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## Description

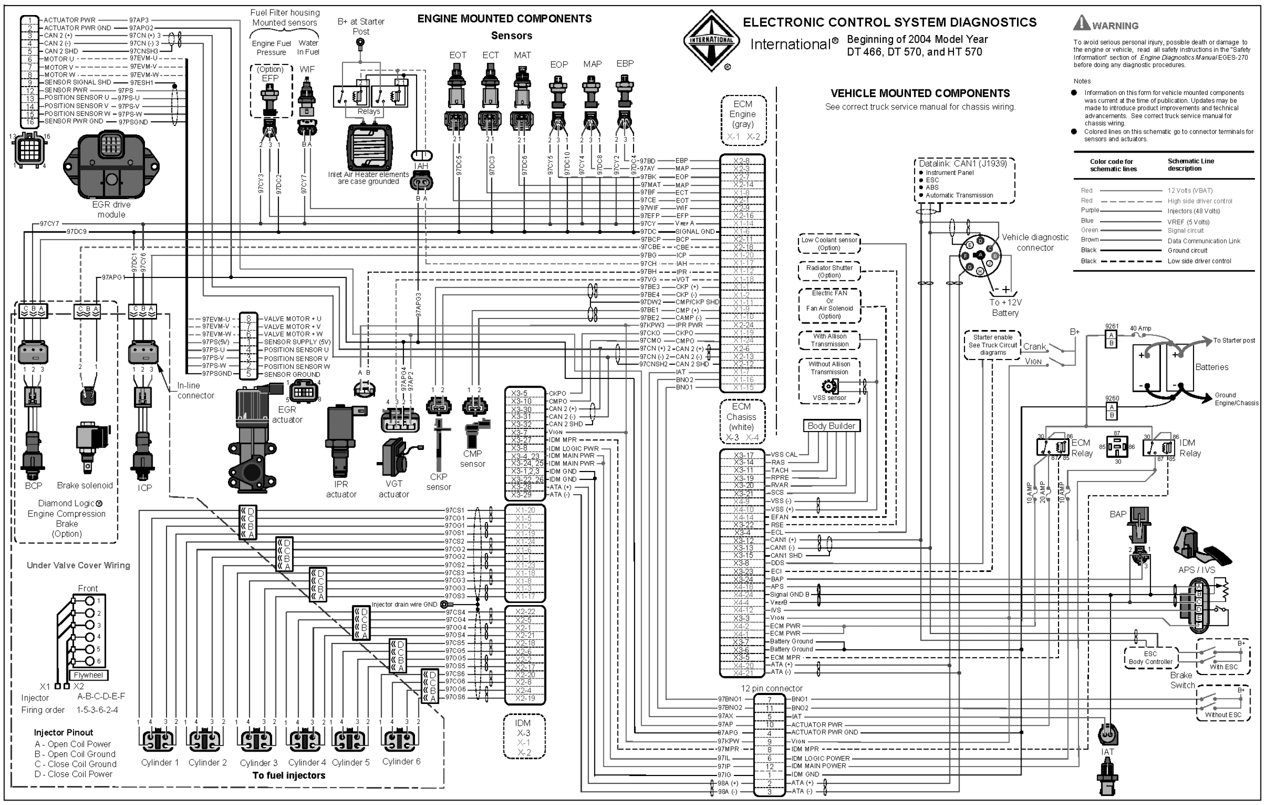
**Section Information**

The following diagnostic information is included in this section:

- Sensor and actuator locations
- Sensor and actuator tests
- Diagnostic procedures for sensors and actuators
- Pin-point diagnostics
- Circuit diagnostics – Circuit diagnostics pertain to a specific ECM circuit and has the following structure:
  - Function diagram and text
  - Circuit diagram and diagnostic tests to diagnose Diagnostic Trouble Codes (DTCs) and verify circuit functions

# Electronic Control System Diagnostics Form

### EGED-285 Diagnostic Form Example




EGED-285 © 2005 INTERNATIONAL TRUCK AND ENGINE CORPORATION

**Figure 364 EGED-285 (Front Side)**

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

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

**NOTE:** All recorded signal values are with the breakout box installed on the ECM and harness.

Diagnostic Form EGED-285 is available in 50 sheet pads. To order forms, use the following contact information:

**International Truck and Engine Corporation**
Order Desk
Moore Wallace North America
1750 Wallace Avenue
St. Charles, IL 60174
Phone (1-630) 313-7507
Fax (1-800) 882–0484

# Sensor and Actuator Locations

### Engine Mounted Components

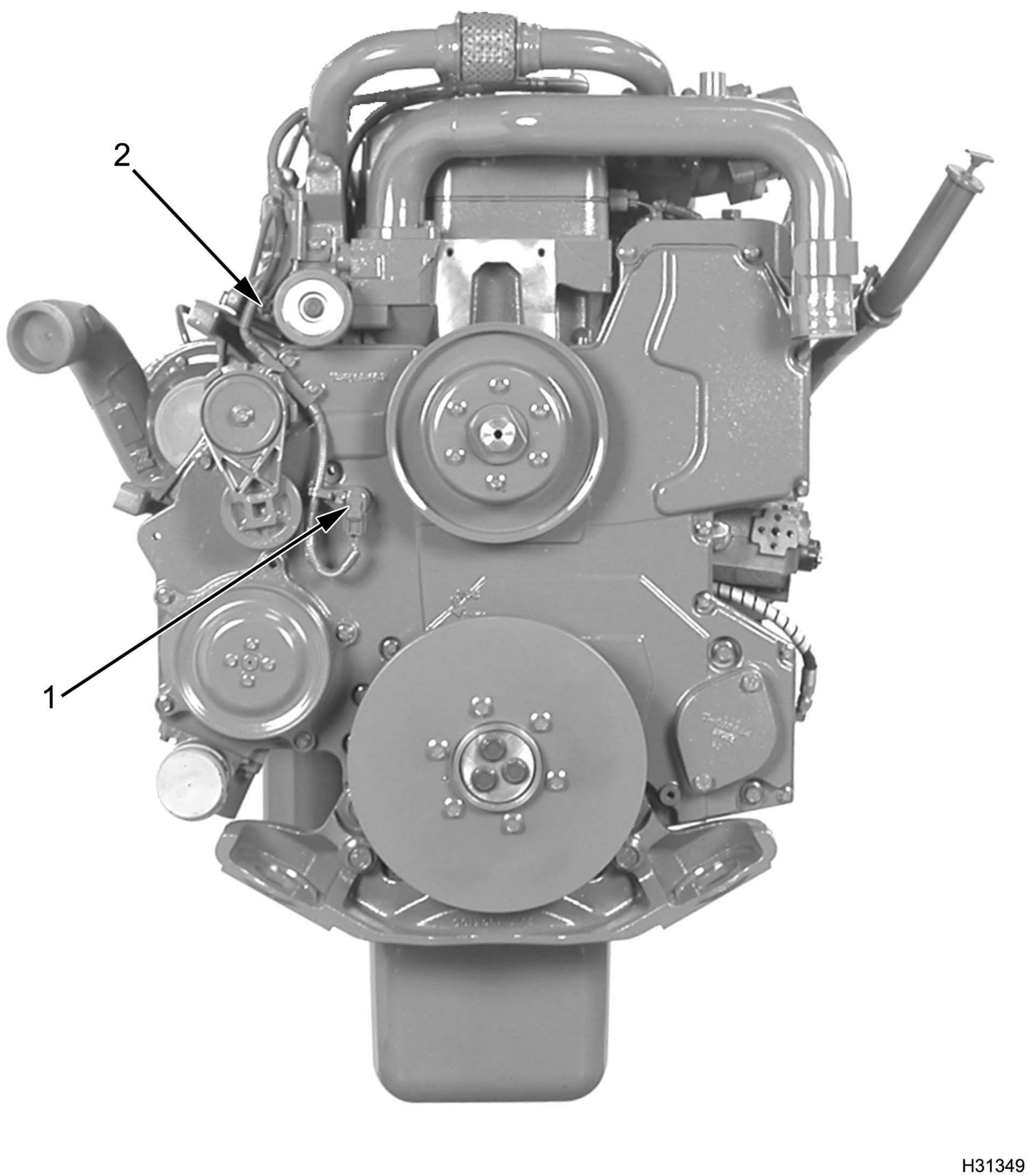



**Figure 365 Sensor location – Front View**

1. Camshaft Position (CMP) sensor
2. Engine Coolant Temperature (ECT) sensor

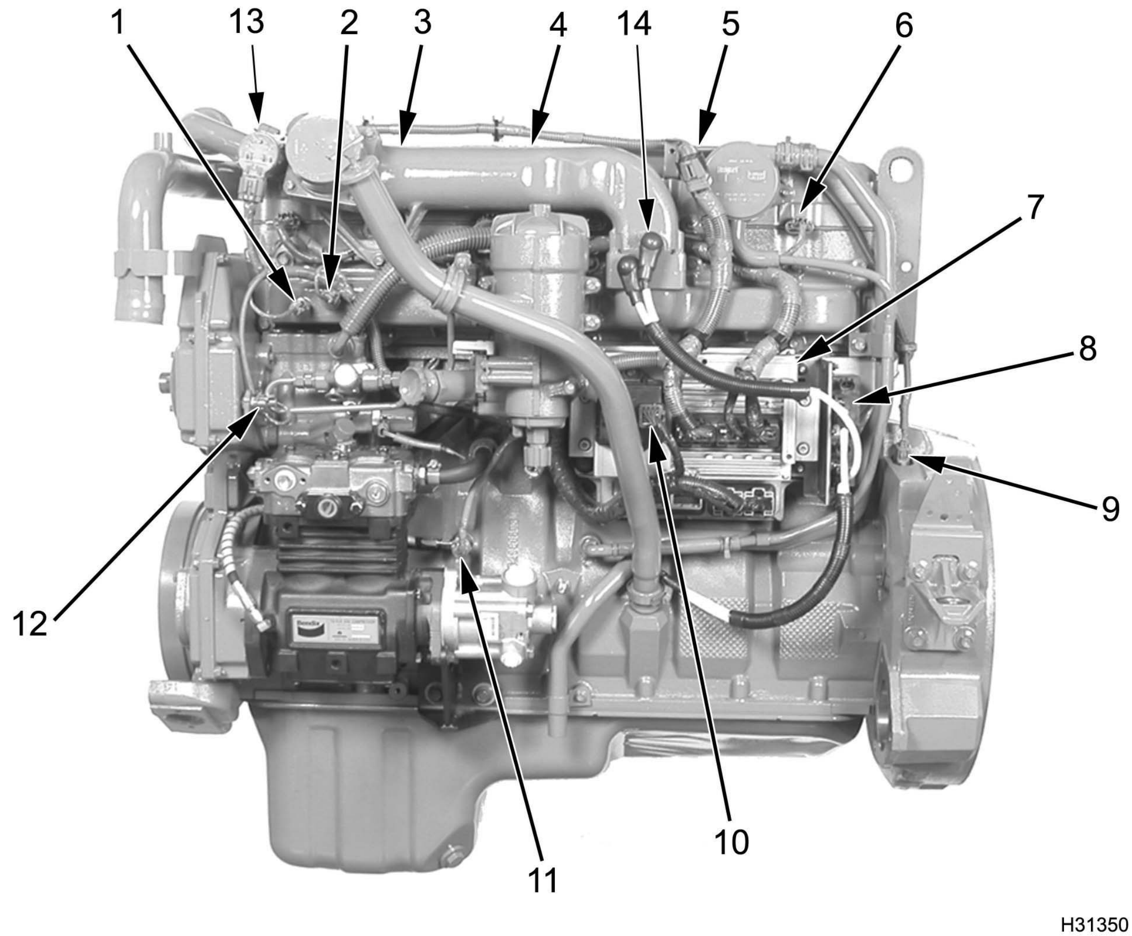



**Figure 366 Sensor location – Left View**

1. Manifold Absolute Pressure (MAP) sensor
2. Manifold Air Temperature (MAT) sensor
3. Optional Brake Control Pressure (BCP) sensor (under valve cover)
4. Optional Brake Shut-off Valve (under valve cover)
5. Injection Control Pressure (ICP) sensor (under valve cover)
6. Valve cover gasket pass-through connector
   a. (6) four-wire connectors for fuel injectors
   b. (1) three-wire connector for ICP sensor
   c. Engine brake application – (1) three-wire connector for the BCP sensor and (1) three-wire connector for the brake shut-off valve.
7. Electronic Control Module (ECM) and Injector Drive Module (IDM) assembly
8. Inlet Air Heater (IAH) relays
9. Crankshaft Position (CKP) sensor
10. Exhaust Gas Recirculation (EGR) drive module
11. Engine Oil Pressure (EOP) sensor
12. Engine Oil Temperature (EOT) sensor
13. Exhaust Gas Recirculation (EGR) valve
14. Inlet Air Heater (IAH) elements

**NOTE:** For Water in Fuel (WIF) sensor and optional Engine Fuel Pressure (EFP) sensor location, see “Fuel Flow” in Section 1 (page 35).

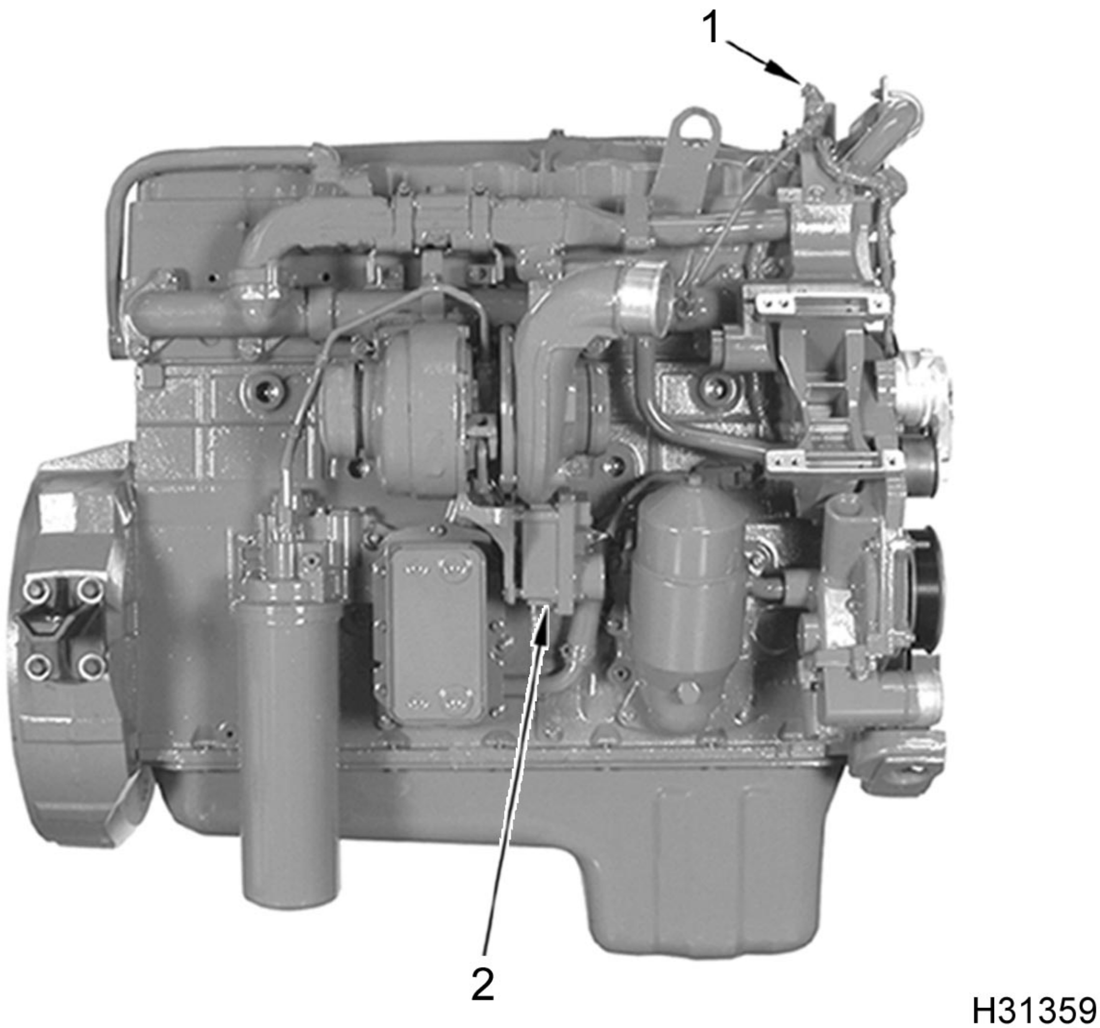



**Figure 367 Sensor location – Right View**

1. Exhaust Back Pressure (EBP) sensor
2. Turbocharger control module

**Vehicle Mounted Components**

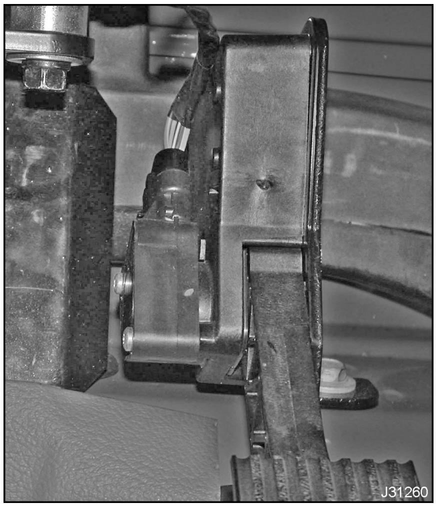



**Figure 368 APS/IVS sensor**

The APS/IVS sensor is located above the accelerator pedal.

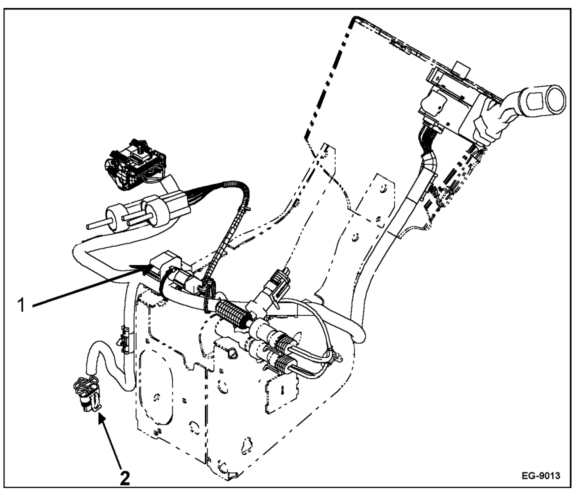



**Figure 369 Under the dashboard sensors**

1. Barometric Absolute Pressure (BAP) sensor
2. Accelerator Pedal Position and Idle Validation Connector (APS/IVS)

The BAP sensor is located in the cab of the vehicle.

## Diagnostic Procedures for Sensors and Actuators

### Pin Grip Inspection

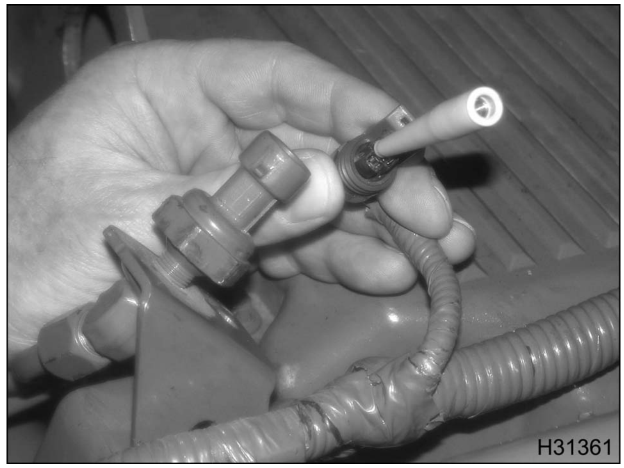



**Figure 370 Pin grip check**

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

**Operational Diagnostics**

Operational Diagnostic tests use the MasterDiagnostics® Continuous Monitor Test. For help, see “Diagnostic Software Operation” in Section 3 (page 68) for procedure to run the Continuous Monitor Test.

**$V_{REF}$ Tests using MasterDiagnostics®**

1. Plug the Electronic Service Tool (EST) tool into the American Trucking Association (ATA) datalink connector and start MasterDiagnostics®.
2. Disconnect sensor to be tested.
3. Connect breakout harness to harness only.
4. Turn the ignition switch to ON.
5. Monitor signal voltage with the EST using continuous monitor session and initiating KOEO Continuous Monitor Test.

   Voltage should be near 0, unless the signal circuit is shorted or incorrectly wired to $V_{REF}$, B+, or other voltage sources. See Circuit Diagnostics in this section for sensor specifications.
6. Use a Digital Multimeter (DMM) to verify $V_{REF}$ at BLUE pin ($V_{REF}$) in breakout harness (voltage should be 5 V ± 0.5 V). Connect positive to BLUE and negative to chassis ground.

   If voltage is greater than 5.5 V, check $V_{REF}$ for short to B+.

   If voltage is less than 4.5 V, check $V_{REF}$ for open or short to ground.
7. Install 500 ohm harness between GREEN (signal circuit), and BLUE ($V_{REF}$) pin of breakout harness. Monitor signal voltage with EST.

   If voltage is less than 4.5 V, check signal circuit for open or short to ground.
8. Use a DMM to check resistance from BLACK pin (signal ground) of breakout harness to chassis ground.

   If resistance is greater 5 ohm, check for open or high resistance between ECM and sensor connector.
9. Connect engine or chassis harness to sensor.
10. Use the EST to clear DTCs.

    If an active DTC remains after checking test conditions, replace sensor.

**Temperature Sensor Tests using MasterDiagnostics®**

1. Plug the Electronic Service Tool (EST) tool into the ATA connector and start MasterDiagnostics®.
2. Disconnect sensor to be tested.
3. Connect breakout harness to harness only.
4. Turn the ignition switch to ON.
5. Monitor signal voltage with the EST using continuous monitor session and initiating KOEO Continuous Monitor Test (voltage should be greater than 4.6 V). See Circuit Diagnostics in this section for sensor specifications.

   If voltage is less than 4.6 V, check signal circuit for short to ground.

