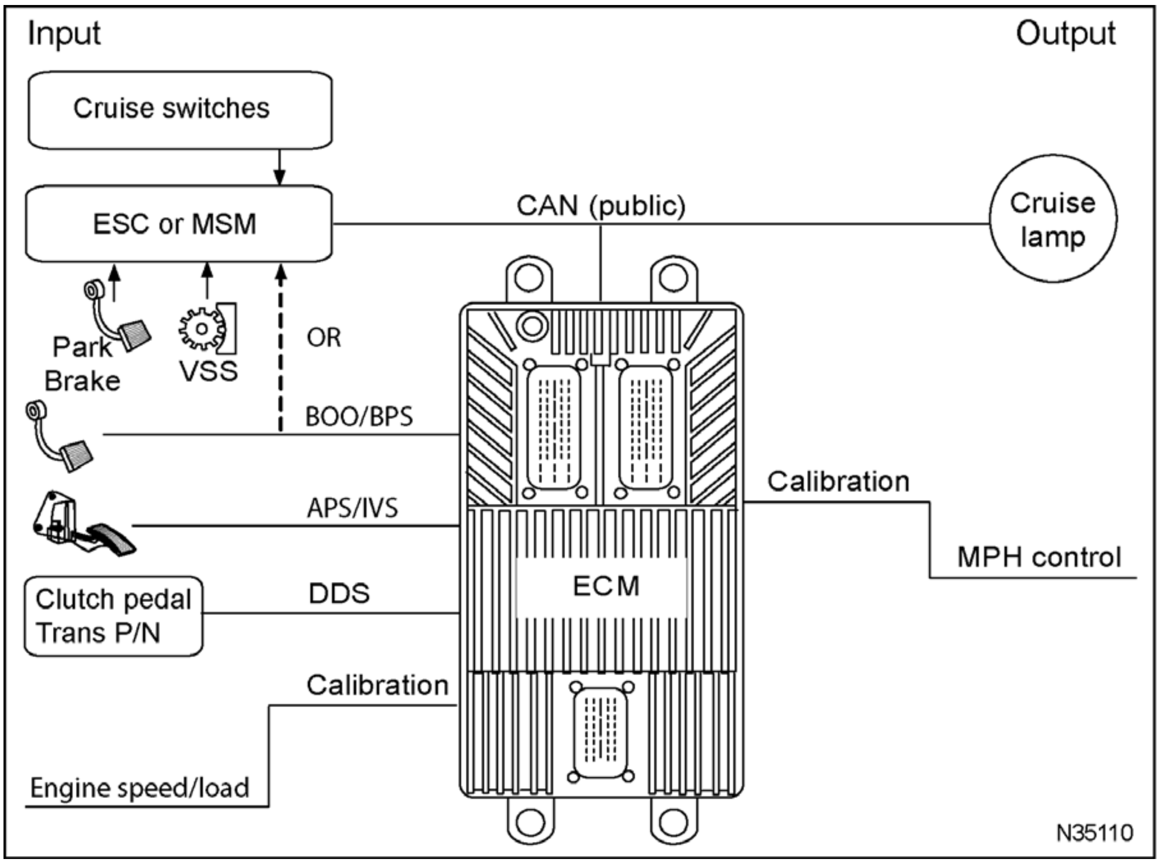

Figure 171 Cruise control system function diagram

The cruise control system functional diagram includes the following:

- Multiplex System Module (MSM) body module
- 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.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)

Cruise Control System Pin-point Diagnostics

DTC	Condition	Possible Causes
1221	SCCS switch circuit fault	See Switch Checks

Switch Checks

Turn ignition switch to ON. Connect EST to the EST connector. Open the cruise control session to monitor 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 Depressed = Applied	If not within specification, Go to BOO/BPS Pin-point Test (page 223)
BPS	Normal state = Released Depressed = Applied	If not within specification, Go to BOO/BPS Pin-point Test (page 223)
Park brake	Normal state = Released Depressed = Applied	• If not within specification, diagnose switch interface with ESC or MSN module. See *Chassis Electrical Circuit Diagnostic Manual* and *Electrical System Troubleshooting Guide*. • If within specification, go to next test point.
Cruise On/Off	Unlatched = OFF Latched = ON	• If not within specification, diagnose switch interface with ESC or MSN module. See *Chassis Electrical Circuit Diagnostic Manual* and *Electrical System Troubleshooting Guide*. • If within specification, go to next test point.
Cruise Set	Normal state = OFF Depressed = ON	• If not within specification, diagnose switch interface with ESC or MSN module. See *Chassis Electrical Circuit Diagnostic Manual* and *Electrical System Troubleshooting Guide*. • If within specification, go to next test point.
Cruise Resume/Accel	Normal state = OFF Depressed = ON	• If not within specification, diagnose switch interface with ESC or MSN module. See *Chassis Electrical Circuit Diagnostic Manual* and *Electrical System Troubleshooting Guide*. • If within specification, do next test point.
If all switches are okay, do 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
4612	8021	7	CMP to CKP incorrect reference

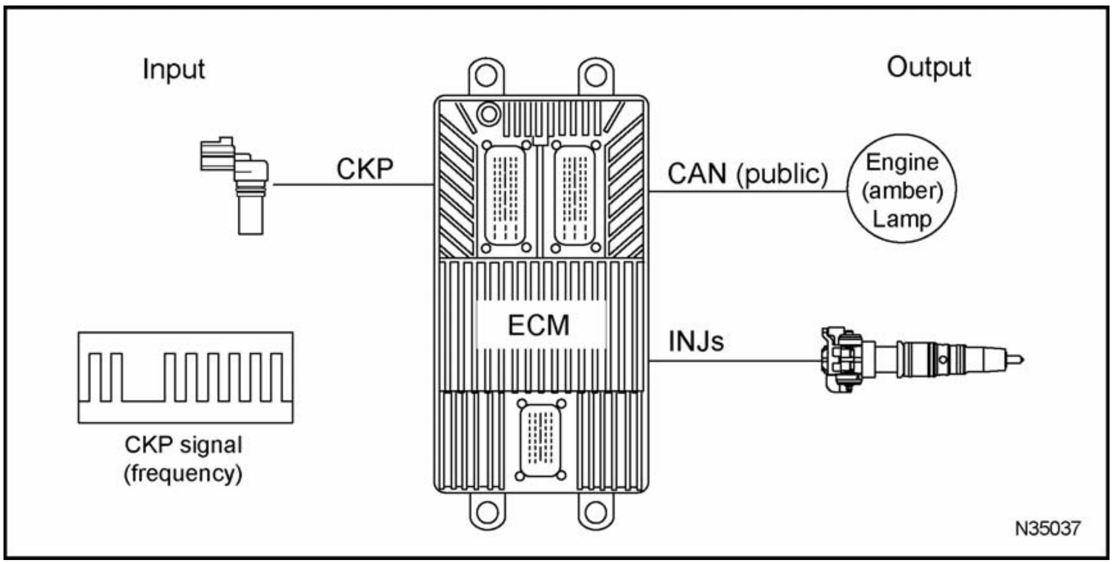

Figure 172 CKP sensor function diagram

The CKP sensor function diagram includes the following:

- Crankshaft Position (CKP) sensor
- Electronic Control Module (ECM)
- Fuel injectors (INJ)
- Engine lamp (amber)

Function

The CKP sensor sends a pulsed signal to the ECM as the crankshaft turns. The ECM uses this signal with the 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

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 180-Pin Breakout Box (page 385)
- Terminal Test Adapter Kit (page 392)

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	
4554	CKP loss of sync	
4555	CKP signal noise detected	
4556	CKP period too short	
4611	CKP signature one tooth off	
4612	CMP to CKP incorrect reference	

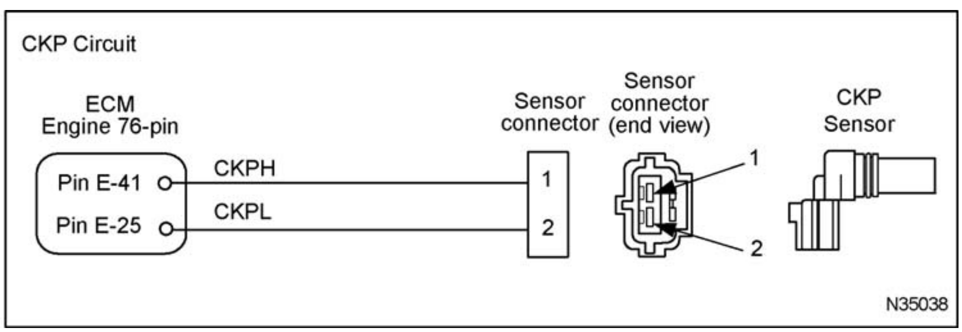

Figure 173 CKP circuit diagram

Sensor and Circuit Resistance Check

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

Test Point	Spec	Comment
E-25 to E-41	300 Ω to 400 Ω	If < 300 Ω, check for failed sensor. Do Harness Resistance Check (page 234). If > 400 Ω, check for OPEN circuit or failed sensor. Do Harness Resistance Check.

Harness Resistance Check

Turn ignition switch 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, avoid rotating parts (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	5.5 Hz to 6.5 Hz (650 rpm to 700 rpm)
	High idle	21.50 Hz to 23.5 Hz (3200 rpm)

CKP Circuit Operation

The CKP sensor contains a permanent magnet which creates a magnetic field. The CKP signal is induced when the 60 tooth crankshaft timing disk rotates and each tooth breaks the magnetic field created by the sensor. Teeth 59 and 60 are missing. The CKP low signal is sent to ECM pin E-25 and CKP high to E-41.

Crankshaft speed is derived from the frequency of the CKP sensor signal. Crankshaft position is determined by synchronizing the SYNC tooth with the SYNC gap signals.

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

Fault / Detection Management

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

During engine cranking the ECM monitors the CMP signal to verify the engine is rotating. If the CKP signal is inactive during this time a DTC will be set. Electrical noise can also be detected by the ECM, if the level is sufficient to effect engine operation a corresponding DTC will be set.

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

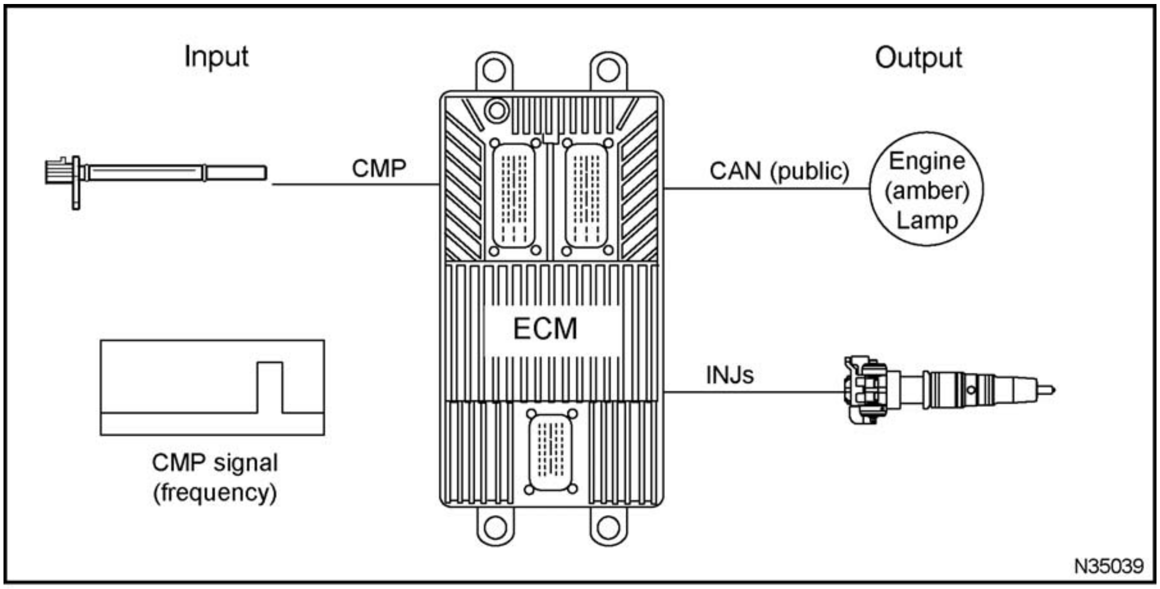

Figure 174 CMP sensor function diagram

The CMP sensor function diagram includes the following:

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

Function

The CMP sensor sends a pulsed signal to the ECM when a single peg on the camshaft rotates past the CMP sensor once during each revolution of the camshaft. The ECM uses the CMP signal and the CKP signal to calculate crankshaft speed and position.

Sensor Location

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

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 180-Pin Breakout Box (page 385)
- Terminal Test Adapter Kit (page 392)

CMP Pin-point Diagnostics

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

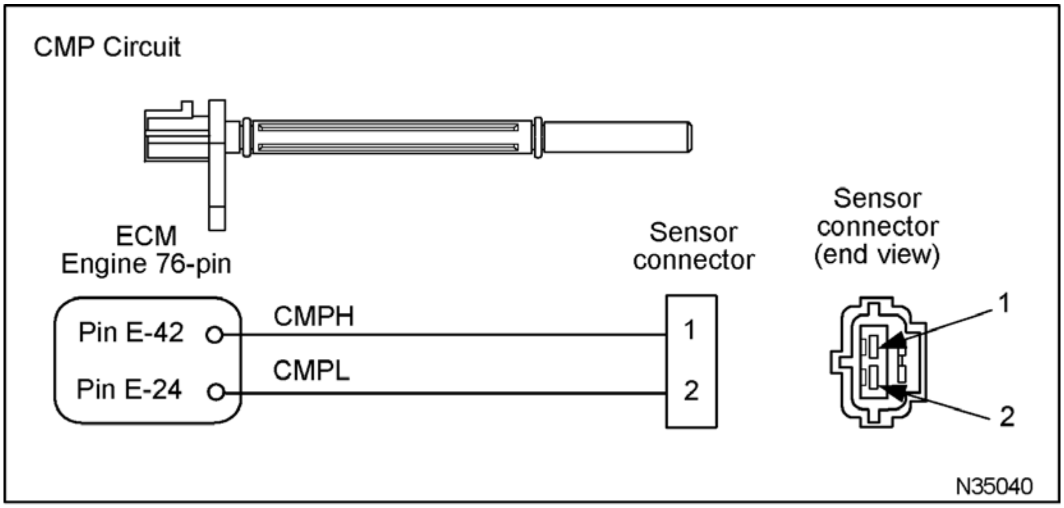

Figure 175 CMP circuit diagram

Sensor and Circuit Resistance Check

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

Test Point	Spec	Comment
E-24 to E-42	800 Ω to 1 kΩ	If < 800 Ω, check for failed sensor. Do Harness Resistance Check (page 237). If > 1 kΩ, check for OPEN circuit or failed sensor. Do Harness Resistance Check (page 237).

Harness Resistance Check

Turn ignition switch 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, avoid rotating parts (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	3200 rpm

CMP Circuit Operation

The CMP sensor sends the ECM with a signal indicating camshaft speed and position.

The CMP sensor contains a permanent magnet which creates a magnetic field. The CMP signal is created when a peg on the camshaft rotates and breaks the CMP sensor magnetic field. The CMP low signal is sent to ECM pin E-24 and high to 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 doing accuracy checks on frequency and duty cycle with software strategies.

Fault / Detection Management

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

During engine cranking the ECM monitors the CKP signal to verify the camshaft is rotating. If the CMP signal is inactive during cranking a DTC will be set. Electrical noise can also be detected by the ECM, if the level is sufficient to effect engine operation a DTC will be set.

Cylinder Balance

DTC	SPN	FMI	Condition
None			

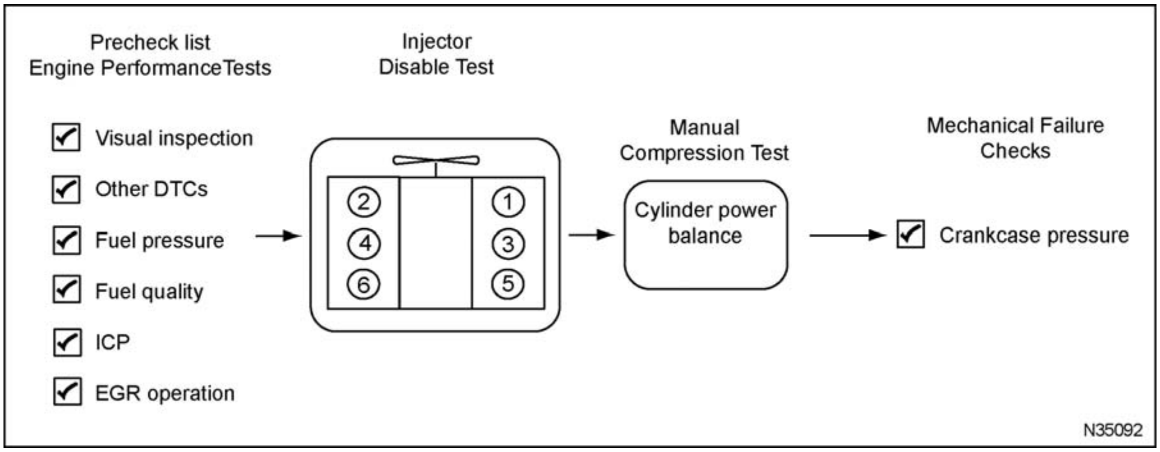

Figure 176 Function diagram for cylinder balance

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 uneven torque contributions from one cylinder to the next, causing low power, increased engine noise and vibration, and rough idle.

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

Cylinder Balance Diagnostics

DTC	Condition	Possible Causes
None	Cylinder imbalance	• Cylinder compression • Injector failure • Aerated fuel

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 level and quality for efficient engine operation. See Fuel Supply System (page 161).
4. Check ICP pressure and voltage.
   - Check ICP voltage at KOEO. See “Performance Specifications” (page 427).
   - Check ICP system pressure at low idle. Run KOER Standard Test.

     See “Performance Specifications” appendix.
5. Inspect EGR valve. Verify valve is not stuck open.
   - Run KOEO Standard test. See KOEO Standard Test (page 156) in the “Performance Diagnostics” section of this manual.

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

1. Run KOER Injector Disable test to identify imbalanced cylinder. See Injector Disable Test (page 177).
2. Do the Manual Compression Test to verify cylinder imbalance is a mechanical or injector problem. See Manual Compression Test .
   - Check crankcase pressure.
   - Check valve lash.

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

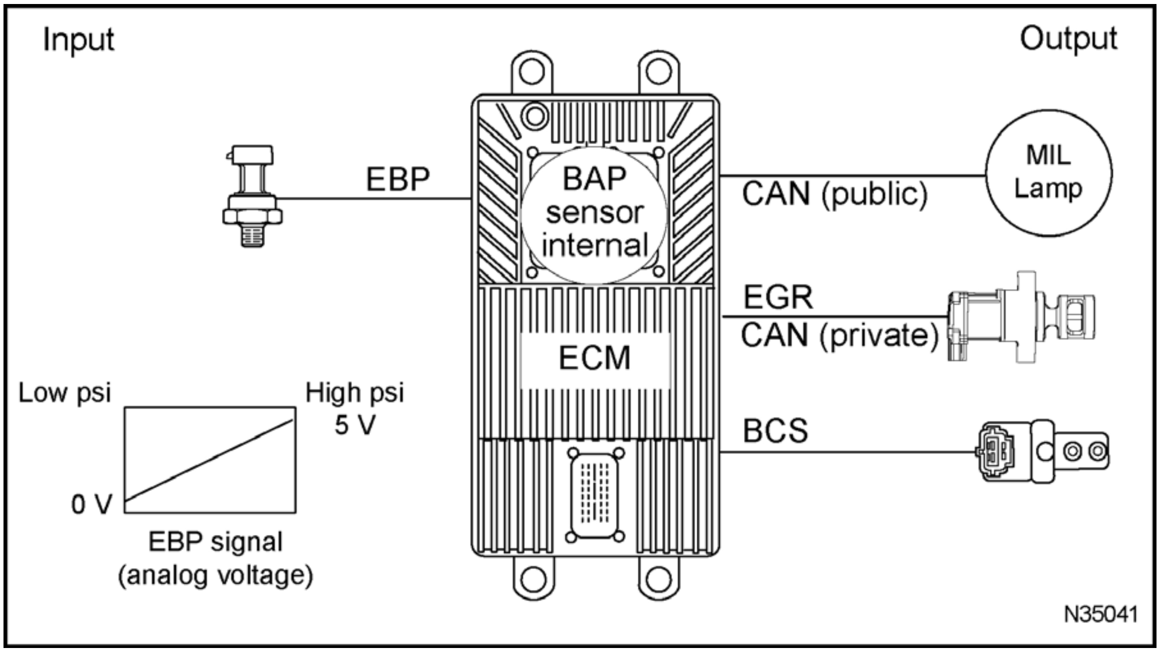

Figure 177 Function diagram for the EBP sensor

The EBP sensor function diagram includes the following:

- Exhaust Back Pressure (EBP) sensor
- Electronic Control Module (ECM) with internal Barometric Absolute Pressure (BAP) sensor
- Boost Control Solenoid (BCS)
- Exhaust Gas Recirculation (EGR) valve
- Malfunction Indicator Lamp (MIL)

Function

The EBP sensor measures exhaust back pressure before the turbochargers. The ECM uses the EBP signal to control the BCS and EGR systems.

Sensor Location

The EBP sensor is installed in a tube mounted on the left exhaust manifold.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 3-banana Plug Harness (page 386)
- 180-Pin Breakout Box (page 385)
- Pressure Sensor Breakout Harness (page 391)
- Terminal Test Adapter Kit (page 392)

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 • Failed sensor
3342	EBP signal out-of-range HIGH	• EBP signal circuit short to PWR • Failed sensor

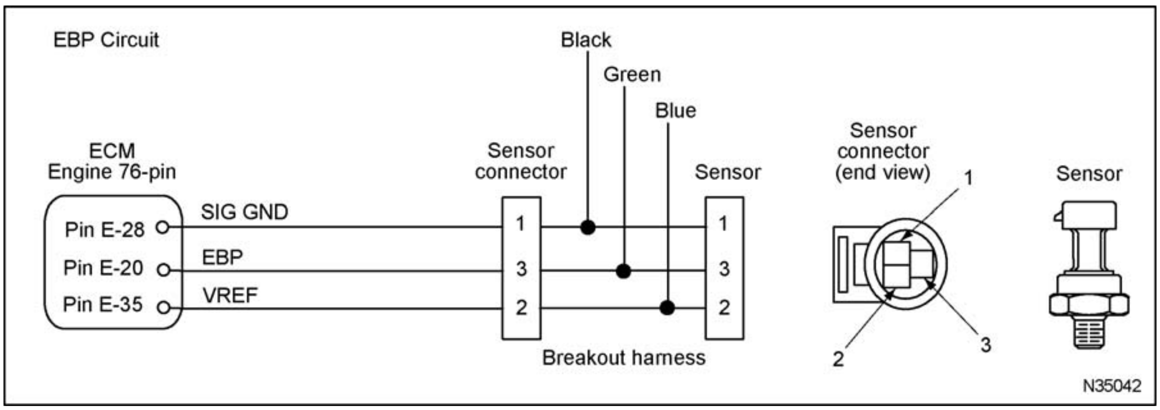

Figure 178 EBP circuit diagram

WARNING: To prevent personal injury or death, avoid 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”.
3. Monitor sensor voltage. Verify an active DTC for the sensor.
   - 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 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 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 243).
EST - Check DTC Short breakout harness across 2 and 3	DTC 3342	If DTC 3341 is active, check EBP signal for OPEN or short to GND. Do Harness Resistance Check (page 243).
DMM - Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check GND for OPEN. Do Harness Resistance Check (page 243).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

EBP Pin-point Diagnostics

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 243).
3 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 243).

Connector Resistance Check

Turn ignition switch 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.

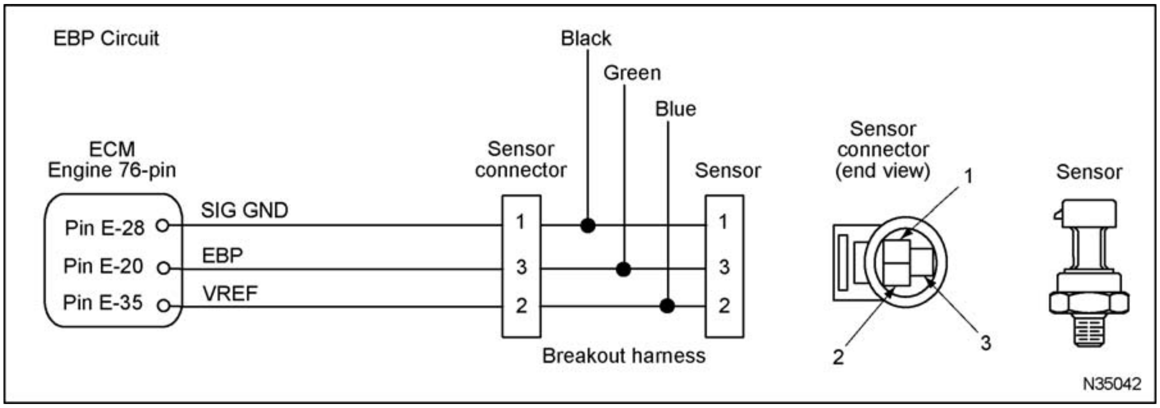

Figure 179 EBP circuit diagram

Harness Resistance Check

Turn ignition switch 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 and returns a variable voltage signal from Pin 3 to ECM Pin E-20.

Fault Detection / Management

The ECM continuously monitors the EBP signal. If the signal is higher or lower than expected, the ECM disregards the sensor signal and uses a calibrated default value. The ECM will set a DTC, turn on the warning lamp, and run the engine in a default range. The EGR valve will close and the ECM will rely on the turbocharger boost pre-programmed values.

ECI Circuit (Engine Crank Inhibit)

DTC	SPN	FMI	Condition
None			Engine starter motor will not engage.

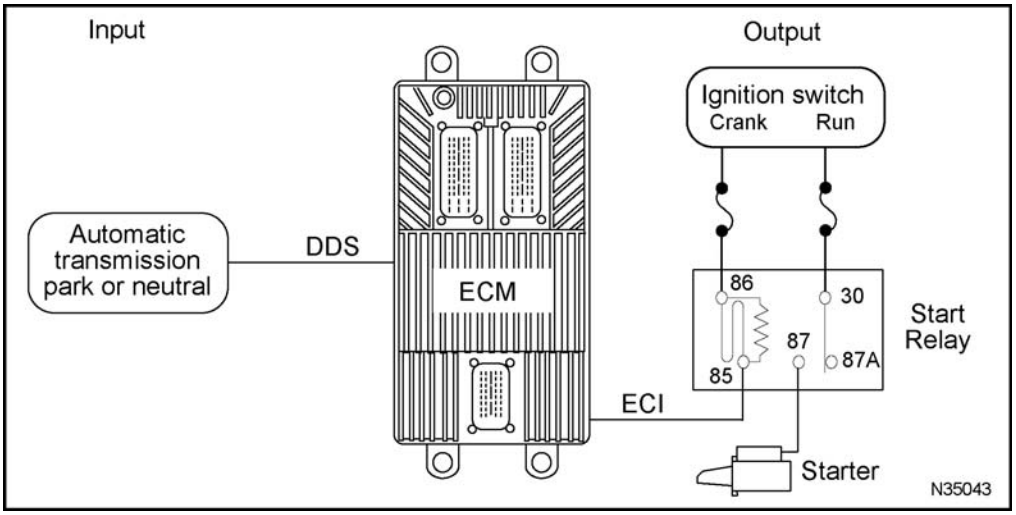

Figure 180 ECI circuit functional diagram

The ECI system consists of the following:

- Electronic Control Module (ECM)
- Starter
- Start relay
- Engine Crank Inhibit (ECI) Circuit
- Driveline Disengagement Switch (DDS)

Function

The Engine Crank Inhibit (ECI) is a function of the ECM. It prevents starter engagement while the engine is running (above a set calibrated rpm) or when the automatic transmission is in gear. The start relay can also be disabled by an optional overcrank thermocouple.

Location

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

Tools

- Digital Multimeter (DMM) (page 388)
- 180-Pin Breakout Box (page 385)
- Relay Breakout Harness (page 391)

ECI Circuit Diagnostics

DTC	Condition	Possible Causes
None	No engine crank	• Transmission in gear • 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

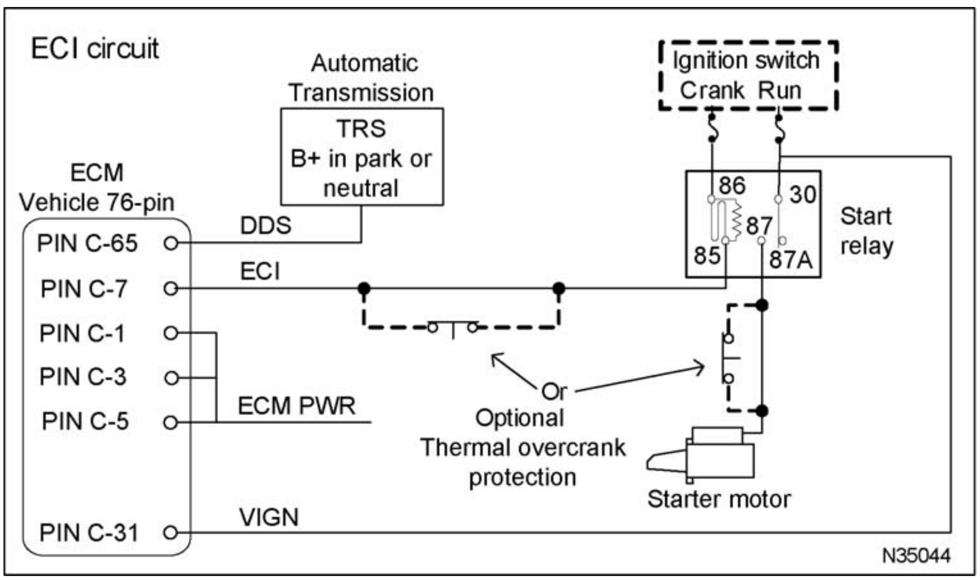

Figure 181 ECI circuit diagram

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

Voltage Check at Relay

Connect breakout harness between relay and relay socket. Turn 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 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. If 4 V to 5 V, check DDS circuit to ECM and do Voltage Check at ECM (page 246).
87 to GND	B+	If < B+, replace relay. If B+, check voltage at starter.

Voltage Check at ECM

Connect breakout box between ECM and chassis harness. Turn 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 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 in this section (page 253).
Shift transmission in park or neutral. Use DMM to measure voltage.		
C-65 to GND	B+	If < B+, check DDS for OPEN circuit, see transmission diagnostics.
C-7 to GND	2 V	If > 2 V, check ECM programming.

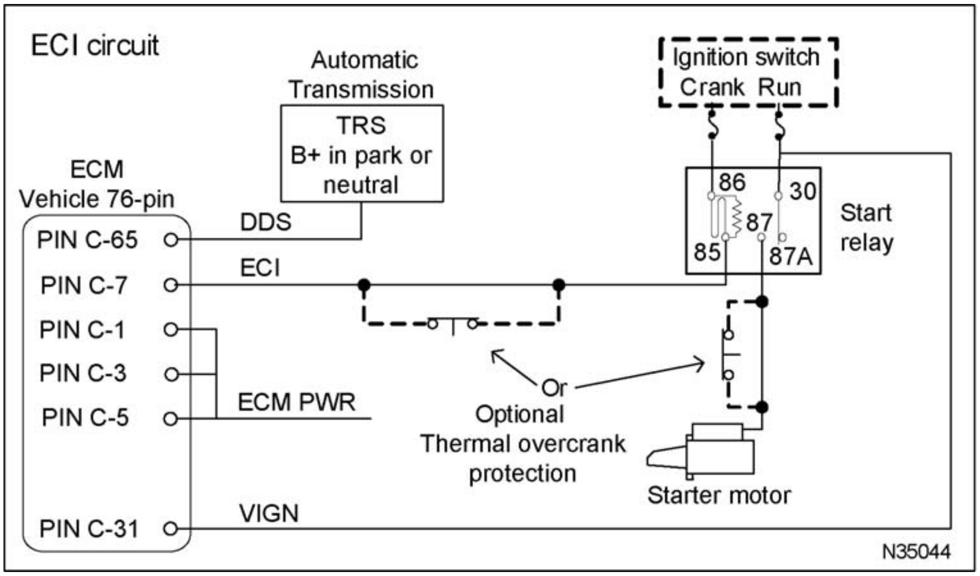

Figure 182 ECI circuit diagram

Harness Resistance Check - ECM to Relay

Turn ignition switch 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.
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 VIGN	< 5 Ω	If > 5 Ω, check circuit for OPEN.
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	See chassis electrical diagrams. Check for OPEN or short to GND. Check for TCM circuit faults.	

Operational Voltage Check

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

Test Point	Spec	Condition
DDS C-65 to GND	0 V	ECM Input - Automatic transmission in gear. Cranking is disabled.
	B+	ECM Input - Automatic transmission in park or neutral. Cranking is enabled.
ECI C-7 to GND	B+	ECM Output - Cranking is disabled.
	0 V	ECM Output - Cranking is enabled.

ECI Circuit Operation

DDS Circuit

The ECM monitors the Driveline Disengagement Switch (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 chassis's hardware configuration. See appropriate electrical diagrams when diagnosing this circuit.

Ignition Switch

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

ECI Circuit

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

Electronic Control Module (ECM)

When the ECM recognizes the engine is not running and the driveline is not engaged, the ECM will ground 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 depressed.

When the ECM recognizes the engine is running or the driveline is engaged, the ECM will OPEN Pin C-7. This prevents the Start relay from closing and the starter from engaging.

Start Relay

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

Neutral Switch

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

ECL Switch (Engine Coolant Level)

DTC	SPN	FMI	Condition
2323	111	1	ECL below Warning/Critical level

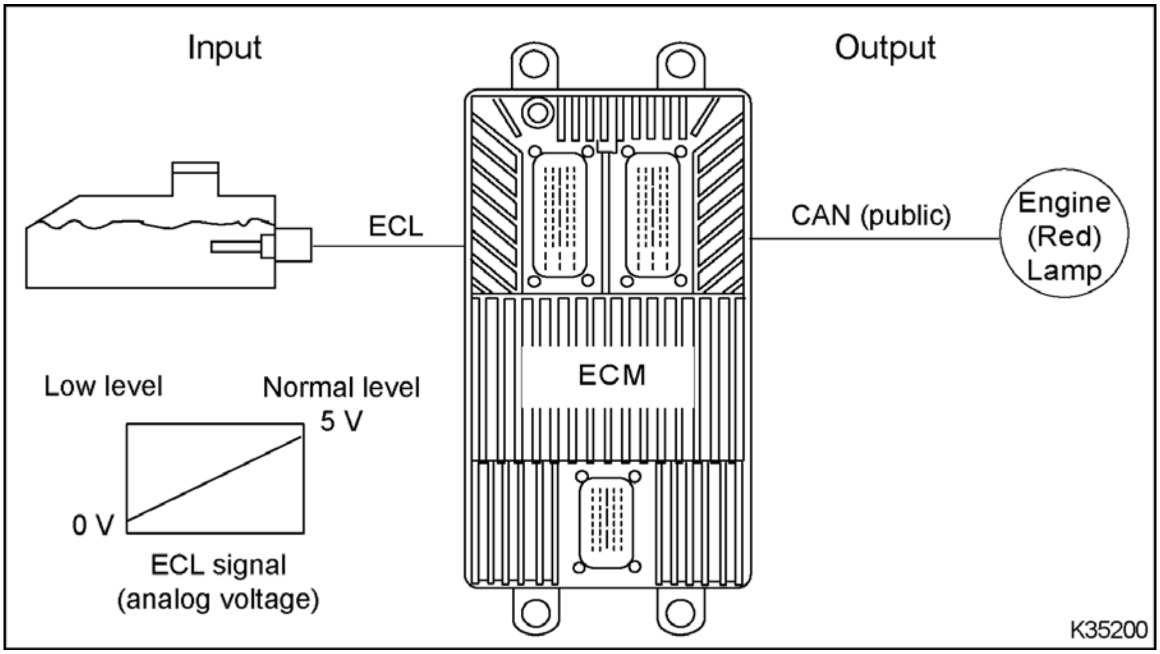

Figure 183 Function diagram for the ECL system

The ECL function diagram includes the following:

- Engine Coolant Level (ECL) switch
- Electronic Control Module (ECM)
- Engine lamp (red)

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 customer programmable feature that can be programmed with and Electronic Service Tool (EST). The coolant level feature is operational if programmed for EWPS 3-way warning or 3-way protection.

Location

The ECL switch is installed in the engine cooling system deaeration tank.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- Breakout Box

ECL Pin-point Diagnostics

DTC	Condition	Possible Causes
2323	ECL below Warning/Critical level	• ECL circuit OPEN or shorted to GND or PWR • Failed switch • Engine coolant level indicates engine coolant not sufficient

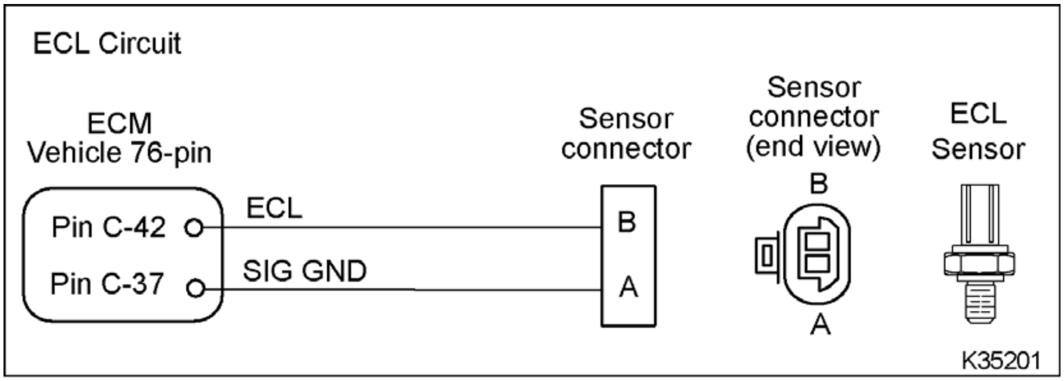

Figure 184 ECL circuit diagram

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 251).

Connector Resistance Check to GND

Turn ignition switch 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 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 will pull the level switch OPEN. This allows a 5 volt signal at ECM Pin C-42. When the level is low, the switch will close and ECM Pin C-42 will be 0 volts.

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

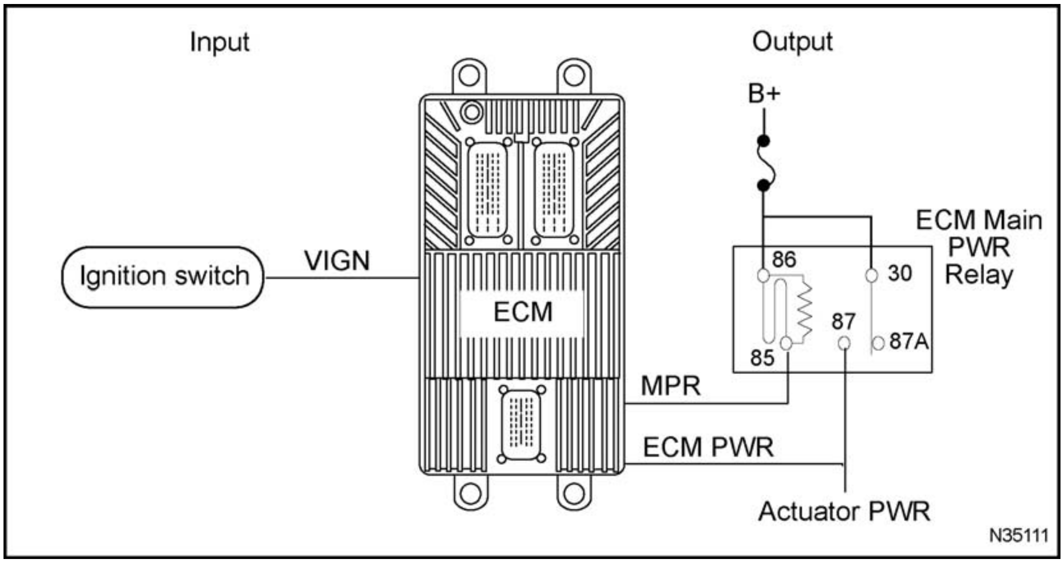

Figure 185 Function diagram for ECM PWR

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 the ignition switch is turned 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 will enable the ECM relay to power-up. When the ignition switch is turned off, the ECM performs internal maintenance, then disables the ECM main power relay.

ECM Location

The ECM is chassis mounted on the ECM bracket.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 180-Pin Breakout Box (page 385)
- Relay Breakout Harness (page 391)
- Terminal Test Adapter Kit (page 392)

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
1113	B+ out-of-range LOW	• Weak or discharged batteries • Charging system fault • High resistance in ECM powering circuits (ECM PWR, ECM GND, or VIGN)

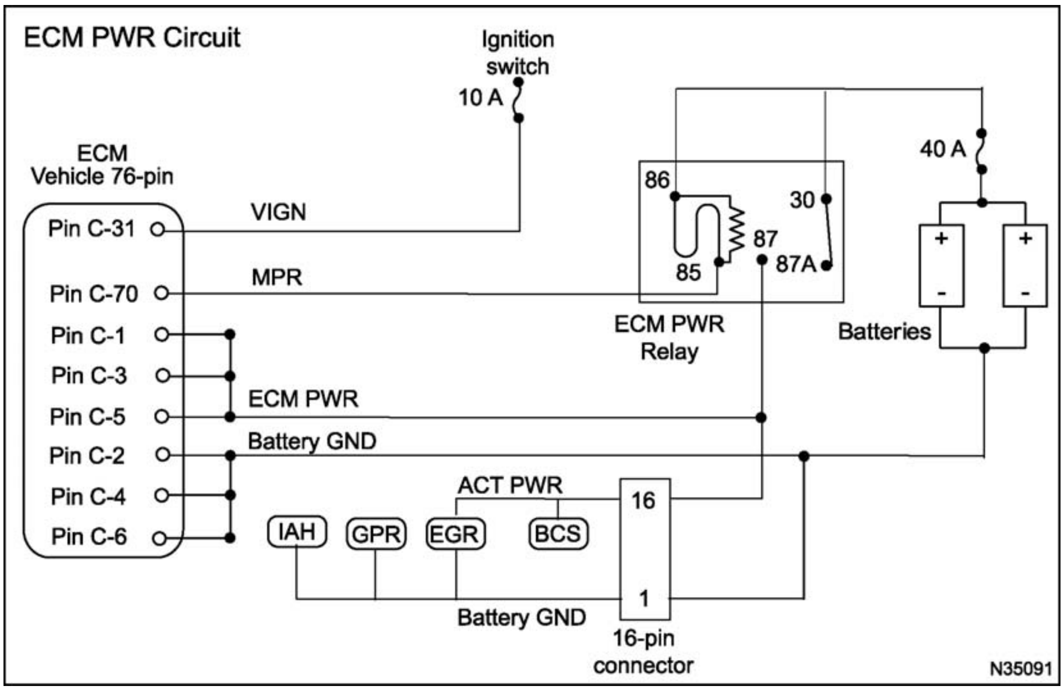

Figure 186 ECM PWR circuit diagram

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

Voltage Checks at Relay

Connect Relay Breakout Harness between relay and relay socket. Turn ignition switch to ON. Use DMM to measure voltage.

CAUTION: To prevent engine damage, turn ignition switch OFF before removing the main power relay or any ECM connector supplying power to the ECM. Failure to turn ignition switch OFF will cause a voltage spike and damage 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 Checks.
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 Checks.
85 to GND	0 V to 2 V	If > 2 V, check MPR control circuit for OPEN or short to PWR. Do Harness Resistance Checks.
87 to GND	B+	If < B+, replace relay. If B+, check ECM PWR and ECM GND circuits at the ECM. Do Voltage Checks at ECM.

Voltage Check at ECM

Connect breakout box between ECM and chassis harness. Turn 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	0 V	If voltage is present, check for OPEN circuit. Do Harness Resistance Check (page 255).
C-4 to GND	0 V	
C-6 to GND	0 V	
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 255).
C-1 to GND	B+	If < B+, check for OPEN circuit, failed relay, or blown fuse. Do Harness Resistance Check (page 255).
C-3 to GND	B+	
C-5 to GND	B+	

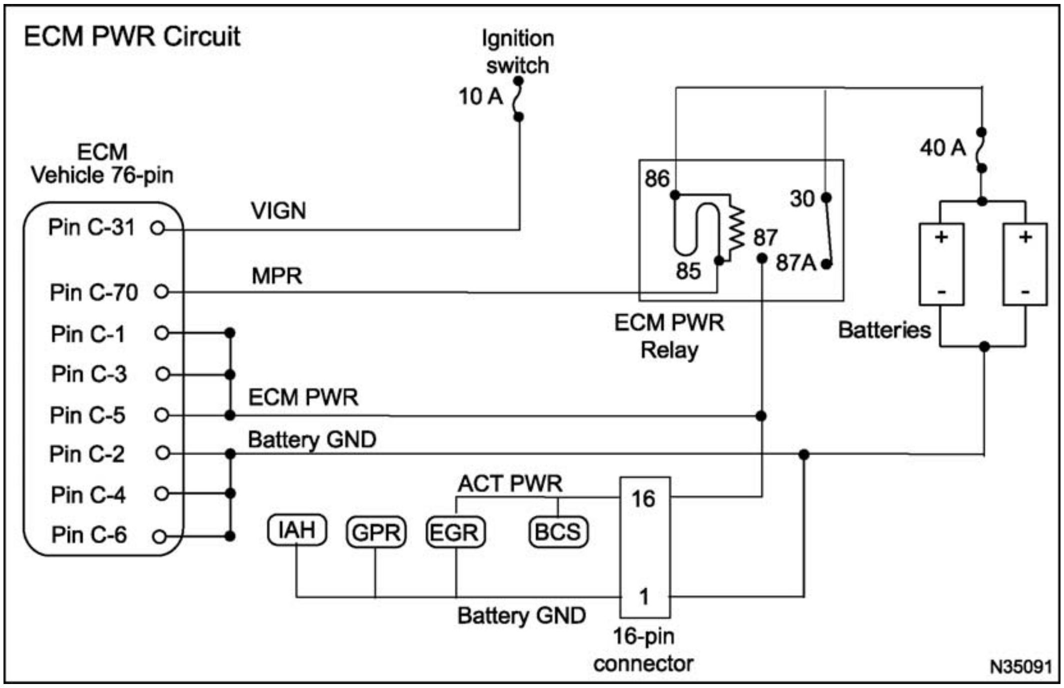

Figure 187 ECM PWR circuit diagram

Harness Resistance Check

Turn ignition switch OFF. Connect breakout box and breakout harness. Leave ECM, ECM PWR relay, and ACT 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 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 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. The ECM then provides a ground path from Pin C-70 to switch the ECM main power relay at Pin 85. Switching the relay provides power from the battery positive terminal through a fuse, relay contacts 30 and 87, and then to ECM Pins C-1, C-3, C-5 and 16-pin connector pin 16.

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 V or more than 17.5 V, a Diagnostic Trouble Code (DTC) will 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
5382	1136	0	ECM Error – ECM over temperature
5618	8334	2	ECM Error – SPI-BUS error 1
5619	8334	12	ECM Error – SPI-BUS error 2
5627	8333	12	ECM Error – Checksum program
5628	8333	2	ECM Error – Checksum dataset
5632	8254	12	ECM Error – RAM/CPU self test fault
5633	8254	0	ECM Error – 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
5644	190	2	ECM Error – Engine Speed limitation
5645	7253	7	ECM Error – EEPROM failure
5646	190	14	ECM Error – Engine Speed: monitoring
5649	1136	14	ECM Error – A/D conversion monitoring
5652	8240	14	ECM Error – NVMY channel
5653	8300	14	ECM Error – PPS monitoring
5656	8335	14	ECM Error – Processor monitoring

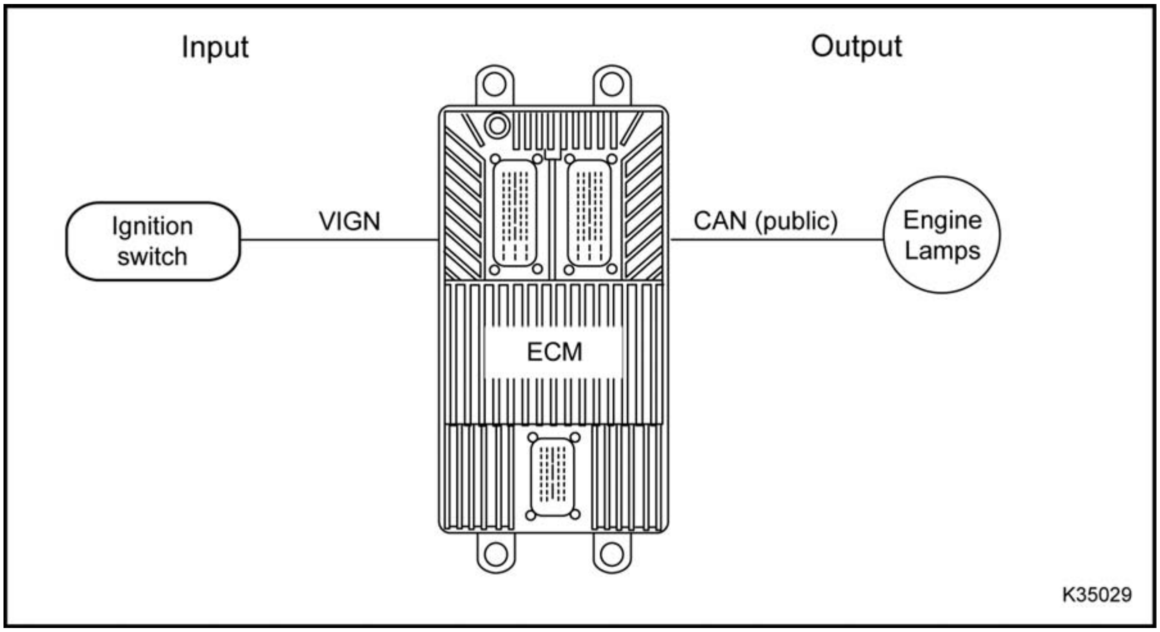

Figure 188 Function diagram for the ECM

The ECM does the following:

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

Fault Detection / Management

The ECM automatically performs diagnostic self-checks. The ECM self-test includes memory, programming, and internal power supply checks. The ECM will detect internal Diagnostic Trouble Codes (DTCs) depending on the severity of the problem. Additionally, the ECM provides DTC management strategies to permit limited engine and chassis operation.

When DTC 1151, 1152, 5644, or 5656 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 5382 - ECM Error – over temperature

Pin-point ECM Self Diagnostic Fault

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

DTC 5618 - ECM Error – 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 - ECM Error – 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 - ECM Error – Checksum program

Pin-point ECM Self Diagnostic Fault

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

DTC 5628 - ECM Error – Checksum dataset

Pin-point ECM Self Diagnostic Fault

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

DTC 5632 - ECM Error – Random Access Memory (RAM) / CPU self-test fault

Internal ECM problem, RAM memory fault, causes an engine no start.

Pin-point ECM Self Diagnostic Fault

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

DTC 5633 - ECM Error – 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 - ECM Error – 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 - ECM Error – 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 - ECM Error – 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 5644 - ECM Error – Engine speed limitation error

Pin-point ECM Self Diagnostic Fault

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

DTC 5645 - ECM Error – EEPROM failure

Pin-point ECM Self Diagnostic Fault

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

DTC 5646 - ECM Error – Engine Speed: monitoring

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, replace ECM.

DTC 5649 - ECM Error – A/D conversion monitoring

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, replace ECM.

DTC 5652 - ECM Error – NVMY channel

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, replace ECM.

DTC 5653 - ECM Error – PPS monitoring

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, replace ECM.

DTC 5656 - ECM Error – Processor monitoring

Indicates the ECM software is corrupted.

Pin-point ECM Self Diagnostic Fault

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

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

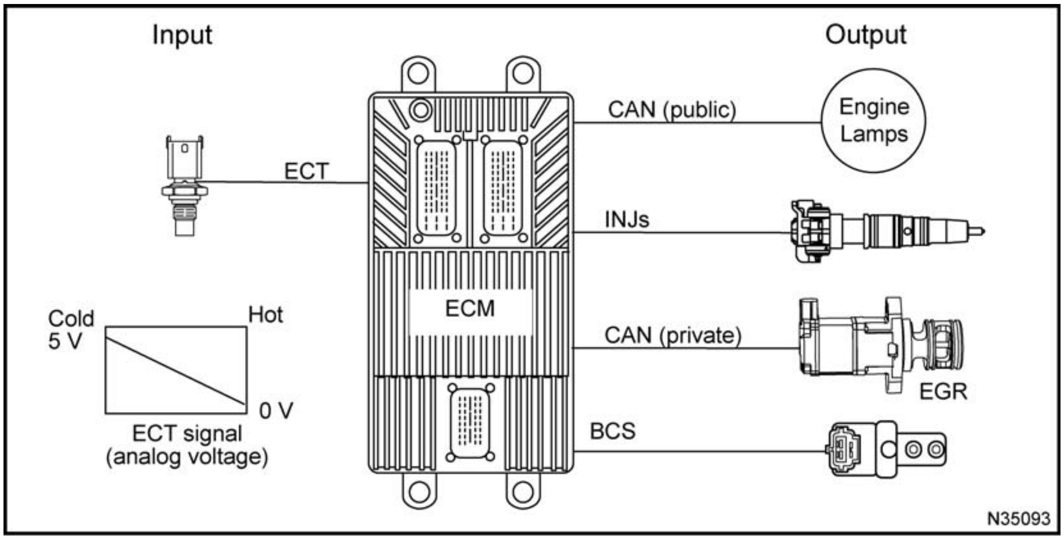

Figure 189 ECT sensor function diagram

The ECT sensor function diagram includes the following:

- Engine Coolant Temperature (ECT) sensor
- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR) valve
- Fuel injectors (INJ)
- Turbocharger boost control
- Engine lamps (amber and red)

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:

- Engine Warning and Protection System (EWPS)
- Cold Ambient Protection (CAP)
- Idle Shutdown Timer (IST)
- Coolant Temperature Compensation (CTC)

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

Sensor Location

The ECT sensor is installed in the left side of the front cover, near the thermostat.

Tools

- EZ-Tech® Electronic Service Tool (EST) with MasterDiagnostics® software (page 389)
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 3-banana Plug Harness (page 386)
- 500 Ohm Resistor Harness (page 387)
- 180-Pin Breakout Box (page 385)
- Temperature Sensor Breakout Harness (page 392)
- Terminal Test Adapter Kit (page 392)

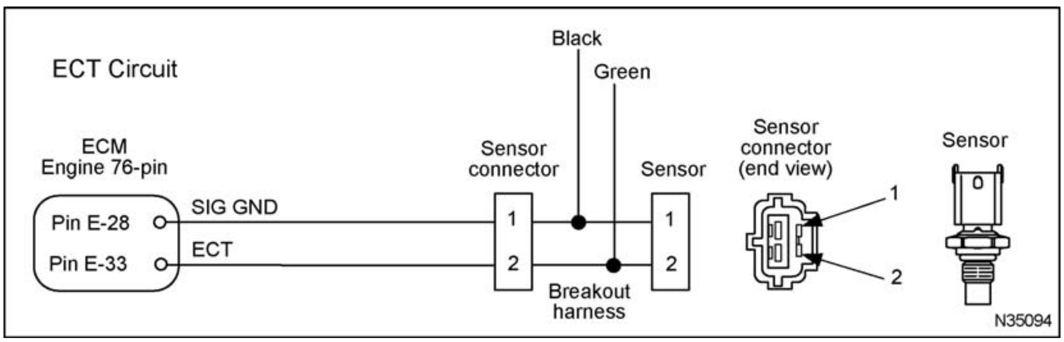

Figure 190 ECT circuit diagram

ECT Sensor End Diagnostics

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

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

1. Using EST with MasterDiagnostics® software, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active DTC for the sensor.
   - 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 spike 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 265).
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 265).
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 265).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

ECT Pin-point Diagnostics

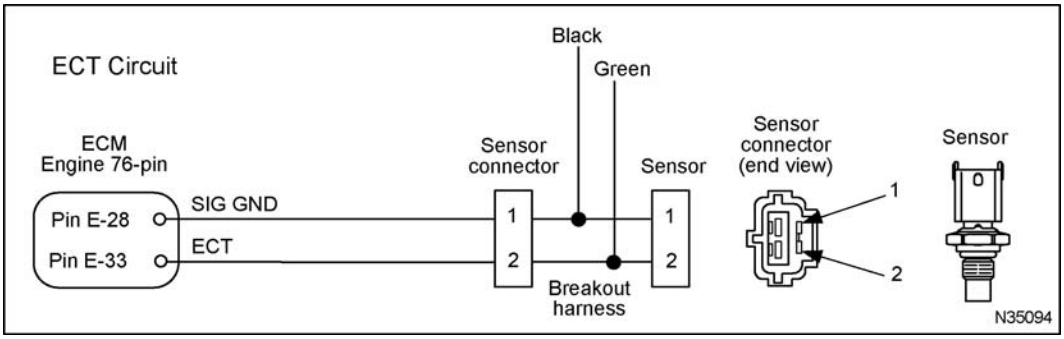

Figure 191 ECT circuit diagram

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 265).

Connector Resistance Check to GND

Turn ignition switch 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 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.

Operational Voltage Check

Use EST to read PIDs during Continuous Monitor test or DMM to read signal circuit with breakout harness or breakout box.

Test Point	Coolant Temperature	Resistance	Voltage
EST / DMM	108 °C (228 °F)	1.605 kΩ	0.37 V
2 to GND or E-33 to GND	87.7 °C (190 °F)	3 kΩ	0.65 V
	0 °C (32 °F)	91.1 kΩ	3.86 V
	-17.8 °C (0 °F)	208 kΩ	4.25 V

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 ECT is grounded at Pin 1 from ECM Pin E-28. As coolant temperature increases, thermistor resistance decreases, causing 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% will be 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 the ECM memory.

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

Engine Warning and Protection (EWPS)

EWPS is an optional feature that can be enabled or disabled. When enabled, the EWPS will warn the operator of an overheat condition and can be programmed to shut down the engine.

The red engine lamp will illuminate when ECT reaches approximately 109 °C (228 °F). A warning buzzer will sound 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 sensor signal and uses a calibrated default value. The ECM will set a DTC, turn on the amber engine lamp, and run the engine in a default range.

When this occurs, the EWPS, CAP, IST, and Coolant Temperature Compensation features are disabled.

EFAN (Engine Fan) Control

DTC	SPN	FMI	Condition
2338	1639	1	Engine fan speed too low

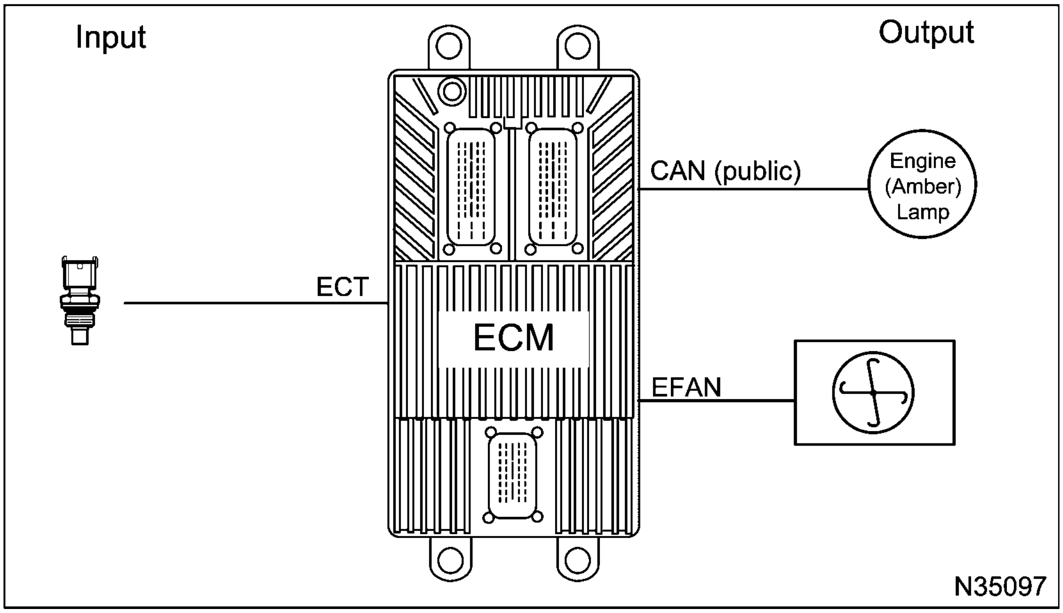

Figure 192 Function diagram for EFAN

The EFAN function diagram includes the following:

- Engine Fan (EFAN) control
- Electronic Control Module (ECM)
- Engine Coolant Temperature (ECT) sensor

Function

The Engine Fan (EFAN) draws additional air through the radiator when the ECT goes above a set temperature (CityStar™only). The EFAN is an electronically controlled viscous drive fan with a fluid port valve that receives a Pulse Width Modulation (PWM) signal from the ECM to control fan speed. The ECM monitors actual fan speed by reading a hall-effect sensor. The ECM adjusts the PWM signal to the EFAN to meet desired fan speed.

Location

The EFAN is mounted to the water pump assembly, on the front of the engine. For additional information, see *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide Electrical Circuit Diagram Manual*.

Tools

- Digital Multimeter (DMM) (page 388)
- 180-Pin Breakout Box (page 385)
- 3-banana Plug Harness (page 386)

EFAN Circuit Diagnostics

DTC	Condition	Possible Causes
2338	Engine fan speed too low	• Fan speed below 400 rpm • ACT PWR OPEN circuit • VREF OPEN or short circuit • SIG GND OPEN circuit • EFAN OPEN or shorted circuit • EFANS OPEN or shorted circuit • Failed EFAN

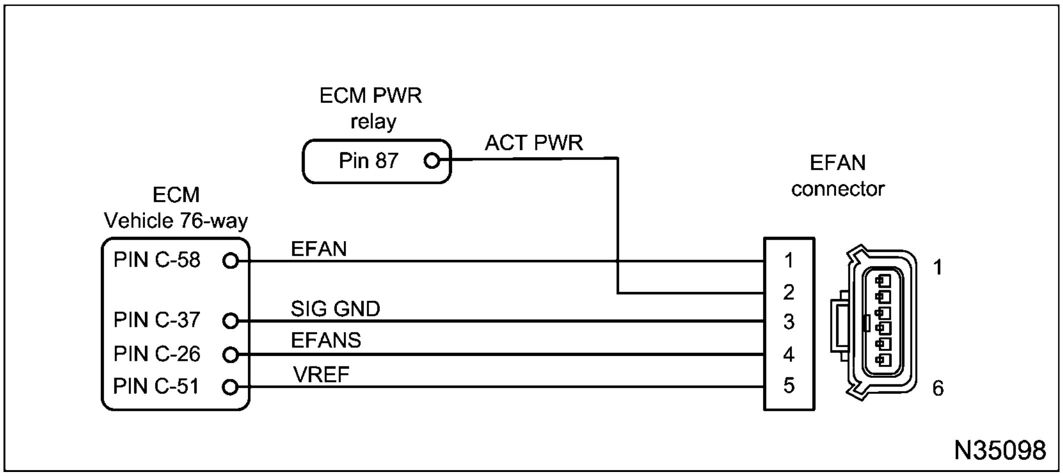

Figure 193 EFAN circuit diagram

Connector Voltage Check

Disconnect EFAN 6-pin connector. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	4.5 ± 0.5 V	If < 4 V, check EFAN circuit for OPEN or short to GND. If > 5 V, check EFAN circuit for short to PWR.
2 to GND	B+	If < B+, check for OPEN or short to GND.
3 to GND	0 V	If > 0 V, check for short to PWR.
4 to GND	5 ± 0.5 V	If < 4.5 V, check EFANS circuit for OPEN or short to GND. If > 5.5 V, check EFANS circuit for short to PWR.
5 to GND	5 ± 0.5 V	If < 4.5 V, check VREF circuit for OPEN or short to GND. If > 5.5 V, check VREF circuit for short to PWR.