   If voltage is greater than 5.5 V, check signal circuit for short to B+.
6. Install 3–Banana plug harness between GREEN (signal circuit), and BLACK (signal ground) pin of breakout harness.

   If voltage is more than 0.127 V, check ground circuit for open or high resistance. See Circuit Diagnostics in this section for sensor specifications.
7. Remove 3–Banana plug harness.
8. Connect engine or chassis harness to sensor.
9. Use the EST to clear DTCs.

   If an active DTC remains after checking test conditions, replace sensor.

## Pin-Point Diagnostics

Some Pin-Point Diagnostic tests use the MasterDiagnostics® Output State Tests. For help, see “Diagnostic Software Operation” in Section 3 (page 68) for procedure to run the Low and High Output State Tests.

## Connector Voltage Checks to Ground


**Figure 371 $V_{REF}$ check**

### Procedure

1. Turn the ignition switch to ON.
2. Connect breakout harness to the harness only.
3. Measure voltage at each pin with a DMM.
4. Compare sensor or actuator voltage readings with the expected voltages. See Circuit Diagnostics in this section for circuit specifications.

   If a breakout harness is not available, use the correct tool from Terminal Test Adapter Kit. Do not directly probe the connector pins with the DMM leads. For a circuit with an expected voltage, this test will verify circuit integrity.
5. Turn the ignition to OFF.

For circuits without an expected voltage, this test will determine if that circuit is shorted or incorrectly wired to ground, $V_{REF}$, B+ or other voltage sources.

## Connector Resistance Checks to ECM Chassis Ground

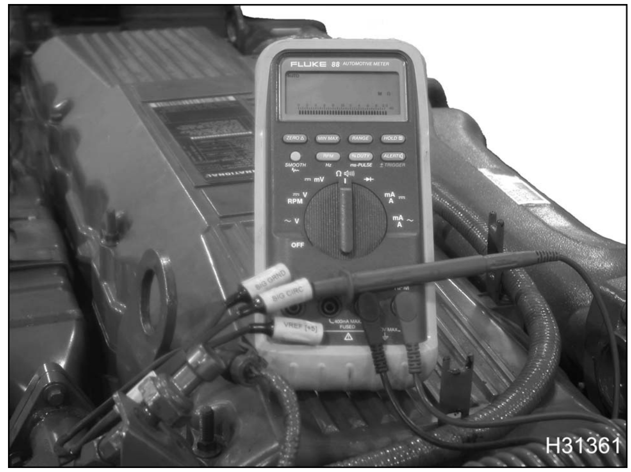



**Figure 372 Resistance check to ECM chassis ground**

### Procedure

**NOTE:** The truck *Chassis Electrical Circuit Diagram Manual* should always be used for chassis ground circuit information.

1. Disconnect chassis connector 9260.

   **NOTE:** Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck *Chassis Electrical Circuit Diagram Manual* for complete chassis side ECM and IDM ground circuit information.
2. Connect breakout harness to harness only.
3. Use breakout harness to measure resistance from the lead of the breakout harness to the connector 9260 Pin A.

   See Circuit Diagnostics in this section for circuit specifications.

   Sensor signal ground circuits should measure less than 5 ohms.

   $V_{REF}$ and signal circuits should measure more than 1 k ohm.

   The control side of an actuator will measure more than 1 k ohms, but the expected voltage for the other side of the actuator circuit will measure the voltage that the control side was switching, either power or ground.

If the ECM is switching the ground circuit, the other side of the actuator circuit should measure more than 1 k ohms from the connector pin to connector 9260 Pin A.

If the ECM is switching the power circuit, the other side of the actuator circuit should measure less than 5 ohms from the connector pin to connector 9260 Pin A.

**Connector Resistance Checks to Chassis Ground**


**Figure 373 Resistance check to chassis ground**

**Procedure**

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**NOTE:** The truck *Chassis Electrical Circuit Diagram Manual* should always be used for chassis ground circuit information.

1. Disconnect chassis connector 9260.

   **NOTE:** Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck *Chassis Electrical Circuit Diagram Manual* for complete chassis side ECM and IDM ground circuit information.

2. Connect breakout harness to harness only.
3. Disconnect negative battery cable.
4. Use breakout harness to measure resistance from the lead of the breakout harness to the negative battery cable.

   See Circuit Diagnostics in this section for circuit specifications.

   Sensor signal ground circuits should measure greater than 500 ohms.

   $V_{REF}$ and signal circuits should measure more than 1 k ohm.

   The control side of an actuator will measure more than 1 k ohms, but the expected voltage for the other side of the actuator circuit will measure the voltage that the control side was switching, either power or ground.

   If the ECM is switching the ground circuit, the other side of the actuator circuit should measure more than 1 k ohms from the connector pin to battery ground.

   If the ECM is switching the power circuit, the other side of the actuator circuit should measure greater than 500 ohms from the connector pin to battery ground.

**Harness Resistance Checks**

**Procedure**

**CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting the connector or relay for the ECM and IDM. Failure to turn the switch to OFF will cause a voltage spike and damage to electrical components.**

1. Check harness resistance if high resistance or an open circuit is suspected.
2. Connect breakout harness to harness only.
3. Connect breakout box to the ECM end of the harness only.
4. Measure resistance from breakout box pin to the breakout harness pin. Circuit wires should have a resistance of less than 5 ohms.

   See Circuit Diagnostics in this section for circuit specifications.

**Operational Voltage Checks**

Operational voltages checks determine In-range faults or intermittent connections.

To determine in-range faults and intermittent connections, monitor a suspected circuit and recreate conditions likely to cause the problem.

Monitor signal voltage with the EST using continuous monitor session and initiating KOEO Continuous Monitor Test. See Circuit Diagnostics in this section for circuit specifications.

Use a DMM and breakout harness or a DMM and breakout box. See Circuit Diagnostics in this section for circuit specifications.

# Circuit Diagnostics

### AMS (Air Management System)

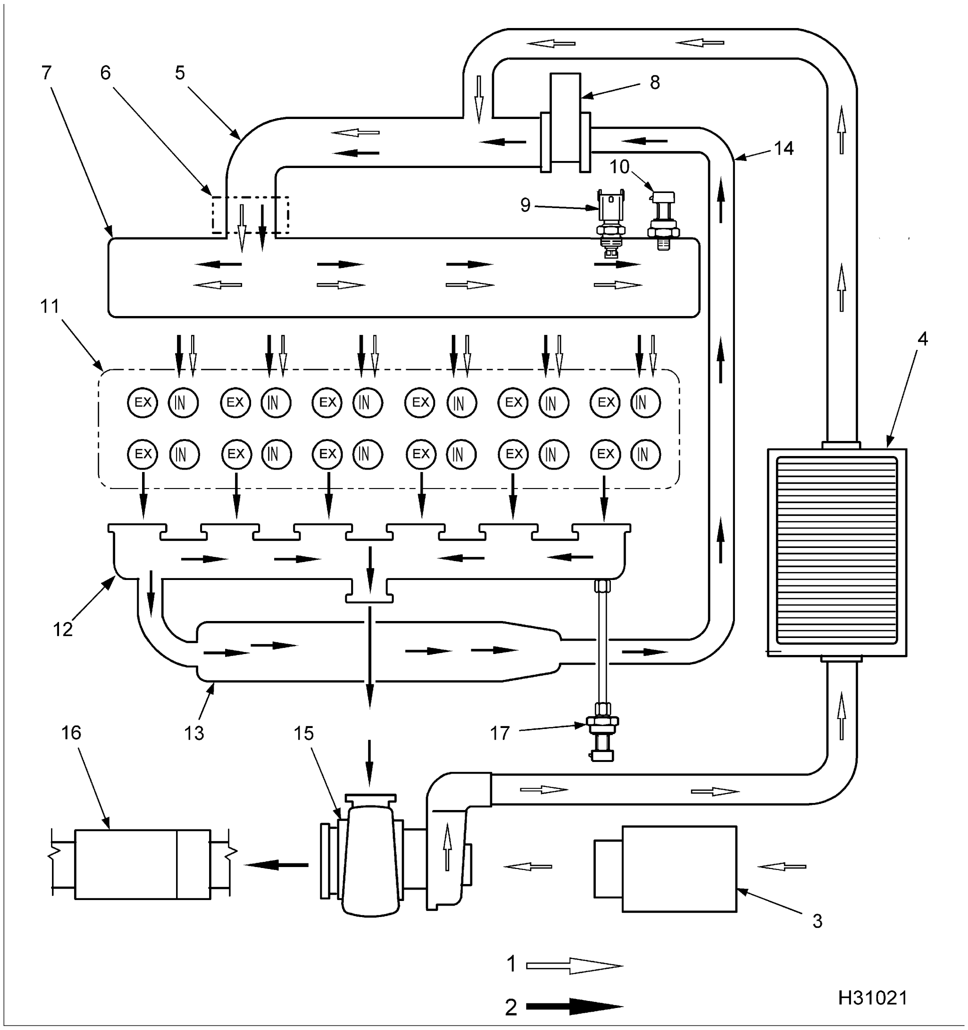



**Figure 374 Air Management System (AMS)**

1. Intake air
2. Exhaust gas
3. Air filter assembly
4. Charge Air Cooler (CAC)
5. Inlet and EGR mixer duct
6. Inlet Air Heater (IAH) assembly
7. Intake manifold
8. EGR valve
9. Manifold Air Temperature (MAT) sensor
10. Manifold Absolute Pressure (MAP) sensor
11. Cylinder head
12. Exhaust manifold
13. EGR cooler
14. Exhaust gas crossover
15. Variable Geometry Turbocharger (VGT)
16. Muffler
17. Exhaust Back Pressure (EBP) sensor

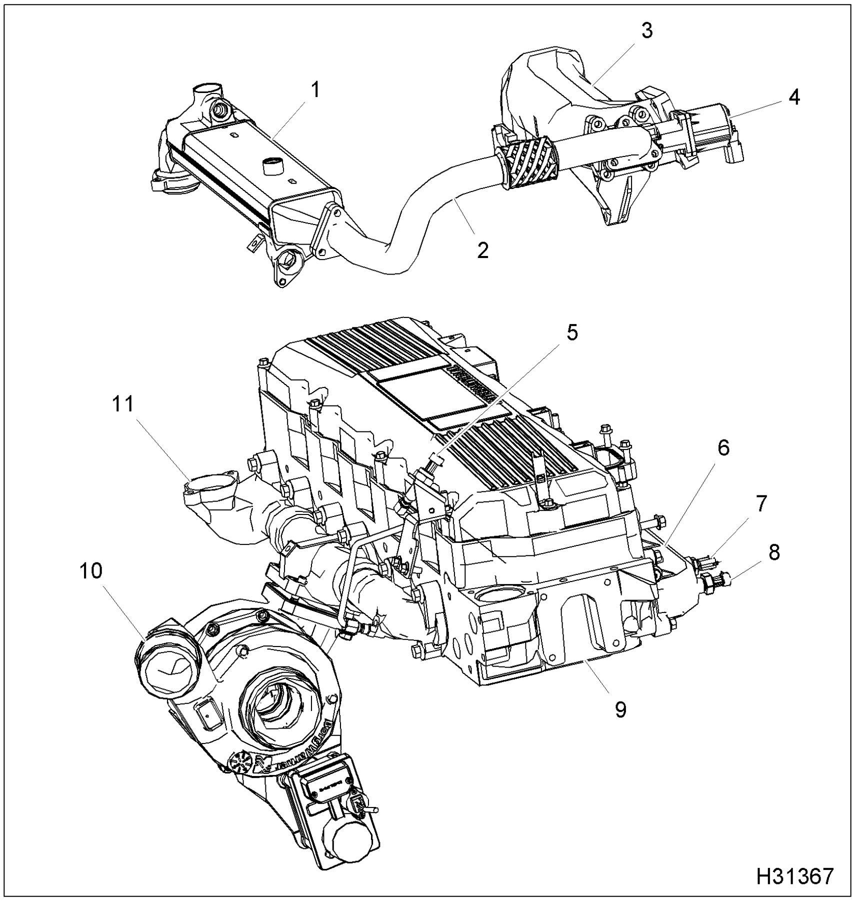



**Figure 375 AMS components**

1. EGR cooler
2. EGR tube assembly crossover
3. Intake and EGR mixer duct (heater optional)
4. EGR valve assembly
5. EBP sensor
6. Intake manifold
7. MAT sensor
8. MAP sensor
9. Cylinder head
10. Turbocharger (VGT)
11. Exhaust manifold

**AMS Operation**

**Function**

The **Variable Geometry Turbocharger (VGT)** has actuated vanes in the turbine housing. The vanes modify flow characteristics of exhaust gases through the turbine housing. The benefit is the ability to control boost pressure for various engine speeds and load conditions.

The VGT is a closed loop system that uses the Exhaust Back Pressure (EBP) sensor to provide feedback to the Electronic Control Module (ECM). The ECM uses the EBP sensor to continuously monitor EBP and adjust the duty cycle to the VGT to match engine requirements.

The VGT actuator is a control module that contains a microchip and a DC motor. The VGT actuator is located below the turbocharger. The microchip operates a DC motor which rotates a crank lever controlling the vane position in the turbine housing. The position of the vanes is based off the pulse width modulated signal sent from the ECM.

Actuated vanes are mounted around the inside circumference of the turbine housing. A unison ring links all the vanes. When the unison ring moves, all vanes move to the same position. Unison ring movement occurs when the crank lever in the control module moves.

Exhaust gas flow can be regulated depending on required exhaust back pressure for engine speed and load. As demand for EBP increases, the ECM increases the pulse-width modulation to the VGT control module. When EBP demand decreases, the ECM decreases the duty cycle to the control module.

Actuator control for the vane position is achieved by setting a pulse width modulated signal from the ECM in response to the following:

- Engine speed
- Desired fuel quantity
- Boost
- Exhaust back pressure and altitude

The **Exhaust Gas Recirculation (EGR) system** controls the amount of exhaust gas being introduced to the engine mixer duct by modulating the EGR valve. The EGR actuator is located at the front of the engine on the mixer duct.

The EGR drive module controls the EGR actuator and is located on the left side of the engine on the ECM and Injector Driver Module (IDM).

The ECM calculates the appropriate desired EGR valve position in response to the changing engine speed, fuel desired, operator demand, engine operating temperatures, exhaust back pressure, boost pressure and altitude. The ECM uses sensor input from the following:

- Variable Geometry Turbocharger (VGT) actuator
- Accelerator Position Sensor (APS)
- EGR actuator with position sensors
- EGR drive module
- Exhaust Back Pressure (EBP) sensor
- Manifold Absolute Temperature (MAT) sensor
- Barometric Absolute Pressure (BAP) sensor
- Engine Coolant Temperature (ECT) sensor
- Engine Oil Temperature (EOT) sensor
- Manifold Absolute Pressure (MAP) sensor

The EGR drive module provides feedback to the ECM on the valve position. The EGR drive module interprets the ECM command and sends the command using three pulse width modulated signals to the valve actuator.

The system is closed loop control using the EGR position signals. The EGR drive module provides a 9 V supply and ground to the Integrated Circuit (IC) in the motor of the valve. When the EGR drive module directs the valve to move, the IC with three Hall effect sensors provides the EGR drive module with the valve position signals. The EGR drive module interprets the three signals to determine valve position and sends the information back to the ECM.

### Fault Detection / Management

The ECM continuously monitors the Air Management System (AMS). When the ECM detects a fault in the any of the interdependent systems, the ECM will set a DTC and illuminate the amber ENGINE lamp.

**The Variable Geometry Turbocharger (VGT)** is continuously monitored by the ECM using the exhaust back pressure and the VGT pulse-width modulated signal's duty cycle. A DTC is logged when the ECM determines that the duty cycle required to reach the desired boost or exhaust back pressure is greater or less than the ECM's pre-programmed expected values.

**The Exhaust Gas Recirculation (EGR)** actuator is continuously monitored by the EGR drive module. When an EGR control error is detected, the EGR drive module sends a message to the ECM, a DTC is set, and the amber ENGINE lamp is illuminated. For additional function and operational information, see "EGR Actuator" (page 430).

### AMS Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

**NOTE:** Before proceeding make sure all sensor, injector and actuator electrical DTCs have been repaired. Follow the procedures outlined in Section 6 or Performance Diagnostics form.

**DTC 343 – Excessive EBP (gauge)**

DTC 343 is set by the ECM when the exhaust back pressure is greater than 260 kPa (37.7 psi) for more than 2.5 seconds.

| Possible Causes | Comment |
|---|---|
| EBP sensor bias high | Check sensor signal voltage. See “EBP Sensor”(page 375) . |
| EBP signal ground open | Check sensor signal voltage. See “EBP Sensor” (page 375). |
| Exhaust restriction (muffler or catalytic converter) | Inspect exhaust. Do “Performance Diagnostics” (page 213). |
| VGT actuator or vanes stuck closed | Do “Performance Diagnostics” (page 213). |
| VGT control circuit short to B+ | Do VGT Pin-Point Diagnostics. See “VGT Actuator” (page 548). |

**DTC 344 – EBP above spec when engine off**

DTC 344 is set by the ECM when the EBP is greater than 300 kPa (43.5 psi) when engine is off or being cranked for more than 2.5 seconds.

| Possible Cause | Comment |
|---|---|
| EBP sensor bias high | Check sensor signal voltage. See “EBP Sensor” (page 375). |
| EBP sensor or tube line plugged | Clean and retest. Replace if required. |

**DTC 345 – Faults detected during VGT portion of the AMS test**

DTC 345 is set by the ECM during the AMS test when the ECM measures the EBP and does not see the expected response in pressures.

| Possible Cause | Comment |
|---|---|
| High intake restriction | Do “Performance Diagnostics” (page 213). |
| Intake / CAC system leak (pipes, loose clamps, hoses) | Do “Performance Diagnostics” (page 213). |
| Exhaust system leak | Do “Performance Diagnostics” (page 213). |
| MAP sensor bias | Check sensor signal voltage. See “MAP Sensor” (page 523). |
| EBP sensor bias | Check sensor signal voltage. See “EBP Sensor” (page 375). |
| EGR valve stuck open | Do “Performance Diagnostics” (page 213). |
| VGT actuator or vanes sticking | Do “Performance Diagnostics” (page 213). |
| EBP sensor or tube plugged | Clean and retest (replace if needed) |
| Power cylinder integrity | Do “Performance Diagnostics” (page 213) |
| VGT control circuit open or short to ground | Do VGT Pin-Point Diagnostics. See “VGT Actuator” (page 548). |
| VGT power and ground circuits | Do VGT Pin-Point Diagnostics. See “VGT Actuator” (page 548). |

**DTC 346 – Faults detected during EGR portion of the AMS test**

DTC 346 is set by the ECM during AMS test when the ECM measures EBP and does not see the expected response in pressures.

| Possible Cause | Comment |
|---|---|
| EGR valve stuck or sticking | Do “Performance Diagnostics” (page 213). |
| EBP sensor bias | Check sensor signal voltage. See “EBP Sensor” (page 375). |
| EBP sensor or tube plugged | Clean and retest (replace if needed) |
| EGR control circuit | Do EGR Pin-Point Diagnostics. See “EGR Actuator” (page 430). |

**DTC 353 – VGT control over duty cycle**

DTC 353 is set when the ECM overcompensates by increasing duty cycle to the VGT to achieve desired boost/back pressure.

| Possible Cause | Comment |
|---|---|
| High intake restriction | Do “Performance Diagnostics” (page 213). |
| Intake / CAC system leak (pipes, loose clamps, hoses) | Do “Performance Diagnostics” (page 213). |
| Exhaust system leak | Do “Performance Diagnostics” (page 213) |
| BAP sensor bias low | Check sensor signal voltage. See “BAP Sensor” (page 327). |
| MAP sensor bias low | Check sensor signal voltage. See “MAP Sensor” (page 523). |
| EBP sensor bias low | Check sensor signal voltage. See “EBP Sensor” (page 375). |
| ICP sensor bias high | Check sensor signal voltage. See “ICP Sensor” (page 477). |
| Power cylinder integrity | Do “Performance Diagnostics” (page 213). |
| ICP system integrity | Do “Performance Diagnostics” |
| Injector operation / part number | Check previous repairs. Do “Performance Diagnostics” (page 213). |
| EGR valve stuck open | Do “Performance Diagnostics” (page 213). |
| VGT actuator or vanes sticking | Do “Performance Diagnostics” (page 213). |
| VGT control circuit open or short to ground | Do VGT Pin-Point Diagnostics. See “VGT Actuator” (page 548). |
| VGT power and ground circuits. | Do VGT Pin-Point Diagnostics. See “VGT Actuator” (page 548). |

**DTC 354 – VGT control under duty cycle**

DTC 354 is set when the ECM overcompensates by decreasing duty cycle to the VGT to achieve the desired boost/back pressure.

| Possible Cause | Comment |
|---|---|
| BAP sensor bias high | Check sensor signal voltage. See “BAP Sensor” (page 327). |
| MAP sensor bias high | Check sensor signal voltage. See “MAP Sensor” (page 523). |
| EBP sensor bias high | Check sensor signal voltage. See “EBP Sensor” (page 375). |
| Open Exhaust (no muffler) | Inspect exhaust system. |
| ICP sensor bias low | Check sensor signal voltage. See “ICP Sensor” (page 477). |
| ICP system integrity | Do “Performance Diagnostics” (page 213). |
| Injector operation / part number | Check previous repairs. Do “Performance Diagnostics” (page 213). |
| Exhaust restriction (muffler or catalytic converter) | Inspect exhaust. Do“Performance Diagnostics” (page 213). |
| VGT control circuit short to B+. | Do VGT Pin-Point Diagnostics. See “VGT Actuator” (page 548). |
| VGT actuator or vanes stuck | Do “Performance Diagnostics” (page 213). |

**DTC 355 – VGT overspeed**

DTC 355 is set when the ECM detects turbo over speed several times in a specific period of time (dependent on ECM calibration). Turbo speed is estimated by engine speed, boost pressure, and barometric pressure.