EFAN Operational Check

Run test with engine cold to ensure correct measurements. Connect breakout box between ECM and EFAN. Start engine. Set DMM to DC Volts – Hz

Test Point	Low idle	High idle	Comments
4 to GND (EFANS measure Hz)	45 ± 5 Hz	115 ± 15 Hz	If within spec. speed signal indicates the fan is not engaged. Go to next test point. If Above spec, fan is engaged. Check for short in EFAN circuit. Do Harness Resistance Checks. If Below spec. or no frequency, check for circuit faults. Do Harness Resistance Checks. If okay, replace EFAN.
Short 3-banana Plug Harness across EFAN pin 1 to GND, measure EFANS signal			
4 to GND (EFANS measure Hz)	80 ± 15 Hz	280 ± 15 Hz	If within spec. speed signal indicates the fan is engaged. The EFAN is working correctly. If Below spec. or no frequency, check for circuit faults. Do Harness Resistance Checks. If okay, replace EFAN.

If EFANS signal is within specification, the EFAN is working correctly. If DTC is being set, then do Harness Resistance Checks to verify EFANS circuit is not at fault.

Harness Resistance Check

Turn ignition switch OFF. Connect breakout box. Leave ECM and EFAN disconnected.

Test Point	Spec	Comment
1 to C-58	< 5 Ω	If > 5 Ω, check EFAN for OPEN in circuit.
2 to C-1, 3, 5	< 5 Ω	If > 5 Ω, check ACT PWR for OPEN in circuit.
3 to C-37	< 5 Ω	If > 5 Ω, check SIG GND for OPEN in circuit.
4 to C-26	< 5 Ω	If > 5 Ω, check EFANS for OPEN in circuit.
5 to C-51	< 5 Ω	If > 5 Ω, check VREF for OPEN in circuit.

EFAN Circuit Operation

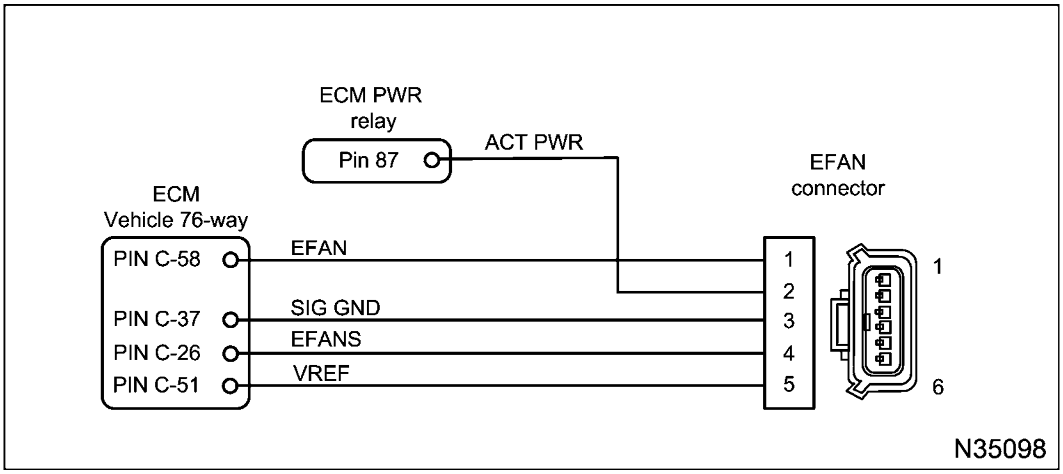

Figure 194 Fan clutch circuit diagram

The EFAN fluid port valve is wired to ACT PWR on pin 2 and, pin 1 is connected to a switching low side driver in the ECM at pin C-58. The EFANS circuit gives ECM pin C-26 a feedback signal from a hall-effect sensor in the EFAN at pin 3, indicating EFAN actual speed. VREF pin C-51 and SIG GND pin C-37 provide power and ground for the EFANS feedback signal.

Fault Detection / Management

The Engine Fan (EFAN) will operate at 100% duty cycle, when a fault is detected. Engine coolant temperature is continuously monitored. If a DTC is detected in the ECT circuit, EFANS circuit, or ECT > 104 °C (219 °F), the fan remains on. When EFANS is less then 400 rpm for 2.5 seconds, a DTC will set.

EFP (Engine Fuel Pressure) Switch

DTC	SPN	FMI	Condition
2372	94	1	Fuel pressure below normal

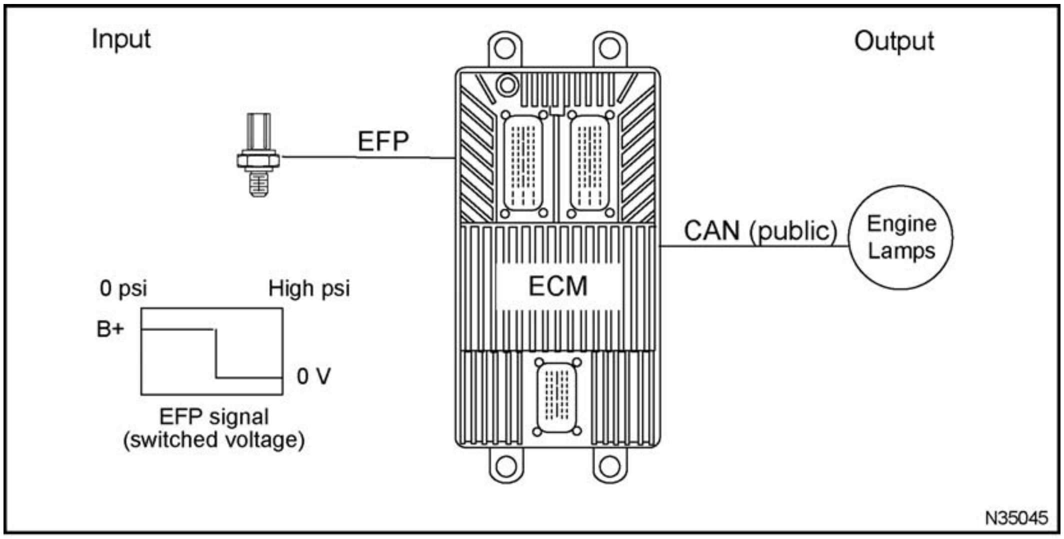

Figure 195 EFP switch function diagram

The EFP switch function diagram includes the following:

- Engine Fuel Pressure (EFP) switch
- Electronic Control Module (ECM)
- Engine lamps

Function

The EFP switch provides a signal to the ECM indicating fuel supply pressure. During engine operation, if fuel pressure is below 30 psi, the ECM reduces ICP pressure to 14 MPa.

Switch Location

The EFP switch is installed in the secondary fuel filter housing.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 180-Pin Breakout Box (page 385)
- Terminal Test Adapter Kit (page 392)
- 3–banana Plug Harness (page 386)

EFP Switch End Diagnostics

DTC	Condition	Possible Causes
2372	Fuel pressure below normal	• Dirty fuel filter • Fuel inlet restriction • Debris in fuel regulator • Failed fuel pump • EFP circuit OPEN • Failed EFP switch

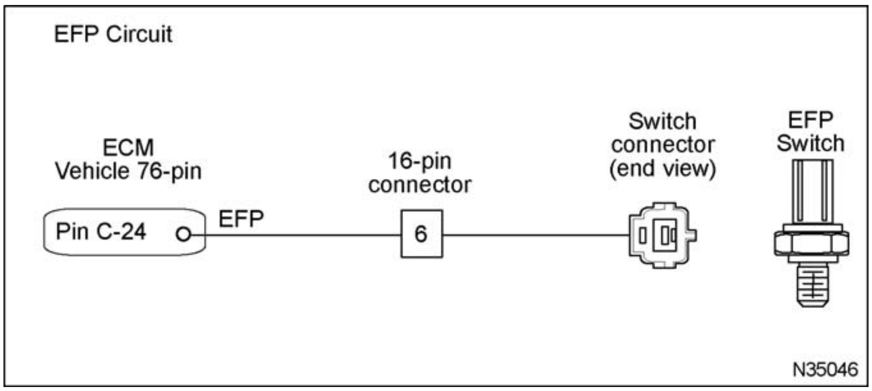

Figure 196 EFP circuit diagram

EFP Pin-point Diagnostics

Connector Voltage Check

Clear DTC. Disconnect sensor connector. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	B+	If < B+, check for short to GND. Do Harness Resistance Check.

Short EFP circuit to GND. Start engine. If DTC does not set, check actual fuel pressure. If within specification, then replace EFP switch.

Harness Resistance Check

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

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

EFP Circuit Operation

Fault Detection / Management

The ECM monitors the EFP switch when the engine is running. If signal voltage is not 0 V while the engine is running, a DTC will be set. The EFP switch is a normally OPEN switch and closes at 30 psi.

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 mismatched between key-on/off

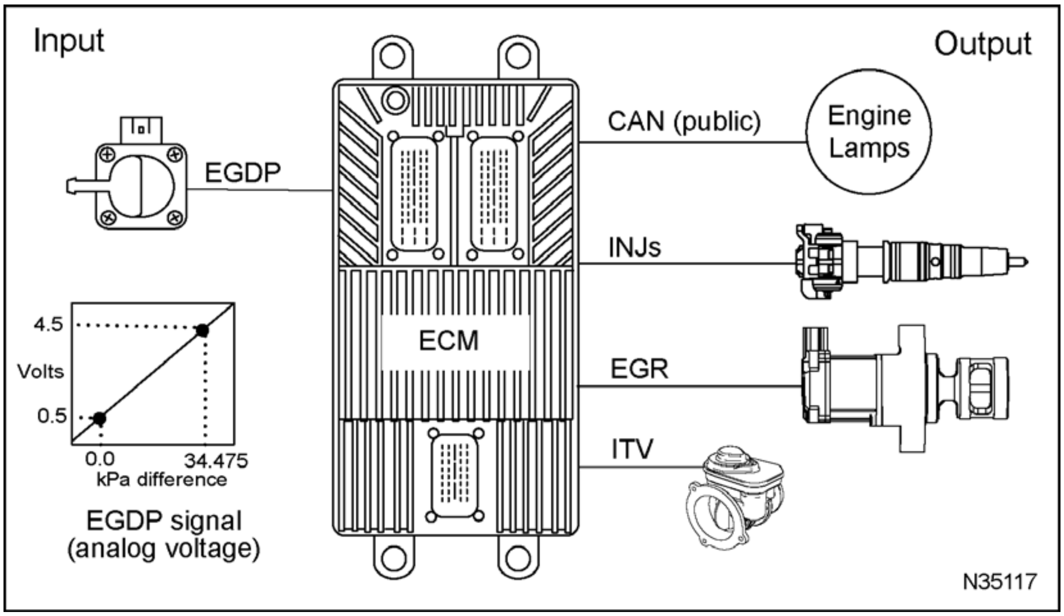

Figure 197 Function diagram for the EGDP sensor

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)
- Engine lamps
- 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 will monitor this sensor along with the EGT1, EGT2, EGT3, EGR and ITV.

Sensor Location

The EGDP sensor is a differential pressure sensor with two tap-offs installed down stream of the turbocharger, one before the DPF and one after.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 3-banana Plug Harness (page 386)
- Breakout Box
- DDP Breakout Harness (page 390)
- Terminal Test Adapter Kit (page 392)

EGDP Sensor End Diagnostics

DTC	Condition	Possible Causes
1729	EGDP signal out-of-range LOW	• EGDP signal OPEN or short to GND • VREF circuit Open • Failed sensor
1731	EGDP signal out-of-range HIGH	• EGDP signal short to PWR • 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

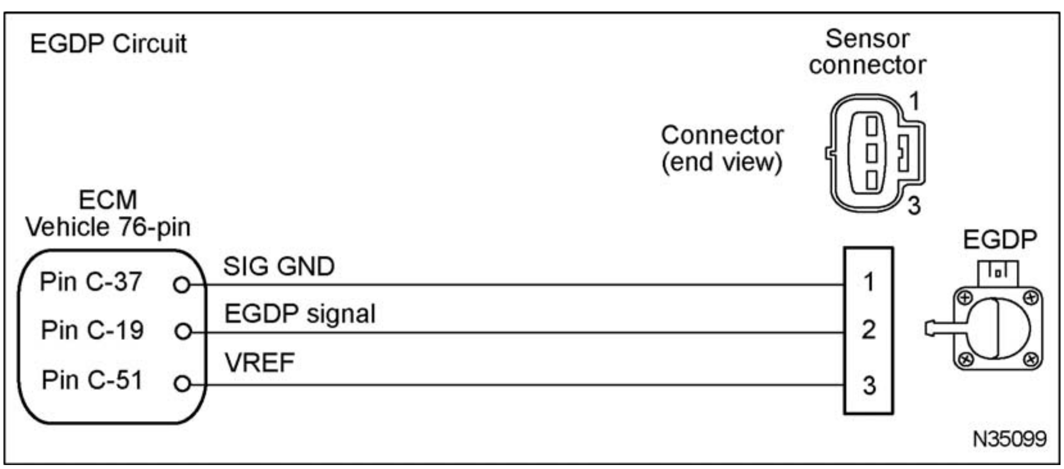

Figure 198 EGDP circuit diagram

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 KOEO specifications. See “Performance Specifications”.
4. Monitor sensor voltage. Verify an active DTC for the sensor.
   - 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 spike and the DTC will go 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 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 Checks (page 278).
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 Checks (page 278).
DMM - Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Checks (page 278).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

EGDP Pin-point Diagnostics

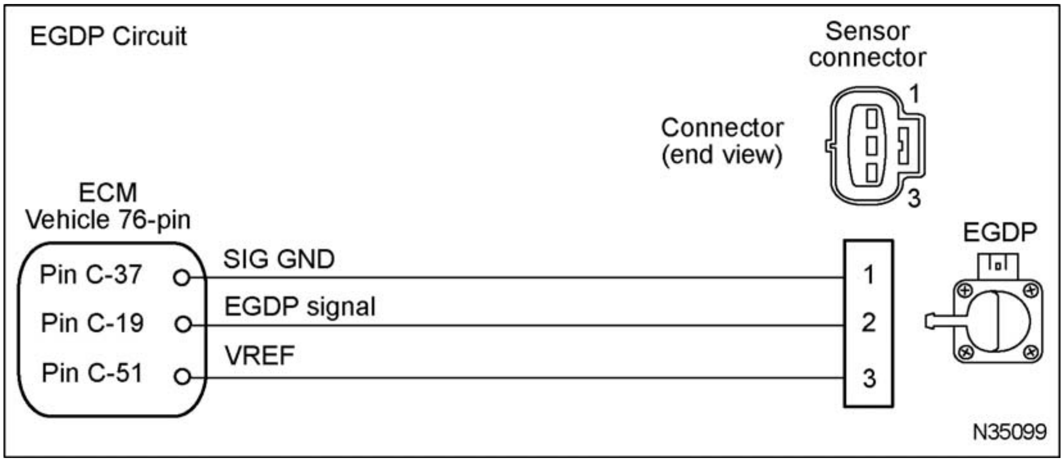

Figure 199 EGDP circuit diagram

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	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Checks (page 278).
2 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Checks (page 278).

Connector Resistance Checks to GND

Turn ignition switch 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 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 a 5 V reference voltage at Pin 3 from ECM Pin C-51. The EGDP is grounded at Pin 1 from ECM Pin C-37 and returns a variable voltage signal from Pin 2 to ECM Pin C-19.

EGR (Exhaust Gas Recirculation) Valve

DTC	SPN	FMI	Condition
1362	412	0	EGR valve internal high circuit failure
1363	412	1	EGR valve internal low circuit failure
1396	7137	12	EGRV Initialization Fault
1397	7137	4	EGR position in-range fault
1398	8327	7	EGR unable to achieve desired position
2368	8146	7	EGR valve communication fault
2391	2791	11	EGR valve internal circuit failure
2392	7138	6	EGR duty cycle above limit
2393	7137	2	EGR position sensor fault
2394	8146	2	EGR valve not receiving ECM CAN messages
2395	7317	3	EGRH OCC self-test failed
2396	7317	4	EGRL OCC self-test failed

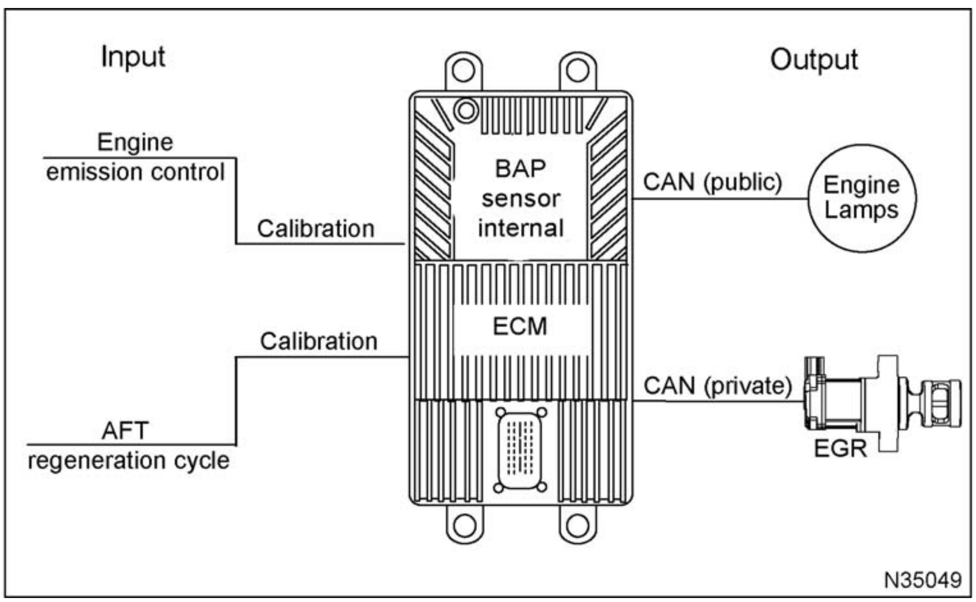

Figure 200 Function diagram for the EGR valve

The EGR valve function diagram includes the following:

- Electronic Control Module (ECM) with internal Barometric Absolute Pressure (BAP) sensor
- Exhaust Gas Recirculation (EGR) valve
- Engine lamps

Function

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

The EGR system reduces NO_X by recirculating exhaust gasses 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 top front of intake manifold.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 180-Pin Breakout Box (page 385)
- EGR Valve Breakout Harness (page 389)
- Terminal Test Adapter Kit (page 392)

EGR Pin-point Diagnostics

DTC	Condition	Possible Causes
1362	EGR valve internal high circuit failure	Failed EGR valve
1363	EGR valve internal low circuit failure	
1396	EGRV Initialization Fault	• Private CAN circuits OPEN or short to PWR or GND • OPEN PWR or GND circuits to EGR valve • Failed EGR valve
1397	EGR position in-range fault	
1398	EGR unable to achieve desired position	
2368	EGR valve communication fault	
2391	EGR valve internal circuit failure	
2392	EGR duty cycle above limit	
2393	EGR position sensor fault	
2394	EGR valve not receiving ECM CAN messages	
2395	EGRH OCC self-test failed	
2396	EGRL OCC self-test failed	

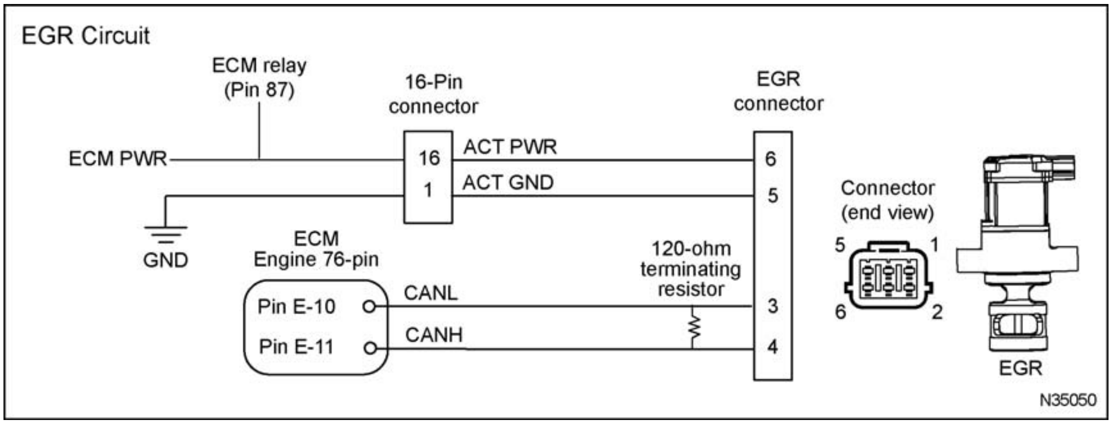

Figure 201 EGR circuit diagram

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Verify sensor voltage is within KOEO specification. See “Performance Specification” section.
3. Monitor sensor voltage. Verify an active 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 PID will spike 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.

Connector Voltage Check

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

Test Point	Spec	Comment
6 to GND	B+	If < B+, check ACT PWR circuit for OPEN or short to GND, or blown fuse. Do Harness Resistance Check (page 282).
5 to 6	B+	If < B+, check ACT PWR GND circuit for OPEN. Do Harness Resistance Check (page 282).
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.

EGR Actuator – Standard and Output State Test

Connect breakout harness between ECM and EGR valve. Run KOEO Standard Test and KOEO Output State Test.

Test	Spec	Comment
Standard Test / Output Circuit Check	90 %	If < 90 %, check for OPEN or Short in EGR Control Circuit. Do Harness Resistance Check (page 282).
Output State HIGH	90 %	If < 90 %, check for OPEN or Short in EGR Control Circuit. Do Harness Resistance Check (page 282).
Output State LOW	0 %	If > 0%, check for OPEN or Short in EGR Control Circuit. Do Harness Resistance Check (page 282).

Harness Resistance Check

Turn ignition switch OFF. Connect breakout box and breakout harnesses to EGR valve and ACT PWR relay. Leave ECM, EGR, and relay disconnected.

Test Point	Spec	Comment
3 to E-10	< 5 Ω	If > 5 Ω, check CANL for OPEN in circuit.
3 to GND	> 1 kΩ	If < 1 kΩ, check CANL for short to GND.
4 to E-11	< 5 Ω	If > 5 Ω, check CANH for OPEN in circuit.
4 to GND	> 1 kΩ	If < 1 kΩ, check CANH for short to GND.
5 to GND	< 5 Ω	If > 5 Ω, check ACT PWR GND for OPEN in circuit. See *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for additional information.
6 to 87 (relay)	< 5 Ω	If > 5 Ω, check ACT PWR for OPEN in circuit.
		If < 5 Ω, and no voltage was detected on the connector voltage table, do ACT PWR relay test.
6 to GND	> 1 kΩ	If < 1 kΩ, check ACT PWR for short to GND.
If measurements are in specification, replace the EGR valve.		

EGR Circuit Operation

The EGR valve receives power at Pin 6, from ACT PWR relay Pin 87. Ground for the EGR valve is supplied at Pin 5. The ECM controls the EGR valve through the CAN (private) circuits, CANH, ECM E-11 to EGR Pin 4, and CANL, ECM E-10 to EGR Pin 3.

CAN (private) Circuit Operation

The private Controller Area Network (CAN) provides a communication link between the ECM and a specific engine controller. The EGR valve communicates faults and is controlled through the private CAN network.

CAN (private) versus CAN (public)

Public CAN networks communicates with many different modules. Each path ends in a module connection or a 120-ohm terminating resistor which reduce reflections. The private CAN system only communicates 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 will disrupt communications.

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

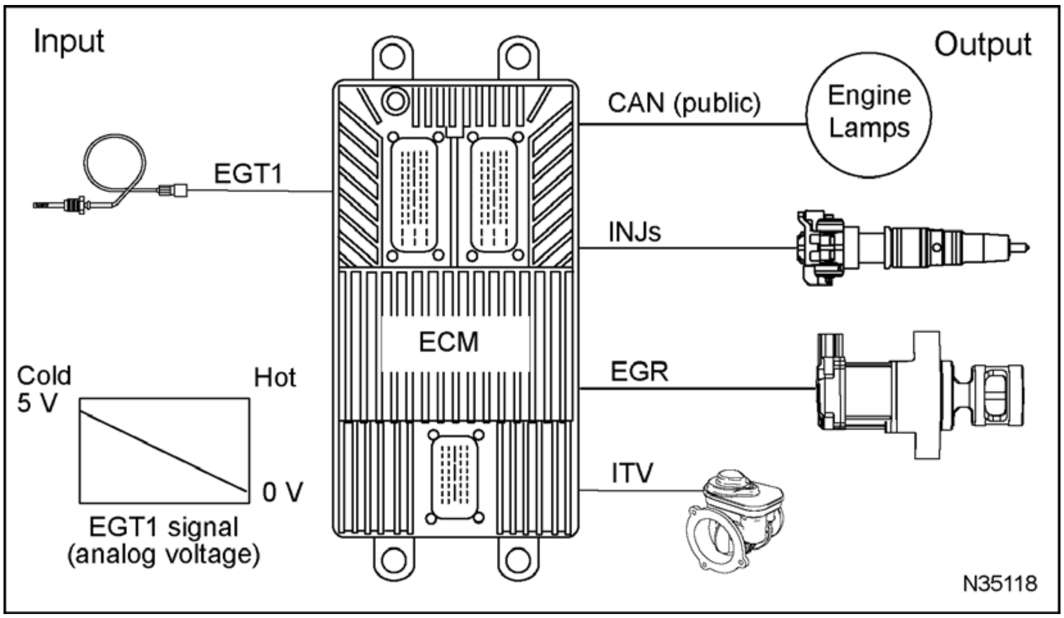

Figure 202 EGT1 sensor function diagram

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)
- Engine lamps
- Regeneration lamp

Function

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

Sensor Location

The EGT1 sensor is the first exhaust temperature sensor installed down stream of the turbocharger, installed just before the Diesel Oxidation Catalyst.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 3-banana Plug Harness (page 386)
- 500 Ohm Resistor Harness (page 387)
- Breakout Box
- Exhaust Temperature Breakout Harness (page 390)
- Terminal Test Adapter Kit (page 392)

EGT1 Sensor End Diagnostics

DTC	Condition	Possible Causes
1737	EGT1 signal out-of-range LOW	• EGT1 signal circuit short to GND • Failed sensor
1738	EGT1 signal out-of-range HIGH	• EGT1 signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor
2675	EGT1 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

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 DTC for the sensor.
   - 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 spike 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.

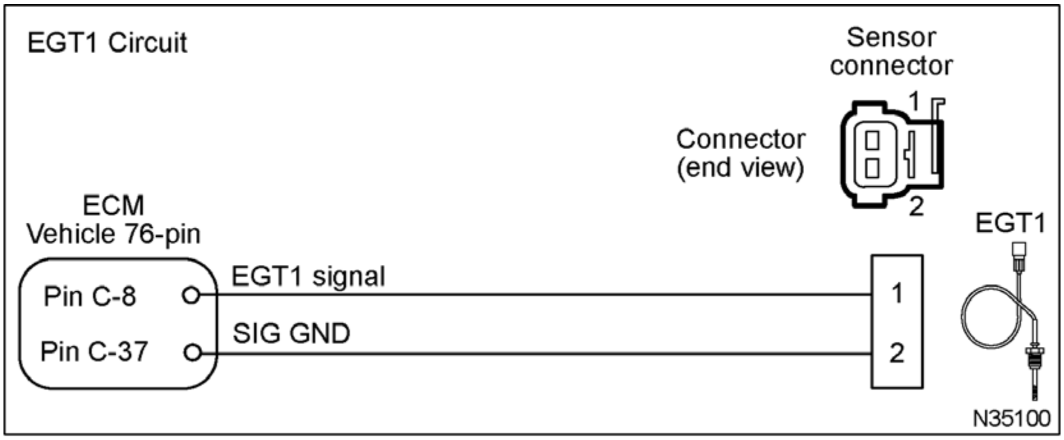

Figure 203 EGT1 circuit diagram

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 1738	If DTC 1737 is active, check EGT1 signal for short to GND. Do Harness Resistance Checks (page 286).
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 Checks.
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 Checks.
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

EGT1 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
2 to GND	0 V	If > 0.25 V, check for short to PWR.
1 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Checks (page 286).

Connector Resistance Checks to GND

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

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

Harness Resistance Check

Turn ignition switch OFF. Connect breakout box and Exhaust Temperature Breakout Harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

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

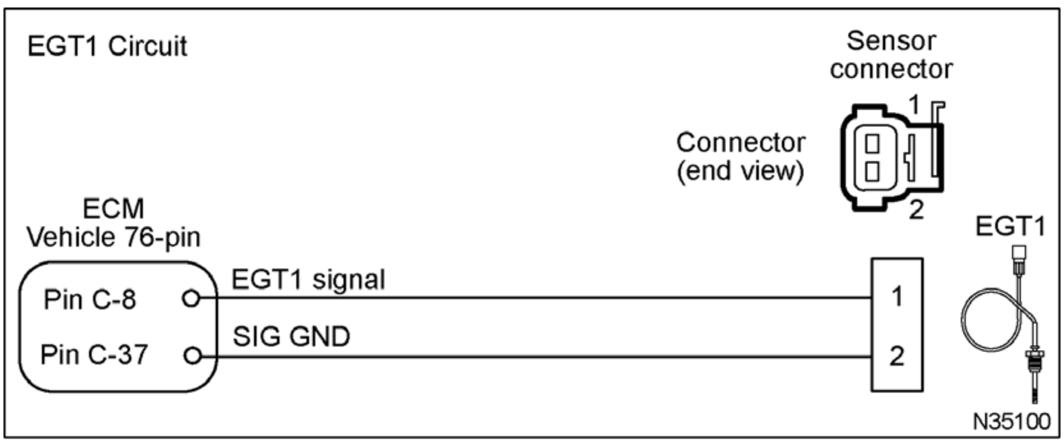

Figure 204 EGT1 circuit diagram

EGT1 Circuit Operation

The EGT1 is a thermistor sensor supplied with a 5 V reference voltage at Pin 1 from ECM Pin C-8. EGT1 is grounded at Pin 2 from ECM Pin C-37.

As temperature increases, the resistance of the thermistor decreases. This causes the signal voltage to decrease.

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	2	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

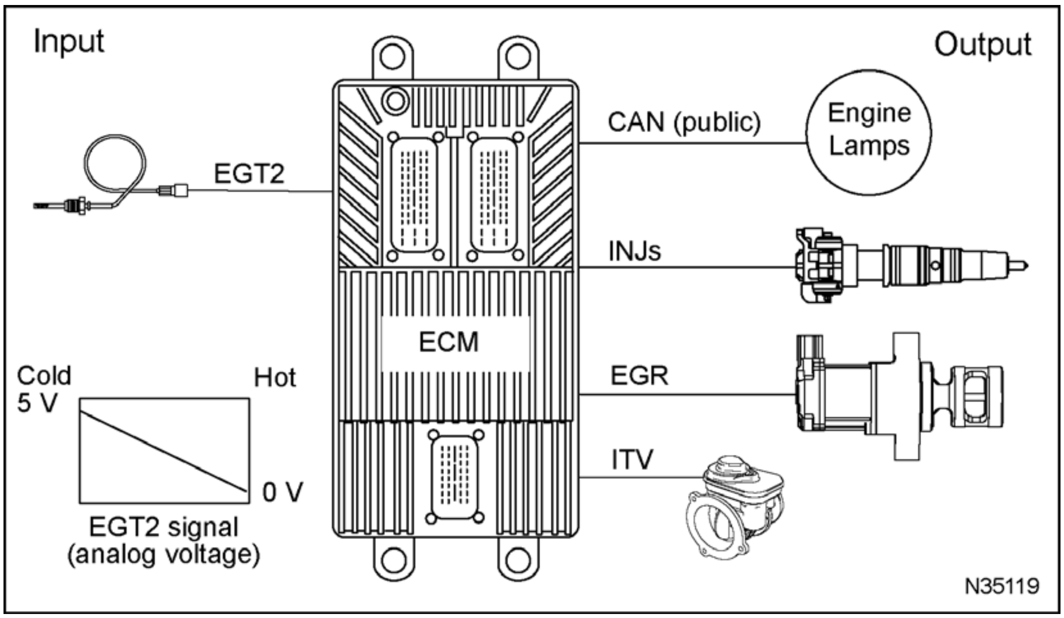

Figure 205 EGT2 sensor function diagram

The EGT2 sensor function diagram includes the following:

- Exhaust Gas Temperature 2 (EGT2) sensor
- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR) valve
- Intake Throttle Valve (ITV)
- Fuel injectors (INJ)
- Engine lamps
- Regeneration lamp

Function

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

Sensor Location

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

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 3-banana Plug Harness (page 386)
- 500 Ohm Resistor Harness (page 387)
- Breakout Box
- Exhaust Temperature Breakout Harness (page 390)
- Terminal Test Adapter Kit (page 392)

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 2681	EGT2 reading off compared to EGT1 and EGT3	• EGT2 biased circuit or sensor • EGT2 sensor outside of exhaust system

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 DTC for the sensor.
   - 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 spike 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.

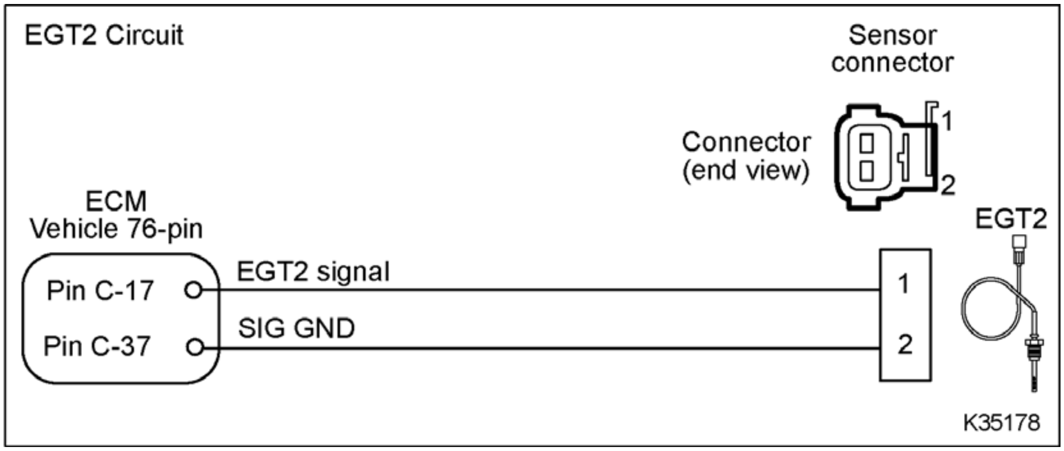

Figure 206 EGT2 circuit diagram

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 1742	If DTC 1741 is active, check EGT2 signal for short to GND. Do Harness Resistance Checks (page 290).
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 Checks (page 290).
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 Checks (page 290).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

EGT2 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
2 to GND	0 V	If > 0.25 V, check for short to PWR.
1 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Checks (page 290).

Connector Resistance Checks to GND

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

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

Harness Resistance Check

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

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

EGT2 Circuit Operation

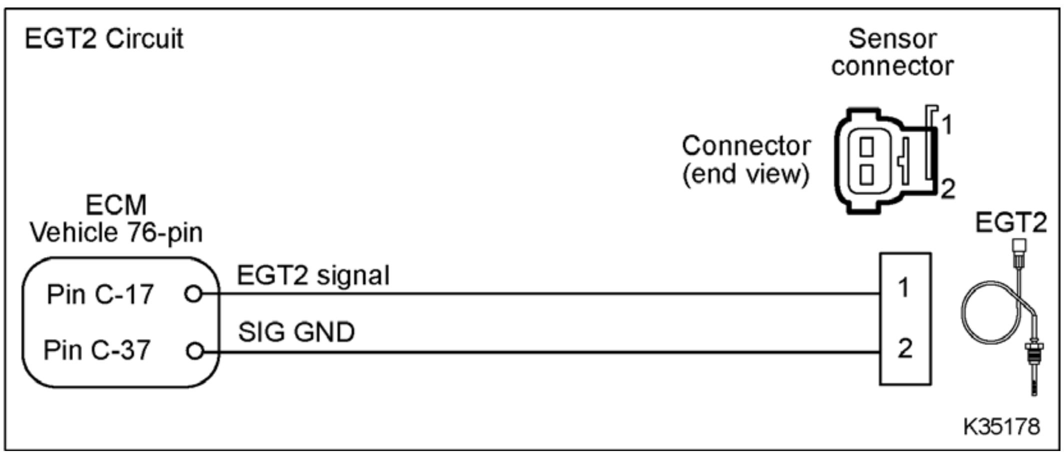

Figure 207 EGT2 circuit diagram

The EGT2 is a thermistor sensor supplied a 5 V reference voltage at Pin 1 from ECM Pin C-17 and is grounded at Pin 2 from ECM Pin C-37. As temperature increases, the resistance of the thermistor decreases. This causes the signal voltage to decrease.

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

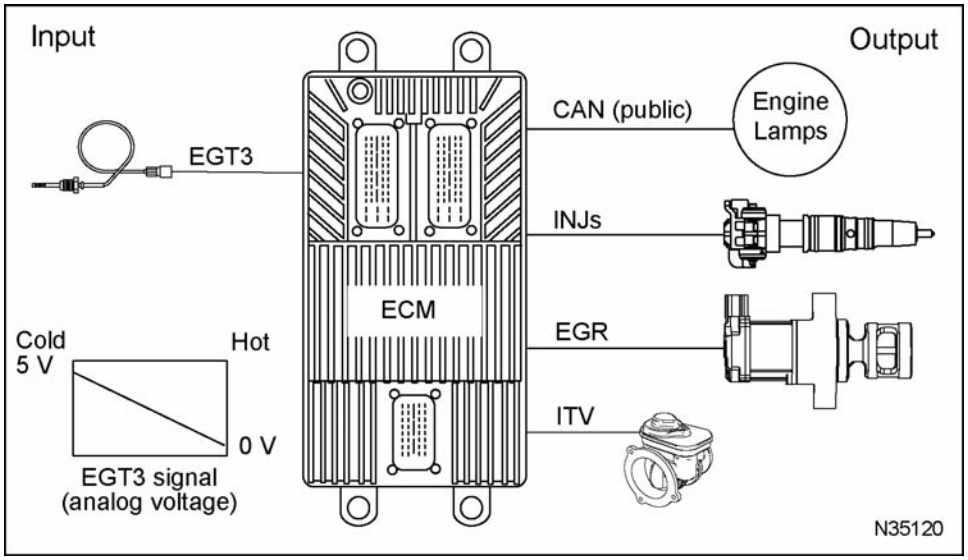

Figure 208 Function diagram for the EGT3 sensor

The EGT3 sensor function diagram includes the following:

- Exhaust Gas Temperature 3 (EGT3) sensor
- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR) valve
- Intake Throttle Valve (ITV)
- Fuel injectors (INJ)
- Engine lamps
- Regeneration lamp

Function

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

Sensor Location

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

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 3-banana Plug Harness (page 386)
- 500 Ohm Resistor Harness (page 387)
- Breakout Box
- Exhaust Temperature Breakout Harness (page 390)
- Terminal Test Adapter Kit (page 392)

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

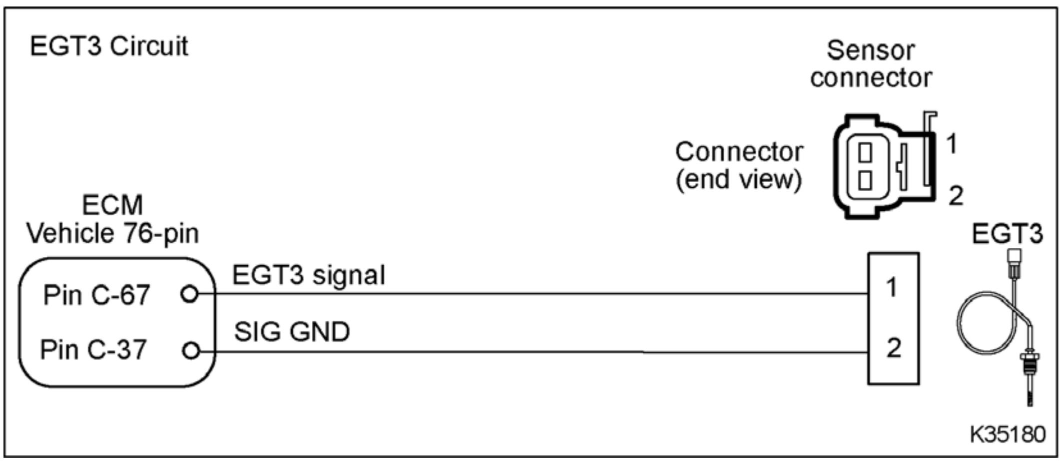

Figure 209 EGT3 circuit diagram

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 DTC for the sensor.
   - 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 spike 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 1745	If DTC 1744 is active, check EGT3 signal for short to GND. Do Harness Resistance Checks (page 293).
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 Checks (page 293).
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 Checks (page 293).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

EGT3 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
2 to GND	0 V	If > 0.25 V, check for short to PWR.
1 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Checks (page 293).

Connector Resistance Checks to GND

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

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

Harness Resistance Check

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

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

EGT3 Circuit Operation

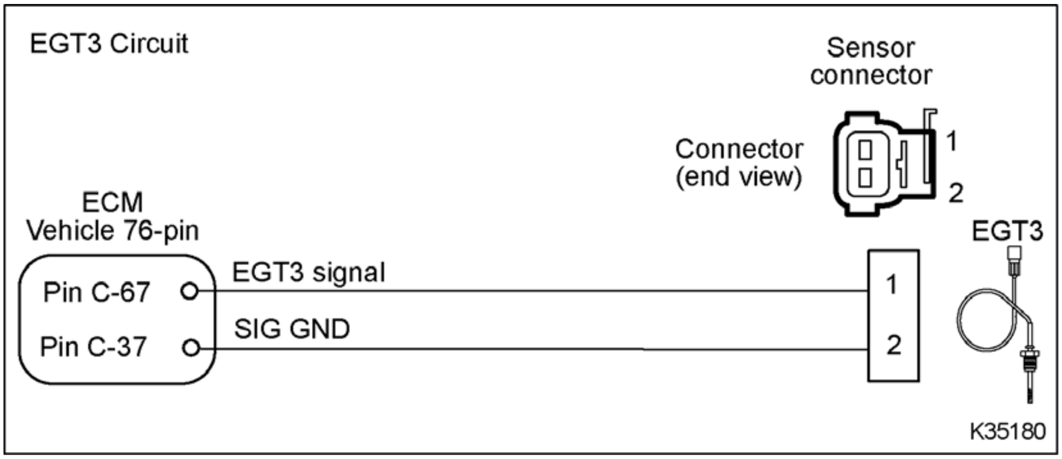

Figure 210 EGT3 circuit diagram

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

EOP Switch (Engine Oil Pressure)

DTC	SPN	FMI	Condition
None			

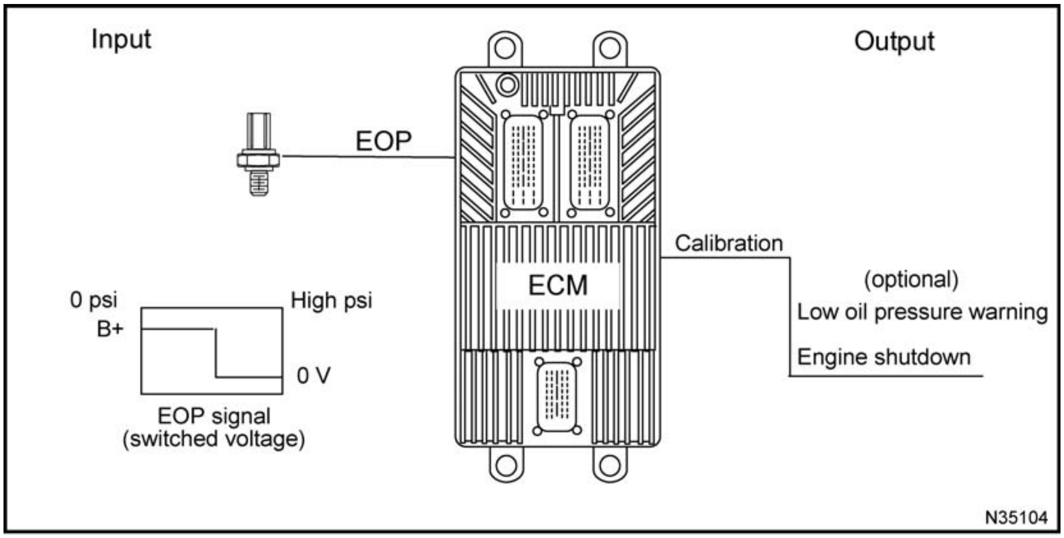

Figure 211 Function diagram for the EOP switch

The EOP switch function diagram includes the following:

- Engine Oil Pressure (EOP) switch
- Electronic Control Module (ECM)

Function

The EOP switch provides a signal to the ECM indicating oil pressure. The optional Engine Warning and Protection System (EWPS), warns the operator when engine oil pressure is low.

Switch Location

The EOP switch is installed in the oil filter housing on top of the engine.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 3-banana Plug Harness (page 386)
- 180-Pin Breakout Box (page 385)
- Terminal Test Adapter Kit (page 392)

EOP Switch End Diagnostics

DTC	Condition	Possible Causes
None	Warning lamp or gauge alert	• Low oil level • Low oil pressure due to mechanical failure • EOT circuit OPEN • Failed EOP switch

Figure 212 EOP circuit diagram

EOP Pin-point Diagnostics

Connector Voltage Check

Turn ignition switch to ON, engine OFF. Use EST to monitor PID.

Test Point	Spec	Comment
EST – Monitor EOP	0 psi	If > 0 psi, check EOP circuit for short to GND.
Start engine and monitor EOP to change state.		
EST – Monitor EOP	25 psi	If < 25 psi, check EOP circuit for OPEN.
If EOP PID did not change state at engine start-up, check actual oil pressure with a gauge. If EOP circuit is not OPEN and oil pressure is within specification, replace the EOP switch.		

Harness Resistance Check

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

Test Point	Spec	Comment
1 to E-16	< 5 Ω	If > 5 Ω, check circuit for OPEN.
1 to GND	> 1K Ω	If < 1K Ω, check for short to GND

EOP Circuit Operation

The ECM monitors the EOP switch at pin E-16. If signal voltage is not 0 V while the engine is running, the EWPS will set a DTC and the Oil Lamp or gauge will indicate low oil pressure. The EOP switch is a normally OPEN switch and closes at 6 psi.

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

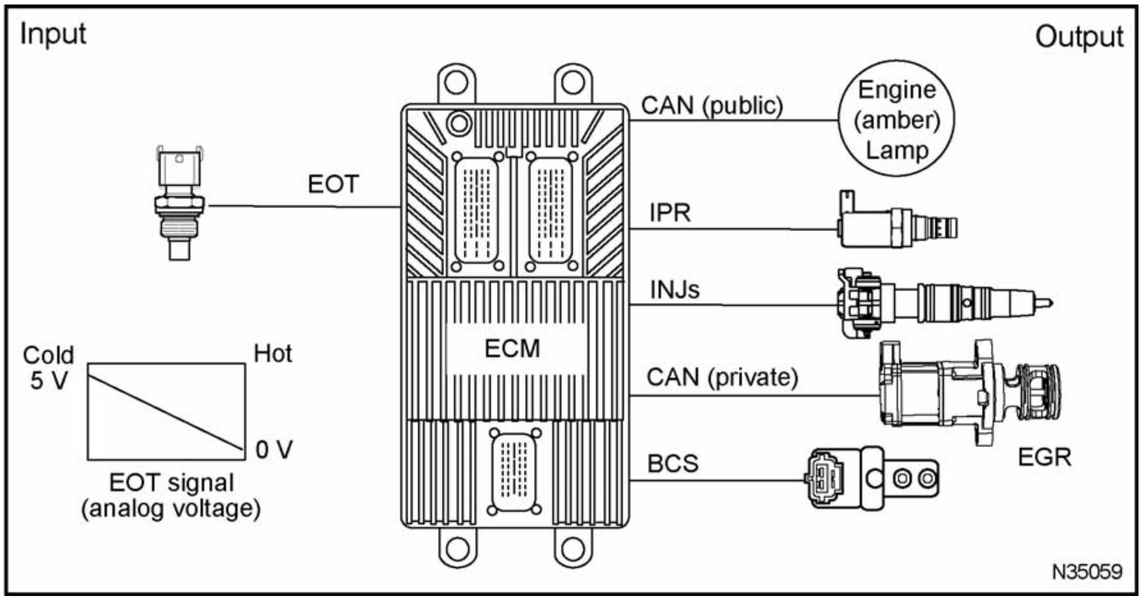

Figure 213 EOT sensor function diagram

The EOT sensor function diagram includes the following:

- Engine Oil Temperature (EOT) sensor
- Electronic Control Module (ECM)
- Fuel injectors (INJ)
- Exhaust Gas Recirculation (EGR) valve
- Boost Control Solenoid (BCS)
- Injection Pressure Regulator (IPR) valve
- Engine lamp (amber)

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. This is accomplished by the ECM monitoring the EOT sensor input and adjusting the fuel injector operation accordingly.

Low idle speed is increased proportionally when the engine oil temperature is between 15 °C (59 °F) at 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 next to the EOP switch.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 3-banana Plug Harness (page 386)
- 500 Ohm Resistor Harness (page 387)
- 180-Pin Breakout Box (page 385)
- Temperature Sensor Breakout Harness (page 392)
- Terminal Test Adapter Kit (page 392)

EOT Sensor End Diagnostics

DTC	Condition	Possible Causes
1299	EOT in-range fault	• Biased EOT circuit/sensor
1311	EOT signal out-of-range LOW	• EOT signal circuit short to GND • Failed sensor • Incorrect EOT sensor connection
1312	EOT signal out-of-range HIGH	• EOT signal OPEN or short to PWR • SIG GND circuit OPEN • Incorrect EOT sensor connection • Failed EOT sensor

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

1. Using EST with MasterDiagnostics® software, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active DTC for the sensor.
   - 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 spike and the DTC will go active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor. Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.
4. Connect breakout harness to engine harness. Leave sensor disconnected.

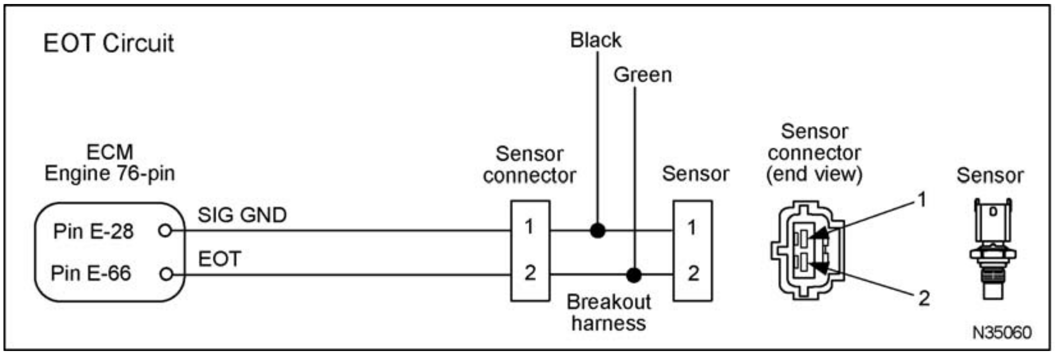

Figure 214 EOT circuit diagram

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 1312	If DTC 1311 is active, check EOT signal for short to GND. Do Harness Resistance Checks (page 301).
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 Checks (page 301).
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 Checks (page 301).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

EOT 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 301).

Connector Resistance Check to GND

Turn ignition switch 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 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.

Operational Voltage Check

Use EST to read PIDs during Continuous Monitor test or DMM to read signal circuit with breakout harness or breakout box.

Test Point	Coolant Temperature	Resistance	Voltage
EST / DMM	108 °C (228 °F)	1.605 kΩ	0.37 V
2 to GND or E-66 to GND	87.7 °C (190 °F)	3 kΩ	0.65 V
	0 °C (32 °F)	91.1 kΩ	3.86 V
	-17.8 °C (0 °F)	208 kΩ	4.25 V

EOT Circuit Operation

The EOT is a thermistor sensor supplied with a 5 volt reference voltage at Pin 2 from ECM Pin E–66 and is grounded at Pin 1 from ECM Pin E–28. As temperature increases, thermistor resistance decreases, causing 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 will set a DTC, turn on the amber engine lamp, and run 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 and 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

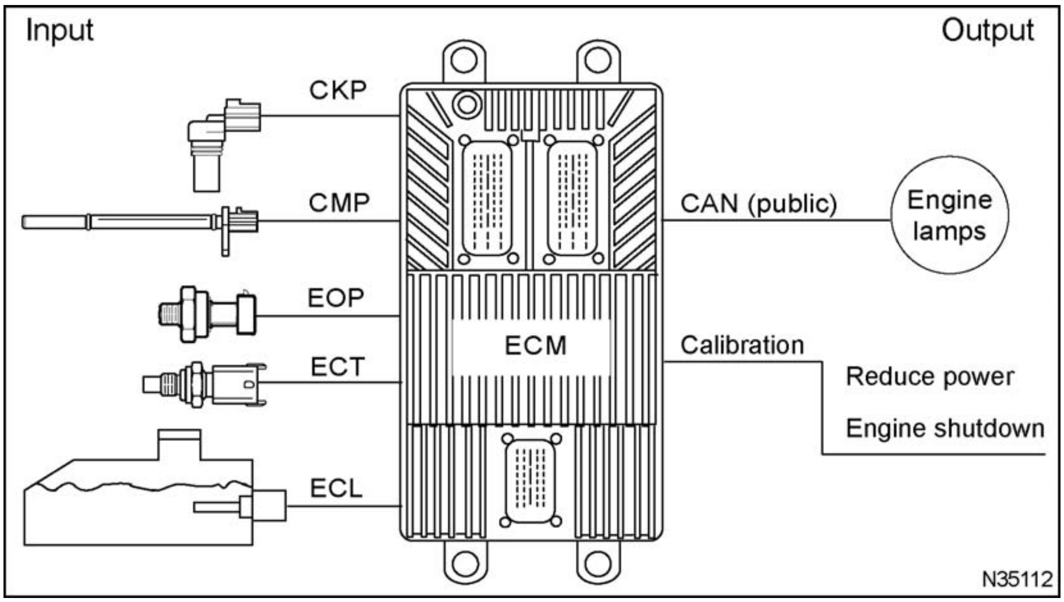

Figure 215 Function diagram for EWPS

The EWPS function diagram includes the following:

- Electronic Control Module (ECM)
- Crankshaft Position (CKP) sensor
- Camshaft Position (CMP) sensor
- Engine Oil Pressure (EOP) switch
- Engine Coolant Temperature (ECT)
- Engine Coolant Level (ECL) switch
- Engine lamps

Function

The Engine Warning Protection System (EWPS) warns the operator of conditions that can damage the engine. Optional engine shut down is available and is activated if one or more critical conditions are detected.

The Standard Warning System is the base system in which all engines are equipped. If one of these faults are detected, the ECM will illuminate the red OIL/WATER (OWL) lamp and set a corresponding DTC.

Standard Warning – No engine shut down available.

- RPM - Engine over-speed warning

- ECT - Engine over-heat warning

The following optional features to this base system provide added warning or protection.

2-way Warning – No engine shut down available.

- ECT - Engine over-heat warning
- EOP - Low engine oil pressure warning

3-way Warning – No engine shut down available.

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

3-way Protection – Engine shut down is available if one or more critical condition is detected.

NOTE: The protection mode is not offered on school buses or emergency vehicles.

- ECT, EOP, ECL - Same as 3-way Warning
- ECT - Engine over-heat 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 red OIL/WATER (OWL) lamp and set a DTC.

Critical – Temperature above specific threshold will shut down the engine and set a DTC. The operator has 30 seconds before the engine shuts off. The ECM allows the engine to be restarted and run for 30 second periods.

Event log – This feature will log occurrences of the event according to the engine hours and odometer readings.

EWPS Programmable Parameters

ENG-PROT-MODE

- 0 = Standard Warning
- 1 = 3-way Warning
- 2 = 3-way Protection
- 3 = 2-way Warning

ECT-WARNING – Specifies temperature threshold where the OIL/WATER lamp and warning buzzer will be turned on.

ECT-CRITICAL – Specifies temperature threshold where an engine shut down will be 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 then (PROT-ENG-SPD1). Failure to meet set point will turn on the OIL/WATER lamp and warning buzzer.

OIL-PRES-WARN-SPD2 – Specifies the minimum oil pressure with engine speed greater then (PROT-ENG-SPD1) but less then (PROT-ENG-SPD2). Failure to meet set point will turn on the OIL/WATER lamp and warning buzzer.

OIL-PRES-WARN-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 turn on the OIL/WATER lamp and warning buzzer.

OIL-PRES-CRIT-SPD1 – Specifies the minimum oil pressure with engine speed greater then (PROT-ENG-SPD1). Failure to meet set point will command an engine shut down.

OIL-PRES-CRIT-SPD2 – Specifies the minimum oil pressure with engine speed greater then (PROT-ENG-SPD1) but less then (PROT-ENG-SPD2). Failure to meet set point will command 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.

EWPS DTCs

DTCs are read using the EST with MasterDiagnostics® software.

DTC 2313
EWPS - 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 (page 110).
- DTC 2313 can be set by an OPEN, circuit short to voltage source in the EOP circuit, a loose or failed EOP switch, or low oil pressure.
- When DTC 2313 is active, the red lamp is illuminated.

DTC 2314
EWPS - 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 test (page 110).
- DTC 2314 can be set by an OPEN, circuit short to voltage source in the EOP circuit, a loose or failed EOP switch, or low oil pressure.
- When DTC 2314 is active, the red lamp flashes and sounds an audible signal.

DTC 2315
Engine Speed above Warning Level

- DTC 2315 is set by the ECM when engine rpm exceeds 3600 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 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 by six percent for each degree Celsius of temperature increase. As temperature is reduced, the fuel compensation level is reduced. When cooling system temperature drops below 111 °C (232 °F) the DTC becomes inactive and the engine returns to normal operation.

DTC 2321
ECT above Warning level

- DTC 2321 is set by the ECM when engine coolant temperature is above 113 °C (235 °F). The ECM illuminates the red lamp (OWL for CityStar™). When the temperature drops below 113 °C (235 °F) the DTC will become inactive. For diagnostics, see Coolant Over-temperature (page 100).
- 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 (241 °F). When the temperature drops below 116 °C (241 °F) the DTC will become inactive.

DTC 2322
ECT above Critical level

- DTC 2322 is set by the ECM when the engine coolant temperature is above 116 °C (240 °F). The ECM illuminates the red lamp. When the temperature drops below 116 °C (240 °F) the DTC will become inactive. For diagnostics, see Coolant Over-temperature (page 100).
- For high altitude applications (103 kPa [15 psi] radiator cap), DTC 2322 is set by the ECM when the engine coolant temperature is above 119 °C (246 °F). When the temperature drops below 119 °C (246 °F) the DTC will become inactive.

DTC 2323
ECL below Warning/Critical level

DTC 2323 is set by the ECM when engine coolant is low. When the EWPS mode is set to 3-way protection and DTC 2323 is active, the engine shuts down and the ECM logs engine hours and odometer readings. After shutdown, the engine can be restarted for thirty seconds while DTC 2323 is active. If the coolant level is correct and DTC 2323 is active do ECL Connector Voltage Check (page 250).

FPC (Fuel Pump Control)

DTC	SPN	FMI	Condition
2614	7277	10	Fuel pump relay circuit fault

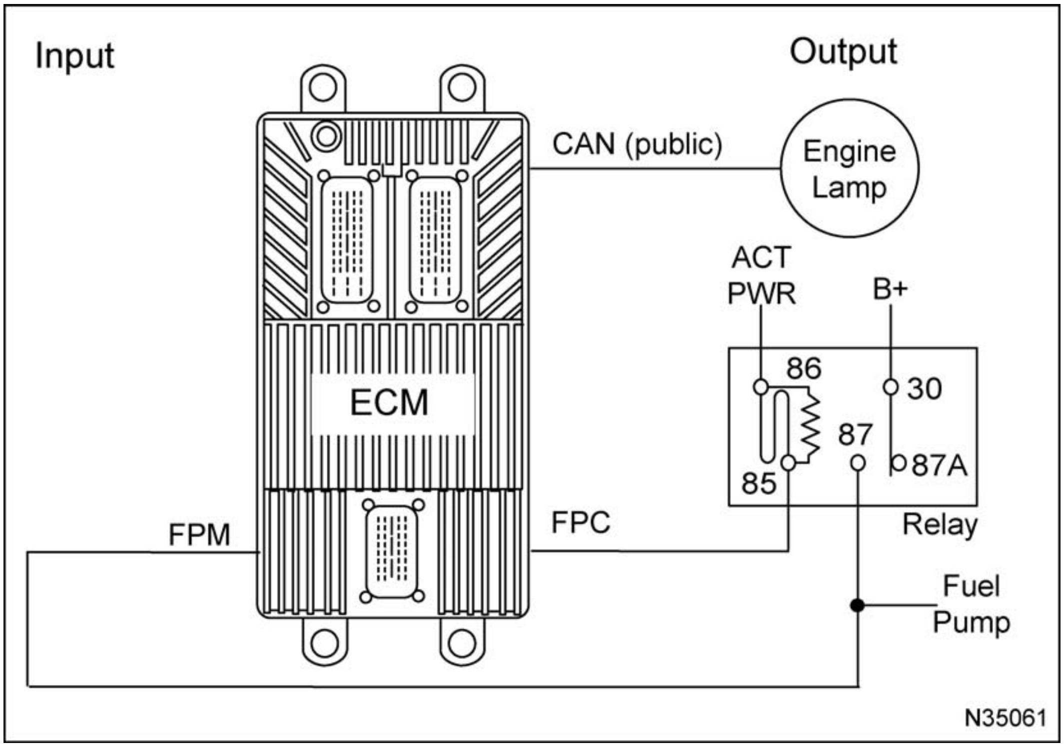

Figure 216 Function diagram for FPC

The fuel pump function diagram includes the following:

- Fuel pump
- Fuel Pump Control (FPC) circuit
- Fuel Pump Monitor (FPM) circuit
- Electronic Control Module (ECM)
- Fuel pump relay
- Engine lamp (amber)

Function

The fuel pump supplies fuel to the engine at approximately 60 psi. The ECM controls the fuel pump through a relay. When the ignition switch is turned on, the ECM energizes the fuel pump relay for 60 seconds. After 60 seconds the ECM turns the fuel pump off unless the engine is running. The ECM monitors the relay's operation with the FPM circuit.

Component Location

The fuel pump is installed inside the Horizontal Fuel Conditioning Module (HFCM) which is mounted on the left frame rail. The fuel pump is serviced separately from the HFCM.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 180-Pin Breakout Box (page 385)

FPC Pin-point Diagnostics

DTC	Condition	Possible Causes
2614	Fuel Pump relay circuit fault	• B+ supply circuit to relay switch OPEN or blown fuse • FPM circuit OPEN or short to GND • Failed relay

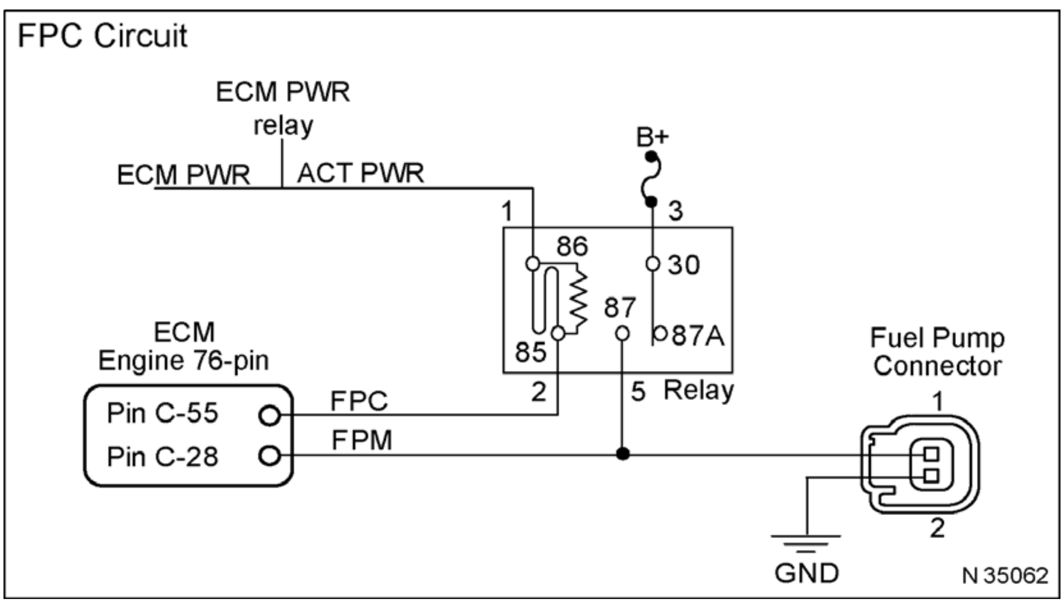

Figure 217 FPC circuit diagram

Voltage Check at Fuel Pump Connector - Output State Test

NOTE: This test is only designed to check electrical circuits to the fuel pump, not the ability to build pressure. See the fuel pressure test in the “Hard Start and No Start Diagnostic” section for low or no fuel pressure.