| Possible Cause | Comment |
|---|---|
| High intake restriction | Do “Performance Diagnostics” (page 213). |
| Intake / CAC system leak (pipes, loose clamps, hoses) | Do “Performance Diagnostics” (page 213). |
| Restricted CAC system | Do “Performance Diagnostics” (page 213). |
| VGT actuator or vanes sticking | Do “Performance Diagnostics” (page 213). |
| Open exhaust (no muffler) | Inspect exhaust system |
| BAP sensor bias | Check sensor signal voltage. See “BAP Sensor” (page 327). |
| MAP sensor bias high | Check sensor signal voltage. See “MAP Sensor” (page 523). |
| EBP sensor bias low | Check sensor signal voltage. See “EBP Sensor” (page 375). |

| DTC 361 – VGT control input (EBP) above or below desired level | |
|---|---|
| DTC 361 is set when the ECM detects an in range error in the EBP signal. | |
| **Possible Cause** | **Comment** |
| High intake restriction | Do “Performance Diagnostics” (page 213). |
| Intake / CAC system leak (pipes, loose clamps, hoses) | Do “Performance Diagnostics” (page 213). |
| BAP sensor bias | Check sensor signal voltage. See “BAP Sensor” (page 327). |
| MAP sensor bias | Check sensor signal voltage. See “MAP Sensor” (page 523). |
| EBP sensor bias | Check sensor signal voltage. See “EBP Sensor” (page 375). |
| ICP sensor bias | Check sensor signal voltage. See “ICP Sensor” (page 477). |
| Power cylinder integrity | Do “Performance Diagnostics” (page 213). |
| ICP system integrity | Do “Performance Diagnostics” (page 213). |
| Injector operation / part number | Check previous repairs. Do “Performance Diagnostics” (page 213). |
| EGR valve stuck open | Do “Performance Diagnostics” (page 213) |
| VGT actuator or vanes sticking | Do “Performance Diagnostics” (page 213) |
| VGT control circuit open, short to ground, or short to B+ | Do VGT Pin-Point Diagnostics. See “VGT Actuator” (page 548). |
| Open Exhaust (no muffler) | Inspect exhaust system. |
| Exhaust restriction or leak (muffler or catalytic converter) | Inspect exhaust and do “Performance Diagnostics” (page 213). |
| VGT power or ground circuits | Do VGT Pin-Point Diagnostics. See “VGT Actuator” (page 548). |

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

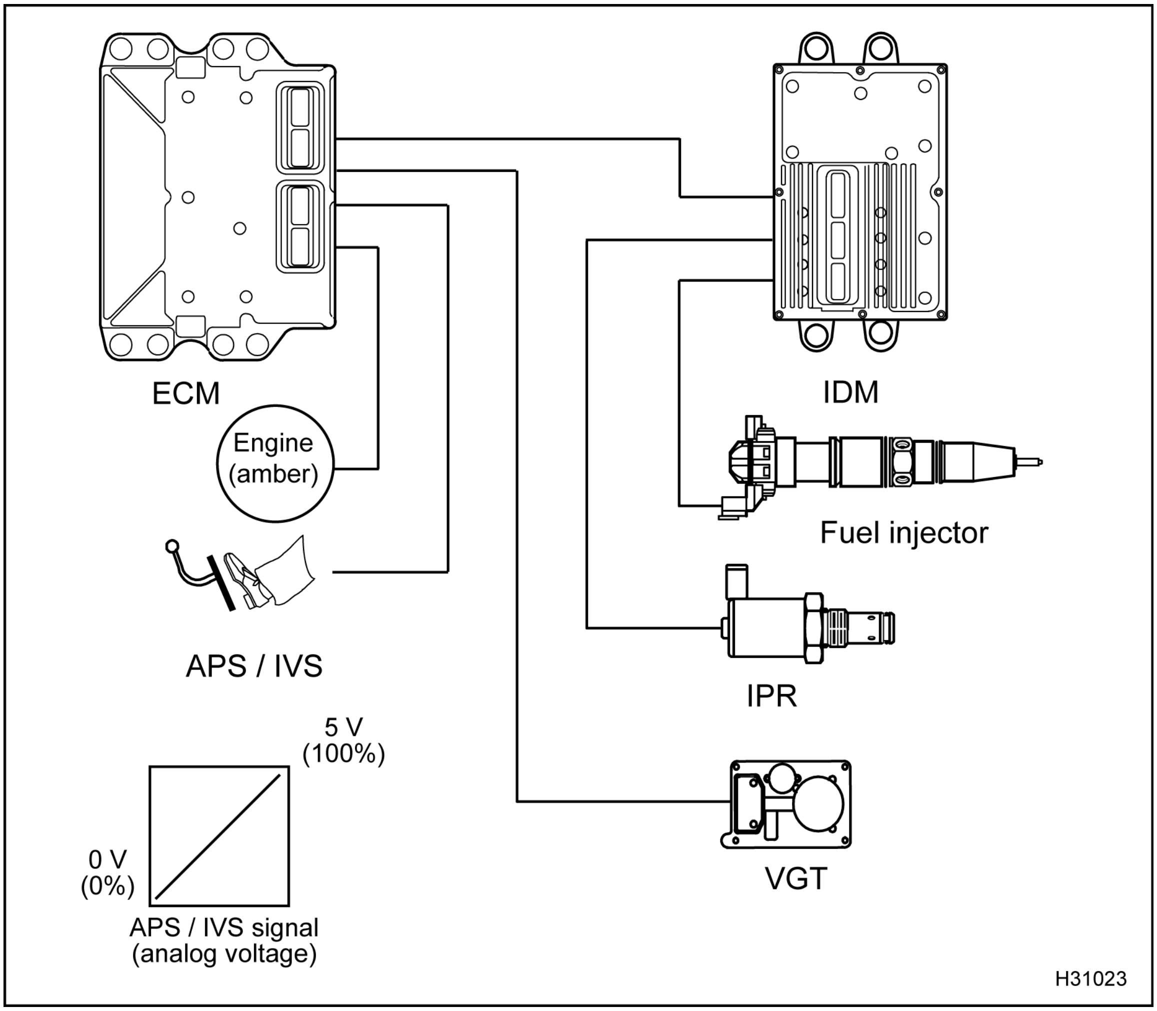



**Figure 376 Function diagram for the APS/IVS**

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

- APS/IVS
- Injection Control Pressure Regulator (IPR)
- Electronic Control Module (ECM)
- Variable Geometry Turbocharger (VGT)
- Injection Driver Module (IDM)
- Fuel injector
- ENGINE lamp (amber)

**Function**

The APS/IVS sensor is a cab mounted potentiometer sensor. When the APS receives a 5 V reference signal and a ground from the ECM, a linear analog voltage signal from the sensor will indicate the operator’s demand for power. The IVS provides 0 V or 12 V to the ECM as redundant signal to verify the pedal idle position.

### APS/IVS Circuit Operation

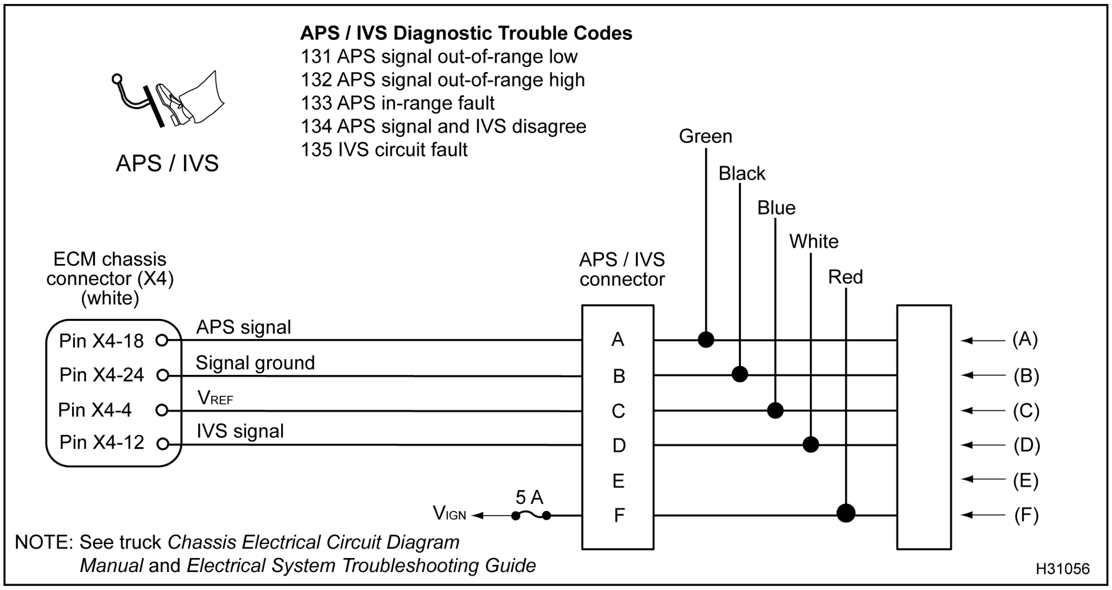



**Figure 377 APS/IVS circuit diagram**

The APS/IVS are integrated into one component and mounted on the pedal. The accelerator pedal assembly is serviceable to the extent that the APS/IVS switch can be replaced without replacing the complete assembly.

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

The accelerator pedal position is one of the controlling variables in the calculation of desired injection control pressure.

### APS

The ECM supplies a regulated 5 V signal from ECM chassis connector Pin X4–4 to APS connector Pin C. The APS returns a variable voltage signal (depending on pedal position) from the APS connector Pin A to ECM Pin X4–18. The APS is grounded at Pin B from the ECM Pin X4–24.

### APS Auto-Calibration

The ECM learns the lowest and highest pedal positions by reading and storing the minimum and maximum voltage levels from the APS. In this manner the ECM auto-calibrates the system to allow maximum pedal sensitivity. The ECM auto-calibrates as the ignition switch is on, but when the ignition switch is turned OFF, these values are lost. When the key is turned on again, this process starts over. When the pedal is disconnected (or a new one is installed), the pedal does not need to be calibrated. It simply auto-calibrates the new pedal assembly whenever the key is turned on again.

### IVS

The ECM expects to receive one of two signals through the ECM chassis connector Pin X4–12 from APS/IVS connector Pin D:

- 0 V when the pedal is at the idle position.
- B+ when the pedal is depressed

The IVS receives a 12 V ignition voltage at Pin F from the ignition fuse in the power distribution box. When the pedal is not in the idle position (throttle applied), the IVS supplies a 12 V signal to the ECM.

The ECM compares APS/IVS inputs to verify when the pedal is in the idle position. If the APS signal at Pin X4–18 indicates throttle is being applied, the ECM expects to see 12 V at the IVS. If the APS signal indicates throttle is not applied, the ECM expects to see 0 V at the IVS. The timing process is critical between the APS and IVS sensors. For this reason, it is very difficult to determine if the APS/IVS assembly is working correctly when using a Digital Multimeter (DMM).

**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 the signals are not what the ECM expects to see, Diagnostic Trouble Codes (DTCs) will be set.

Any detected 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 by the ECM and the ECM determines that it is an IVS fault, the ECM will only allow a maximum of 50% APS to be commanded. If the ECM cannot discern if it is an APS or IVS fault, the engine will be allowed to operate at low idle only.

**APS/IVS Diagnostic Trouble Codes (DTCs)**

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

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

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

**DTC 131**
**APS signal out-of-range low**

- DTC 131 is set if the ECM detects voltage less than 0.147 V. The ECM will then restrict engine speed to idle.
- DTC 131 can be set due to a short to ground or an open $V_{REF}$ or signal circuits. If the condition causing DTC 131 is intermittent and the condition is no longer present, the code will become inactive and normal engine operation will resume.
- When DTC 131 is active the amber ENGINE lamp is illuminated.

**DTC 132**
**APS signal out-of-range high**

- DTC 132 is set if the ECM detects a voltage greater than 4.55 V. The ECM will then restrict engine speed to idle.
- DTC 132 can be set due to a short to $V_{REF}$ or B+ in the APS signal circuit.
- When DTC 132 is active the amber ENGINE lamp is illuminated.

**DTC 133, 134, and 135**

- The ECM checks the voltage output of the APS by comparing the APS signal to the IVS signal. APS and IVS signals can disagree in the following situations:
  - The APS signal indicates the pedal is pressed down to accelerate, but the IVS signal indicates idle position.
  - The APS signal indicates the pedal has been released to allow the engine to return to idle, but the IVS signal indicates off-idle position of the pedal.

    If the ECM detects either of the above conditions, the ECM attempts to isolate the source of conflict and set a DTC.

**DTC 133**
**APS in-range fault**

- If the IVS signal is changing and the APS signal is constant, the ECM assumes the APS is the conflict source and sets DTC 133. The engine rpm is restricted to idle.
- When DTC 133 is active the amber ENGINE lamp is illuminated.

**DTC 134**
**APS signal and IVS disagree**

- If neither the APS or IVS is changing, or both are changing, or the ECM cannot determine the DTC in specified time, DTC 134 is set and engine rpm is restricted to idle.
- When DTC 134 is active the amber ENGINE lamp is illuminated.

**DTC 135**
**IVS circuit fault**

- If the APS is changing but IVS is constant, the ECM assumes the IVS is the conflict source and sets DTC 135. In this case the ECM limits the APS signal to a lower value that provides less than full rpm, but does not limit engine rpm to idle.
- When DTC 135 is active the amber ENGINE lamp is illuminated.

DTC 133, 134, and 135 are caused by intermittent conditions. These DTCs remain active until the vehicle has been shutdown and restarted. They do not recover without cycling the ignition switch. Later calibration versions may allow DTC recovery without cycling the ignition switch.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 500 Ohm Resistor Harness
- Breakout Box
- APS/IVS Breakout Harness
- Terminal Test Adapter Kit

The APS/IVS circuit requires the use of vehicle circuit diagrams. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

## APS/IVS Operational Diagnostics

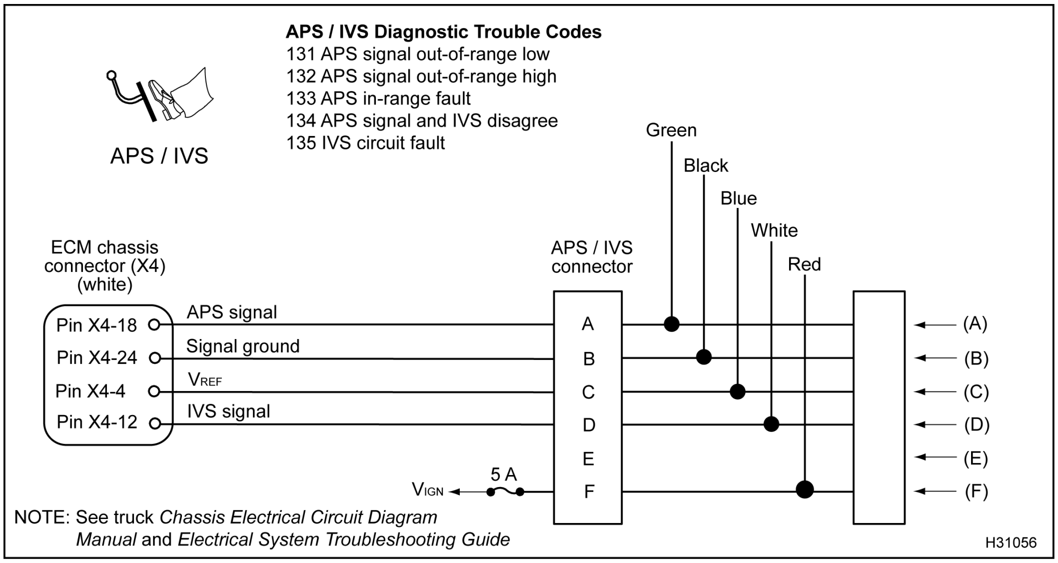



**Figure 378 APS/IVS circuit diagram**

> **WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:**
>
> **Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.**

1. Using EST, open the continuous monitor session. To monitor signal voltage, run KOEO Continuous Monitor Test.

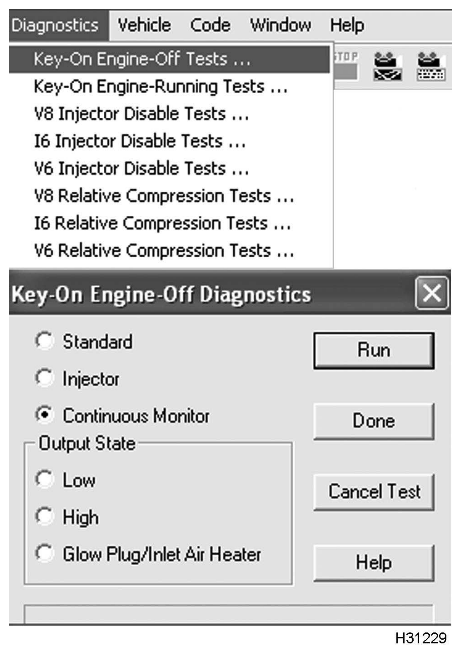



**Figure 379 Continuous Monitor Test**

2. To monitor signal voltage, run KOEO Continuous Monitor Test. For help, see “Continuous Monitor Test” in Section 3 (page 68).
3. Monitor APS signal voltage. Verify an active DTC for the APS/IVS circuit.

4. If code is active, do step 6 and 7 to check circuit for the APS sensor using the following table.
   - Circuit Checks for APS Sensor
5. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will display DTCs related to the condition.
6. Disconnect chassis harness from APS sensor.

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

7. Connect APS Sensor Breakout Harness to chassis harness only.

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Circuit Checks for APS Sensor** (Use EST, DMM, breakout harness, and 500 Ohm Resistor Harness.)

| Test Condition | Spec | Checks |
|---|---|---|
| Sensor disconnected using EST | 0 V | If voltage > 0.147 V, check signal circuit for short to $V_{REF}$ or B+. |
| Measure voltage from Pin C (Blue) to ground using DMM | 5 V ±0.5 V | If voltage > 5.5 V, check $V_{REF}$ for short to B+. If voltage is < 4.5 V, check $V_{REF}$ for open or short to ground. |
| 500 Ohm Resistor Harness connected between Pin A (Green) and Pin C (Blue) of breakout harness using. | 5 V | If voltage < 4.55 V, check signal circuit for open or short to ground.<br>— Disconnect connector 9260[1]. Measure resistance from Pin C to Pin A of connector 9260 (spec > 1 kΩ) to check for short to ground within wiring harness.<br>— Disconnect negative battery cable. Measure resistance from Pin C to ground cable to check for short to ground.<br>— Use a breakout box to measure from Pin A to Pin X4–18 (spec < 5 Ω) to check for open in the harness. |
| Resistance from Pin B (Black) of breakout harness to ECM chassis ground Pin A of connector 9260 using DMM. | < 5 Ω | If resistance is > 5 Ω, check for open or high resistance between ECM and sensor connector. Use a breakout box and measure resistance from between Pin B and Pin X4–24 (spec < 5 Ω). |

**Connect chassis harness to sensor and cycle key. Use the EST to clear DTCs. If an active code remains after checking test conditions, inspect pedal assembly for excessive wear. If pedal assembly is in tact, replace the APS/IVS sensor.**

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

### APS/IVS Pin-Point Diagnostics

| **Connector Voltage Checks** (Disconnect harness from sensor. Inspect for bent pins or corrosion. Connect breakout harness to chassis harness only. Turn the ignition switch to ON.) | | |
|---|---|---|
| **Test Point** | **Spec** | **Comment** |
| A to gnd | 0 to 0.25 V | Voltage > 0.25 V, signal is shorted to $V_{REF}$ or B+ |
| B to gnd | 0 V | Ground circuit, no voltage expected |
| C to gnd | 5 V ±0.05 V | Voltage > spec, wire shorted to B+; Voltage < spec, wire open or shorted to ground |
| D to gnd | 0 V to 0.25 V | Voltage > 0.25 V, IVS signal wire shorted to $V_{REF}$ or B+ |
| F to gnd | B+ | Voltage < 10.5 V check circuit for open or high resistance – blown fuse |
| **Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Connect breakout harness to chassis harness only. Disconnect chassis connector 9260[1].) | | |
| A to Pin A (9260) | > 1 k Ω | If < 1 kΩ, check for short to ground within wiring harness. |
| B to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open signal ground. |
| C to Pin A (9260) | > 500 Ω | If < 500 Ω, check for short to ground within wiring harness. |
| D to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |
| F to Pin A (9260) | > 1 kΩ | If < 1 kΩ with fuse removed, check for short to ground within wiring harness. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.)

| | | |
|---|---|---|
| A to gnd cable | > 1 k Ω | If < 1 kΩ, check for short to ground. |
| B to gnd cable | > 500 Ω | If < 500 Ω, check for open signal ground. |
| C to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| D to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| F to gnd cable | > 1 kΩ | If < 1 kΩ with fuse removed, check for short to ground. |

**Harness Resistance Checks** (Connect breakout box [X4 only] to chassis harness only. Connect breakout harness to chassis harness only.)

| | | |
|---|---|---|
| X4–18 to A | < 5 Ω | If > 5 Ω, check for APS signal wire open. |
| X4–24 to B | < 5 Ω | If > 5 Ω, check for open signal ground. |
| X4–4 to C | < 5 Ω | If > 5 Ω, check for open $V_{REF}$ wire. |
| X4–12 to D | < 5 Ω | If > 5 Ω, check for open IVS signal wire. |
| Fuse to F | < 5 Ω | If > 5 Ω, check for open IVS power wire. |

**NOTE:** See truck *Chassis Electrical Circuit Diagram Manual* for fuse location.

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

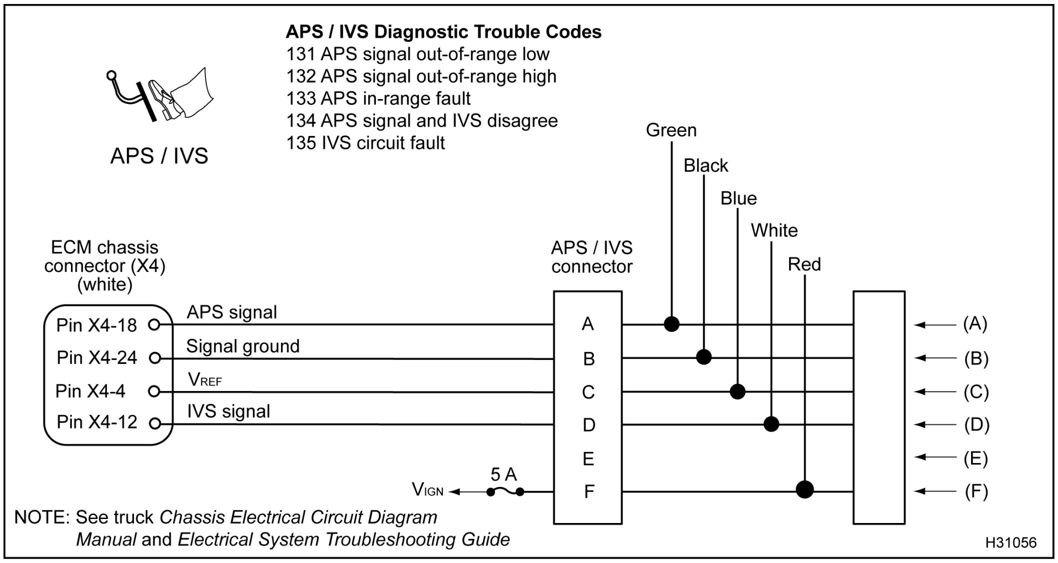



**Figure 380 APS/IVS circuit diagram**

**Operational Voltage Checks for APS/IVS Sensor with Breakout Harness** (Check with breakout harness connected to sensor and chassis harness with key-on engine-off.)