Disconnect fuel pump 2-pin connector. Turn ignition switch to ON, 60 seconds after the key is turned on, the fuel pump is commanded off. Run Output State Test HIGH and LOW. Monitor PID and use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	0 V	If > 0.25 V after 60 seconds, check for short to PWR or FPC circuit for short to GND, or failed relay.
2 to B+	B+	If < B+, check GND circuit for OPEN
Run Output State Test HIGH.		
1 to GND	0 V	If > 0.25 V, check for short to PWR, or FPC circuit for short to GND, or failed relay.
FPM PID	OFF	If ON when fuel pump is off during output state test HIGH. Check FPM circuit for short to PWR.
Run Output State Test LOW.		
1 to GND	B+	If < B+, check for OPEN circuit between relay and fuel pump connector, or FPC circuit for OPEN, or blown fuse, or failed relay. Do Harness Resistance Check (page 309).
1 to 2	B+	If < B+, check GND circuit for OPEN. Do Harness Resistance Check (page 309).
FPM PID	ON	If OFF when fuel pump is on during output state test LOW. Check FPM circuit for OPEN.

Voltage Check at Relay - Output State Test

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

Test Point	Spec	Comment
3 (30) to GND	B+	If < B+, check B+ circuit to relay switch for OPEN or short to GND, or blown fuse.
1 (86) to GND	B+	If < B+, check ACT PWR circuit to relay coil for OPEN or short to GND, or blown fuse.
Run Output State Test HIGH.		
2 (85) to GND	B+	If < B+, check FPC circuit for short to GND. Do Harness Resistance Check (page 309).
Run Output State Test LOW.		
2 (85) to GND	< 2 V	If > 2 V, check FPC circuit for OPEN. Do Harness Resistance Check (page 309).
5 (87) to GND	B+	If < B+, replace relay.
If all voltage checks are okay, replace the fuel pump.		

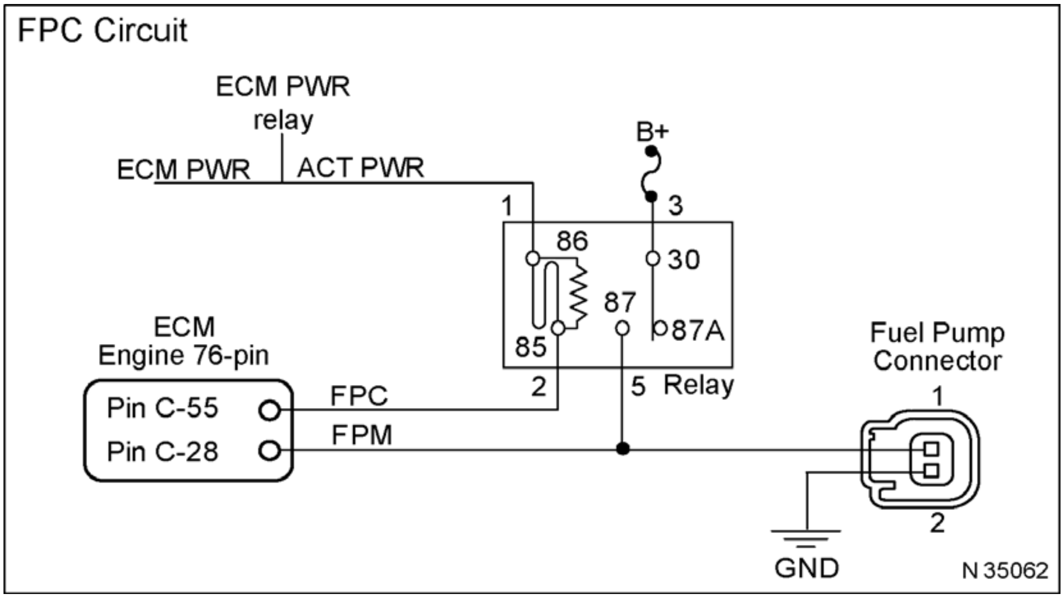

Figure 218 FPC circuit diagram

Harness Resistance Check

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

Test Point	Spec	Comment
C-55 to 2 (85)	< 5 Ω	If > 5 Ω, check for OPEN circuit between ECM and relay terminal.
5 (87) to 1 (fuel pump)	< 5 Ω	If > 5 Ω, check for OPEN circuit between relay terminal and 1 (fuel pump).
C-28 to 5 (87)	< 5 Ω	If > 5 Ω, check for OPEN circuit between ECM and relay terminal.

Turn ignition switch OFF. Disconnect battery GND. Connect breakout box and breakout harness. Leave ECM and relay 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.

1 (86) to C-1, 3 and 5	< 5 Ω	If > 5 Ω, check for OPEN circuit
1 (86) to GND	> 1 kΩ	If < 1 kΩ, check for short to GND
3 (30) to B+	< 5 Ω	If > 5 Ω, check for OPEN circuit or blown fuse.
3 (30) to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

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

FPC Circuit Operation

The ECM uses a relay to control the fuel pump. The ECM energizes the relay by supplying a GND path from Pin C-55 to Pin 2 (85) on the relay coil. The relay coil is powered by ACT PWR at Pin 1 (86). See chassis electrical diagrams.

B+ is supplied to the switch side of the relay Pin 3 (30). When the relay is energized, power is supplied from relay Pin 5 (87) to fuel pump connector Pin 1.

The ECM monitors the relays operation with the FPM circuit Pin C-28 to relay Pin 5 (87).

Fault Detection / Management

The ECM continuously monitors the output of the fuel pump relay, when voltage is not as expected a DTC will be set.

An OPEN or short to ground in the fuel pump 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 will set.

GPC System (Glow Plug Control)

DTC	SPN	FMI	Condition
1375	7264	11	Glow Plug Relay circuit fault

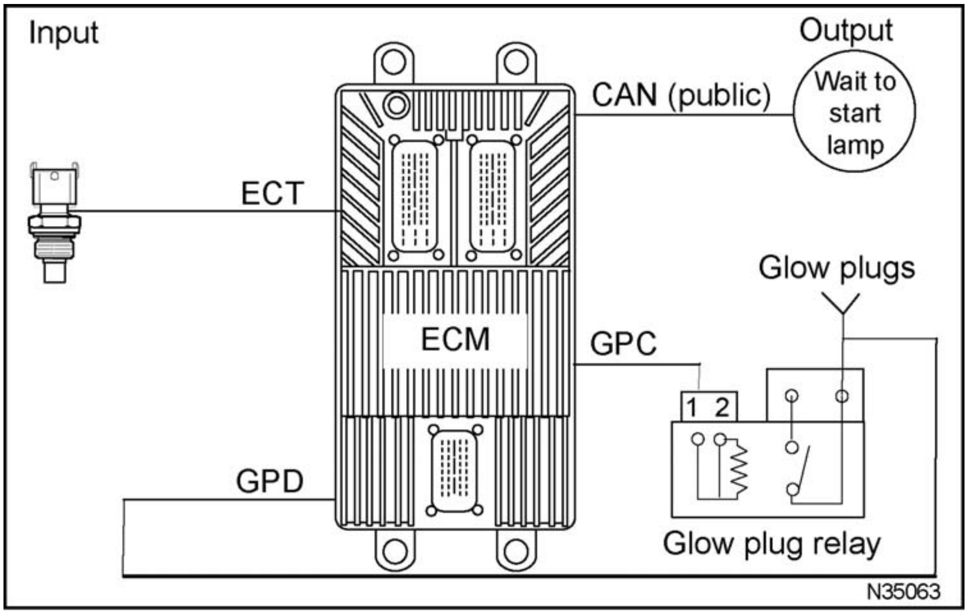

Figure 219 Function diagram for the GPC system

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
- Battery
- Wait To Start lamp (amber)

Function

The Glow Plug Control (GPC) system warms the cylinders before engine cranking to aid cold engine starting and reduce white smoke during warm-up.

Component Location

The glow plug relay is chassis mounted on the ECM bracket. Three glow plugs are installed in each cylinder head, one for each cylinder.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- Amp Clamp (page 387)
- 180-Pin Breakout Box (page 385)
- 16-pin Breakout Harness (page 385)

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 • Failed relay • Glow plug relay control circuit faults

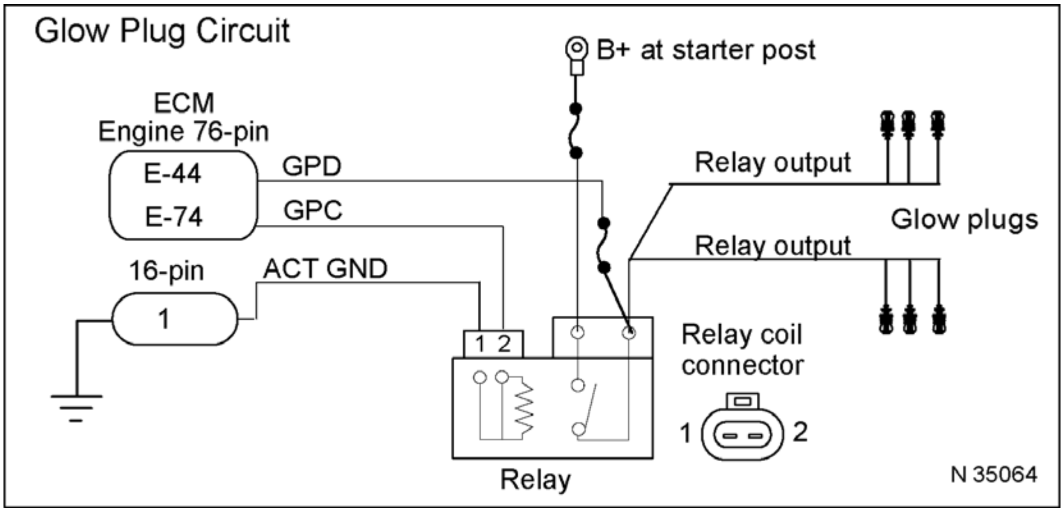

Figure 220 GPC circuit diagram

NOTE: For this procedure, run the KOEO Standard Test. Do not run GPC/IAH test. KOEO Standard Test will enable the relay for 2 to 4 seconds every time the test is run. The GPC/IAH test only enables the relay twice for 30 seconds to prevent element overheating.

Voltage Check on Relay Switch

Turn ignition switch 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 ignition switch 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.

Turn ignition switch to ON. Run KOEO Standard Test. (Relay is commanded on for 2 seconds during this test). Use DMM to measure voltage when the relay is commanded on.		
Measure voltage Relay Output side to GND	B+	If 0 V, do Voltage Check - Relay Coil. If < B+, check for corroded terminal on relay or blown fuse link. Do Amperage Draw Check (page 313).
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

Disconnect relay 2-pin connector. Turn ignition switch to ON. Use DMM to measure voltage

Test Point	Spec	Comment
Pin 1 to GND	0 V	If > 0 V, check for OPEN or short to PWR
Pin 2 to GND	2.74 V	If < 2 V, check for OPEN or short to GND. Do Harness Resistance Checks – Relay Coil.
Run KOEO Standard Test (relay is commanded on for 2 seconds during this test). Use DMM to measure voltage when relay is commanded on.		
Pin 2 to GND	B+	If < B+, check ACT PWR circuit for OPEN. Do Harness Resistance Checks – Relay Coil.
Pin 1 to 2	B+	If < B+, check actuator GND circuit for OPEN. Do Harness Resistance Checks – Relay Coil.
If voltage checks at relay coil are okay, but voltage checks at relay switch failed, replace the relay.		

Amperage Draw Check

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

Measure the amperage going to both cylinder heads, one at a time. 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	30 to 42 Amps after 9 seconds	If 0 A, do Voltage Check on Relay Switch - Output State Test (page 314). If > 0 A, but below specification, check for corroded terminals on relay, glow plugs, and power source. Do Glow Plug Resistance Check (page 314).
Right side	30 to 42 Amps after 9 seconds	If 0 A, do Voltage Check on Relay Switch - Output State Test (page 314). If > 0 A, but below specification, check for corroded terminals on relay, glow plugs, and power source. Do Glow Plug Resistance Check (page 314).
If > 0 A, but below specification, and glow plugs and wiring check out okay, replace the relay.		

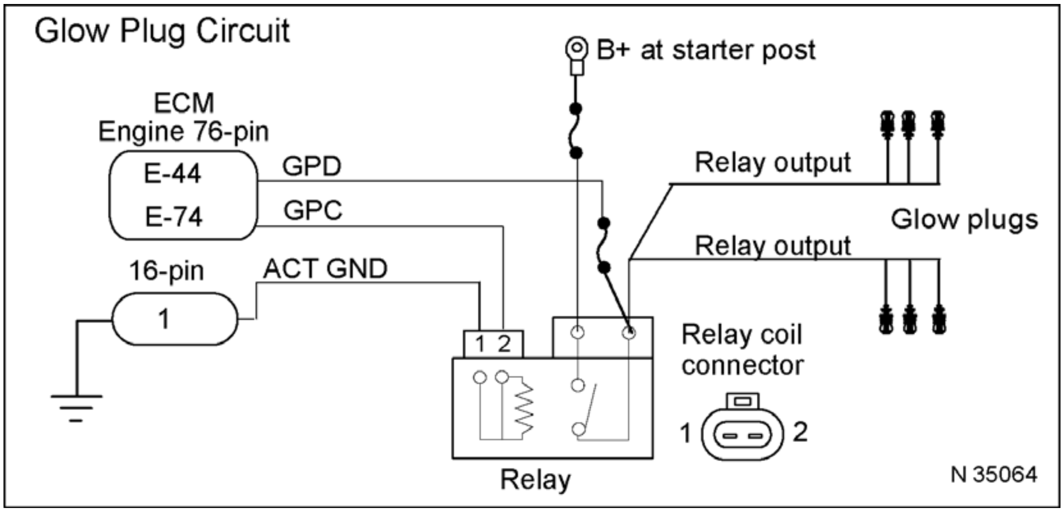

Figure 221 GPC circuit diagram

Glow Plug Resistance Check

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

Test Point	Spec	Comment
Pin 2 to E-74	< 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-44	< 5 Ω	If > 5 Ω, check GPD circuit for OPEN, corroded terminal, or blown fuse link.
E-74 to GND	> 1 kΩ	If < 1 kΩ, check GPC for short to GND.
Connect 16-pin Breakout Harness to engine harness. Leave relay and chassis harness disconnected.		
Pin 1 to 16-pin Pin 1	< 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 ignition 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.

Disconnect battery GND cable.

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

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

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

GPC Circuit Operation

The ECM controls the wait to start lamp and glow plugs based on ECT input. The wait to start lamp ON-time (0 to 10 seconds) is independent of the glow plugs ON-time (0 to 120 seconds).

The ECM controls the wait to start lamp through public CAN communication to the electronic gauge cluster.

The ECM uses a relay to control the glow plugs. The ECM energizes the relay by supplying power from Pin E-74 to Pin 2 on the relay coil. The relay coil is grounded at Pin 2 through the 16-pin connector Pin 1 from battery ground.

Power is supplied to the switch side of the 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 from the relay output to ECM Pin E-44.

Fault Detection / Management

The ECM continuously monitors the output of the glow plug relay, when voltage is not as expected a 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 can not be detected by the ECM.

IAH System (Inlet Air Heater)

DTC	SPN	FMI	Condition
1374	7279	11	IAH Relay circuit fault

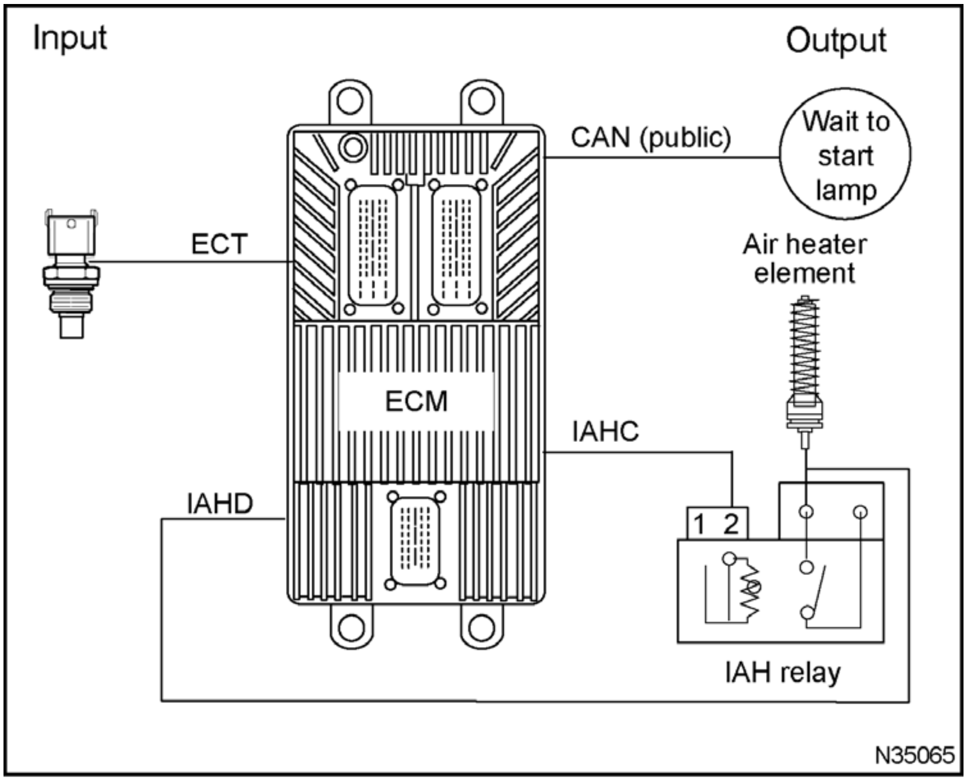

Figure 222 Function diagram for the IAH system

The IAH system function diagram includes the following:

- IAH relay
- IAH element
- Electronic Control Module (ECM)
- Engine Coolant Temperature (ECT) sensor
- Wait to Start lamp (amber)

Function

The Inlet Air Heater (IAH) system warms air coming into the intake manifold to improve cold engine start up and cold engine performance after start up.

Component Location

The IAH element is installed in the front of intake manifold under the intake elbow assembly. The IAH relay is chassis mounted on the ECM bracket.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4–USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- Amp Clamp (page 387)
- 180-Pin Breakout Box (page 385)
- 16-pin Breakout Harness (page 385)

IAH Pin-point Diagnostics

DTC	Condition	Possible Causes
1374	IAH relay circuit fault	DTC 1374 is set if both digital feedback signal and digital output signal differ for more than 1 second.
none	Inactive Intake Air Heater	• B+ supply circuit to relay switch OPEN • IAHD circuit OPEN or connected to the wrong terminal • Failed relay • IAH relay control circuit faults

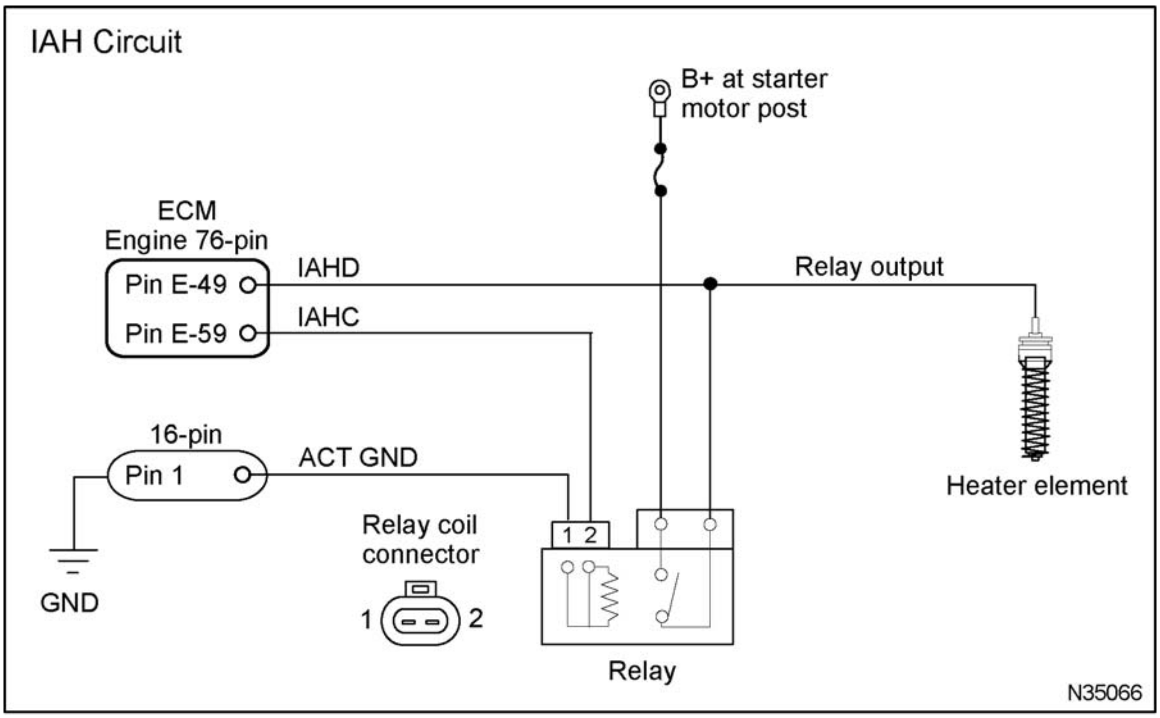

Figure 223 IAH circuit diagram

NOTE: For this procedure, run the KOEO Standard Test. Do not run GPC/IAH test. KOEO Standard Test will enable the relay for 2 seconds every time the test is run. The GPC/IAH test only enables the relay twice for 45 seconds to prevent element overheating.

Voltage Check on Relay Switch - Output State Test

Turn ignition switch 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 ignition switch to ON; 2 minutes after key on, the intake air heater is commanded off. Open the Output State test session to monitor IAHD PID.		
Monitor IAHD	Off after 2 minutes	If ON when output side of relay reads 0 V, verify the IAHD circuit is wired to the output side of the relay and not the B+ side.

Turn ignition switch to ON. Run KOEO Standard Test. (Relay is commanded on for 2 seconds during this test). Use DMM to measure voltage when the relay is commanded on.		
Measure voltage Relay Output side to GND	B+	If 0 V, do “Voltage Check - Relay Coil”. If < B+, check for corroded terminal on relay or blown fuse link. Do Amperage Draw Check (page 319).
Monitor IAHD	ON	If OFF when output side of relay reads B+, check IAHD circuit for OPEN, corroded terminal or blown fuse link.

Voltage Check on Relay Coil - Output State Test

Disconnect relay 2-pin connector. Turn ignition switch to ON. Use DMM to measure voltage		
Test Point	**Spec**	**Comment**
Pin 1 to GND	0 V	If > 0 V, check for OPEN or short to PWR
Pin 2 to GND	2.74 V	If < 2 V, check for OPEN or short to GND. Do Harness Resistance Checks – Relay Coil.
Run KOEO Standard Test (relay is commanded on for 2 seconds during this test). Use DMM to measure voltage when relay is commanded on.		
Pin 2 to GND	B+	If < B+, check ACT PWR circuit for OPEN. Do Harness Resistance Checks – Relay Coil.
Pin 1 to 2	B+	If < B+, check actuator GND circuit for OPEN. Do Harness Resistance Checks – Relay Coil.
If voltage checks at relay coil are okay, but voltage checks at relay switch failed, replace the relay.		

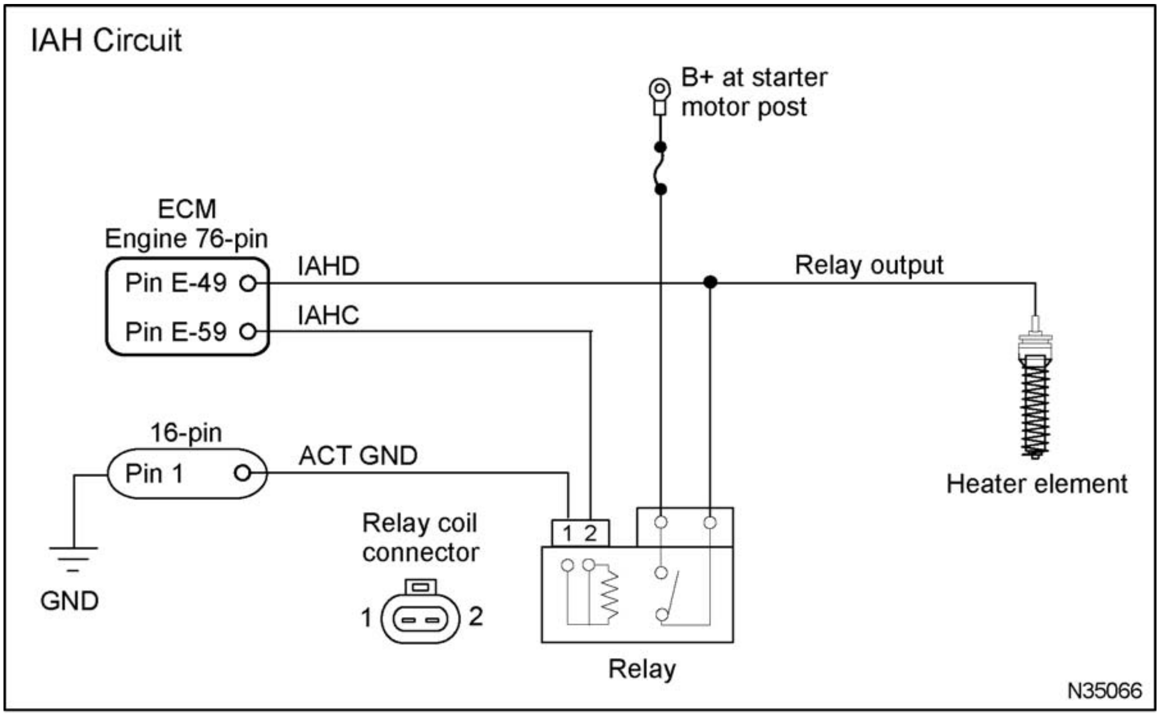

Figure 224 IAH circuit diagram

Amperage Draw Check

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

Measure the amperage going to the heater element. 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
Element	45 to 70 Amps after 4 seconds	If 0 A, do Voltage Check on Relay Switch - Output State Test (page 318) If > 0 A, but below specification, check for corroded terminals on relay, element, and power source. Do Element Resistance Check (page 319).
If > 0 A, but below specification, and element and wiring check out okay, replace the relay.		

Element Resistance Check

Turn ignition switch OFF. Use a DMM to measure resistance from heater element to engine GND.

Test Point	Spec	Comment
Element to GND	< 5 Ω	If > 5 Ω, replace failed heater element.

Harness Resistance Checks - Relay Coil Circuits

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

Test Point	Spec	Comment
Relay Pin 2 to E-59	< 5 Ω	If > 5 Ω, check IAH control circuit for OPEN.
Relay Pin 1 to GND	< 5 Ω	If > 5 Ω, check with 16-pin Breakout Harness.
E-59 to GND	> 1 kΩ	If < 1 kΩ, check IAH control for short to GND.
Connect 16-pin Breakout Harness to engine harness. Leave relay and chassis harness disconnected.		
Pin 1 to 16-pin Pin 1	< 5 Ω	If > 5 Ω, check for OPEN circuit on engine harness.
		If < 5 Ω, check for OPEN circuit on chassis harness.

Harness Resistance Checks - Relay Switch Circuits

Turn ignition to OFF. Use DMM to measure resistance.

Test Point	Spec	Comment
Relay Output side to element	< 5 Ω	If > 5 Ω, check for OPEN circuit or corroded terminals.
Disconnect battery GND cable.		
WARNING: To prevent personal injury or death, always disconnect main negative battery cable first. Always connect the main negative battery cable last.		
Relay B+ side to battery positive post	< 5 Ω	If > 5 Ω, check for OPEN circuit or corroded terminals.
If circuits and element are okay, but failed amperage test, replace the relay.		

IAH Circuit Operation

The ECM controls the WAIT TO START lamp and IAH element based on ECT and BAP (inside ECM). The WAIT TO START lamp ON-time (0 to 10 seconds) is independent from the IAH element ON-time (0 to 45 seconds).

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

The ECM uses a relay to control the IAH element. The ECM energizes the relay by supplying power from Pin E-59 to Pin 2 on the relay coil. The relay coil is grounded at Pin 1 through the 16-pin connector Pin 1 from battery ground.

Power is supplied to the switch side of the relay from the starter motor through a fusible link. When the relay is energized, power is supplied to the heating element, which is grounded to the intake manifold.

Fault Detection / Management

An OPEN or short to ground in the IAH control circuit can be detected by doing an on-demand Output Circuit Check (OCC) during the KOEO Standard Test. When a fault is detected, a DTC is set.

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

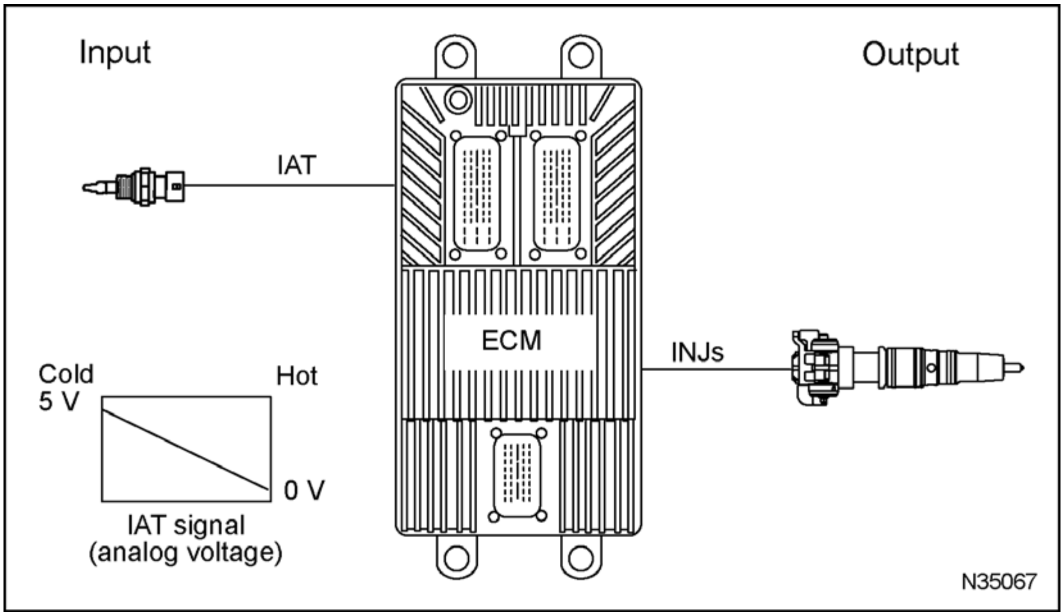

Figure 225 IAT sensor Function diagram

The IAT sensor function diagram includes the following:

- Intake Air Temperature (IAT) sensor
- Fuel injectors (INJ)
- Electronic Control Module (ECM)

Function

The IAT sensor provides a feedback signal to the ECM indicating intake air temperature. The ECM monitors the IAT signal to control the 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 turbocharger air inlet duct.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4-USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 3-banana Plug Harness (page 386)
- 500 Ohm Resistor Harness (page 387)
- 180-Pin Breakout Box (page 385)
- Temperature Sensor Breakout Harness (page 392)
- Terminal Test Adapter Kit (page 392)

IAT Sensor End Diagnostics

DTC	Condition	Possible Causes
1154	IAT signal out-of-range LOW	• IAT signal circuit short to GND • Incorrect IAT sensor connection • Failed sensor
1155	IAT signal out-of-range HIGH	• IAT signal OPEN or short to PWR • SIG GND circuit OPEN • Incorrect IAT sensor connection • Failed sensor

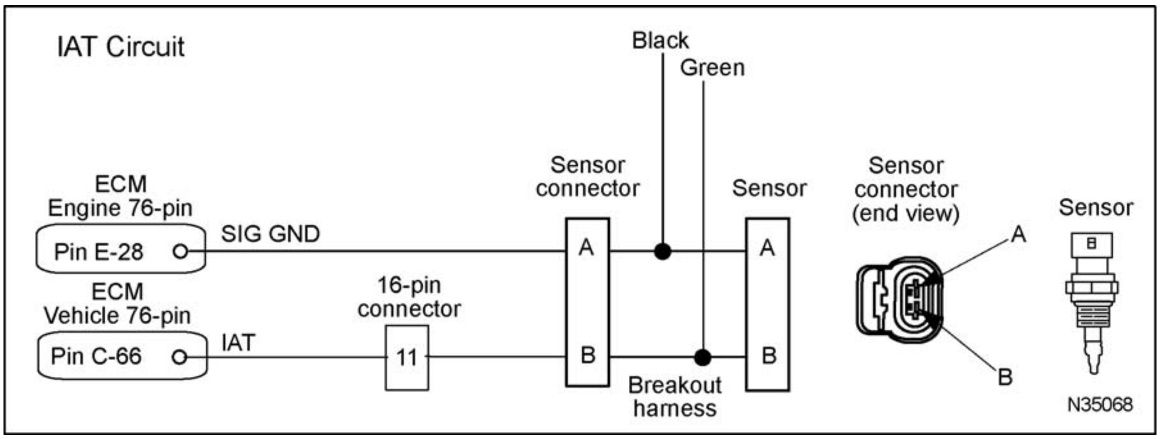

Figure 226 IAT circuit diagram

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

1. Using EST with MasterDiagnostics® software, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active DTC for the sensor.
   - 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 spike 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 EST - Check PID	DTC 1155 4.68 V	If DTC 1154 or < 4.5 V, check IAT signal for short to GND. Do Harness Resistance Checks (page 324).
EST - Check DTC Short 3-banana Plug Harness across B and GND	DTC 1154	If DTC 1155 is active, check IAT signal for OPEN. Do Harness Resistance Checks (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 Checks (page 324).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

IAT 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
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 Checks (page 324).

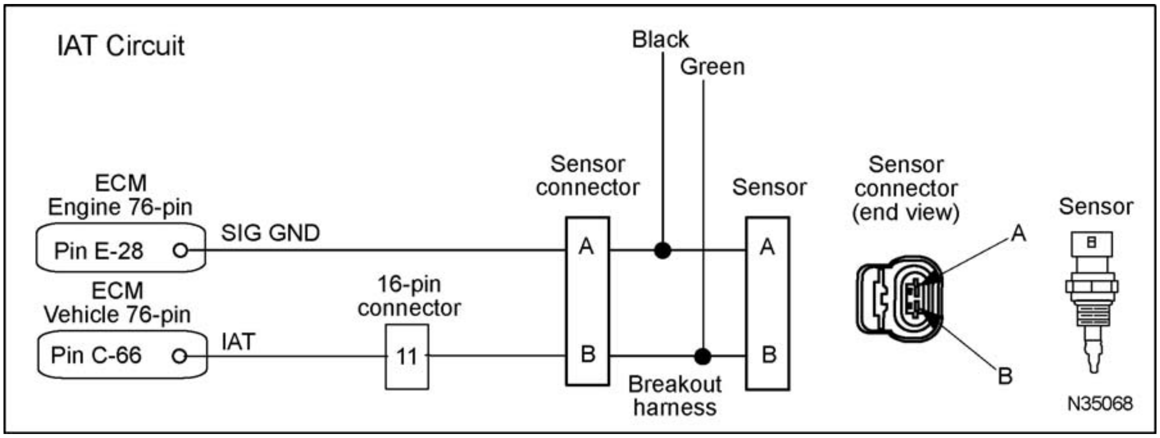

Figure 227 IAT circuit diagram

Connector Resistance Checks to GND

Turn ignition switch OFF. Connect breakout harness. Leave sensor 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.

Harness Resistance Check

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

Test Point	Spec	Comment
A to E-28	< 5 Ω	If > 5 Ω, check for OPEN circuit.
B to C-66	< 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 B from ECM Pin C-66 and is grounded at Pin A from ECM Pin E-28. As temperature increases, thermistor resistance decreases, causing 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, sets a DTC, and runs the engine in a default range.

ICP Sensor (Injection Control Pressure)

DTC	SPN	FMI	Condition
1124	164	4	ICP signal out-of-range LOW
1125	164	3	ICP signal out-of-range HIGH
1328	164	2	ICP signal constant
2332	164	13	ICP above KOEO spec

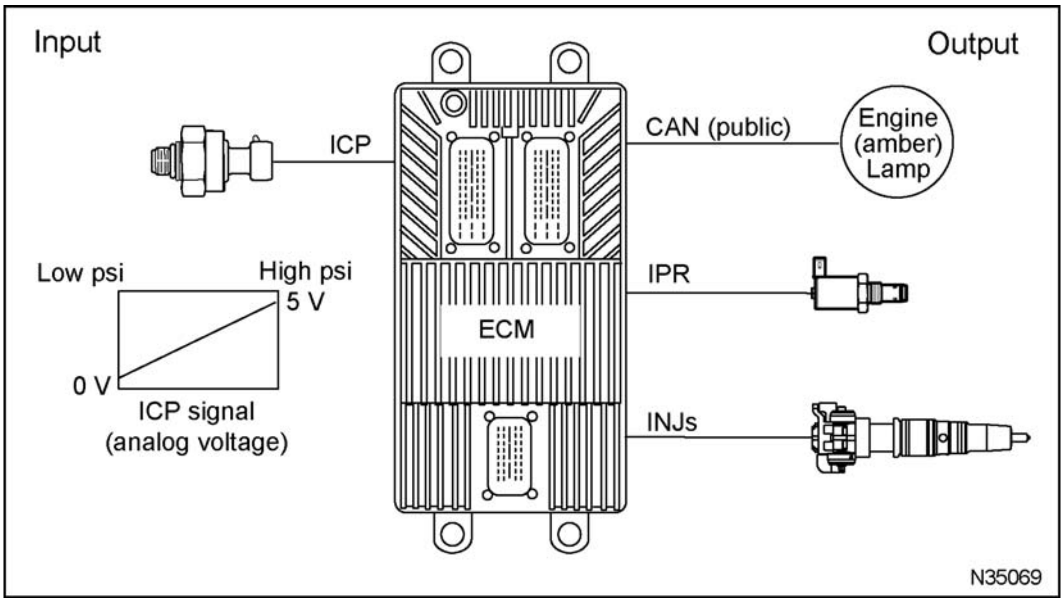

Figure 228 ICP sensor Function diagram

The ICP sensor function diagram includes the following:

- Injection Control Pressure (ICP) sensor
- Electronic Control Module (ECM)
- Fuel injectors (INJ)
- Injection Pressure Regulator (IPR)
- Engine lamp (amber)

Function

The ICP sensor provides a feedback signal to the ECM indicating Injection Control Pressure (ICP). The ECM monitors the ICP sensor as the engine operates to modulate the IPR valve and control ICP pressure. This is a closed loop system in which the ECM continuously monitors and adjusts ICP determined by engine load, speed, and temperature.

Sensor Location

The ICP sensor is installed through the right side valve cover in the right high-pressure oil rail.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4-USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 3-banana Plug Harness (page 386)
- Pressure Sensor Breakout Harness (page 391)
- 180-Pin Breakout Box (page 385)
- Terminal Test Adapter Kit (page 392)

ICP Sensor End Diagnostics

DTC	Condition	Possible Causes
1124	ICP signal out-of-range LOW	• ICP signal circuit short to GND • Failed sensor
1125	ICP signal out-of-range HIGH	• ICP signal circuit OPEN or short to PWR • SIG GND circuit OPEN • VREF circuit OPEN • Failed sensor
1328	ICP signal constant	• Failed sensor • ICP circuit fault
2332	ICP above KOEO spec	• Biased circuit/sensor (ICPV above KOEO spec)

WARNING: To prevent personal injury or death, avoid 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”.
3. Monitor sensor voltage. Verify an active DTC for the sensor.
   - 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 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.

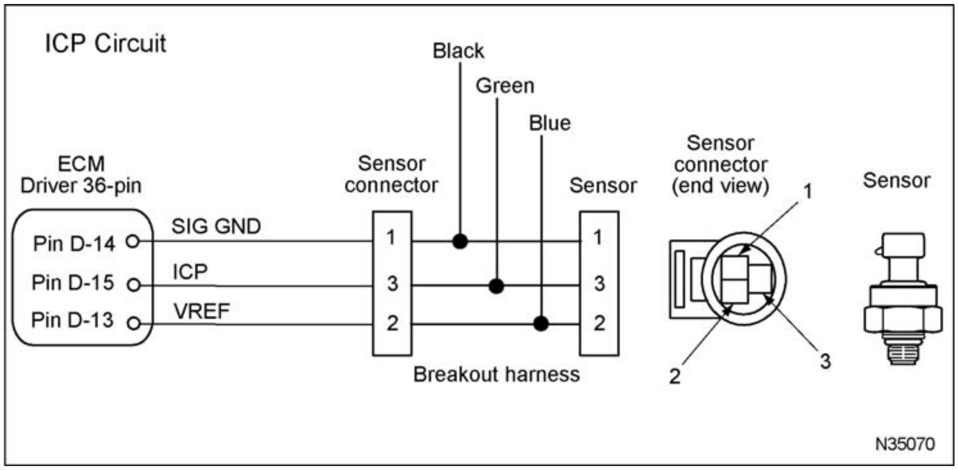

Figure 229 ICP circuit diagram

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 1125	If DTC 1124 is active, check ICP signal for short to GND.
DMM - Measure resistance 2 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Checks (page 328).
EST - Check DTC Short breakout harness across 2 and 3	DTC 1124	If DTC 1125 is active, check ICP signal for OPEN. Do Harness Resistance Checks (page 328).
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 Checks (page 328).

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

ICP Pin-point Diagnostics

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	5 V	If < 4.5 V, check for short to GND.
2 to GND	0 V	If > 0.25 V, check for short to PWR.
3 to GND	5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Checks (page 328).

Connector Resistance Check to GND

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

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

Harness Resistance Check

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

Test Point	Spec	Comment
1 to D-14	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
2 to D-13	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
3 to D-15	< 5 Ω	If > 5 Ω, check ICP signal circuit for OPEN.

Operational Voltage Check

Use EST to monitor PID during Continuous Monitor test.

Test Point	Voltage	Pressure	Comment
ICPV PID	0.15 V to 0.3 V	0 kPa (0 psi)	KOEO
	See “Appendix A: Performance Specifications” (page 427).		Minimum at engine cranking speed Low idle, no load High idle, no load Rated speed, full load

ICP Circuit Operation

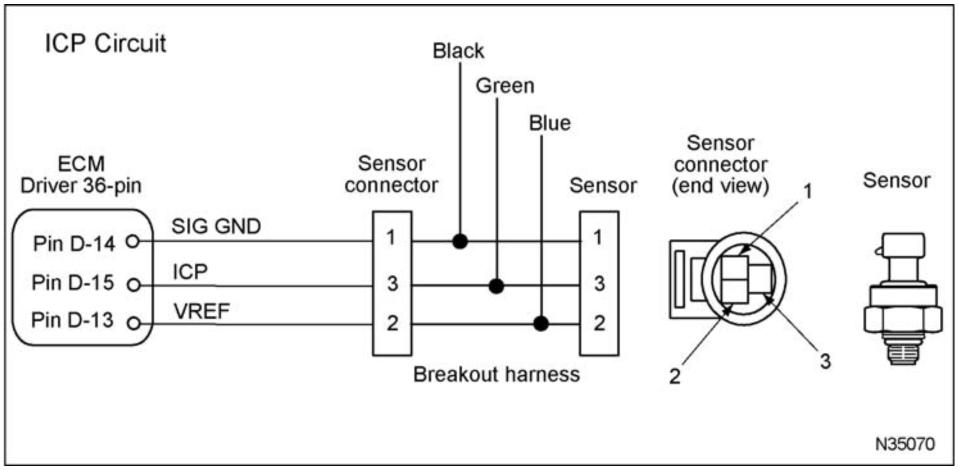

Figure 230 ICP circuit diagram

The ICP sensor is a micro-strain gauge sensor supplied with a 5 volt reference at Pin 2 from ECM Pin D-13. The ICP is grounded at Pin 1 from ECM Pin D-14 and returns a variable voltage signal from Pin 3 to ECM Pin D-15.

Fault Detection / Management

The ECM continuously monitors the ICP sensor signal. If the ICP sensor signal is out of range, the ECM will disregard sensor signals and uses a calibrated default value, set a DTC, and turn on the amber engine lamp.

ICP System (Injection Control Pressure)

DTC	SPN	FMI	Condition
2327	164	10	ICP abnormal rate of change
2335	8392	1	ICP unable to build pressure during engine cranking
3333	8492	0	ICP above desired level
3334	8492	1	ICP below desired level
3373	164	15	ICP too high during test
3374	164	17	ICP unable to build during test

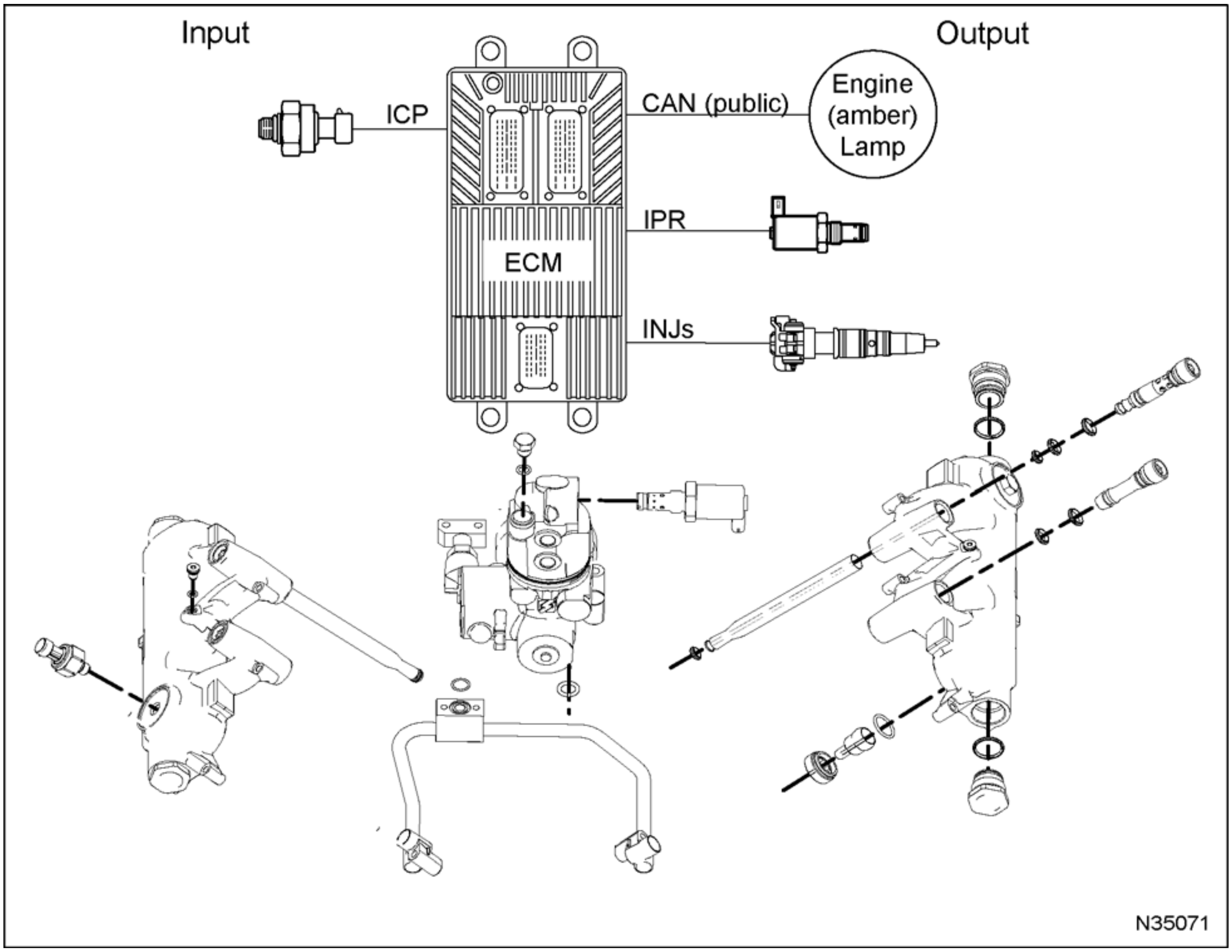

Figure 231 Function diagram for ICP system

The ICP system includes the following:

- High-pressure oil system
  - High-pressure oil pump
  - Branch tube assembly
  - Case-to-head tubes
  - High-pressure oil manifolds
  - Fuel injectors (INJ)
- Injection Pressure Regulator (IPR) valve
- Injection Control Pressure (ICP) sensor
- Electronic Control Module (ECM)
- Engine lamp (amber)

Function

The Injection Control Pressure (ICP) system is a mechanical hydraulic system, electronically controlled by the ECM to increase fuel pressure inside the fuel injectors. The ECM controls ICP pressure by opening and closing the Injection Pressure Regulator (IPR) valve. The ECM monitors the ICP sensor to control the IPR valve.

System Component Location

The IPR valve is installed in the high-pressure oil pump assembly, which is mounted on the top rear of the crankcase. The high-pressure oil manifolds are installed under the valve covers, directly over the injectors. The ICP sensor is installed through the right valve cover in the right high-pressure oil manifold.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4-USB Interface Cable (page 390)

ICP System Diagnostics

DTC	Condition	Possible Causes
2327 3333 3334 3373 3374	ICP abnormal rate change ICP above desired level ICP below desired level ICP too high during test ICP unable to build during test	• Debris or contamination in oil • Incorrect crankcase oil level (high or low) • Aerated oil. • Trapped air in ICP system (can occur after the ICP system was opened to repair) • Leak in ICP system • Biased circuit or sensor (ICP above or below actual) • Intermittent circuit fault on the IPR valve • Sticking IPR valve
2335	ICP unable to build pressure during engine cranking	• Low oil level in crankcase • Trapped air in ICP system (can occur after the ICP system was opened to repair) • Leak in ICP system • Biased circuit or sensor (ICP above actual) • High-pressure oil pump failure • Circuit fault on the IPR valve • Failed IPR valve

WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

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

DTC 2327 – ICP abnormal rate of change

DTC 3333 - ICP above desired level

This DTC is set when actual ICP is above desired ICP by 3%.

DTC 3334 - ICP below desired level

This DTC is set when desired ICP is below actual ICP by 5%.

DTC 3373 – ICP too high during test

DTC 3374 – ICP unable to build during test

Pin-point ICP System Fault

1. Check repair history for recent ICP system repairs. Trapped air in the system from recent repair can cause erratic pressure. To purge air from system, find an open stretch of road and drive the vehicle for a minimum of 20 miles.
2. Check engine oil for correct level and grade. Inspect for contamination or debris.
3. Check for other active or inactive ICP DTCs. See ICP Sensor (Injection Control Pressure) (page 325) and check ICP KOEO specification.
4. Check for IPR DTC by running KOEO Standard test. See IPR Valve (Injection Pressure Regulator) (page 350) and check harness connection.
5. Check for intermittent circuit faults on ICP sensor or IPR valve. Open Continuous monitor session and run Continuous monitor test. With engine at low idle, wiggle harness connection on the ICP, IPR, and 36-pin connector.
6. Check for aerated oil at high idle. See “Performance Diagnostics”.
7. Check the ICP system for leaks. See “Hard Start and No Start Diagnostics”.

DTC 2335 - ICP unable to build pressure during engine cranking

This DTC is set when ICP does not reach 3.5 MPa (508) within 10 seconds of engine cranking above 130 rpm.

Pin-point ICP System Fault

1. Check harness connection to ICP, IPR, and ECM.
2. Check repair history for recent ICP system repairs. Trapped air in the system from recent repair can cause erratic pressure. To purge air from system, find an open stretch of road and drive the vehicle for a minimum of 20 miles.
3. Check engine oil for correct level and grade. Inspect for contamination or debris. Verify lube oil pressure and delivery to reservoir during engine crank. See “Hard Start and No Start Diagnostics”.
4. Check for other active or inactive ICP DTCs. See ICP Sensor (Injection Control Pressure) (page 325) and check ICP KOEO specification.
5. Check for IPR DTC by running KOEO Standard test. See IPR Valve (Injection Pressure Regulator) (page 350) and check harness connection.
6. Check for intermittent circuit faults on ICP sensor or IPR valve. Open Continuous monitor session and run Continuous monitor test. With engine at low idle, wiggle harness connection on the ICP, IPR, and 36-pin connector.
7. Check the ICP system for leaks. See “Hard Start and No Start Diagnostics”.

Fault Detection / Management

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

The ECM continuously monitors the ICP sensor. When the ECM detects an error in the closed loop system, a DTC is set and the ECM will disregard the ICP signal and control the IPR valve from programmed default values. This is open loop operation.

The ECM monitors ICP during engine cranking. If pressure does not build to minimum starting pressure within a set time, a DTC is set.

The KOER Standard test can be used to command the ECM to perform an engine running test on the ICP system. The ECM controls the IPR in a programmed sequence while monitoring the ICP sensor. If pressure set points do not match the expected testing range, a DTC is set.

An electrical fault on the IPR can be detected by running the Output Circuit test during the KOEO Standard test. If a fault is detected, a DTC will be set.

Injector Circuits (INJ)

DTC	SPN	FMI	Condition
4411-4416	8001-8006	6	Close coil: OPEN circuit (Cyl no.)
4421-4426	8001-8006	5	Open coil: OPEN circuit (Cyl no.)
4431-4436	8001-8006	4	Open coil: short circuit (Cyl no.)
4441-4446	8001-8006	3	Close coil: short circuit (Cyl no.)
4515	8151	5	Bank A injector open coil short
4516	8151	6	Bank A injector close coil short
4521	8152	5	Bank B injector open coil short
4522	8152	6	Bank B injector close coil short

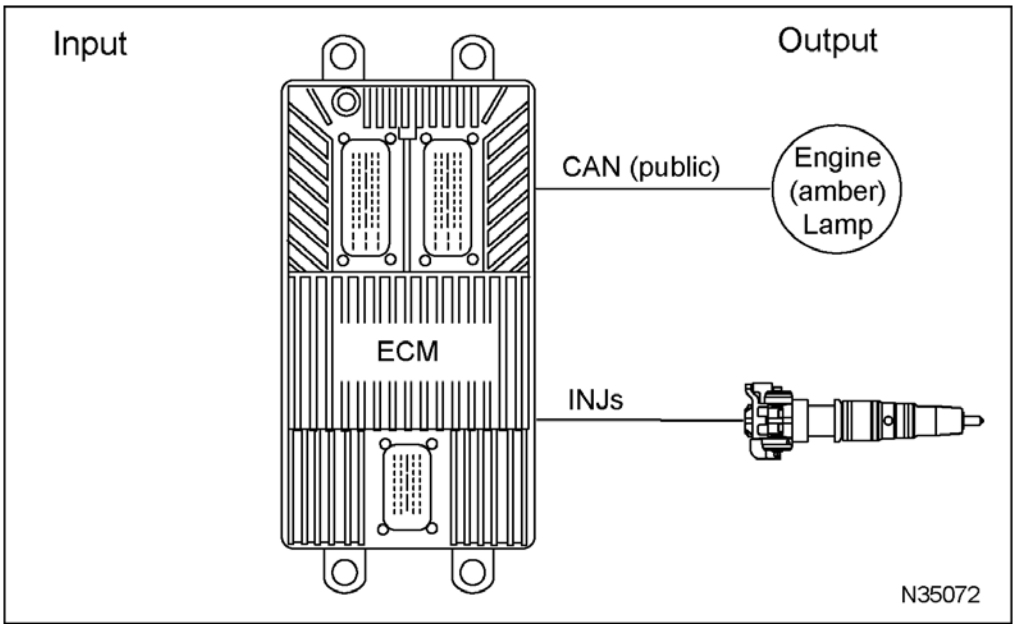

Figure 232 Function diagram for the INJ circuits

The INJ circuits function diagram includes the following:

- Fuel injectors (INJ)
- Electronic Control Module (ECM)
- Engine lamp (amber)

Function

The ECM controls the timing and amount of fuel sprayed from each injector. The ECM also controls the Injection Control Pressure (ICP) system to regulate the pressure fuel is being sprayed.

Component Location

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

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4-USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- Terminal Test Adapter Kit (page 392)
- 180-Pin Breakout Box (page 385)
- 36-pin Injector Driver Cable (page 386)

Injector 1 Checks

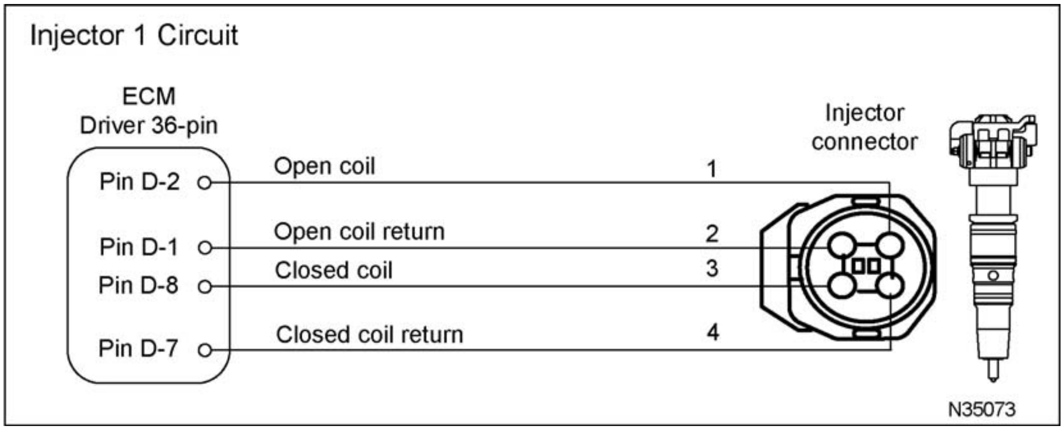

Figure 233 Injector 1 circuit diagram

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 engine is running, injector circuits have high voltage and amperage.

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

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

Test Point	Spec	Comment
D-1 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
D-2 to GND	> 1 kΩ	
D-7 to GND	> 1 kΩ	
D-8 to GND	> 1 kΩ	
D-1 to D-2	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
D-7 to D-8	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
D-1 to D-7	> 1 kΩ	If < 1 kΩ, check for cross-shorted circuits or injector coil for internal short.

Injector 1 - Injector Resistance Checks

Turn ignition switch OFF. Disconnect injector connector. Use DMM to measure injector resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
2 to GND	> 1 kΩ	
3 to GND	> 1 kΩ	
4 to GND	> 1 kΩ	
1 to 2	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN through injector.
3 to 4	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN through injector.
1 to 3	> 1 kΩ	If < 1 kΩ, check for cross-shorted circuits or injector coil for internal short.

Injector 1 - Harness Resistance Check

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

Test Point	Spec	Comment
D-1 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-1 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-2 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-7 to 4	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-7 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-8 to 3	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-8 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 2 Checks

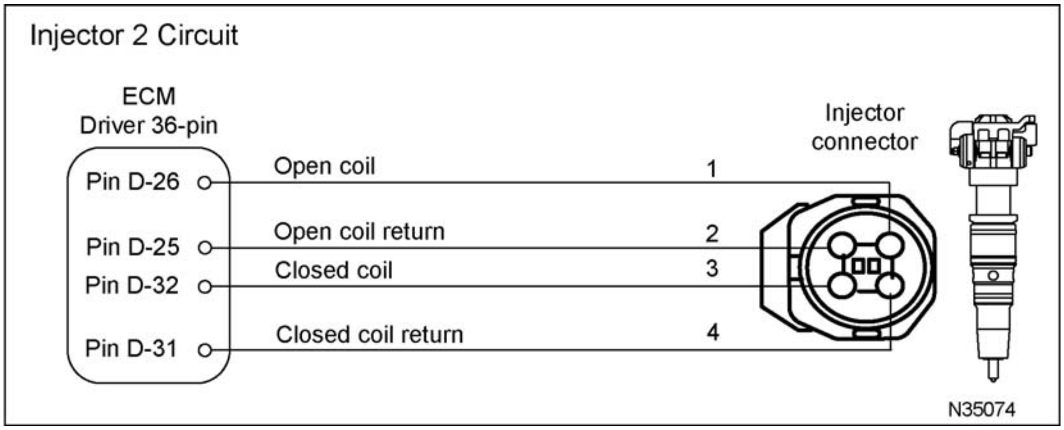

Figure 234 Injector 2 circuit diagram

Injector 2 - Resistance Checks Through Harness and Injector

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

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

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

Test Point	Spec	Comment
D-25 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
D-26 to GND	> 1 kΩ	
D-31 to GND	> 1 kΩ	
D-32 to GND	> 1 kΩ	
D-25 to D-26	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
D-31 to D-32	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
D-25 to D-31	> 1 kΩ	If < 1 kΩ, check for cross-shorted circuits or injector coil for internal short.

Injector 2 - Injector Resistance Checks

Turn ignition switch OFF. Disconnect injector connector. Use DMM to measure injector resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
2 to GND	> 1 kΩ	
3 to GND	> 1 kΩ	
4 to GND	> 1 kΩ	
1 to 2	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN through injector.
3 to 4	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN through injector.
1 to 3	> 1 kΩ	If < 1 kΩ, check for cross-shorted circuits or injector coil for internal short.

Injector 2 - Harness Resistance Check

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

Test Point	Spec	Comment
D-25 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-25 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-26 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-26 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.
D-32 to 3	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-32 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 3 Checks

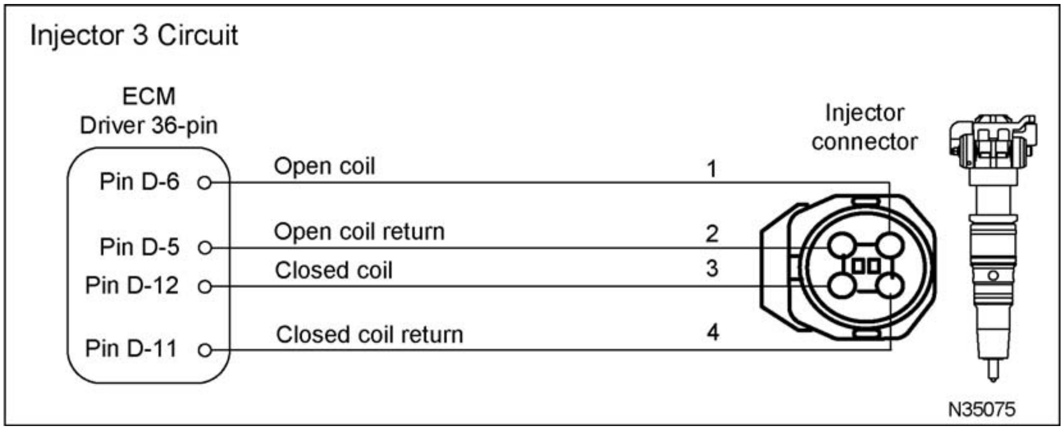

Figure 235 Injector 3 circuit diagram

Injector 3 - Resistance Checks Through Harness and Injector

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

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

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

Test Point	Spec	Comment
D-5 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
D-6 to GND	> 1 kΩ	
D-11 to GND	> 1 kΩ	
D-12 to GND	> 1 kΩ	
D-5 to D-6	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
D-11 to D-12	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
D-5 to D-11	> 1 kΩ	If < 1 kΩ, check for cross-shorted circuits or injector coil for internal short.

Injector 3 - Injector Resistance Checks

Turn ignition switch OFF. Disconnect injector connector. Use DMM to measure injector resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
2 to GND	> 1 kΩ	
3 to GND	> 1 kΩ	
4 to GND	> 1 kΩ	
1 to 2	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN through injector.
3 to 4	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN through injector.
1 to 3	> 1 kΩ	If < 1 kΩ, check for cross-shorted circuits or injector coil for internal short.