- **APS test points:** (+) A (Green) to (-) B (Black)
- **IVS test points:** (+) D (White) to (-) B (Black)

| Position | Voltage | % APS | IVS Voltage | Comment |
|---|---|---|---|---|
| Low idle | 0.64 V to 0.66 V | 0% | 0 V | IVS toggles only off idle |
| High idle | 3.84 V to 3.86 V | 98% to 102% | B+ | |

**Operational Voltage Checks for APS/IVS Sensor with Breakout Box** (Check with breakout box connected [X-4 only] to ECM and chassis harness with key-on engine-off.)

- **APS test points:** (+) X4–18 to (-) X4–24
- **IVS test points:** (+) X4–12 to (-) X4–24

| Position | Voltage | % APS | IVS Voltage | Comment |
|---|---|---|---|---|
| Low idle | 0.64 V to 0.66 V | 0% | 0 V | IVS toggles only off idle |
| High idle | 3.84 V to 3.86 V | 98% to 102% | B+ | |

**APS / IVS Diagnostic Trouble Codes**

DTC 131= APS signal voltage was < 0.147 V for more than 0.35 seconds

DTC 132= APS signal voltage was > 4.55 V for more than 0.35 seconds

DTC 133= APS signal in-range fault

DTC 134= APS and IVS disagree

DTC 135= Idle validation switch circuit fault – 50% APS only

**ATA Datalink (American Trucking Association)**

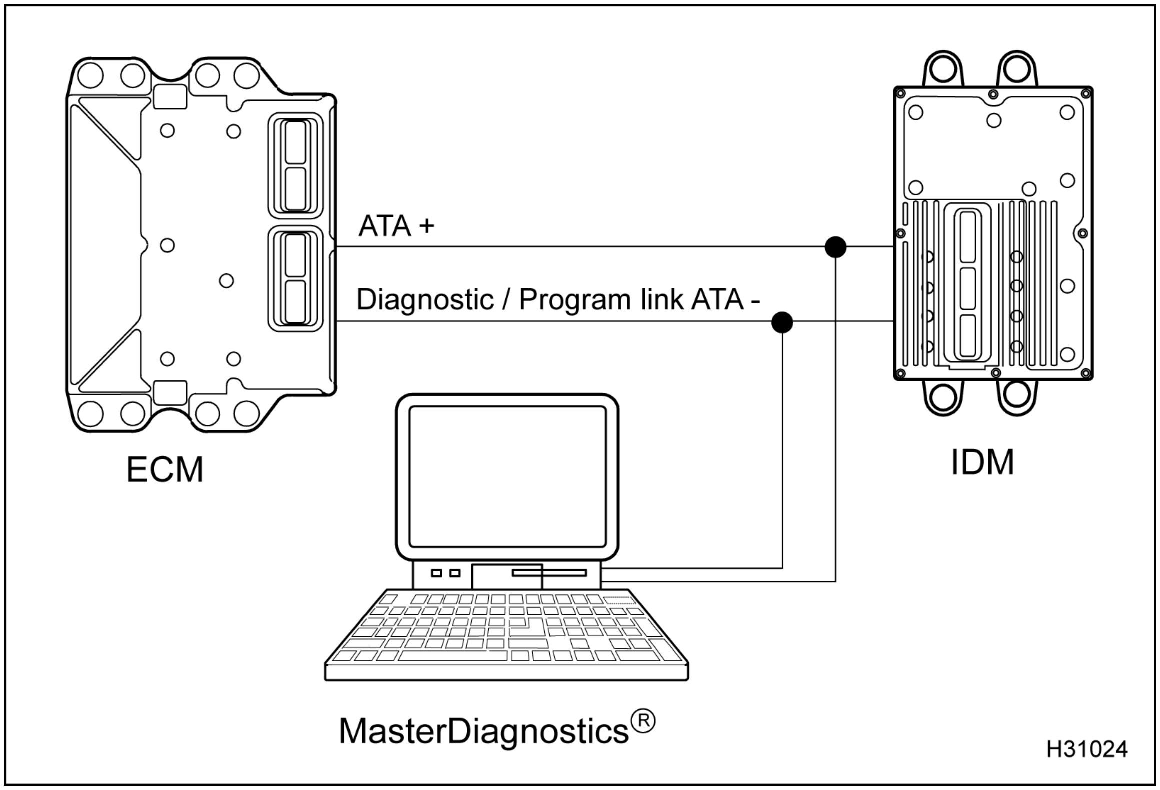



**Figure 381 Function diagram for the ATA datalink**

The function diagram for the ATA datalink includes the following:

- EST with MasterDiagnostics® software
- Electronic Control Module (ECM)
- Injection Driver Module (IDM)

**Function**

The Data Communication Link signal is a 0 V to 5 V variable width square wave form signal that enables communication between the MasterDiagnostics® software and the ECM. The data communication link also allows for programming the ECM and IDM.

**ATA Circuit Operation**

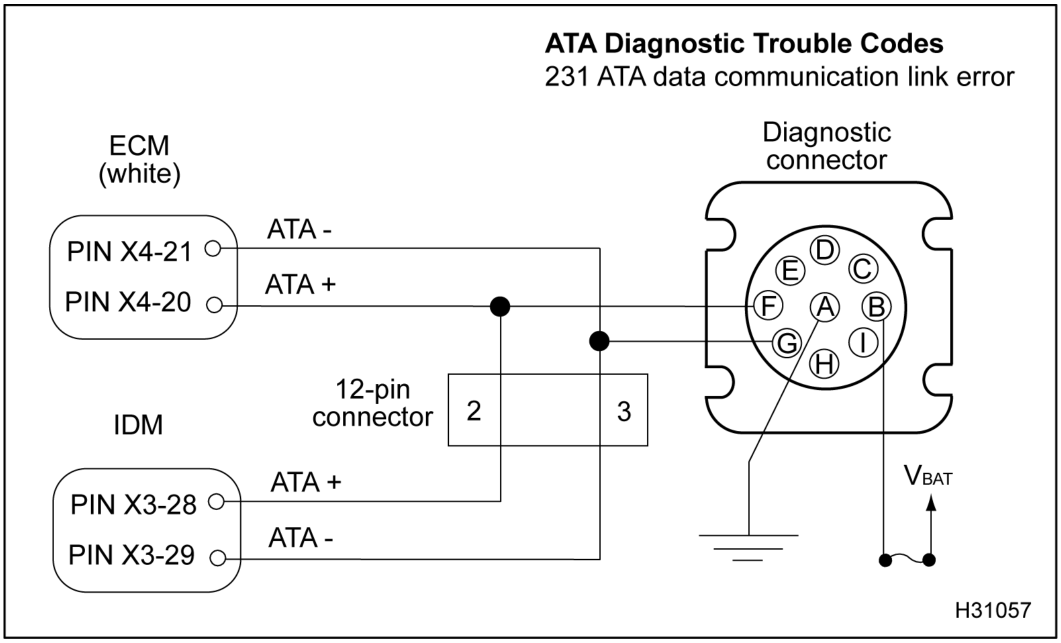



**Figure 382 ATA circuit diagram**

The ECM communicates with the EST and MasterDiagnostics® software through the diagnostic connector. The EST communicates with the ECM using the ATA datalink.

The IDM uses ATA only for programming.

The ATA circuit uses 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) and reversing the polarity of this circuit will disrupt communications.

**ATA Datalink Connector**

Vehicles are equipped with the ATA datalink connector for communication between the Electronic Control Module (ECM) and the EST.

The ATA datalink supports the following functions:

- Transmission of engine parameter data
- Transmission and clearing of DTCs
- Diagnostics and trouble shooting
- Programming performance parameter values
- Programming engine and vehicle features
- Programming calibrations and strategies in the ECM and IDM

**Fault Detection / Management**

The ECM continuously monitors the ATA datalink for an open, short or intermittent connection. If an active DTC occurs on the ATA datalink, the MasterDiagnostics® software will not display correct data.

The IDM uses ATA for programming only. DTCs are not transmitted from the IDM through the ATA datalink.

**ATA Diagnostic Trouble Codes (DTCs)**

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

**DTC 231**
**ATA data communication link error**

- DTC 231 is set when the ECM can not access the ATA datalink. When this occurs, ATA data can not be retrieved using the EST. DTCs can only be retrieved using the cruise control feature.

- DTC 231 can be set when any of the following conditions occur:
  - Inoperative ATA device (transmission controller or anti-lock brake controller) is connected to ATA bus and pulls signal to ground.
  - Number of ATA devices exceeds limit
  - Inoperative ECM
- When DTC 231 is active the amber ENGINE lamp is not illuminated.

**NOTE:** Vehicles equipped with the Allison WTEC transmission may display DTC 231 when attempting to program the ECM. The WTEC controller must be disconnected when programming the engine ECM.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Breakout Box
- Breakout Harness

The ATA circuit requires the use of vehicle circuit diagrams. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**ATA Pin-Point Diagnostics**

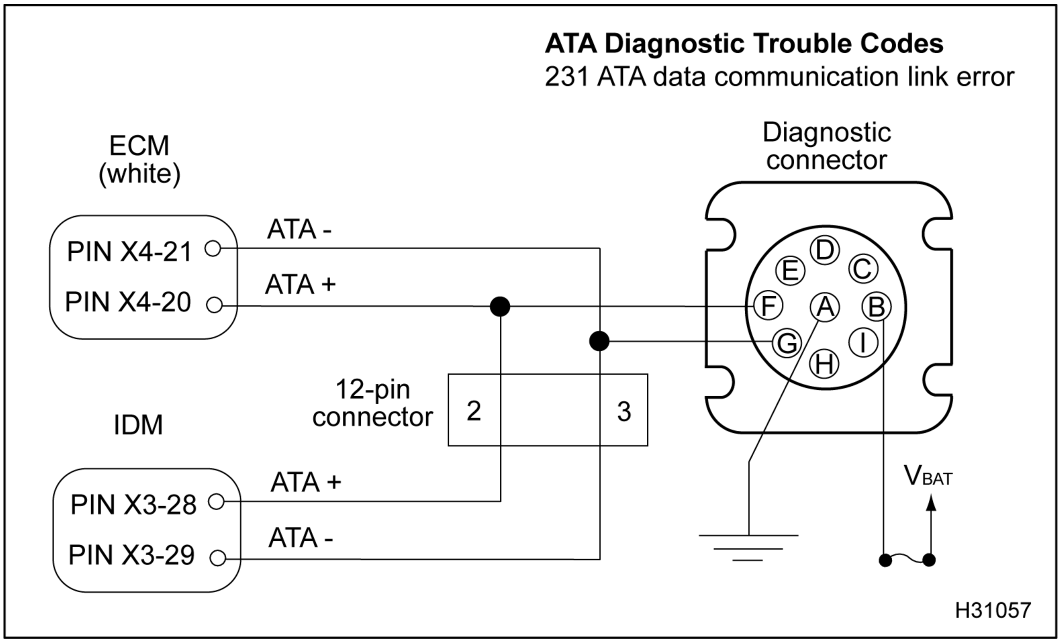



**Figure 383 ATA circuit diagram**

> **WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Diagnostic Connector Voltage Checks** (Key-on engine-off.)

| Test Point | Spec | Signal | Comment |
|---|---|---|---|
| B to A | B+ | Voltage | Should be voltage at B at all times. If no voltage is present, check ground and power circuits. |
| **Diagnostic Connector to Chassis Ground** (Turn the ignition switch to OFF and disconnect negative battery cable.) | | | |
| F to gnd | > 1 kΩ | ATA + | If < 1 kΩ, check for short to ground through harness or internal within the ECM and IDM. Disconnect ECM and IDM and measure ground again. If short is still present, disconnect other devices connected to data communication link and retest. If short is still present, repair harness. |
| G to gnd | > 1 kΩ | ATA – | |
| B to gnd | > 1 kΩ | Power | With fuse removed, if< 1 kΩ, check for short to ground. |
| A to gnd | < 5 Ω | gnd | If > 5 Ω, check for an open circuit. The EST tool will not communicate. |

| | | | |
|---|---|---|---|
| **Harness Resistance Checks – Diagnostic Connector to ECM** (Turn the ignition switch to OFF. Connect breakout box [X4 only] to engine harness only.) | | | |
| F to ECM X4–20 | < 5 Ω | ATA + | Resistance from ECM chassis connector to EST connector. |
| G to ECM X4–21 | < 5 Ω | ATA – | Resistance from ECM chassis connector to EST connector. |
| B to fuse | < 5 Ω | Power | Resistance from EST connector to power fuse. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| A to gnd | < 5 Ω | gnd | If > 5 Ω, check for an open circuit. Open circuit will prevent EST power up. |
| **Harness Resistance Checks – Diagnostic Connector to IDM** (Turn the ignition switch to OFF.) | | | |
| F to IDM X3–28 | < 5 Ω | ATA + | Resistance from IDM connector to EST connector. |
| G to IDM X3–29 | < 5 Ω | ATA – | Resistance from IDM connector to EST connector. |
| **ATA Diagnostic Trouble Codes** | | | |
| 231 ATA data communication link error – ATA wiring or connector | | | |

**BAP Sensor (Barometric Absolute Pressure)**

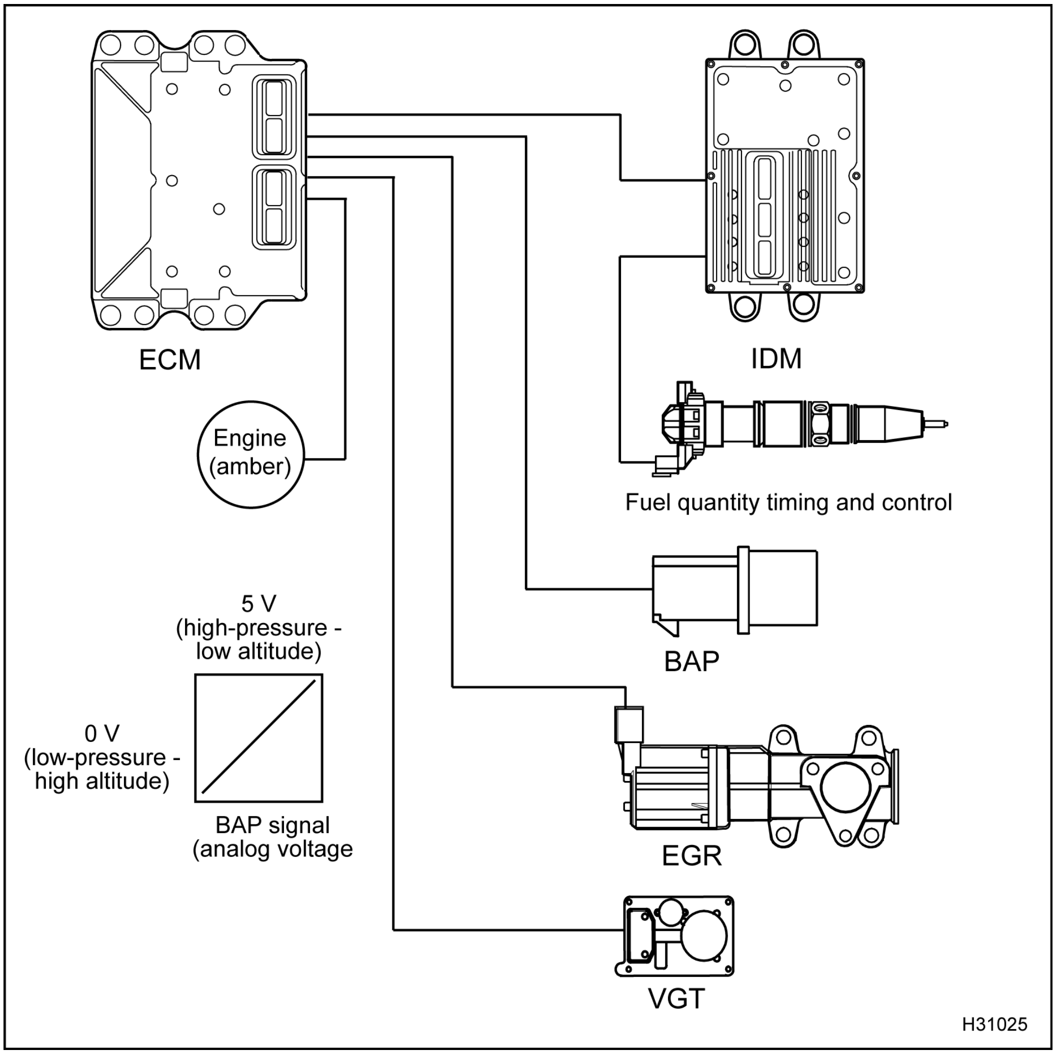



**Figure 384 Function diagram for the BAP sensor**

The function diagram for the BAP sensor includes the following:

- BAP sensor
- Electronic Control Module (ECM)
- Injection Driver Module (IDM)
- Fuel injector
- Exhaust Gas Recirculation (EGR)
- Variable Geometry Turbocharger (VGT)
- ENGINE lamp (amber)

**Function**

The BAP sensor is a variable capacitance sensor and is located in the cab. The ECM supplies a 5 V reference signal which the BAP sensor uses to produce a linear analog voltage signal that indicates pressure.

The primary function of the BAP sensor is to provide a feedback signal to the ECM to adjust timing and fuel quantity. The ECM monitors the BAP signal to determine altitude, adjust timing, fuel quantity, and inlet air heater operation.

### BAP Circuit Operation

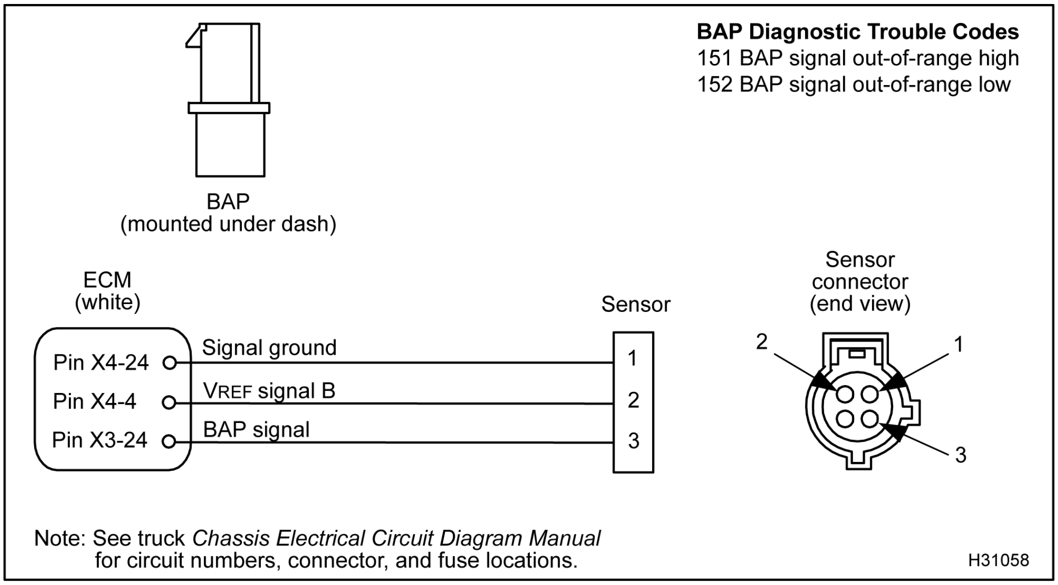



**Figure 385 BAP circuit diagram**

The BAP sensor is supplied with a 5 V reference voltage at Pin 2 from ECM Pin X4–4 . The BAP sensor is grounded at Pin 1 from ECM Pin X4–24. The BAP sensor returns a variable voltage signal from Pin 3 to ECM at Pin X3–24.

### Fault Detection / Management

When the ECM detects the BAP voltage signal out of range high or low, the ECM will ignore the BAP signal and use the Manifold Absolute Pressure (MAP) signal generated at low idle as an indication of barometric pressure. When a MAP fault is detected, the BAP signal will default to barometric pressure at sea level, 101 kPa (29.8 in Hg).

### BAP Diagnostic Trouble Codes (DTCs)

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

### DTC 151
### BAP signal out-of-range high

- DTC 151 is set when the BAP signal is greater than 4.95 V for more than 0.5 second.
- DTC 151 can be set when the signal circuit is shorted to $V_{REF}$ or B+ or a failed BAP sensor.
- When DTC 151 is active the amber ENGINE lamp is illuminated.

### DTC 152
### BAP signal out-of-range low

- DTC 152 is set when the BAP signal is less than 1.0 V for more than 0.5 second.
- DTC 152 can be set when the signal circuit is shorted to ground or open, $V_{REF}$ is shorted to ground, or a failed BAP sensor.
- When DTC 152 is active the amber ENGINE lamp is illuminated.

### Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Breakout Box

### BAP Pin-Point Diagnostics

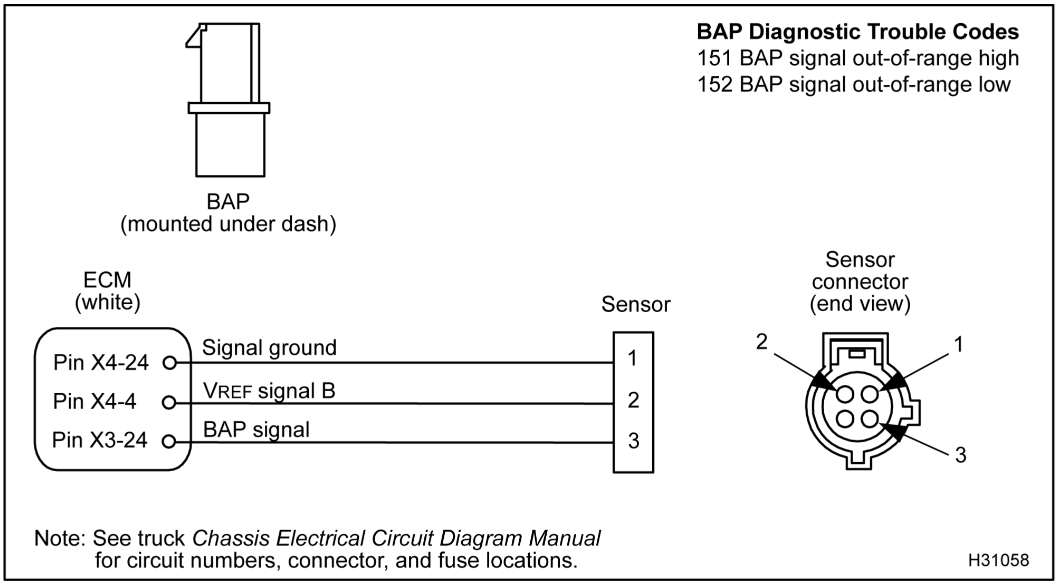



**Figure 386 BAP circuit diagram**

**NOTE:** See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**Connector Voltage Checks to Ground** (Disconnect harness from sensor. Inspect for bent pins or corrosion. Turn the ignition switch to ON.)

| Test Point | Spec | Comment |
|---|---|---|
| 1 to gnd | 0 V to 0.25 V | If > 0.25 V, check ground circuit for open or high resistance. Check signal ground for short to $V_{REF}$ or B+. |
| 2 to gnd | 5 V ± 0.5 V | If voltage is not to spec, $V_{REF}$ circuit is shorted to ground, shorted to B+, or open. |
| 3 to gnd | 0 V to 0.25 V | If voltage > 0.25 V, signal circuit is shorted to $V_{REF}$ or B+. |

**Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1].)

| | | |
|---|---|---|
| 1 to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open signal ground. |
| 2 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for $V_{REF}$ short to ground. |
| 3 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for signal short to ground. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.)

| | | |
|---|---|---|
| 1 to gnd cable | > 500 Ω | If < 500 Ω , check for short to ground. |
| 2 to gnd cable | > 1 kΩ | If < 1 kΩ, check for $V_{REF}$ short to ground. |
| 3 to gnd cable | > 1 kΩ | If < 1 kΩ, check for signal short to ground. |

**Harness Resistance Checks** (Connect breakout box to chassis harness [X3 and X4 only].)

| | | |
|---|---|---|
| X4-24 to 1 | < 5 Ω | If > 5 Ω, check for open signal ground. |
| X4–4 to 2 | < 5 Ω | If > 5 Ω, check for open $V_{REF}$. |
| X3–24 to 3 | < 5 Ω | If > 5 Ω, check for open signal circuit. |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

**Operational Voltage Checks for BAP Sensor** (Check with breakout box connected [X3 and X4 only] to ECM and chassis harness.)

| Test Point | Voltage | Pressure | Comment |
|---|---|---|---|
| X3–24 to X4–24 | 4.89 V | 105 kPa (31 in Hg) | High atmospheric pressure. |
| X3–24 to X4–24 | 4.60 V | 100 kPa (29.5 in Hg) | Normal atmospheric pressure at sea level. |
| X3–24 to X4–24 | 2.60 V | 60 kPa (17.7 in Hg) | Normal atmospheric pressure at 10,000 feet. |

**BAP Diagnostic Trouble Codes**

DTC 151 = Signal voltage was > 4.95 V for more than 0.5 second

DTC 152 = Signal voltage was < 1.0 V for more than 0.5 second

**BCP Sensor (Brake Control Pressure)**

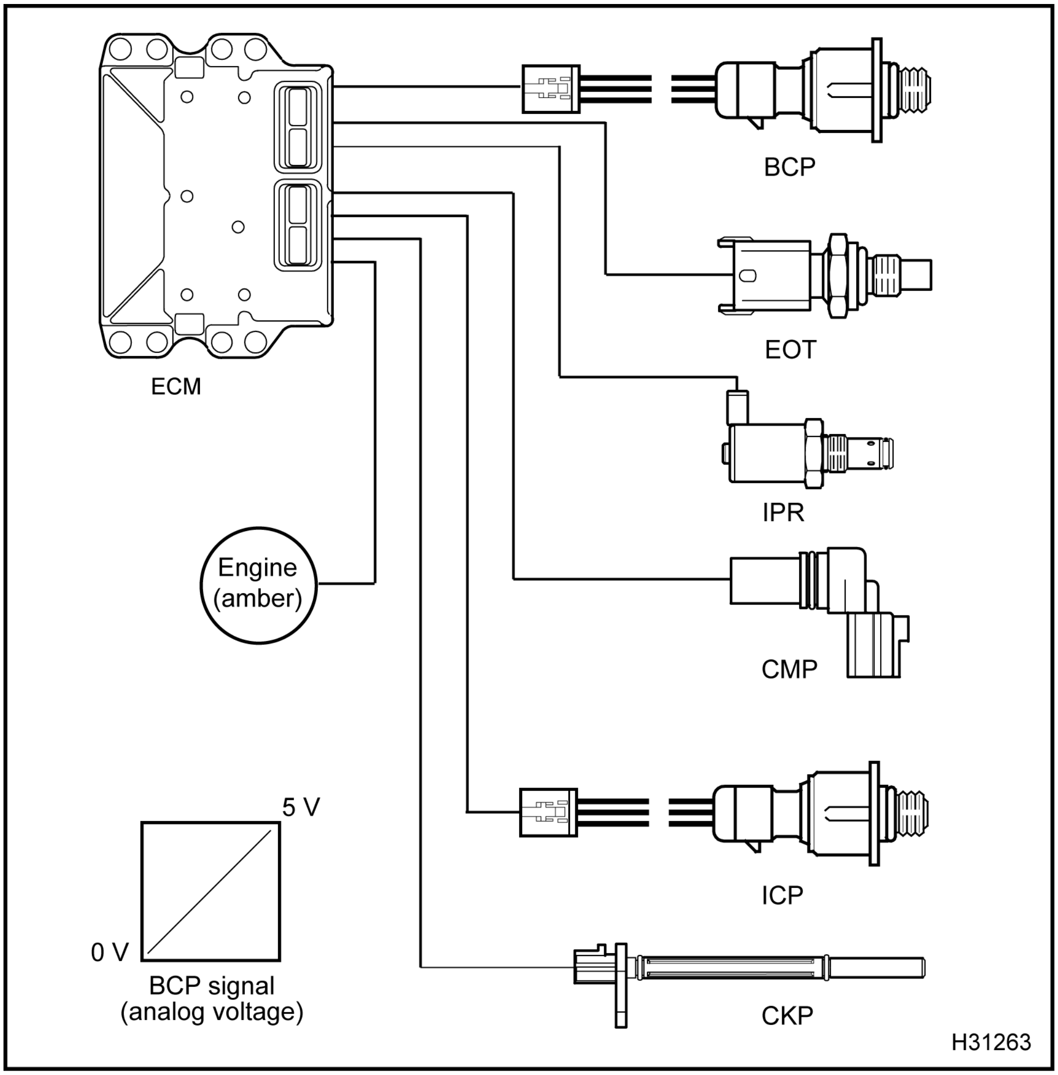



**Figure 387 Function diagram for the BCP sensor**

The function diagram for the BCP sensor includes the following:

- BCP sensor
- Injection Control Pressure (ICP) sensor
- Camshaft Position (CMP) sensor
- Crankshaft Position (CKP) sensor
- Injection Pressure Regulator (IPR)
- Electronic Control Module (ECM)
- Engine Oil Temperature (EOT) sensor
- ENGINE lamp (amber)

**Function**

The BCP sensor is a Micro Strain Gauge (MSG) sensor. The BCP sensor is under the valve cover, forward of the No. 2 fuel injector in the high-pressure oil rail. The engine harness connection on the valve cover gasket for the BCP sensor is left of the No. 2 injector connector. The ECM supplies a 5 V reference signal which the BCP sensor uses to produce a linear analog voltage that indicates pressure.

The ECM monitors the BCP signal to determine the oil pressure in the brake gallery of the high-pressure oil rail. During engine brake operation, if the ECM recognizes that the BCP signal is greater than desired brake control pressure or less than the ICP signal, the ECM will set a DTC and illuminate the amber ENGINE lamp.

**BCP Circuit Operation**

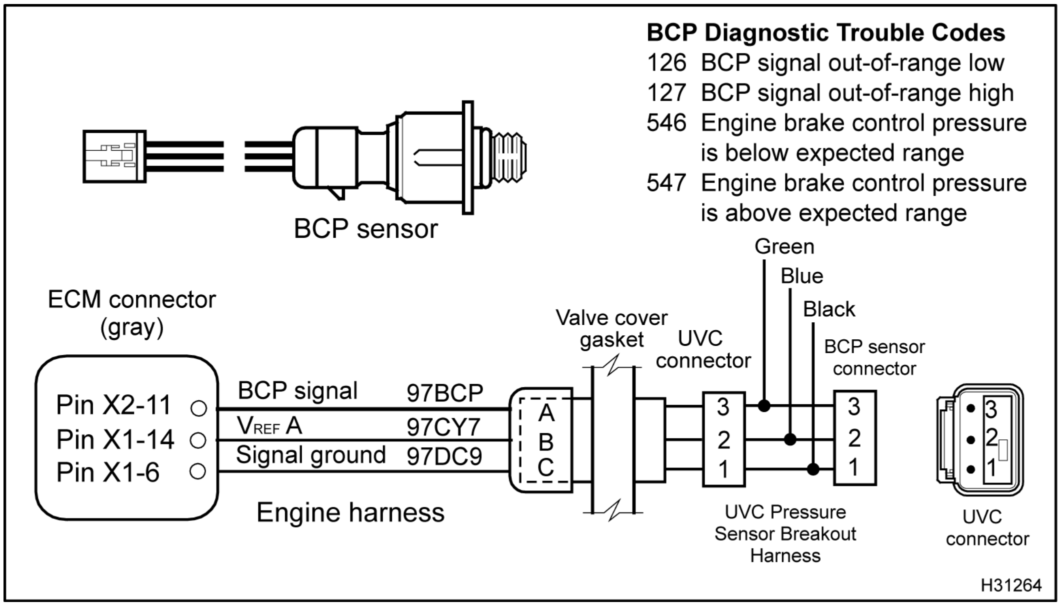



**Figure 388 BCP circuit diagram**

The BCP sensor is supplied with a 5 V reference signal at Pin 2 through the valve cover gasket Pin B from ECM Pin X1–14. The BCP sensor is supplied a signal ground at Pin 1 through the valve cover gasket Pin C from ECM Pin X1–6. The BCP sensor sends a signal from sensor Pin 3 through valve cover gasket Pin A to ECM Pin X2–11.

**Fault Detection / Management**

The ECM continuously monitors the signal of the BCP sensor to determine if the signal is within an expected range. If the ECM detects a voltage greater or less than expected, the ECM will set a DTC and illuminate the amber ENGINE lamp.

**BCP Diagnostic Trouble Codes (DTCs)**

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamps.

**DTC 126**
**BCP signal out-of-range low**

- DTC 126 is set by the ECM if signal voltage is less than 0.039 V for more than 0.35 second.
- DTC 126 can be set due to an open or short to ground on the signal circuit, a failed BCP sensor, an open $V_{REF}$ circuit or $V_{REF}$ short to ground.
- When DTC 126 is active the amber ENGINE lamp is illuminated.

**DTC 127**
**BCP signal out-of-range high**

- DTC 127 is set by the ECM if the signal voltage is greater than 4.9 V for more than 0.35 second.
- DTC 127 can be set due to a signal circuit shorted to $V_{REF}$ or B+, or a failed BCP sensor.
- When DTC 127 is active the amber ENGINE lamp is illuminated.

**DTC 546**
**Engine brake control pressure below expected range**

- DTC 546 is set by the ECM when the brake control pressure is less than injection control pressure by 4 MPa (580 psi) for more than 3.0 seconds.
- DTC 546 can be set due to a bias low BCP sensor or a failed BCP sensor.
- DTC 546 can be set due to an open control circuit (power or ground), a failed brake shut-off valve, or a failed brake shut-off valve solenoid. See “Brake Shut-off Valve – Section 7.
- When DTC 546 is active the amber ENGINE lamp is illuminated.

**DTC 547**
**Engine brake control pressure above expected range**

- DTC 547 is set by the ECM when the brake control pressure is greater than desired brake control pressure of 4.5 MPa (653 psi) for more than three seconds.
- DTC 547 can be set due to an open signal ground, $V_{REF}$ shorted to a voltage source higher than 5.5 V, or a faulty BCP sensor.
- DTC 547 can be set due to a control circuit short to B+ or a brake shut-off valve stuck open. See “Brake Shut-off Valve – Section 7.
- When DTC 547 is active the amber ENGINE lamp is illuminated.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 500 Ohm Resistor Harness
- VC Gasket Breakout Harness
- UVC Pressure Breakout Harness
- Breakout Box
- Terminal Test Adapter Kit

**BCP Operational Diagnostics**

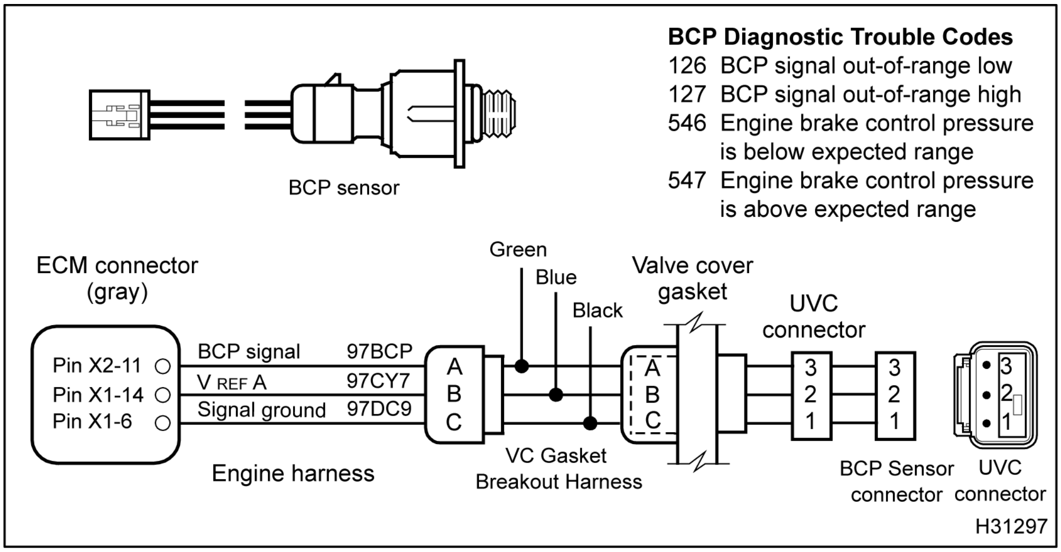



**Figure 389 BCP circuit diagram**

> ⚠ **WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:**
>
> **Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.**

1. Using EST, open the D_ContinuousMonitor.ssn.

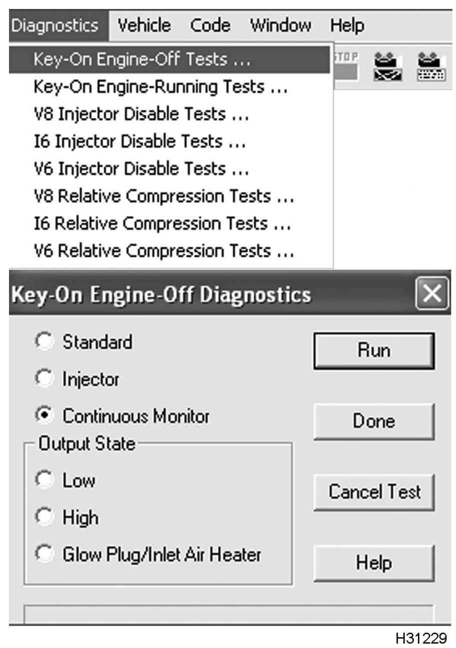



**Figure 390 Continuous Monitor Test**

2. To monitor signal voltage, run KOEO Continuous Monitor Test.
3. Monitor BCP signal voltage. Verify an active DTC for the BCP circuit.

4. If code is active, do step 6 and 7 to check circuit for the BCP sensor using the following tables:
   - Circuit Checks for BCP Sensor – ECM to Valve Cover Gasket Connector
   - Circuit Checks for BCP Sensor – ECM to BCP Sensor
5. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will display DTCs related to the condition.
6. Disconnect engine harness from valve cover gasket connector.

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

7. Connect VC Gasket Breakout Harness to engine harness only.

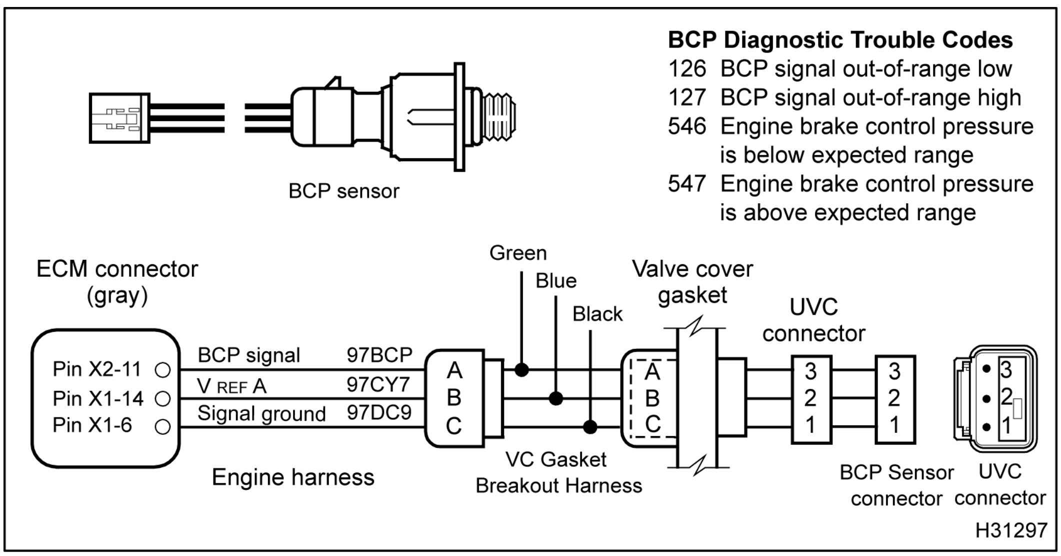



**Figure 391 BCP circuit diagram with breakout harness**

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Circuit Checks for BCP Sensor – ECM to Valve Cover Gasket Connector** (Use EST, DMM, 500 Ohm Resistor Harness, and VC Gasket Breakout Harness to engine harness only.)

| Test Condition | Spec | Checks |
| --- | --- | --- |
| Harness disconnected from valve cover gasket connector using EST | 0 V | If voltage > 0.039 V, check BCP signal for short to $V_{REF}$ or B+. |
| Voltage from Pin B (Blue) of VC Gasket Breakout Harness to ground using DMM | 5 V ±0.5 V | If voltage > 5.5 V, check $V_{REF}$ for short to B+. If voltage is < 4.5 V, check $V_{REF}$ for open or short to ground. |
| 500 Ohm Resistor Harness connected between Pin A (Green) and Pin B (Blue) of VC Gasket Breakout Harness using EST. | 5 V | If voltage < 4.9 V, check BCP signal for open or short to ground.<br>— Disconnect connector 9260[1]. Measure resistance from Pin A to Pin A of connector 9260 (spec > 1 kΩ) to check for short to ground within wiring harness.<br>— Disconnect negative battery cable. Measure resistance from Pin A to ground cable to check for short to ground.<br>— Use a breakout box to measure from Pin A to Pin X2-11 (spec < 5 Ω) to check for open in the harness. |
| Resistance from Pin C (Black) of VC Gasket Breakout Harness to ECM chassis ground (Pin A of connector 9260) using DMM. | < 5 Ω | If resistance is > 5 Ω, check for open or high resistance between ECM and UVC. Use a breakout box to measure resistance from X1-6 to Pin C (spec < 5 Ω). |

Connect engine harness to UVC connector. Use the EST to clear DTCs. If test results are to spec for all test conditions, but an active code remains, remove valve cover and check between UVC gasket connection and BCP sensor. (See Circuit Checks for BCP – ECM to BCP Sensor.)

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

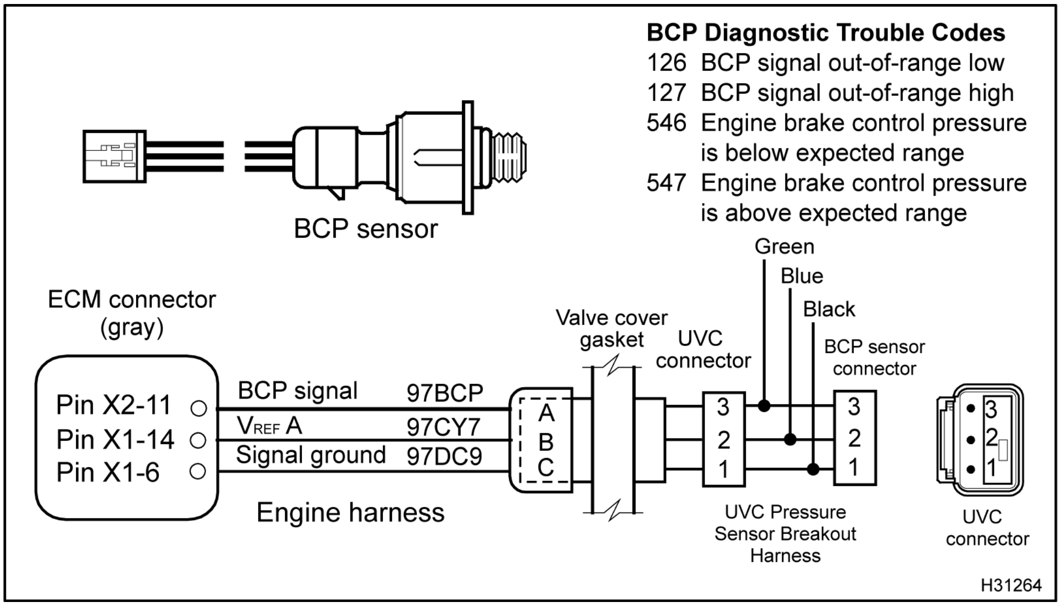



**Figure 392 BCP circuit diagram with UVC Pressure Sensor Breakout Harness**

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Circuit Checks for BCP Sensor – ECM to BCP Sensor** (If Circuit Checks for BCP Sensor – ECM to Valve Cover Gasket Connector are complete and test results are to specification for all test conditions, but an active code remains, remove valve cover following procedure in the *Engine Service Manual*. Use EST, DMM, 500 Ohm Resistor Harness, and UVC Pressure Sensor Breakout Harness connected to UVC connector only.)

| Test Condition | Spec | Checks |
|---|---|---|
| BCP sensor connector removed from UVC connector using EST | 0 V | If voltage > 0.039 V, check BCP signal for short to $V_{REF}$ or B+. |
| Voltage from Pin 2 (Blue) of UVC Pressure Sensor Breakout Harness to ground using DMM. | 5 V ±0.5 V | If voltage > 5.5 V, check $V_{REF}$ for short to B+. If voltage is < 4.5 V, check $V_{REF}$ for open or short to ground. |
| 500 Ohm Resistor Harness connected between Pin 3 (Green) and Pin 2 (Blue) of VC Gasket Breakout Harness using EST | 5 V | If voltage < 4.9 V, check BCP signal for open or short to ground.<br>— Disconnect connector 9260[1]. Measure resistance from Pin 3 to Pin A of connector 9260 (spec > 1 kΩ) to check for short to ground within wiring harness.<br>— Disconnect negative battery cable. Measure resistance from Pin 3 to ground cable to check for short to ground.<br>— Use a breakout box to measure from Pin 3 to Pin X2-11 (spec < 5 Ω) to check for open in the harness. |
| Resistance from Pin 1 (Black) of UVC Pressure Sensor Breakout Harness to ECM chassis ground (Pin A of connector 9260) using DMM. | < 5 Ω | If resistance is > 5 Ω, check for open or high resistance between ECM and UVC connector. Use a breakout box to measure resistance from X1-6 to Pin 1 (spec < 5 Ω). |

Connect BCP sensor to UVC connection. Use the EST to clear DTCs. If test results are to spec for all test conditions, but an active code remains, replace sensor.

**NOTE:** If all tests are to specification, but DTCs return when the valve cover is torqued down, replace the valve cover gasket.

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

### BCP Pin-Point Diagnostics (ECM to Valve Cover Gasket Connector)

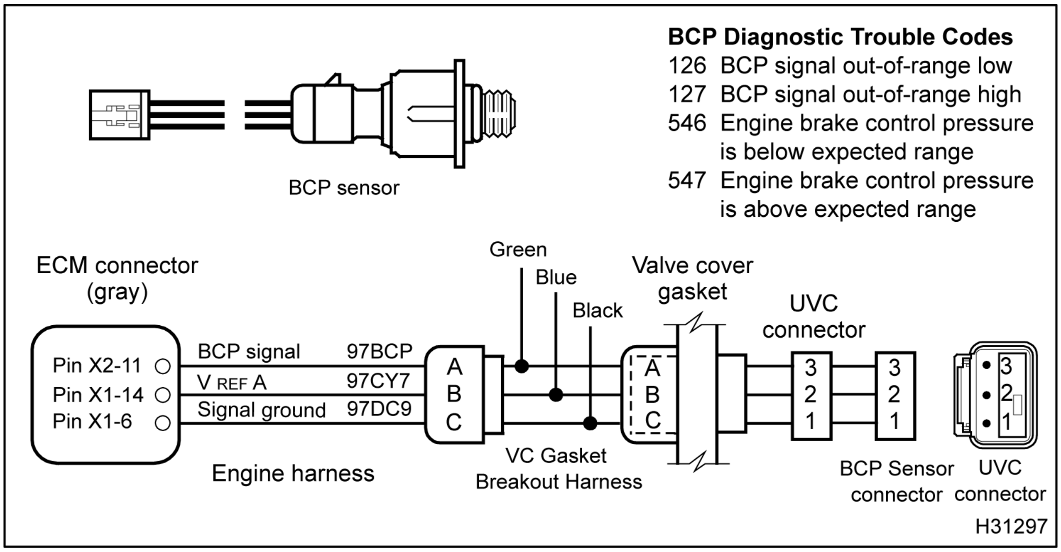



**Figure 393 BCP circuit diagram with VC Gasket Breakout Harness**

| | | |
|---|---|---|
| **Connector Voltage Checks** (Disconnect engine harness from valve cover gasket connector and connect VC Gasket Breakout Harness to engine harness only. Turn the ignition switch to ON.) | | |
| **Test Point** | **Spec** | **Comment** |
| A to gnd | 0 V to 0.25 V | If > 0.25 V, signal circuit is shorted to $V_{REF}$ or B+. |
| B to gnd | 5 V ± 0.5 V | If voltage is not to spec, $V_{REF}$ shorted to ground, shorted to B+, or open. |
| C to gnd | 0 V to 0. 25 V | Signal ground (no voltage expected). If > 0.25 V, check ground circuit for open or high resistance and check signal ground for short to $V_{REF}$ or B+. |
| **Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect harness from valve cover gasket connector. Connect VC Gasket Breakout Harness to engine harness only.[1]) | | |
| A to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |
| B to Pin A (9260) | > 500 Ω | If < 500 Ω, check for short to ground within wiring harness. |
| C to Pin A (9260) | < 5 kΩ | If > 5 kΩ, check for open circuit . |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

| | | |
|---|---|---|
| **Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.) | | |
| A to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| B to gnd cable | > 500 Ω | If< 500 Ω , check for short to ground. |
| C to gnd cable | > 500 Ω | If< 500 Ω , check for short to ground. |
| **Harness Resistance Checks** (Connect breakout box [X1] to engine harness only. Connect VC Gasket Breakout Harness to engine harness only.) | | |
| X1–20 to A | < 5 Ω | If > 5 Ω, check for open BCP signal. |
| X1–14 to B | < 5 Ω | If > 5 Ω, check for open $V_{REF}$. |
| X2–11 to C | < 5 Ω | If > 5 Ω, check for open ground. |

1 Connector 9260 is a 2-wire connector usually in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

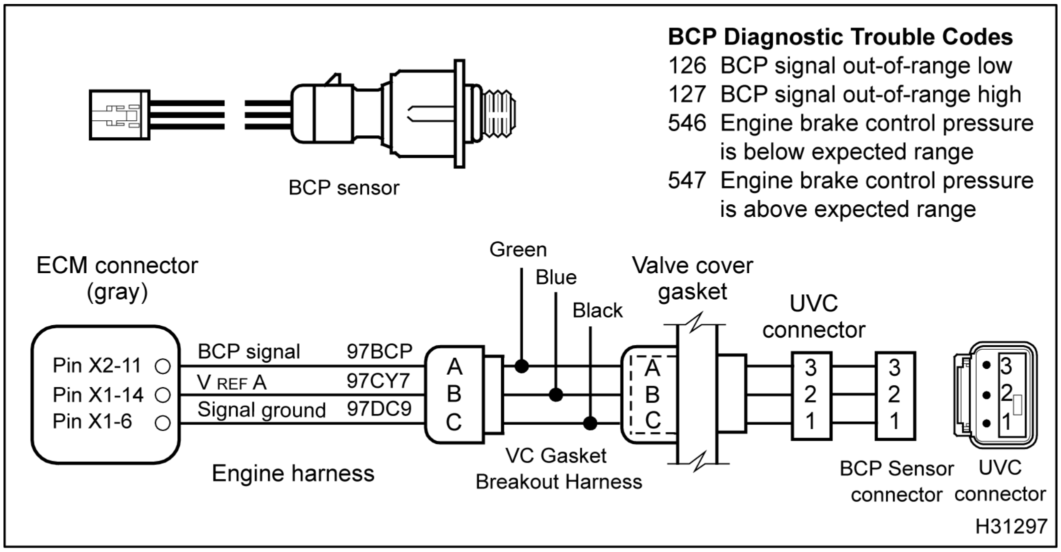



**Figure 394 BCP circuit diagram with VC Gasket Breakout Harness**

| Test Point | EST voltage readings: Signal to ground | Spec | Checks |
|---|---|---|---|
| **Operational Voltage Checks for BCP Sensor with VC Gasket Breakout Harness** (These checks are done if an EST is not available and the valve cover is not removed. Check with VC Gasket Breakout Harness connected to valve cover gasket connector and engine harness.) | | | |
| A to C | 0.15 V to 0.3 V | 0 psi (0 kPa) | Atmospheric pressure with key-on engine-off |
| A to C | 0.15 V to 0.3 V | 0 psi (0 kPa) | Maximum at engine cranking speed |
| **Operational Voltage Checks for BCP Sensor with breakout box** (Check with breakout box connected to ECM and engine harness.) | | | |
| X2–11 to X1–6 | 0.15 V to 0.3 V | 0 psi (0 kPa) | Atmospheric pressure with key-on engine-off |
| X2–11 to X1–6 | 0.15 V to 0.3 V | 0 psi (0 kPa) | Maximum at engine cranking speed |

**BCP Diagnostic Trouble Codes**

DTC 126 = Signal voltage was < 0.039 V for more than 0.1 second

DTC 127 = Signal voltage was > 4.9 V for more than 0.1 second

DTC 546 = Brake control pressure was < 4 MPa (580 psi) for more than 3.0 seconds

DTC 547 = Brake control pressure was > 4.5 MPa (653 psi) for more than 3.0 seconds

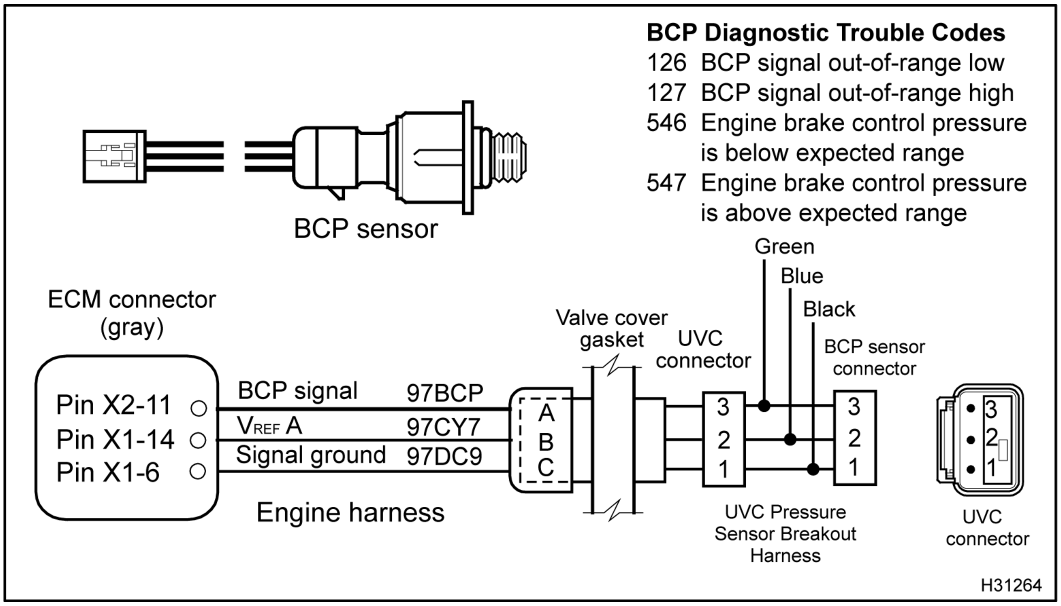



**Figure 395 BCP circuit diagram with UVC Pressure sensor Breakout Harness**

| **Connector Voltage Checks to Ground with Valve Cover Removed** (Disconnect sensor from UVC connector and connect UVC Pressure Sensor Breakout Harness to UVC connector only. Turn the ignition switch to ON.) | | |
|---|---|---|
| **Test Point** | **Spec** | **Comment** |
| 1 to gnd | 0 V to 0.25 V | Signal ground (no voltage expected). If > 0.25 V, check ground circuit for open or high resistance and check for short to $V_{REF}$ or B+. |
| 2 to gnd | 5 V ± 0.5 V | If voltage is not to spec, $V_{REF}$ is shorted to ground, shorted to B+, or open. |
| 3 to gnd | 0 V to 0.25 V | If voltage > 0.25 V, signal circuit is shorted to $V_{REF}$ or B+. |
| **Connector Resistance Checks to ECM Chassis Ground with Valve Cover Removed** (Turn the ignition switch to OFF. Disconnect sensor from UVC connector. Disconnect chassis connector 9260[1]. Connect UVC Pressure Sensor Breakout Harness to UVC connector only.) | | |
| 1 to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open circuit. |
| 2 to Pin A (9260) | > 500 Ω | If < 500 Ω, check for short to ground within wiring harness. |
| 3 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

| **Connector Resistance Checks to Chassis Ground with Valve Cover Removed** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.) | | |
|---|---|---|
| 1 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| 2 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| 3 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| **Harness Resistance Checks with valve cover removed** (Connect breakout box [X1 and X2] to engine harness only. Connect UVC Pressure Sensor Breakout Harness to UVC connector only.) | | |
| X1–6 to 1 | < 5 Ω | If > 5 Ω, check for open ground. |
| X1–14 to 2 | < 5 Ω | If > 5 Ω, check for open $V_{REF}$. |
| X2–11 to 3 | < 5 Ω | If > 5 Ω, check for open BCP signal. |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

### BCP Pin-Point Diagnostics (ECM to BCP Sensor– valve cover removed)

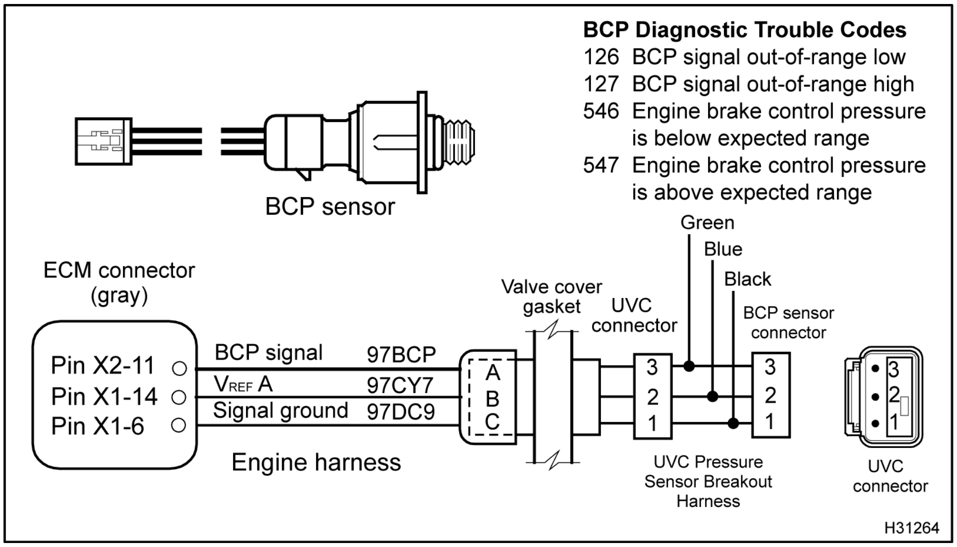



**Figure 396 BCP circuit diagram with UVC Pressure Sensor Breakout Harness**

**Operational Voltage Checks for BCP Sensor with UVC Pressure Sensor Breakout Harness** (Check with UVC Pressure Sensor Breakout Harness connected to UVC connector and sensor.)

**NOTE:** These checks are done only if an EST is not available. Do not use this method to measure BCP when engine is running.

| Test Point | EST voltage readings: Signal to ground | Spec | Checks |
|---|---|---|---|
| 3 to 1 | 0.15 V to 0.3 V | 0 kPa (0 psi) | Atmospheric pressure with key-on engine-off |
| 3 to 1 | 0.15 V to 0.3 V | 0 kPa (0 psi) | Maximum at engine cranking speed |

**BCP Diagnostic Trouble Codes**

DTC 126 = Signal voltage was < 0.039 V for more than 0.1 second

DTC 127 = Signal voltage was > 4.9 V for more than 0.1 second

DTC 546 = Brake control pressure was < 4 MPa (580 psi) for more than 3.0 seconds

DTC 547 = Brake control pressure was > 4.5 MPa (653 psi) for more than 3.0 seconds

**Brake Shut-off Valve**

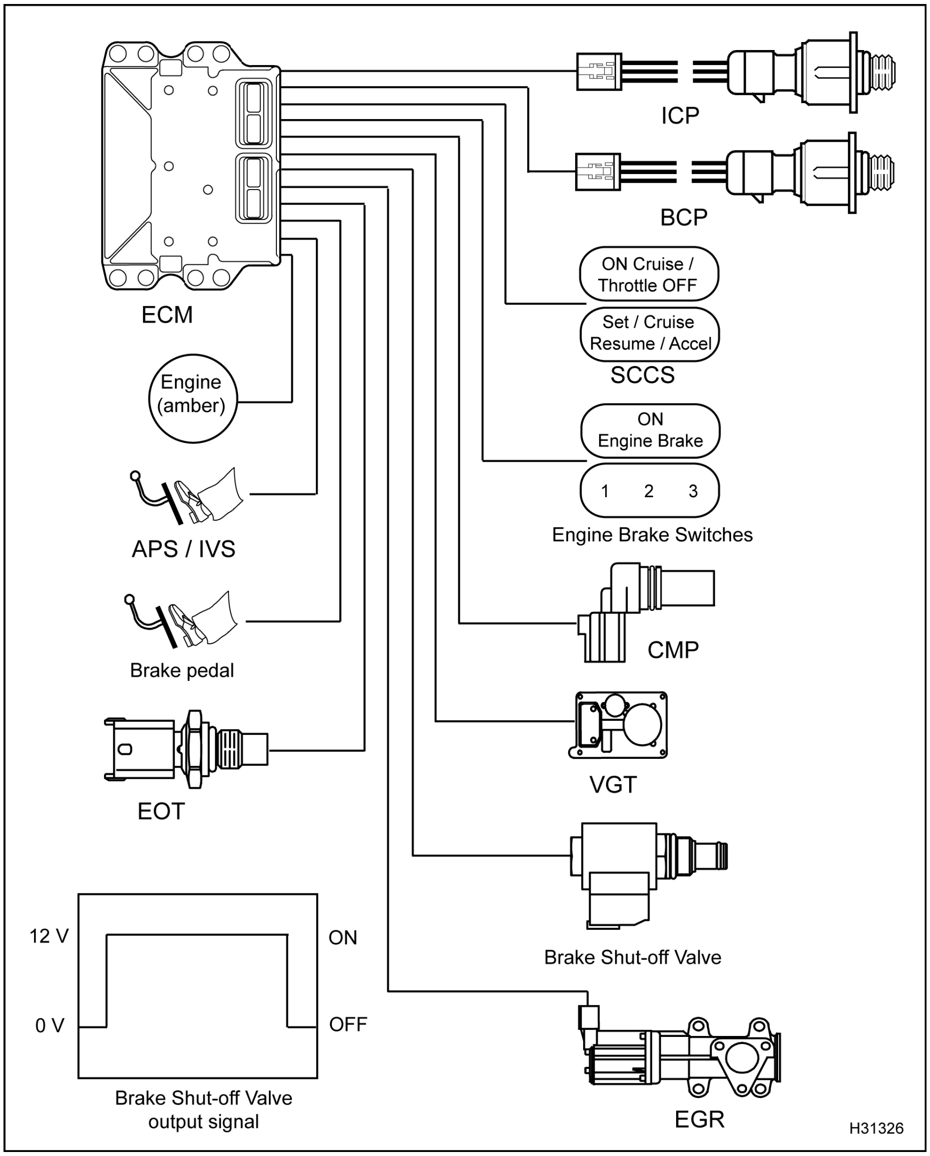



**Figure 397 Function diagram for the Brake Shut-off Valve**

The function diagram for the brake shut-off valve includes the following:

- Engine Oil Temperature (EOT) sensor
- Speed Control Command Switches (SCCS)
- Injection Control Pressure (ICP) sensor
- Brake Control Pressure (BCP) sensor
- Engine brake switches
- Camshaft Position (CMP) sensor
- Accelerator Position / Idle Validation (APS/IVS) sensors
- Electronic Control Module (ECM)
- Brake pedal
- Brake shut-off valve
- Variable Geometry Turbocharger (VGT) actuator

- Exhaust Gas Recirculation (EGR) actuator
- ENGINE lamp (amber)

**Function**

The brake shut-off valve controls pressure in the oil gallery of the high-pressure oil rail. When the engine brake is activated, the ECM provides power to activate the brake shut-off valve to allow oil from the injector oil gallery to flow to the brake oil gallery. High oil pressure activates the brake actuator pistons to open the exhaust valves.