Injector 3 - Harness Resistance Check

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

Test Point	Spec	Comment
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.
D-6 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-6 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-11 to 4	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-11 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-12 to 3	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-12 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 4 Checks

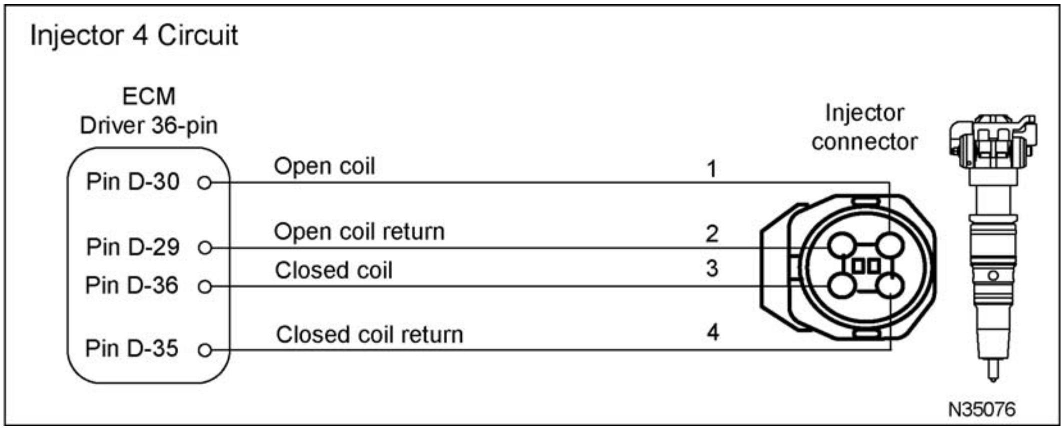

Figure 236 Injector 4 circuit diagram

Injector 4 - Resistance Checks Through Harness and Injector

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

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

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

Test Point	Spec	Comment
D-29 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
D-30 to GND	> 1 kΩ	
D-35 to GND	> 1 kΩ	
D-36 to GND	> 1 kΩ	
D-29 to D-30	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
D-35 to D-36	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
D-29 to D-35	> 1 kΩ	If < 1 kΩ, check for cross-shorted circuits or injector coil for internal short.

Injector 4 - Injector Resistance Checks

Turn ignition switch OFF. Disconnect injector connector. Use DMM to measure injector resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
2 to GND	> 1 kΩ	
3 to GND	> 1 kΩ	
4 to GND	> 1 kΩ	
1 to 2	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN through injector.
3 to 4	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN through injector.
1 to 3	> 1 kΩ	If < 1 kΩ, check for cross-shorted circuits or injector coil for internal short.

Injector 4 - Harness Resistance Check

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

Test Point	Spec	Comment
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.
D-30 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-30 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-35 to 4	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-35 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-36 to 3	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-36 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 5 Checks

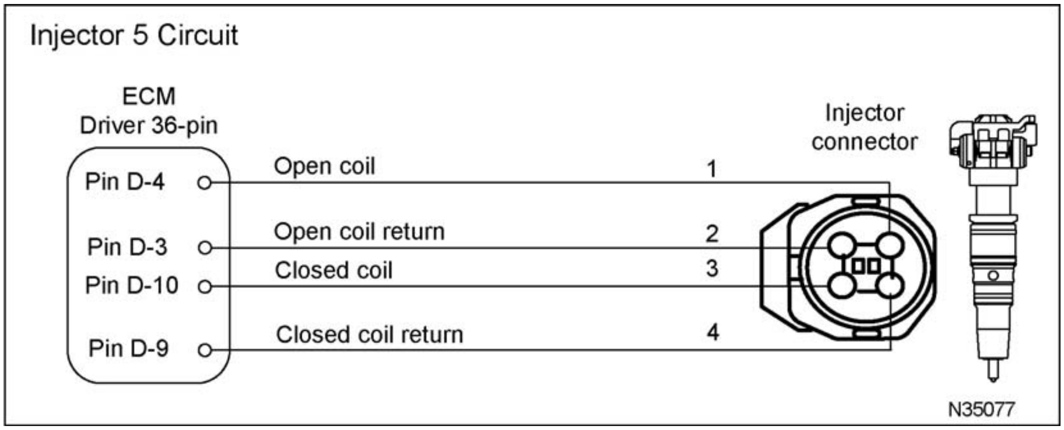

Figure 237 Injector 5 circuit diagram

Injector 5 - Resistance Checks Through Harness and Injector

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

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

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

Test Point	Spec	Comment
D-3 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
D-4 to GND	> 1 kΩ	
D-9 to GND	> 1 kΩ	
D-10 to GND	> 1 kΩ	
D-3 to D-4	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
D-9 to D-10	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
D-3 to D-9	> 1 kΩ	If < 1 kΩ, check for cross-shorted circuits or injector coil for internal short.

Injector 5 - Injector Resistance Checks

Turn ignition switch OFF. Disconnect injector connector. Use DMM to measure injector resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
2 to GND	> 1 kΩ	
3 to GND	> 1 kΩ	
4 to GND	> 1 kΩ	
1 to 2	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN through injector.
3 to 4	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN through injector.
1 to 3	> 1 kΩ	If < 1 kΩ, check for cross-shorted circuits or injector coil for internal short.

Injector 5 - Harness Resistance Check

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

Test Point	Spec	Comment
D-3 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-3 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-4 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-4 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.
D-10 to 3	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-10 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 6 Checks

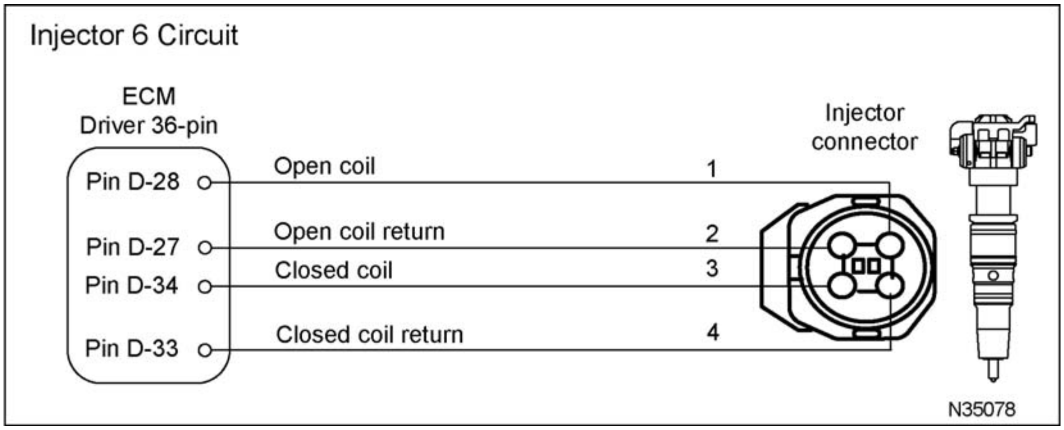

Figure 238 Injector 6 circuit diagram

Injector 6 - Resistance Checks Through Harness and Injector

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

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

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

Test Point	Spec	Comment
D-27 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
D-28 to GND	> 1 kΩ	
D-33 to GND	> 1 kΩ	
D-34 to GND	> 1 kΩ	
D-27 to D-28	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
D-33 to D-34	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
D-27 to D-33	> 1 kΩ	If < 1 kΩ, check for cross-shorted circuits or injector coil for internal short.

Injector 6 - Injector Resistance Checks

Turn ignition switch OFF. Disconnect injector connector. Use DMM to measure injector resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
2 to GND	> 1 kΩ	
3 to GND	> 1 kΩ	
4 to GND	> 1 kΩ	
1 to 2	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN through injector.
3 to 4	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN through injector.
1 to 3	> 1 kΩ	If < 1 kΩ, check for cross-shorted circuits or injector coil for internal short.

Injector 6 - Harness Resistance Check

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

Test Point	Spec	Comment
D-27 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-27 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-28 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-28 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-33 to 4	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-33 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-34 to 3	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-34 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector Circuit Operation

Each injector has an open and close coil. The ECM controlling circuits run from the ECM Driver 36-pin connector to each injector 4-pin connector.

When a coil needs to be energized, the ECM turns on the high and low side driver. The high side output supplies the injectors with a power supply of 48 volts DC at 20 amps. The low side output supplies a return circuit to each injector coil.

High Side Drive Output

The ECM regulates the current at an average of 20 amps. When the current reaches 24 amps, the ECM shuts off the high side driver. When the current drops to 16 amps, the ECM turns on the high side driver.

Low Side Drive Return

The injector solenoids are grounded through the low side return circuits. The ECM monitors the low side return signal for diagnostic purposes and utilizes the fly-back current from the injector solenoids to help charge the drive capacitors internally to the ECM

Fault Detection / Management

The ECM continuously monitors the amount of time (rising time) taken by each coil to draw 20 amps. The time is compared to calibrated values and the ECM determines if a circuit or injector fault exists. Each injector has six failure modes and four DTCs. A failure can occur on the open or close coil circuit. When a fault is detected, a DTC is set.

When an injector short to ground is detected (low or high side), the ECM discontinues power to the shorted injector and operates the engine using the remaining cylinders.

When the engine is running, the ECM can detect individual injector coil and shorts to ground or battery.

KOEO Injector Test

This test enables all injector coils when the engine is off to verify circuit operation.

During this test, injector solenoids will click in numeric order, not firing order. If one or more injectors can not be heard, the injector is not working due to a circuit, injector, or an ECM failure.

IPR Valve (Injection Pressure Regulator)

DTC	SPN	FMI	Condition
1276	8366	6	IPR short to B+, over temperature
1277	8366	5	IPR short circuit

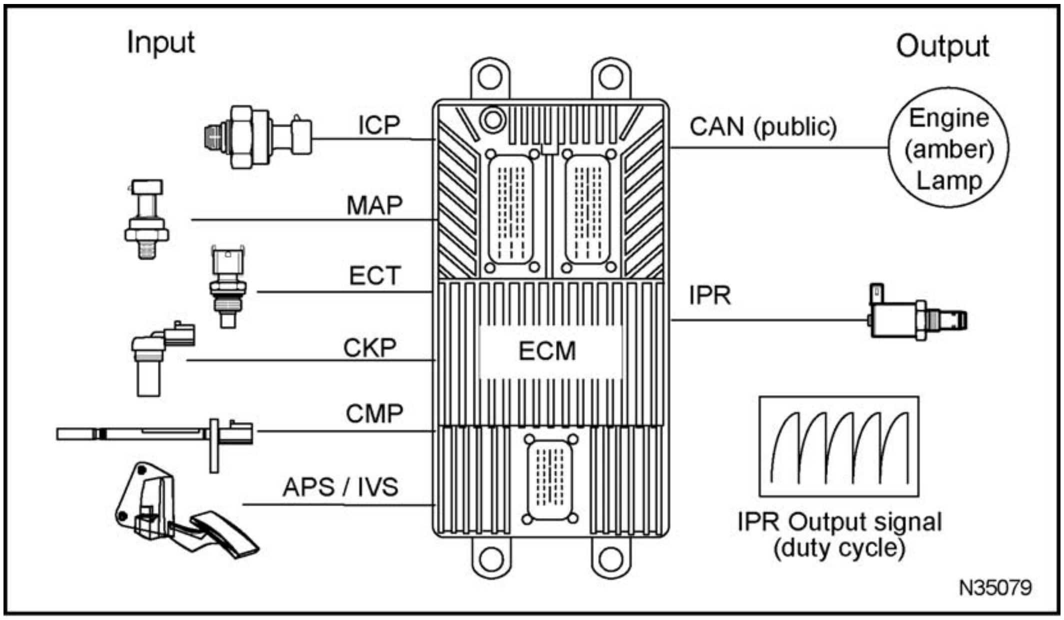

Figure 239 Function diagram for the IPR

The IPR function diagram includes the following:

- Injection Pressure Regulator (IPR) valve
- Engine Coolant Temperature (ECT) sensor
- Injection Control Pressure (ICP) sensor
- Manifold Absolute Pressure (MAP) sensor
- Camshaft Position (CMP) sensor
- Crankshaft Position (CKP) sensor
- Accelerator Position Sensor / Idle Validation Switch (APS/IVS) sensor
- Electronic Control Module (ECM)

Function

The IPR valve regulates high-pressure oil in the Injection Control Pressure (ICP) system. The ICP system intensifies fuel pressure in the injectors. The ECM uses the ICP sensor to monitor system pressure and adjusts the IPR valve duty cycle to match engine requirements (starting, engine load, speed, and temperature).

IPR Location

The IPR valve is installed in left side of the high-pressure oil pump.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4-USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- Terminal Test Adapter Kit (page 392)
- 180-Pin Breakout Box (page 385)
- Actuator Breakout Harness (page 387)
- 16-pin Breakout Harness (page 385)

IPR Pin-point Diagnostics

DTC	Condition	Possible Causes
1276	IPR short to B+, over temperature	• IPR control circuit short to power • Failed IPR valve
1277	IPR short circuit	• IPR control circuit OPEN or short to ground • VIGN circuit OPEN • Failed IPR valve

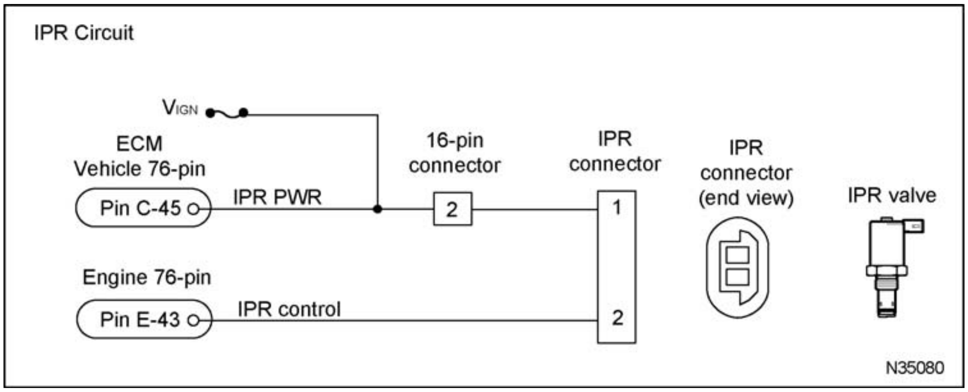

Figure 240 IPR circuit diagram

Connector Voltage Check

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

Test Point	Spec	Comment
1 to GND	B+	If < B+, check VIGN circuit for OPEN or short to GND, or blown fuse.
2 to GND	0 V	If > 0.25 V, check IPR control circuit for short to PWR.

Operational Voltage Check - Output State Test

Connect breakout harness between ECM and IPR valve. Run KOEO Standard Test and Output State Test Low. Use DMM to measure voltage.

Test Point	Test	Spec	Comment
1 to GND	KOEO	B+	If < B+, check for OPEN circuit
2 to GND	KOEO	B+	If < B+, check IPR coil for OPEN.
2 to GND	Output State HIGH	B+	If < B+, check IPR control circuit for short to GND.
2 to GND	Output State LOW	7.5 V	If > 7.5 V, check IPR control circuit for OPEN or short to PWR or failed IPR coil.

Actuator Resistance Check

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

Test Point	Spec	Comment
1 to 2	5 Ω to 20 Ω	If out of specification, replace IPR valve.
1 to GND	> 1 kΩ	If < 1 kΩ, replace IPR valve.

Connector Resistance Checks to GND

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

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

Harness Resistance Check

Turn ignition switch OFF. Disconnect battery GND cable. Connect breakout box and breakout harness. Leave ECM and IPR disconnected. 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
2 to E-43	< 5 Ω	If > 5 Ω, check for OPEN circuit.
1 to C-45	< 5 Ω	If > 5 Ω, check with 16-pin Breakout Harness.
Connect 16-pin and Actuator Breakout Harnesses to engine harness. Leave IPR and chassis harness disconnected.		
1 to 2 (16-pin)	< 5 Ω	If > 5 Ω, check for OPEN circuit on engine harness.
		If < 5 Ω, check for OPEN circuit on chassis harness.

IPR Circuit Operation

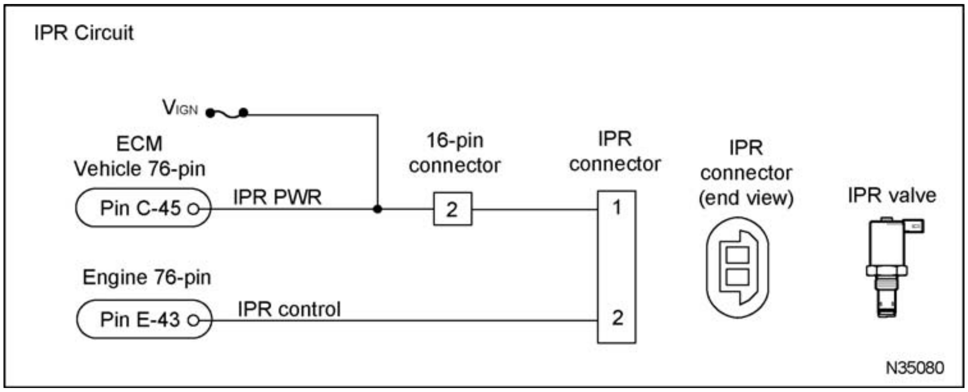

Figure 241 IPR circuit diagram

The IPR valve consists of a solenoid, poppet, and a spool valve assembly. The ECM regulates ICP pressure by controlling the ON/OFF time of the IPR solenoid. An increase or decrease in the ON/OFF time positions the poppet and spool valve inside the IPR which maintains pressure in the ICP system or vents pressure to the oil sump.

The IPR valve is supplied with voltage at Pin 1 of the IPR connector through the 16-pin connector (Pin 2) from VIGN. The ECM Controls the ICP system by grounding Pin 2 of the IPR valve through ECM Pin E-43.

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

Fault Detection / Management

An OPEN or short to ground in the ICP control circuit can be detected by an on demand output circuit check during KOEO Standard Test. If there is a circuit fault detected a Diagnostic Trouble Code (DTC) will set.

IST (Idle Shutdown Timer)

DTC	SPN	FMI	Condition
2324	593	14	Engine stopped by IST

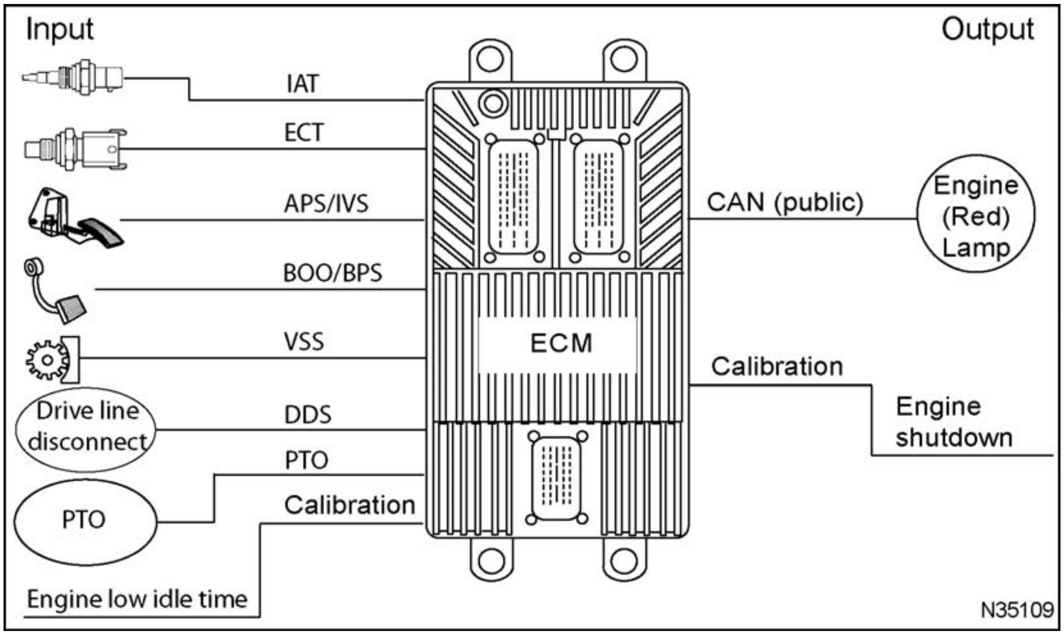

Figure 242 Function diagram for the IST system

The IST 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)
- Warning lamp

Function

The Idle Shutdown Timer (IST) allows the ECM to shut down the engine during extended engine idle times.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4-USB Interface Cable (page 390)

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

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 (MaxxForce 5).

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 is set, 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 Electronic Service Tool (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 can not turn IST off for ESS compliant engines.

CARB IST Conditions

The following conditions must be true for the idle shutdown timer to activate in all modes. Any change of the “true” state of one or more of these conditions will reset or disable 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).
- Power Take Off (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 pre-set position).
- Steady brake pedal state (no transition detected from any pre-set state).
- Steady parking brake state (CAN message) (no transition detected from any pre-set 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 will be 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 idle shutdown timer to activate. Any change to the “true” state of one or more of these conditions will reset or disable 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) (MFG Default, Customer adjustable parameter).
- Intake air temperature lower than 44 ºC (112 ºF) (MFG Default, Customer adjustable parameter).
- Engine coolant temperature greater than 60 ºC (140 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.
- Steady parking brake state (CAN message). No transition detected from any pre-set 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 pre-set position).
- Steady brake pedal state (no transition detected from any pre-set state).

Fault Detection / Management

The IST DTC does not indicate a system fault. DTC 2324 is set by the ECM when the engine has been shutdown 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 / ITV position control deviation below MIN threshold
1288	3464	0	ITVH OCC self-test failed / ITV position control deviation above MAX threshold
1293	7318	3	ITVP signal out-of-range HIGH
1294	7318	4	ITVP signal out-of-range LOW
1295	51	4	ITV H-bridge Electrical Check
1296	51	5	ITV H-bridge Electrical Check
1297	51	3	ITV H-bridge Electrical Check
1298	51	2	ITV operation fault - under Volt, over Amp, over Temp / ITV H-bridge Electrical Check

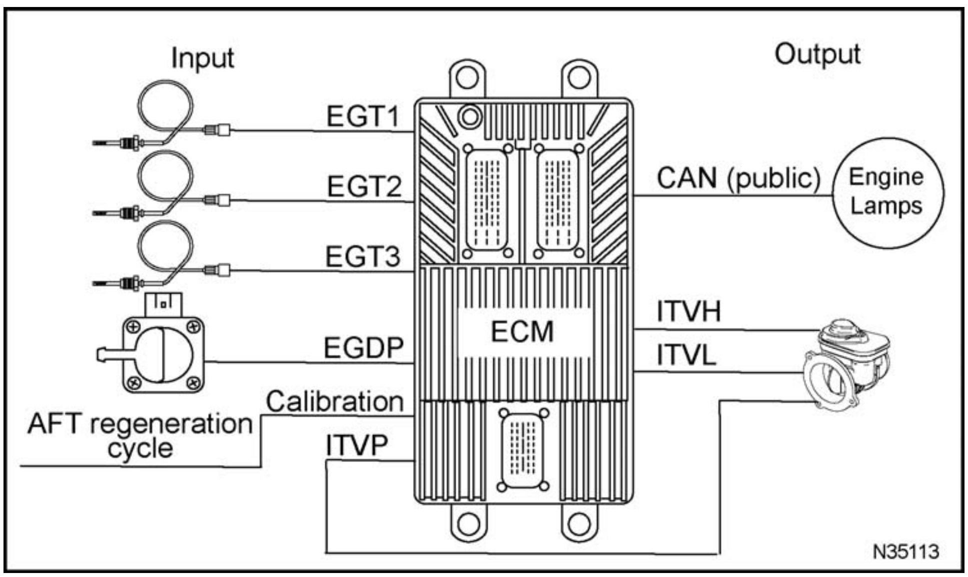

Figure 243 ITV Function diagram

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)
- Engine lamps
- 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 Intake Throttle Valve (ITV) is used to control intake air flow during aftertreatment regeneration. The ITV is also used to restricting air flow for EWPS and IST key-on engine shut down.

Component Location

The ITV is installed on the air intake elbow, on the top front of the engine.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4-USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 3-banana Plug Harness (page 386)
- 180-Pin Breakout Box (page 385)
- Intake Throttle Valve Breakout Harness (page 391)
- Terminal Test Adapter Kit (page 392)

ITV Actuator End Diagnostics

DTC	Condition	Possible Causes
1287	ITVL OCC self-test failed / ITV position control deviation below MIN threshold	• ITVL circuit OPEN, short to PWR, or GND • Failed ITV actuator
1288	ITVH OCC self-test failed / ITV position control deviation above MAX threshold	• ITVH circuit OPEN, short to PWR, or GND • 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	ITV H-bridge Electrical Check	• ITVH control circuit fault
1296	ITV H-bridge Electrical Check	• ITVL control circuit fault
1297	ITV H-bridge Electrical Check	• Failed ITV
1298	ITV operation fault - under Volt, over Amp, over Temp / ITV H-bridge Electrical Check	

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

1. Using EST open the D_ContinuousMonitor.ssn.
2. Verify sensor voltage is within KOEO specifications. See "Performance Specifications".
3. Monitor sensor voltage. Verify an active DTC for the sensor.
   - 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 spike and the DTC will go active.
   - If DTC is active, proceed to the next step.
4. Disconnect engine harness from ITV.

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

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

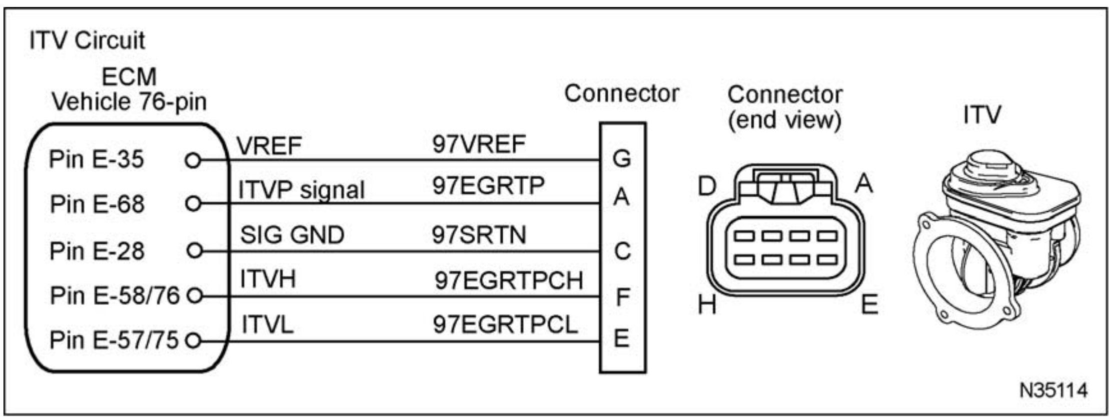

Figure 244 ITV circuit diagram

ITV Actuator Circuit Check

Connect breakout harness. Leave ITV disconnected. Turn 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	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR.
G to GND		If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 361).

ITV Actuator Circuit Check (cont.)

EST - Check DTC Short breakout harness across A and G	DTC 1293	If DTC 1294, check ITVP signal for OPEN or short to GND. Do Harness Resistance Check (page 361).
DMM - Measure resistance C to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 361).
DMM - Measure resistance E to GND	B+	If > B+, check ITVL for OPEN or short to GND. Do Harness Resistance Check (page 361).
DMM - Measure resistance F to GND	B+	If > B+, check ITVH for OPEN or short to GND. Do Harness Resistance Check (page 361).
If checks are within specification, do Connector Voltage Check.		

ITV Actuator Pin-point Diagnostics

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 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 361).
A to GND	0 V	If > 0.25 V, check ITVP for short to PWR. Do Harness Resistance Check (page 361).
If checks are within specification, do Connector Resistance Check to GND.		

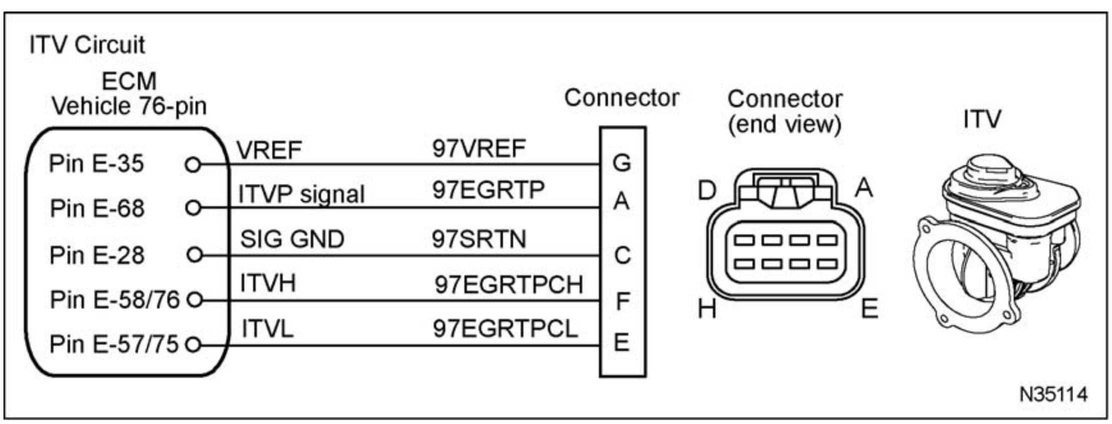

Figure 245 ITV actuator circuit diagram

Connector Resistance Check to GND

Turn ignition switch 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 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 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. The ITV is the control valve actuator and the 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 ITVP is grounded at Pin C from ECM Pin E-28 and 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 by-polar circuit. The ECM closes the ITV by driving the ITVH circuit high, this causes ITVL circuit to go low. The opposite occurs when the valve is commanded open.

Variable voltage is needed to move the valve. Very little 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 then expected, the a DTC will set.

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 will 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 (barometric pressure) BARO at start
1157	102	1	MAP in-range LOW - MAP below BARO at start

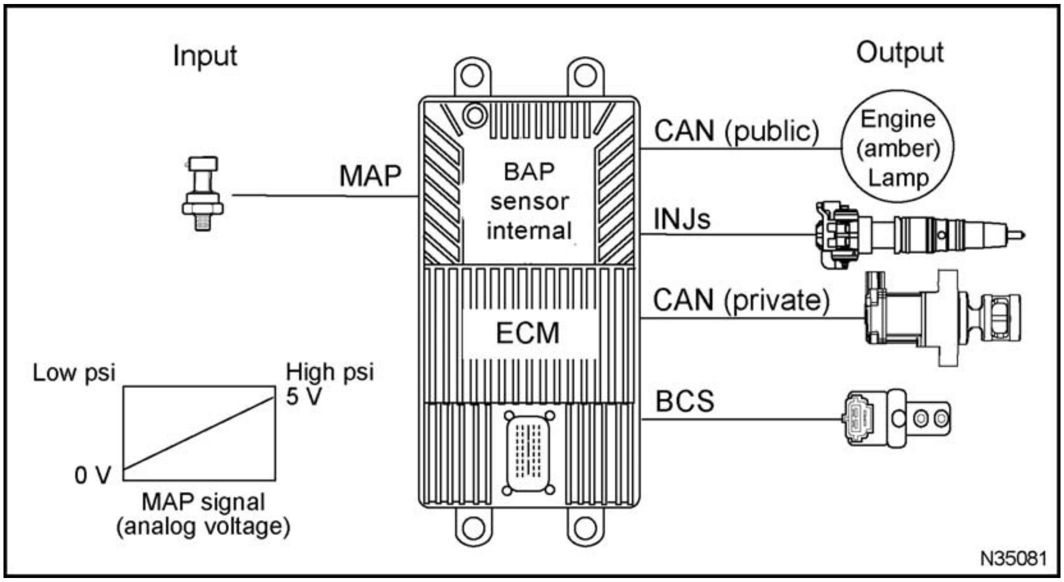

Figure 246 MAP sensor function diagram

The MAP sensor function diagram includes the following:

- Manifold Absolute Pressure (MAP) sensor
- Electronic Control Module (ECM) with internal Barometric Absolute Pressure (BAP) sensor
- Exhaust Gas Recirculation (EGR) valve
- Turbocharger boost control
- Fuel injectors (INJ)
- Engine lamp (amber)

Function

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

Sensor Location

The MAP sensor is installed in the front of the intake manifold to the right of the intake air elbow.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4-USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 3-banana Plug Harness (page 386)
- 180-Pin Breakout Box (page 385)
- Pressure Sensor Breakout Harness (page 391)
- Terminal Test Adapter Kit (page 392)

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 • Slow responding or biased MAP or BAP circuit/sensor
1157	MAP in-range LOW - MAP below BARO at start	• VREF circuit OPEN • Slow responding or biased MAP or BAP circuit/sensor

WARNING: To prevent personal injury or death, avoid 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”.
3. Monitor sensor voltage. Verify an active DTC for the sensor.
   - 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 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.