The ECM removes the power from the brake shut-off valve to deactivate the engine brake. Residual brake gallery pressure initially bleeds from the actuator bore. When brake gallery pressure reaches 1000 psi, the brake pressure relief valve opens, and oil drains back to sump.

The brake shut-off valve consists of a solenoid and valve assembly and is located in the center of the high-pressure oil rail.

The ECM monitors the following criteria to make sure certain conditions are met.

- ABS (inactive)
- RPM (greater than 1200)
- APS (less than 5%)
- EOT (greater than 60 °C [140 °F])
- Idle validation
- Operator input switches (On/Off) (power selection – Low, Medium, High)

**Brake Shut-off Valve Circuit Operation**

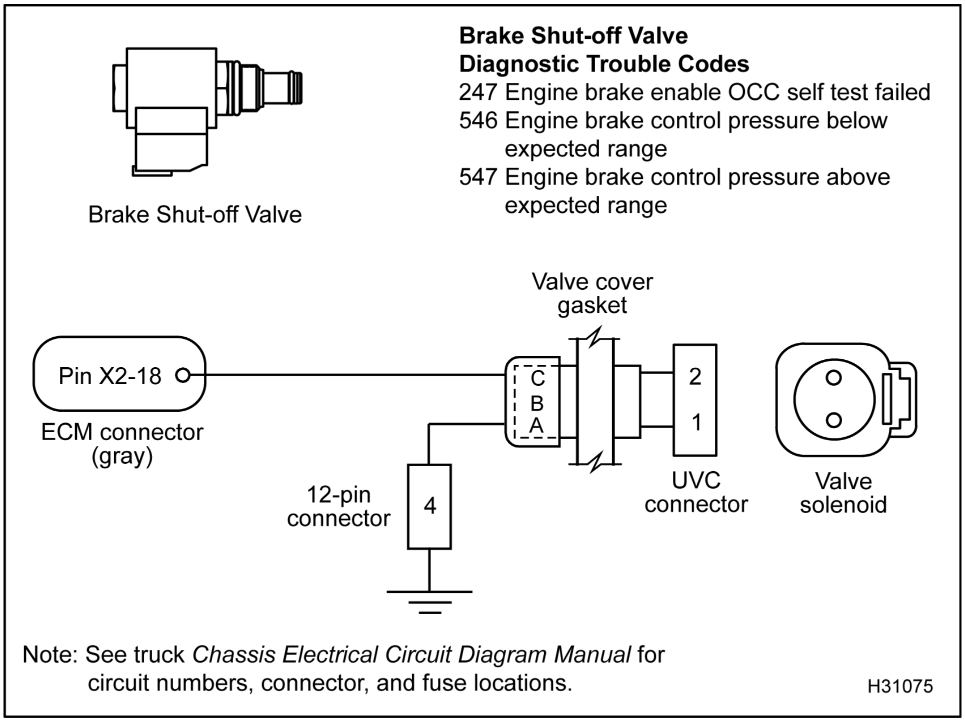



**Figure 398 Brake Shut-off Valve circuit diagram**

The brake shut-off valve is supplied ground to Pin 1 from the battery through Pin 4 of the 12-pin connector and then through Pin A of the valve cover gasket. The ECM controls the engine brake by supplying 12 volts through Pin C of the valve cover gasket to Pin 2 of the brake shut-off valve.

**Fault Detection / Management**

An open or short to ground in the brake shut-off valve control circuit can be detected by an on demand Output Circuit Check (OCC) during KOEO Standard Test. If there is a circuit fault detected a DTC will be set.

When the engine is running, the ECM compares engine brake control pressure to injection control pressure and BCP desired. When the brake is activated, brake control pressure will equal injection control pressure.

If the brake control pressure does not match injection control pressure, the ECM will disable the engine brake, a DTC will be set, and the amber ENGINE lamp will be illuminated.

When the engine brake is not active and the ECM detects an undesired value, the ECM will set a DTC and the amber ENGINE lamp will be illuminated.

A bias BCP sensor can also cause the fault. The brake shut-off valve and the BCP sensor circuit should both be diagnosed.

**Brake Shut-off Valve Diagnostic Trouble Codes (DTCs)**

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

**DTC 247**
**Engine brake enable OCC self-test failed**

- DTC 247 is set by the ECM when the OCC test has failed after the KOEO Standard Test has been run.
- DTC 247 can be set when a poor connection, an open or short to ground in the brake shut-off valve control circuit, or a failed brake shut-off valve solenoid exists.

- When DTC 247 is active the amber ENGINE lamp will be illuminated.

**DTC 546**
**Engine brake control pressure below expected range**

- DTC 546 is set by the ECM when the brake control pressure is less than injection control pressure 4 MPa (580 psi) for more than 3 seconds.
- DTC 546 can be set due to a bias low BCP sensor or a failed BCP sensor. See “Brake Control Pressure (BCP) Sensor – Section 7.
- DTC 546 can be set due to an open control circuit (power or ground), a failed brake shut-off valve, or a failed brake shut-off valve solenoid.
- When DTC 546 is active the amber ENGINE lamp is illuminated.

**DTC 547**
**Engine brake control pressure above expected range**

- DTC 547 is set by the ECM when the brake control pressure is greater than desired brake control pressure by 4.5 MPa (653 psi) for more than 3 seconds.
- DTC 547 can be set due to an open signal ground, $V_{REF}$ shorted to a voltage source higher than 5.5 V, or a failed BCP sensor. See “Brake Control Pressure (BCP) Sensor – Section 7.
- DTC 547 can be set due to a control circuit short to B+ or a brake shut-off valve stuck open.
- When DTC 547 is active the amber ENGINE lamp is illuminated.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- VC Gasket Breakout Harness
- 12-Pin Breakout Harness
- 500 Ohm Resistor Harness
- Breakout Box
- Terminal Test Adapter Kit

### Brake Shut-off Valve Pin-Point Diagnostics (ECM to valve cover gasket connector)

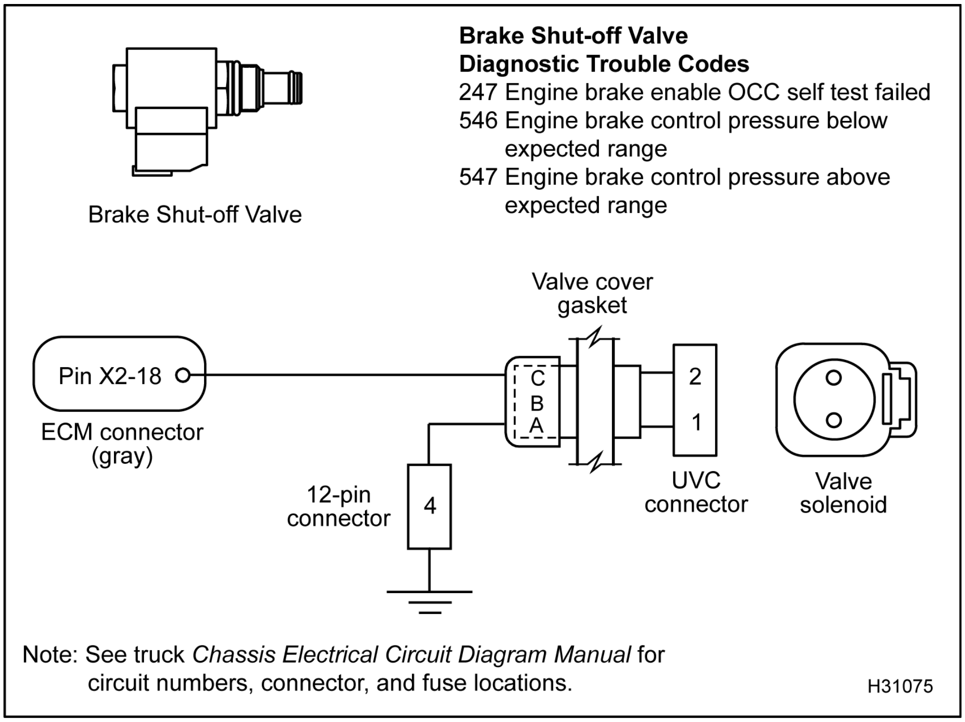



**Figure 399 Brake Shut-off Valve circuit diagram**

**NOTE: Complete all pin-point diagnostics (ECM to valve cover gasket connector) before removing valve cover for under-valve-cover diagnostics.**

- Turn the ignition switch to OFF before disconnecting engine wiring harness connectors from components.
- See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**Actuator Control Voltage Check at Valve Cover Gasket Connector** (Disconnect engine harness from valve cover gasket. Inspect for bent pins or corrosion. Connect VC Gasket Breakout Harness to engine harness and valve cover gasket. Turn the ignition switch to ON.)

| Test Point | Spec | Comment |
|---|---|---|
| C to A | 0 V to 0.25 V | If > 0.25 V, continue with next test point, C to ground. |
| C to gnd | 0 V to 0.25 V | If > 0.25 V, control wire is shorted to $V_{REF}$ or B+, or an open ground, open control circuit, or open solenoid exists. |
| A to gnd | 0 V to 0.25 V | If > 0.25 V, ground wire is shorted to $V_{REF}$ or B+. |

**Output State Test - Signal Check at Valve Cover Gasket Connector** (Disconnect engine harness from valve cover gasket. Connect VC Gasket Breakout Harness to engine harness and valve cover gasket. Run the Output State Tests. For help, see "Diagnostic Software Operation" in Section 3 (page 68) for procedure to run the Low and High Output State Tests.)

| Test State/Point | Setting/Spec | Comment |
|---|---|---|
| KOEO | DMM set to V - DC | |
| C to A | 0 V to 0.25 V | If > 0.25 V, disconnect VC Gasket Breakout Harness from gasket. Connect 500 Ohm Resistor Harness between C and A and retest.<br>• If > 0.25 V, run the Low and High Output State Test.<br>• If < 0.25 V, the concern is the valve cover gasket, UVC wiring, or brake shut-off valve. |
| Output State Test - Low | DMM set to V - DC | Toggling between the Low and High Output State Tests can be done during this procedure. |
| C to A | 0 V to 0.25 V | If > 0.25 V, disconnect VC Gasket Breakout Harness from gasket. Connect 500 Ohm Resistor Harness between C and A and retest Output State Test - Low.<br>• If > 0.25 V the concern is the engine harness or ECM, check for a short to B+ or $V_{REF}$.<br>• If < 0.25 V, the concern is the valve cover gasket, UVC wiring, or Brake Shut-off Valve. |

| | | |
|---|---|---|
| Output State Test - High | DMM set to V - DC | Toggling between the Low and High Output State Tests can be done during this procedure. |
| C to A | B+ ± 0.5 V | If < B+, disconnect VC Gasket Breakout Harness from gasket. Connect 500 Ohm Resistor Harness between C and A and retest and retest Output State Test - High.<br>• If equal to B+ the concern is the valve cover gasket, UVC wiring, or Brake Shut-off Valve. Check for short to ground or open on control circuit, or open ground circuit.<br>• If < B+ the concern is the engine harness or ECM. Check the ECM programming and check for a short to ground or open control circuit. Do the Actuator Control Voltage Check at ECM (page 354) and Harness Resistance Checks (page 355). |

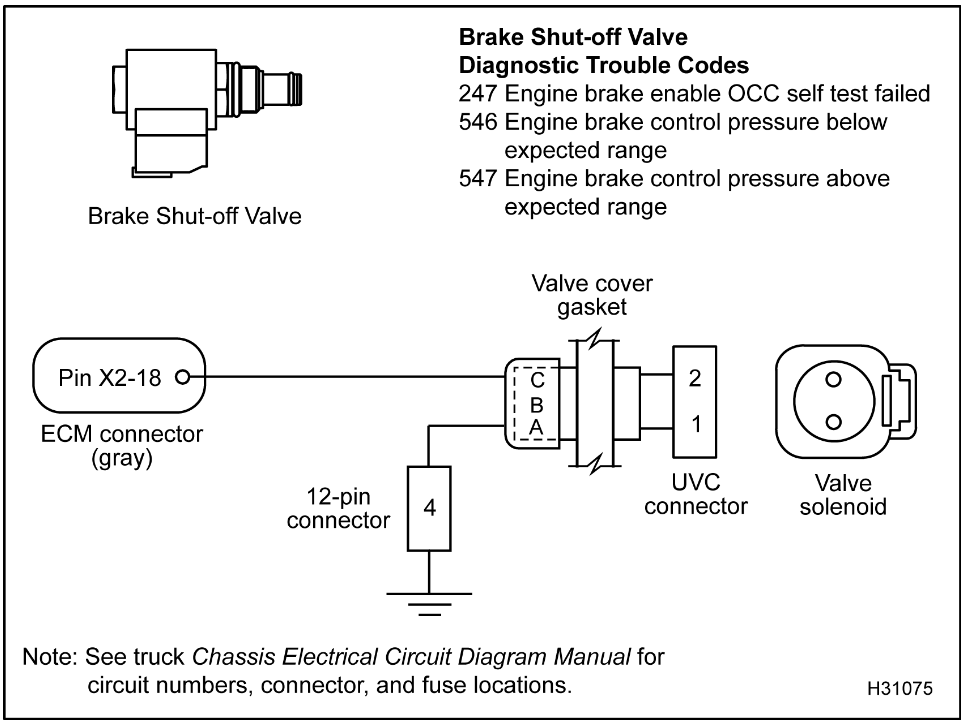



**Figure 400 Brake Shut-off Valve circuit diagram**

**NOTE: Complete all pin-point diagnostics (ECM to valve cover gasket connector) before removing valve cover for under-valve-cover diagnostics.**

- Turn the ignition switch to OFF before disconnecting engine wiring harness connectors from components.
- See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**Actuator Control Voltage Check at ECM** (Connect breakout box [X2 only] to ECM and engine harness. Engine harness is not connected to valve cover gasket. Connect 500 Ohm Resistor Harness to X2–18 and ground. Turn the ignition switch to ON. Run Low and High Output State Test. For help, see “Diagnostic Software Operation” in Section 3 (page 68) for procedure to run the Low and High Output State Tests. Measure across X2–18 and ground.)

| Test State/Point | Setting/Spec | Comment |
|---|---|---|
| KOEO | DMM set to V - DC | |
| X2 - 18 to gnd | 0 V to 0.25 V | If > 0.25 V, disconnect engine harness from breakout box harness and retest.<br>• If > 0.25 V, run the Low and High Output State Tests.<br>• If < 0.25 V, diagnose engine wiring harness. Check for short to $V_{REF}$ or B+. |
| Output State Test - Low | DMM set to V - DC | Toggling between the Low and High Output State Tests can be done during this procedure. |
| X2 - 18 to gnd | 0 V to 0.25 V | If > 0.25 V, disconnect engine harness from breakout box harness and retest.<br>• If < 0.25 V, diagnose engine wiring harness. Check for short to $V_{REF}$ or B+.<br>• If > 0.25 V with breakout box connected only to ECM, replace ECM. |
| Output State Test - High | DMM set to V - DC | Toggling between the Low and High Output State Tests can be done during this procedure. |
| X2 - 18 to gnd | B+ ± 0.5 V | If < B+, disconnect engine harness from breakout box harness and retest.<br>• If equal to B+, diagnose engine wiring harness. Do Harness Resistance Checks (page 355). Check for short to ground or open circuit.<br>• If < B+ with breakout box connected only to ECM, replace the ECM. |

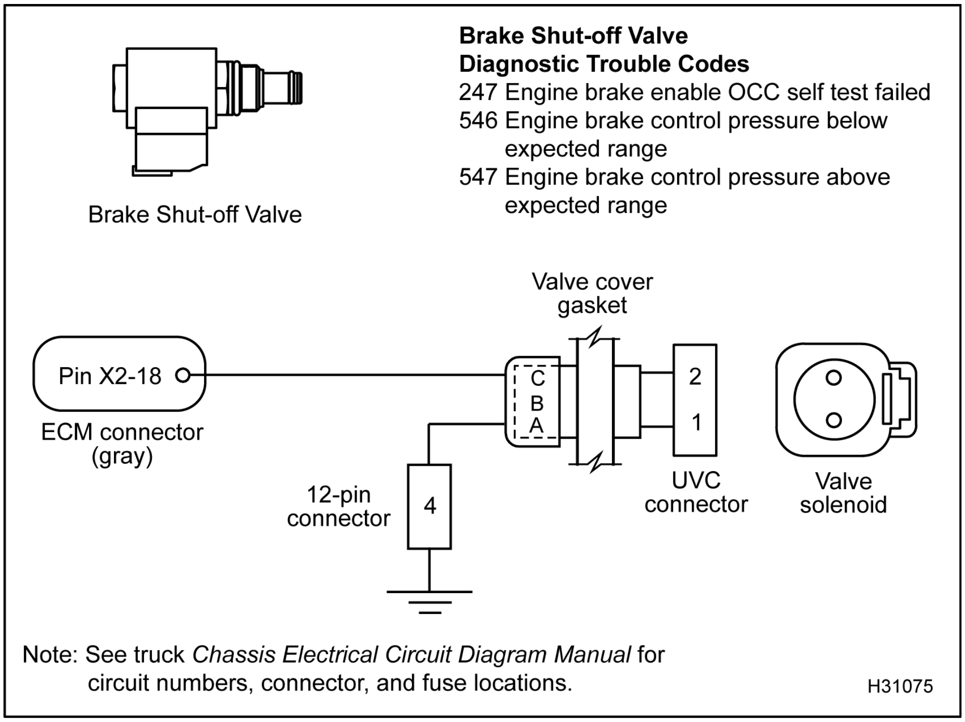



**Figure 401 Brake Shut-off Valve circuit diagram**

**NOTE: Complete all pin-point diagnostics (ECM to valve cover gasket connector) before removing valve cover for under-valve-cover diagnostics.**

- Turn the ignition switch to OFF before disconnecting engine wiring harness connectors from components.
- See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**Harness Resistance Check – Valve Cover Gasket Connector to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Connect VC Gasket Breakout Harness to engine wiring harness only.)

| Test Point | Spec | Comment |
|---|---|---|
| A to Pin A (9260) | < 5 Ω | If > 5 Ω, check for an open circuit. |
| C to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Harness Resistance Check – Valve Cover Gasket Connector to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from valve cover gasket. Use disconnected negative battery cable for ground test point.)

| | | |
|---|---|---|
| A to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| C to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |

| | | |
|---|---|---|
| **Harness Resistance Check – 12-Pin Connector to ECM Chassis Ground** (Turn the ignition switch to OFF. Connect 12-pin Breakout Harness to chassis wiring harness only. Disconnect chassis connector 9260[1].) | | |
| 4 to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open in chassis wiring harness ground circuit. |
| **Harness Resistance Check – 12-Pin Connector to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect 12–pin connector and use chassis side for test point. Use disconnected negative battery cable for ground test point.) | | |
| 4 to gnd cable | < 500 Ω | If > 500 Ω, check for short to ground. |
| **Harness Resistance Check – Valve Cover Gasket Connector to 12-Pin Connector** (Connect VC Gasket Breakout Harness to engine wiring harness only. Connect 12-Pin Breakout Harness to engine wiring harness only.) | | |
| A to 4[1] | < 5 Ω | If > 5 Ω, check for open in actuator ground. |
| **Harness Resistance Check – Valve Cover Gasket Connector to ECM** (Connect VC Gasket Breakout Harness to engine wiring harness only. Connect breakout box X2 to engine wiring harness only.) | | |
| C to X2-18 | < 5 Ω | If > 5 Ω, check for open in control wire. |
| **Resistance Check – Valve Cover Gasket, UVC Wiring, and Brake Shut-off Valve/Solenoid** (Connect VC Gasket Breakout Harness to valve cover gasket only.) | | |
| A to C | 10 Ω ± 2 Ω | • If > 12 Ω, the concern is the valve cover gasket, UVC wiring, or brake shut-off valve/solenoid. Do Harness Resistance Check – Valve Cover Gasket Connector to UVC Connector (page 360) and Solenoid Resistance Check – Brake Shut-off Valve (page 360).<br>• If < 8 Ω, a short to ground exists. The concern is the valve cover gasket, UVC wiring, or brake shut-off valve/solenoid. |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

**Brake Shut-off Valve Pin-Point Diagnostics (ECM to brake valve – valve cover removed)**

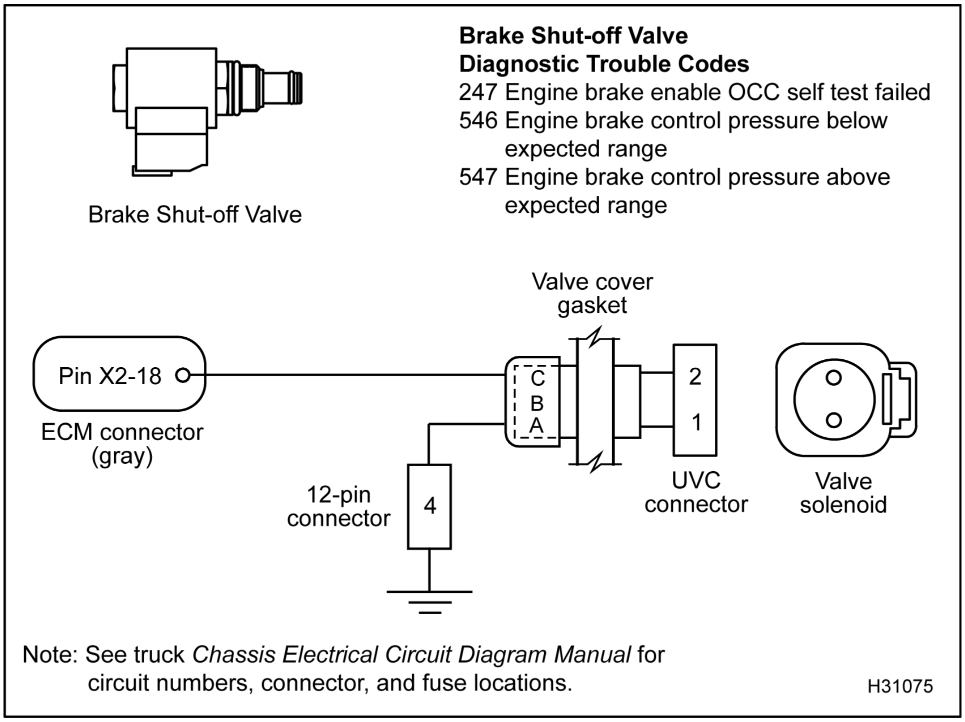



**Figure 402 Brake Shut-off Valve circuit diagram**

**NOTE: Complete all pin-point diagnostics (ECM to valve cover gasket connector) before removing valve cover for under-valve-cover diagnostics.**