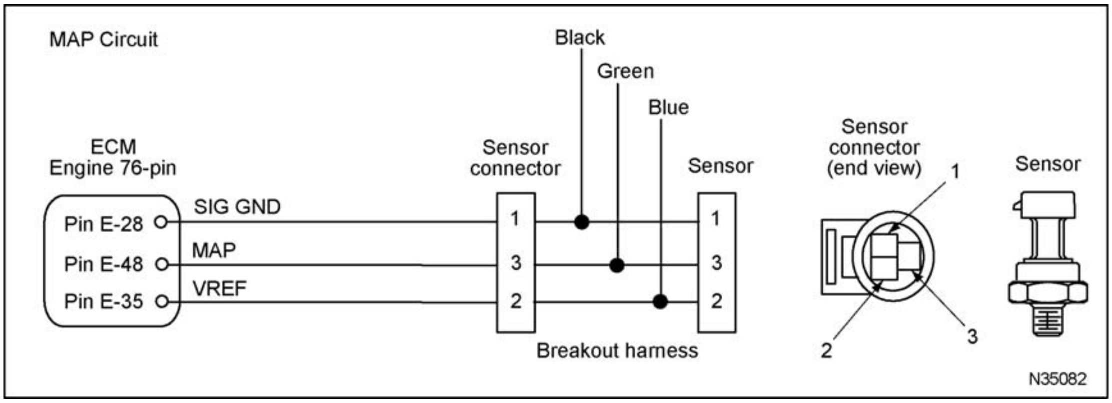

Figure 247 MAP circuit diagram

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 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 365).
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 Check (page 365).
DMM - Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 365).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

MAP 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	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 365).
3 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 365).

Connector Resistance Check to GND

Turn ignition switch 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 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 MAP is grounded at Pin 1 from ECM Pin E-28 and returns a variable voltage signal from Pin 3 to ECM Pin E-48.

Fault Detection / Management

The ECM monitors the internal Barometric Absolute Pressure (BAP) sensor as a base line for zeroing the MAP and Exhaust Back Pressure (EBP) signals.

The ECM continuously monitors the control system. If sensor signal is higher or lower than expected, the ECM disregards the sensor signal and uses a calibrated default value. The ECM will set a DTC, turn on the amber engine lamp, run the engine in a default range, and disable the 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

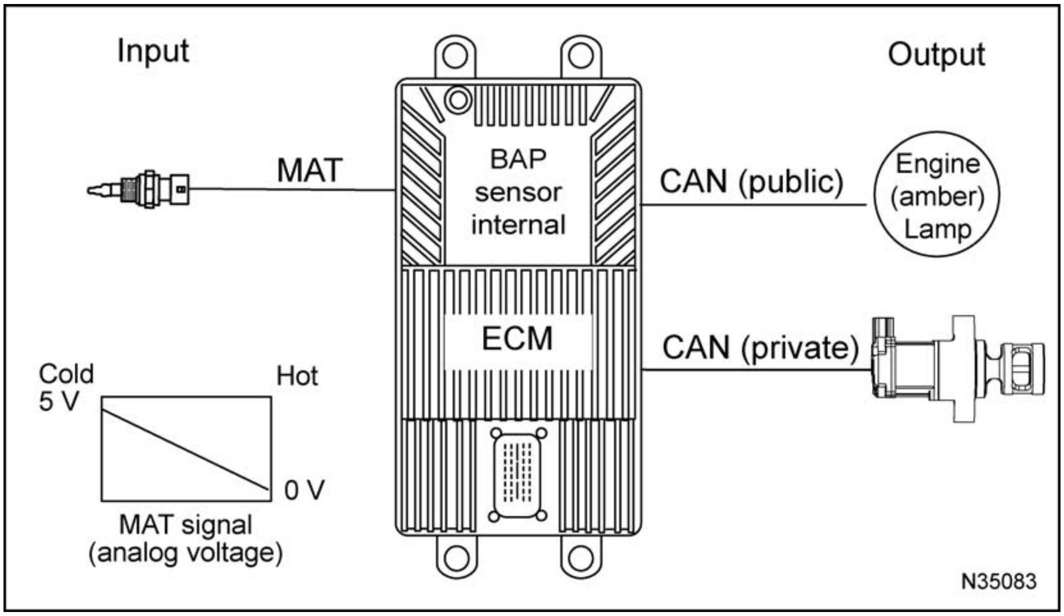

Figure 248 MAT sensor function diagram

The MAT sensor function diagram includes the following:

- Manifold Air Temperature (MAT) sensor
- Exhaust Gas Recirculation (EGR) valve
- Electronic Control Module (ECM) with internal Barometric Absolute Pressure (BAP) sensor
- Engine lamp (amber)

Function

The MAT sensor provides a feedback signal to the ECM indicating 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 front left of the intake manifold.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4-USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 3-banana Plug Harness (page 386)
- 500 Ohm Resistor Harness (page 387)
- 180-Pin Breakout Box (page 385)
- Temperature Sensor Breakout Harness (page 392)
- Terminal Test Adapter Kit (page 392)

MAT Sensor End Diagnostics

DTC	Condition	Possible Causes
1161	MAT signal out-of-range LOW	• MAT signal circuit short to GND • Incorrect MAT sensor connection • Failed sensor
1162	MAT signal out-of-range HIGH	• MAT signal OPEN or short to PWR • SIG GND circuit OPEN • Incorrect MAT sensor connection • Failed sensor

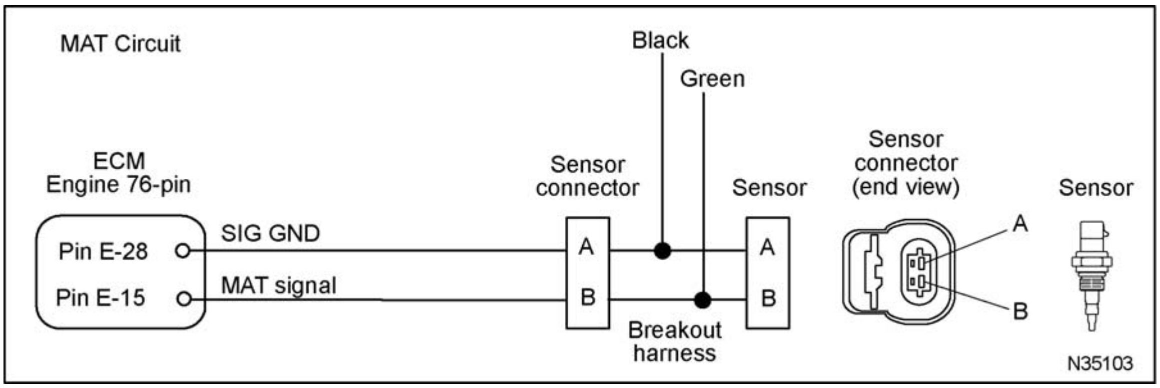

Figure 249 MAT circuit diagram

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

1. Using EST with MasterDiagnostics® software, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active DTC for the sensor.
   - 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 spike 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 1162	If DTC 1161 is active, check MAT signal for short to GND. Do Harness Resistance Checks (page 368).
EST - Check DTC Short 3-banana Plug Harness across B and GND	DTC 1161	If DTC 1162 is active, check MAT signal for OPEN. Do Harness Resistance Checks (page 368).
EST - Check DTC Short 3-banana Plug Harness across A and B	DTC 1161	If DTC 1162 is active, check SIG GND for OPEN. Do Harness Resistance Checks (page 368).
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
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 368).

Connector Resistance Check to GND

Turn ignition switch OFF. Connect breakout harness. Leave sensor 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.

Harness Resistance Check

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

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

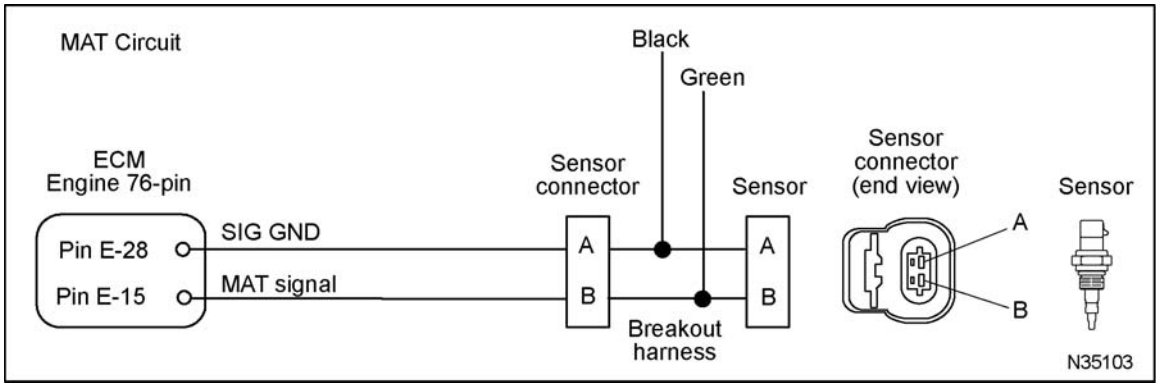

Figure 250 MAT circuit diagram

MAT Circuit Operation

The MAT is a thermistor sensor supplied with a 5 volt reference voltage at Pin B from ECM Pin E-15. The MAT is grounded at Pin A from ECM Pin E-28. As temperature increases, thermistor resistance decreases, causing 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 will set a DTC, turn on the amber engine lamp, and run the engine in a default range.

TACH (Tachometer Output Circuit)

DTC	SPN	FMI	Condition
None			

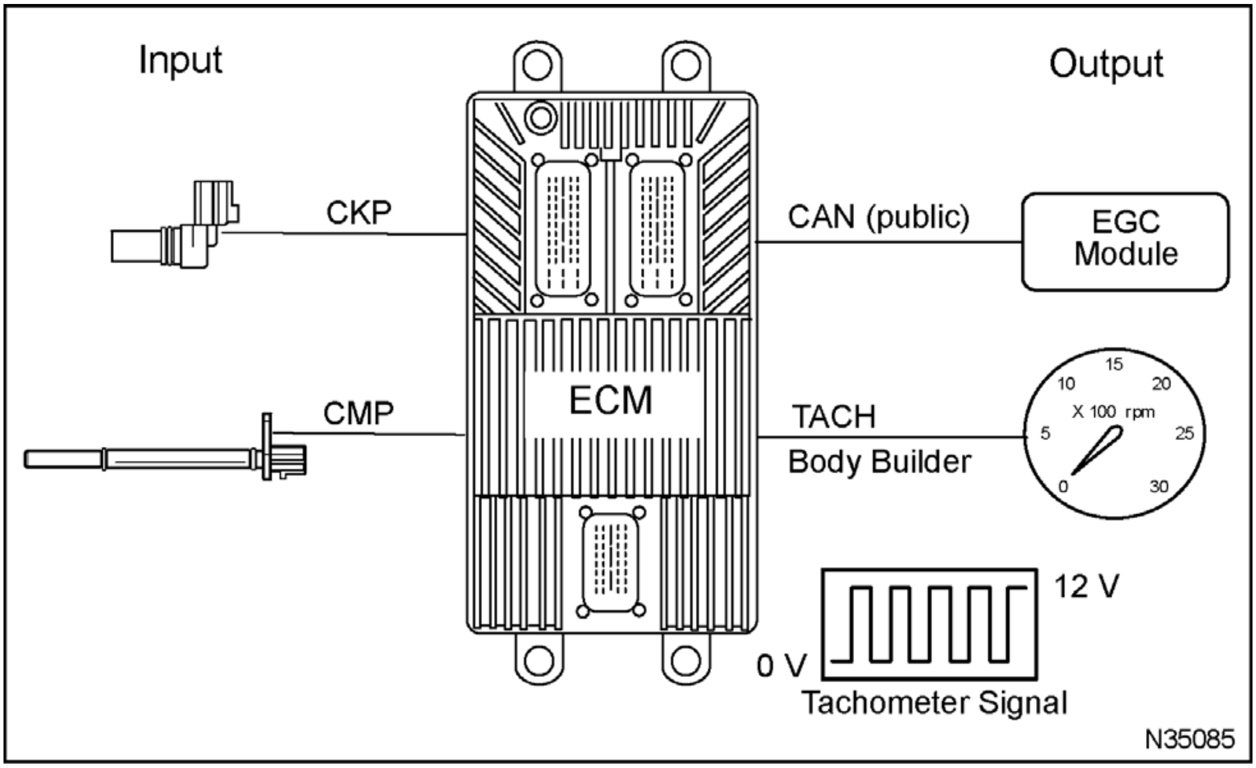

Figure 251 Function diagram for the tachometer output circuit

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

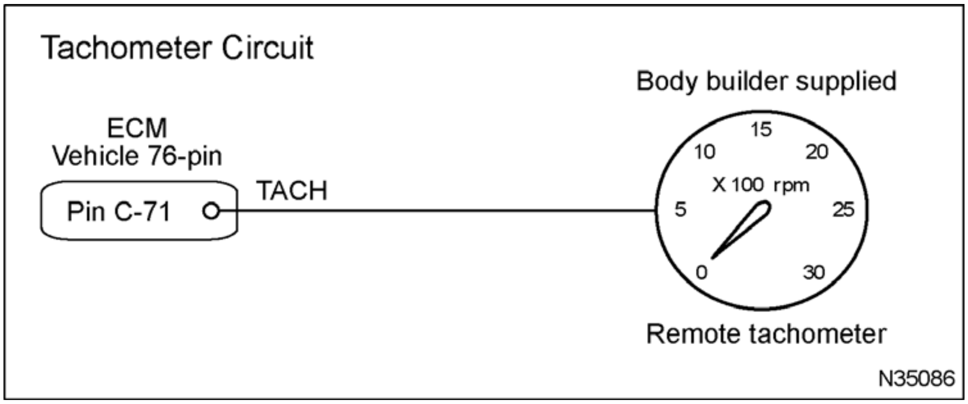

Figure 252 Tachometer circuit diagram

Circuit End Voltage Check

NOTE: If the tachometer is not working on the EGC, see *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.

Disconnect component from the body builder blunt cut off circuit. Turn 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 = 700 RPM	If no signal, do Harness Resistance Check (page 371).
	High idle = 3200 RPM	

Harness Resistance Checks

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

The ECM receives a signal from the CMP 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.

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

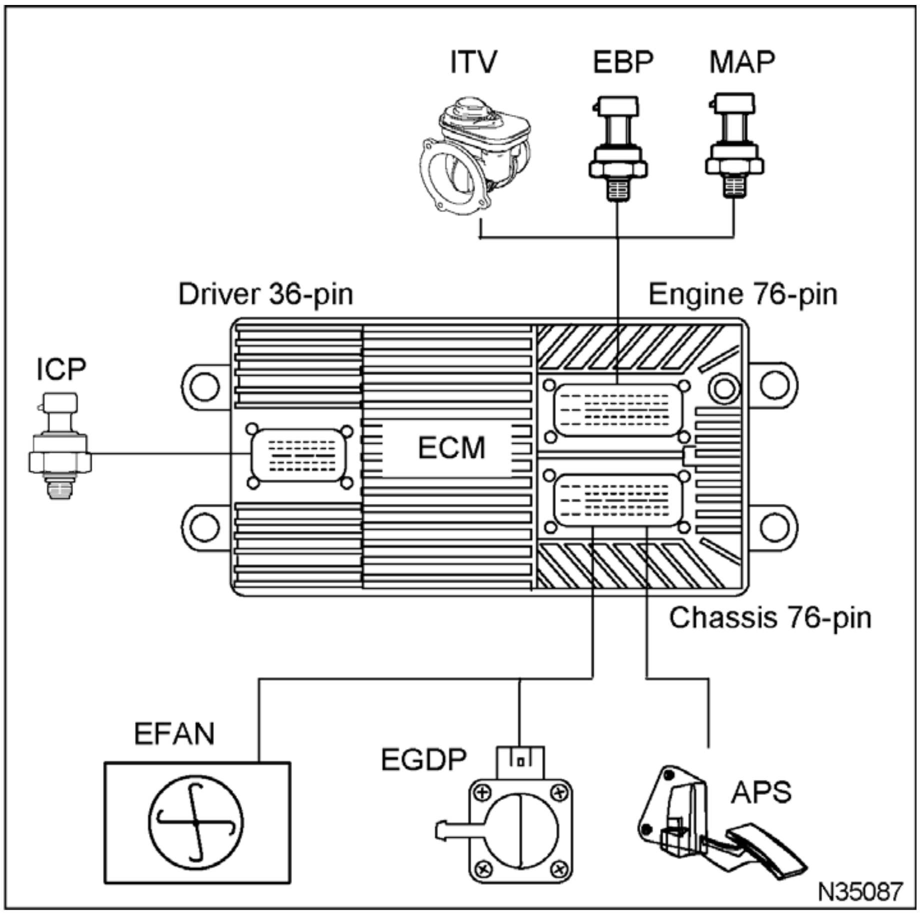

Figure 253 VREF Function diagram

The VREF function diagram includes the following:

- Electronic Control Module (ECM)
- Intake Throttle Valve (ITV)
- Exhaust Back Pressure (EBP) sensor
- Manifold Absolute Pressure (MAP) sensor
- Exhaust Gas Differential Pressure (EDGP) sensor
- Accelerator Position Sensor (APS)
- Electronic Fan (EFAN)
- Injection Control Pressure (ICP) sensor

Function

The VREF circuit is a 5 volt reference supplied by the ECM and provides power to all 3-wire sensors.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4-USB Interface Cable (page 390)
- Digital Multimeter (DMM) (page 388)
- 180-Pin Breakout Box (page 385)
- Terminal Test Adapter Kit (page 392)

VREF Pin-point Diagnostics

DTC	Condition	Possible Causes
5666	VREF engine voltage below min	• VREF circuit short to GND
5668	VREF chassis voltage below min	• Internally shorted sensor on VREF circuit
5671	VREF body voltage below min	
5667	VREF engine voltage above max	• VREF circuit short to PWR
5669	VREF chassis voltage above max	• Internally shorted sensor on VREF circuit
5672	VREF body voltage above max	

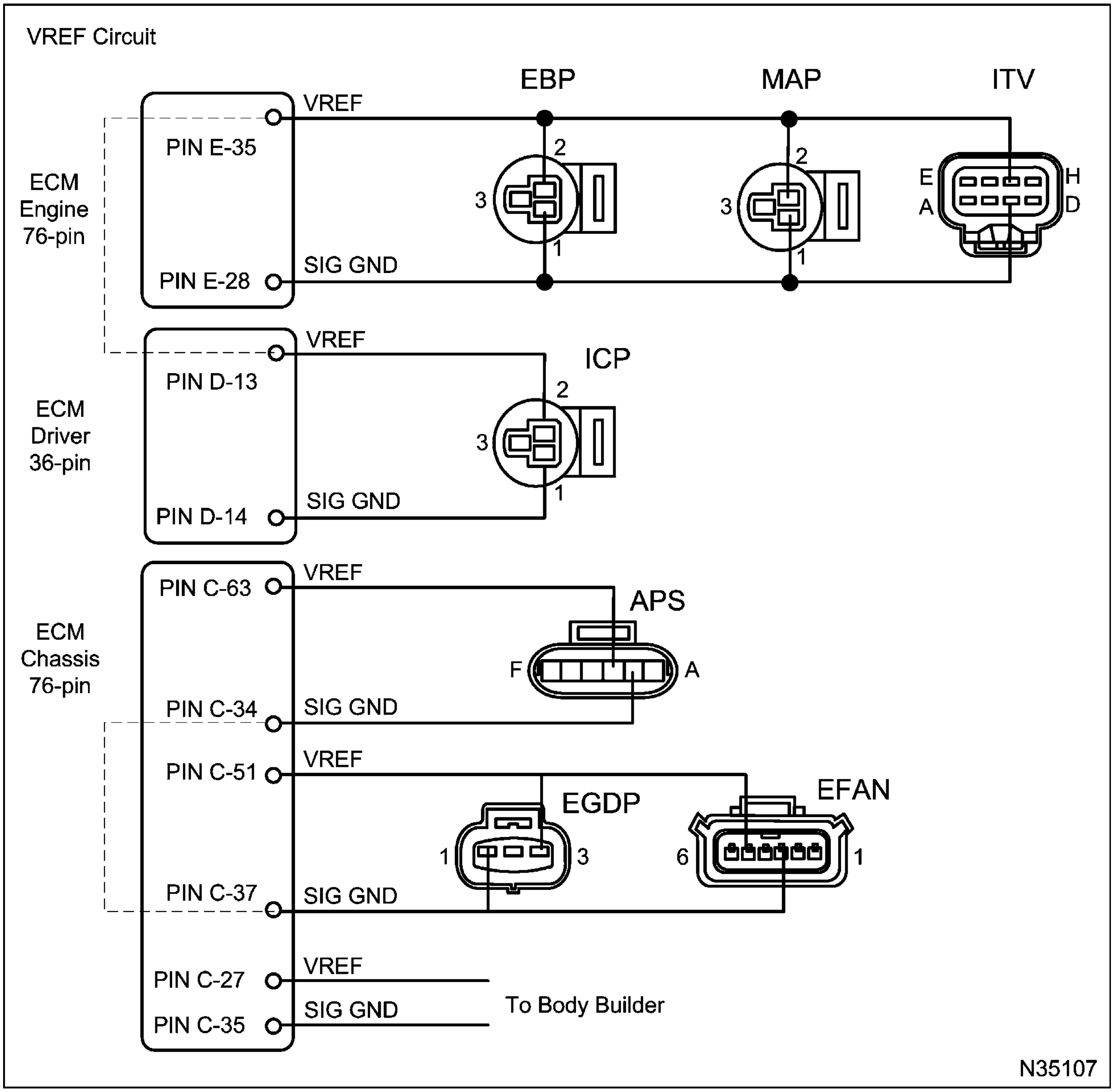

Figure 254 VREF circuit diagram

NOTE: ECM internally bridged Pins C-51 to C-63 and D-13 to E-35.

VREF Voltage Check

If multiple 3-wire sensor DTCs are set, turn ignition switch to ON. Disconnect each component 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 components are disconnected, check for an OPEN circuit between ECM and sensors.

Test Point	Spec	Comment
APS C to GND	5 V ± 0.5 V	See above Note.
EFAN 5 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.
MAP 2 to GND	5 V ± 0.5 V	See above Note.
ITV G to GND	5 V ± 0.5 V	See above Note.
ICP 2 to GND	5 V ± 0.5 V	See above Note.

Connector Resistance Check to GND

Turn ignition switch OFF. Disconnect each component 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.
EFAN 5 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.
MAP 2 to GND	> 1 kΩ	See above Note.
ITV G to GND	> 1 kΩ	See above Note.
ICP 2 to GND	> 1 kΩ	See above Note.

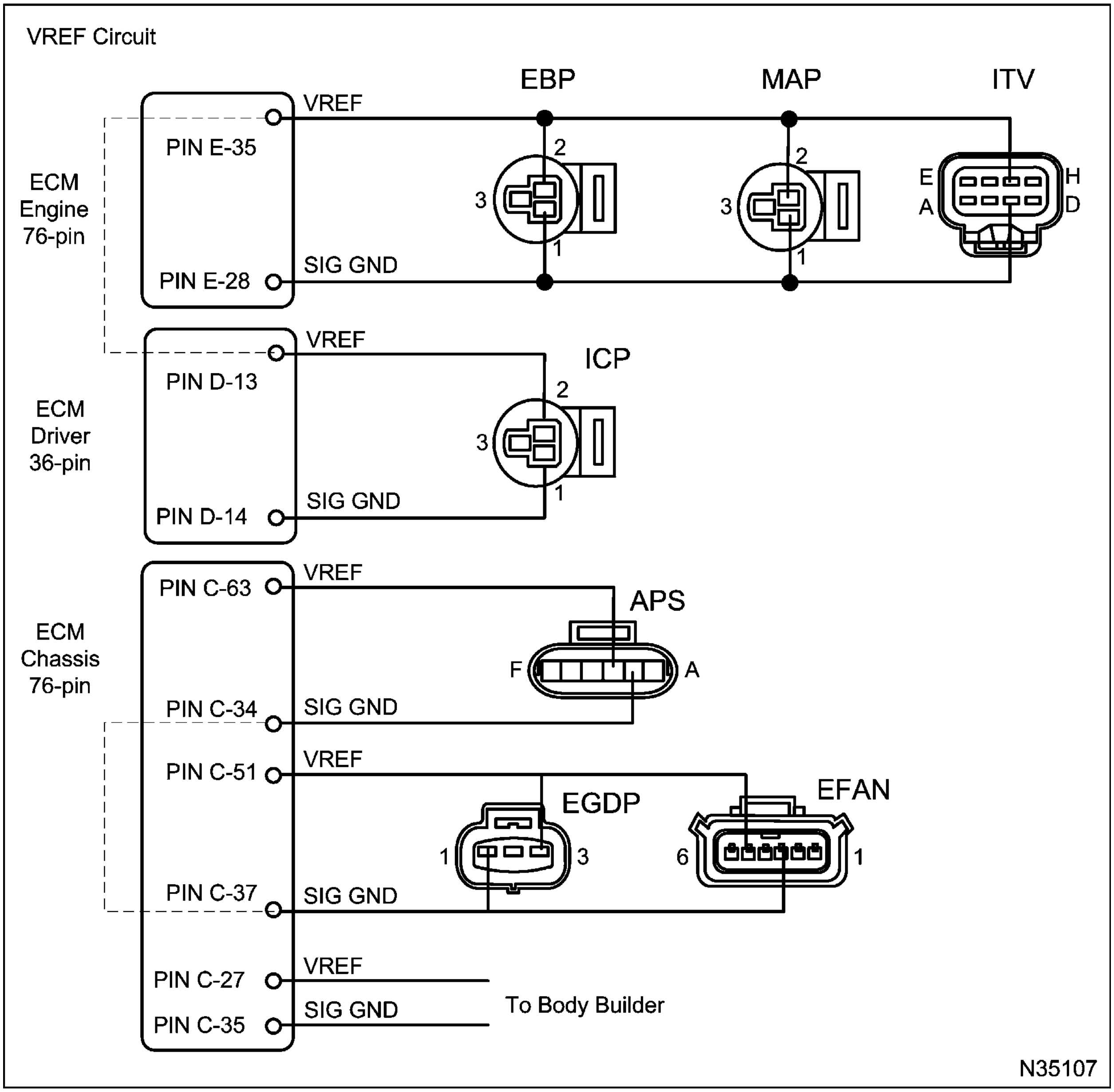

Figure 255 VREF circuit diagram

NOTE: ECM internally bridged Pins C-51 to C-63 and D-13 to E-35.

NOTE: See *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for APS, EFAN, and EGDP circuit diagrams.

Harness Resistance Check

Turn ignition switch OFF. Connect breakout box and breakout harness. Leave ECM and all components in the circuit disconnected. Use DMM to measure resistance.

Sensor	Test Point	Spec	Comment
APS			
VREF	C to C-63	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	B to C-34		
EFAN			
VREF	5 to C-51	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	3 to C-37		
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		
MAP			
VREF	2 to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to E-28		
ITV			
VREF	G to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	C to E-28		
ICP			
VREF	2 to D-13	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to D-14		

VREF Circuit Operation

The ECM supplies VREF at Pin E-35 (engine connector), C-51, C-27 and C-63 (chassis connector), and D-13 (driver connector) when the ignition switch is on.

VREF provides power to all engine 3-wire sensors, ITV, the chassis mounted APS/IVS, EFAN. and EGDP. The ECM also provides these components with a ground point, the SIG GND circuit. Sensor signal voltage is generated between these two reference points based on the pressure or position the sensor is designed to measure.

Fault Detection / Management

When a VREF circuit is open, each sensor on that circuit will set a DTC. When a VREF circuit is shorted to PWR or GND, a VREF DTC will set.

NOTE: After removing connector, inspect for damaged pins, corrosion, or loose pins. Repair as required.

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

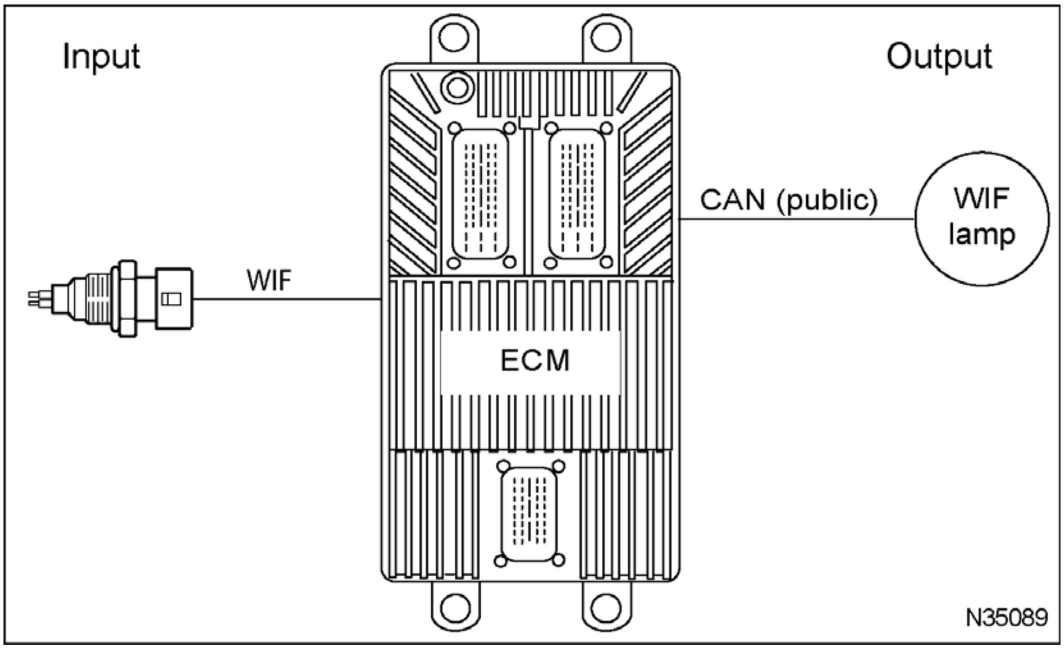

Figure 256 WIF functional diagram

The WIF sensor functional diagram includes the following:

- Water In Fuel (WIF) sensor
- Electronic Control Module (ECM)
- 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 will alert the operator by illuminating the water in fuel lamp. If a circuit fault is detected, a DTC will set and the amber engine lamp will illuminate.

Sensor Location

The WIF sensor is installed in the Horizontal Fuel Conditioning Module (HFCM) on the left inside frame rail.

Tools

- EZ-Tech® Electronic Service Tool (EST) (page 389) with MasterDiagnostics® software
- IC4-USB Interface Cable (page 390)

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 Horizontal Fuel Conditioning Module (HFCM).

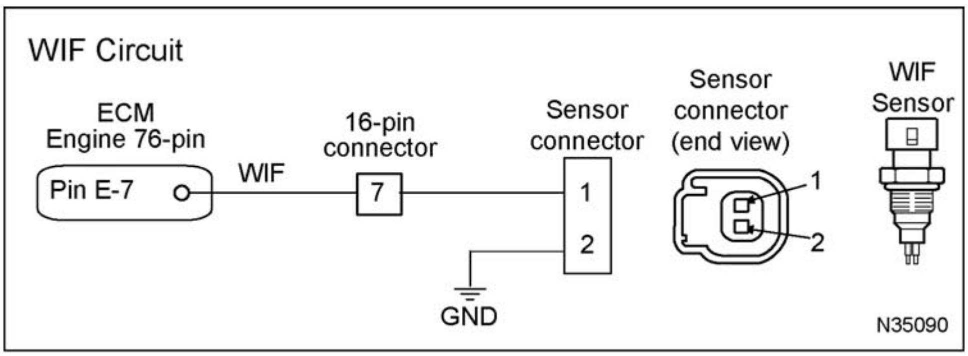

Figure 257 WIF circuit diagram

1. Drain a fuel sample from the HFCM. See Water In Fuel (WIF) Lamp On (Drain Water from HFCM) (page 109).
   - If water is present, drain all water out of the fuel 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 PID will read YES if water is detected.

   - 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 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.

Voltage Check

Disconnect WIF sensor connector. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comments
1 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
2 to B+	B+	If < B+, check GND circuit for OPEN

Connector Resistance Checks to GND

Turn ignition switch OFF, Disconnect harness from WIF sensor, Use DMM to measure resistance.

Test Point	Spec	Comments
1 to GND	> 1 kΩ	If < 1 kΩ, check WIF circuit for short to GND
2 to GND	< 5 Ω	If > 5 Ω, check GND for OPEN circuit

Harness Resistance Check

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

Test Point	Spec	Comments
1 to E-7	< 5 Ω	If > 5 Ω, check for OPEN circuit

WIF Circuit Operation

The WIF sensor is supplied a 5 volt reference voltage at pin 1 from the ECM pin E-7. The WIF is grounded at pin 2. The signal is 4.6 volts at normal state and below 4.0 volts when water is across the sensor.

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 in the circuit or sensor.