- Turn the ignition switch to OFF before disconnecting engine wiring harness connectors from components.
- See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**Actuator Control Voltage Check at UVC Connector** (Remove valve cover following procedure in the *Engine Service Manual*. Disconnect UVC connector from valve. Use the Terminal Test Adapter Kit to connect the 500 Ohm Resistor harness to the UVC connector Pin 2 and ground. Turn the ignition switch to ON.)

| Test Point | Spec | Comment |
|---|---|---|
| 2 to 1 | 0 V to 0.25 V | If > 0.25 V, continue with next test point, 2 to chassis ground. |
| 2 to chassis gnd | 0 V to 0.25 V | If > 0.25 V, control wire is shorted to $V_{REF}$ or B+. |
| 1 to chassis gnd | 0 V to 0.25 V | If > 0.25 V, ground wire is shorted to $V_{REF}$ or B+. |

**Output State Test - Signal Check at UVC Connector** (Disconnect UVC connector from valve. Use the Terminal Test Adapter Kit to connect the 500 Ohm Resistor harness to the UVC connector Pin 2 and ground. Run the Output State Tests. For help, see “Diagnostic Software Operation” in Section 3 (page 68) for procedure to run the Low and High Output State Tests. Measure across adapter and ground.)

| Test State/Point | Setting/Spec | Comment |
|---|---|---|
| Output State Test - Low | DMM set to V - DC | Toggling between the Low and High Output State Tests can be done during this procedure. |
| 2 to gnd | 0 V to 0.25 V | If > 0.25 V, and all pin-point diagnostic tests (ECM to valve cover gasket) were in spec, the valve cover gasket or UVC wiring are suspect. Check for short to $V_{REF}$ or B+. |
| Output State Test - High | DMM set to V - DC | Toggling between the Low and High Output State Tests can be done during this procedure. |
| 2 to gnd | B+ ± 0.5 V | If < B+, and all pin-point diagnostic tests (ECM to valve cover gasket) were in spec, the valve cover gasket or UVC wiring are suspect. Check for short to ground, open control wire, or open ground wire. Do Harness Resistance Checks (page 360).<br><br>If equal to B+, and all pin-point diagnostic tests (ECM to valve cover gasket) were in spec, do Solenoid Resistance Check – Brake Shut-off Valve (page 360). |

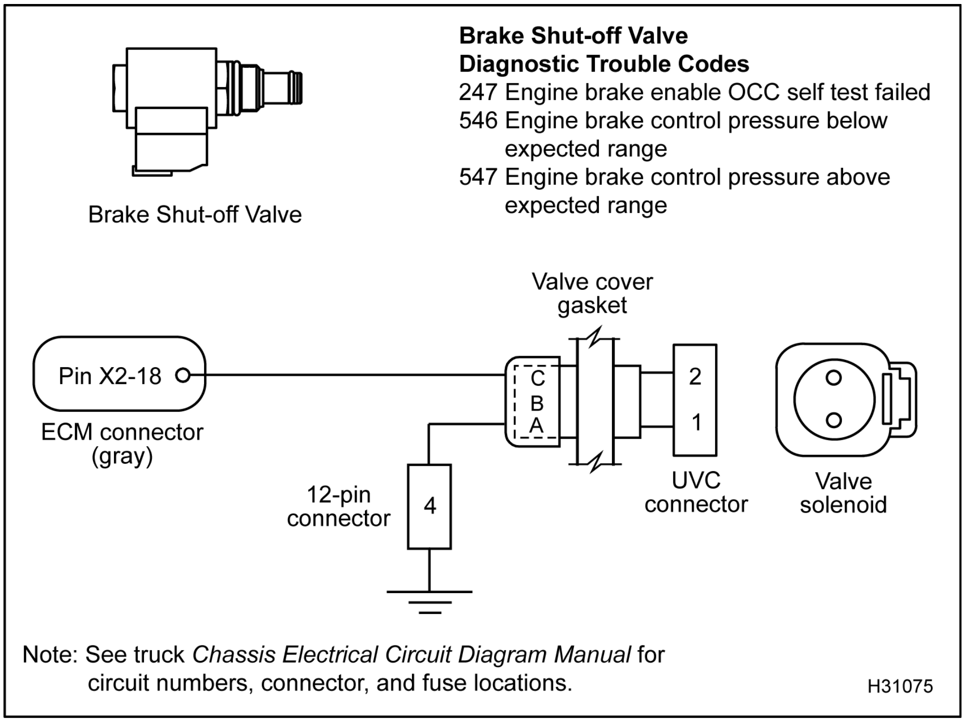



**Figure 403 Brake Shut-off Valve circuit diagram**

**NOTE: Complete all pin-point diagnostics (ECM to valve cover gasket connector) before removing valve cover for under-valve-cover diagnostics.**

- Turn the ignition switch to OFF before disconnecting engine wiring harness connectors from components.
- See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

| | | |
|---|---|---|
| **Harness Resistance Check – UVC Connector to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1].) | | |
| **Test Point** | **Spec** | **Comment** |
| 1 to Pin A (9260) | < 5 Ω | If > 5 Ω, check for an open circuit. |
| 2 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |
| **Harness Resistance Check – UVC Connector to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from valve. Use disconnected negative battery cable for ground test point.) | | |
| 1 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| 2 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| **Harness Resistance Check – Valve Cover Gasket Connector to UVC Connector** (Connect VC Gasket Breakout Harness to valve cover gasket only.) | | |
| A to 1 | < 5 Ω | If > 5 Ω, check for open in actuator ground. |
| C to 2 | < 5 Ω | If > 5 Ω, check for open in control wire. |
| **Solenoid Resistance Check – Brake Shut-off Valve** (Measure across terminals of solenoid.) | | |
| 2 to 1 | 10 Ω ± 2 Ω | If not to specification, replace brake shut-off valve. |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

**Brake Switch Circuit**

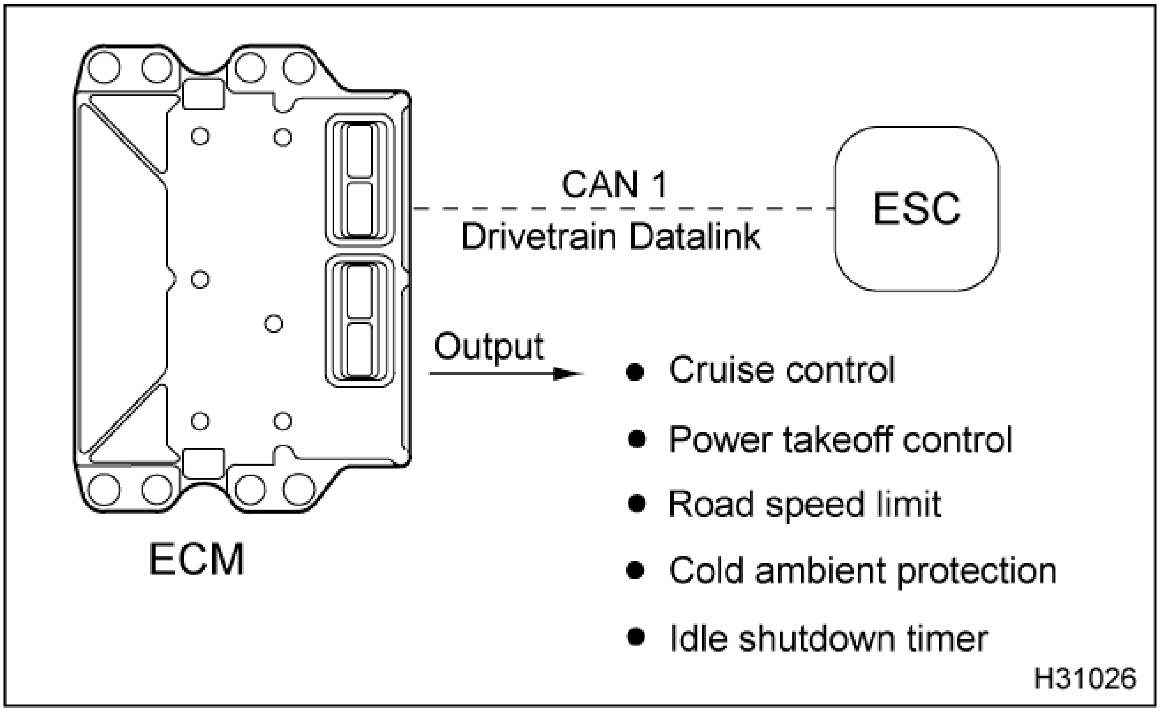



**Figure 404 Function diagram for the Brake Switch**

**Brake Switch Operation**

The service brake circuit signals the ECM when the brakes are applied. The information is used to disengage the Cruise control and Power Takeoff (PTO) function. The brake signal will interrupt the Cold Ambient Protection (CAP) feature and will reset the time interval for the Idle Shutdown Timer (IST) feature.

**CAN Communications (Controller Area Network)**

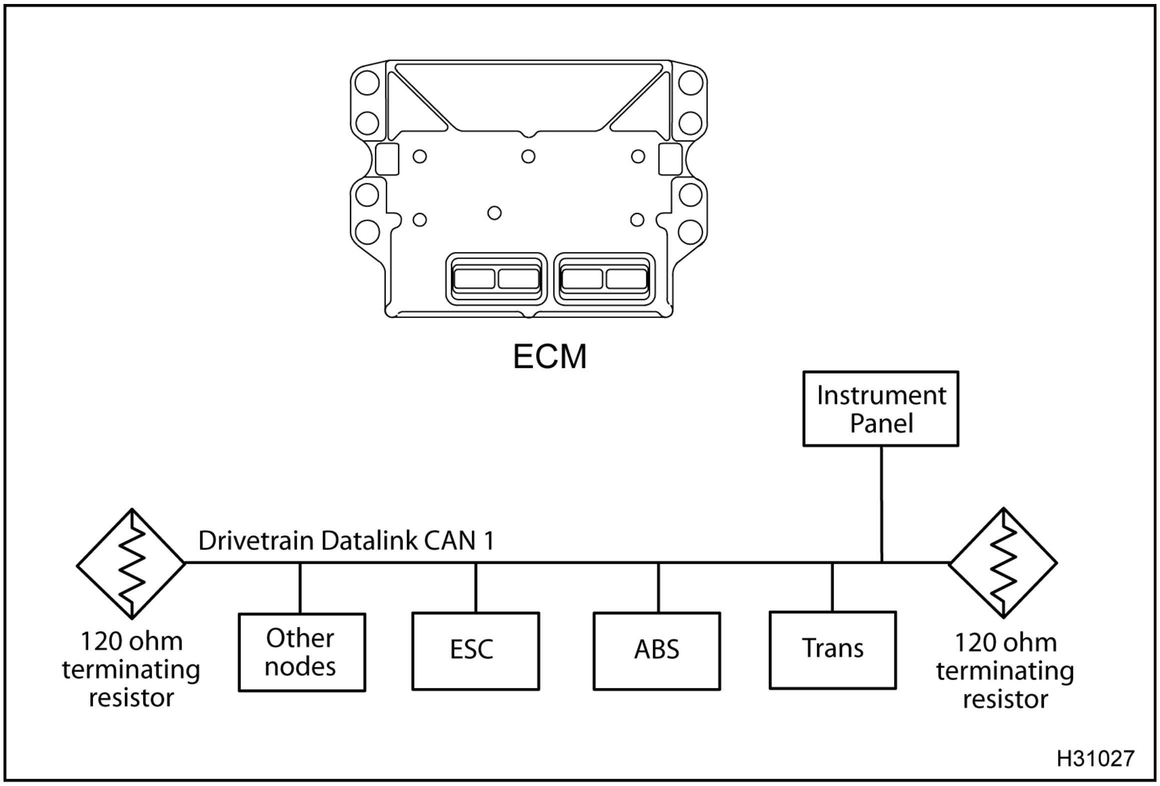



**Figure 405 Function diagram for the CAN**

The function diagram for the CAN includes the following:

- Electronic Control Module (ECM)
- Drivetrain Datalink (CAN 1)
- Terminating resistors – 120 ohm
- Instrument panel (lamps)

**Function**

The Drivetrain Datalink is a Society of Automotive Engineers (SAE) term referring to one of the datalinks common to all trucks. The Drivetrain Datalink is the communication link for the engine Electronic Control Module (ECM), cab and chassis Electronic System Controller (ESC), and the instrument panel. The Drivetrain Datalink is also used for power train communication and control.

The ECM transmits component information across the Drivetrain Datalink to the instrument panel.

The following instrument panel components are in constant communication with the Drivetrain Datalink:

- Oil pressure gauge
- Engine oil temperature gauge
- Tachometer
- Speedometer
- Odometer / hourmeter
- Coolant temperature gauge
- Coolant level lamp
- ENGINE lamp (red)
- ENGINE lamp (amber)
- Fuel filter lamp
- Change oil message
- Cruise / PTO control
- WAIT TO START lamp

The ECM and ESC use the Drivetrain Datalink to provide the instrument panel with status information on the following features.

- Cruise control ON/OFF
- Cruise control Set / Cruise
- Cruise control resume / accelerate
- Driveline Disengagement Switch (DDS)
- Brake pedal
- AC demand
- Self-test input
- Remote Accelerator Pedal (RPS)
- In-Cab PTO / Throttle switch

**Fault Detection / Management**

There are no engine DTCs for CAN 1 communications. See truck *Electrical System Troubleshooting Guide*.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)

**CAN Pin-Point Diagnostics**

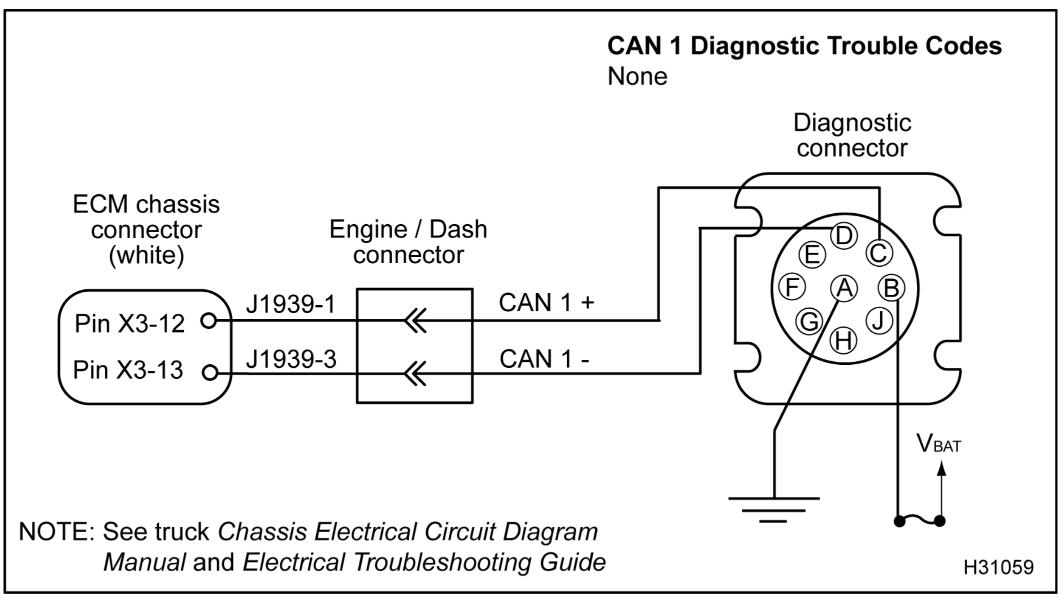



**Figure 406 CAN communication circuit diagram**

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Voltage Check at Diagnostic Connector** (Check at diagnostic connector with key-on engine-off.)

| Test Point | Spec | Signal | Comment |
|---|---|---|---|
| B to A | B+ | Power | Should be B+ power at B all times. If no power, check ground and power circuits. See truck *Chassis Electrical Circuit Diagram Manual*. |
| C to A | 1 V to 4 V | Digital signal | The sum of C to A and D to A equals 4 V to 5 V. |
| D to A | 1 V to 4 V | Digital signal | The sum of C to A and D to A equals 4 V to 5 V. |

**Resistance Check at Diagnostic Connector** (Turn the ignition switch to OFF. Check at diagnostic connector with negative battery cable disconnected.)

| | | | |
|---|---|---|---|
| C to A | > 1 MΩ | CAN+ | If < 1 MΩ, a short between CAN+ and ground exists. Disconnect ECM X3 and check again. If short is no longer present, replace ECM. If short exists, harness or other node component is inoperative. |
| D to A | > 1 MΩ | CAN – | If < 1 MΩ, a short between CAN – and ground exists. Disconnect ECM X3 and check again. If short is no longer present, replace ECM. If short still exists, harness or other node component inoperative. |
| C to D | 60 Ω | CAN | The datalink has two terminating resistors in parallel of 120 Ω each. If > 70 Ω, check for missing terminating resister or open in the CAN+ or CAN – wires. If < 50 Ω, check for extra terminating resistor. If < 5 Ω, check for short between CAN+ and CAN –. |

**CKP Sensor (Crankshaft Position)**

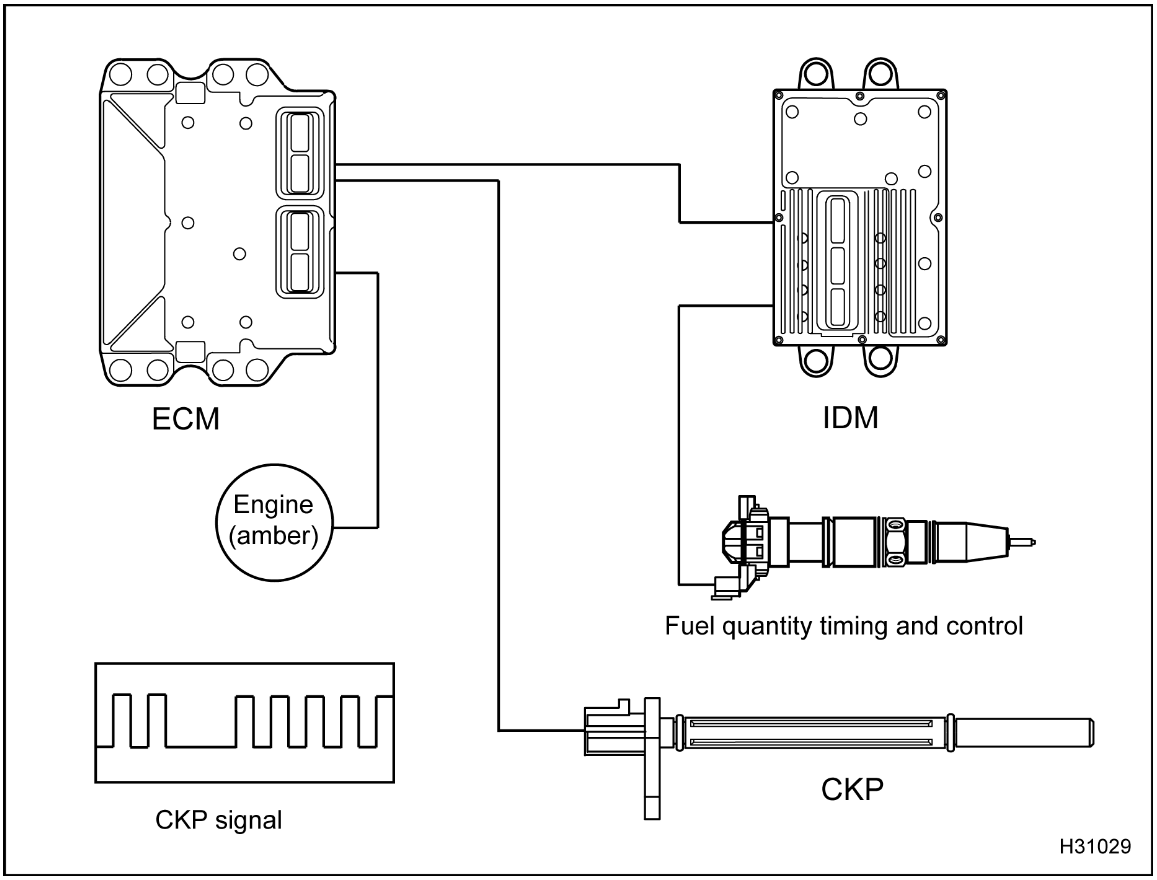



**Figure 407 Function diagram for the CKP sensor**

The function diagram for the CKP sensor includes the following:

- CKP sensor
- Electronic Control Module (ECM)
- Injector Driver Module (IDM)
- Fuel injector
- ENGINE lamp (amber)

**Function**

The CKP sensor provides the ECM with a signal that indicates crankshaft speed and position. As the crankshaft turns the CKP sensor detects a 60 tooth timing disk on the crankshaft. Teeth 59 and 60 are missing. By comparing the CKP signal with the CMP signal, the ECM calculates engine rpm and timing requirements. The CKP is installed in the top left side of the flywheel housing.

The sensor produces pulses for each tooth edge that passes it. Crankshaft speed is derived from the frequency of the CKP sensor signal. The crankshaft position is determined by synchronizing the SYNC tooth with the SYNC gap signals from the target disk. From the CKP signal frequency, the ECM can calculate engine rpm and timing requirements. Diagnostic information on the CKP input signal is obtained by performing accuracy checks on frequency, and duty cycle with software strategies.

**NOTE:** The long CKP sensor, used with International® DT 466, DT 570, and HT 570 diesel engines, is the Camshaft Position (CMP) sensor used with other International® diesel engines.

**CKP Circuit Operation**

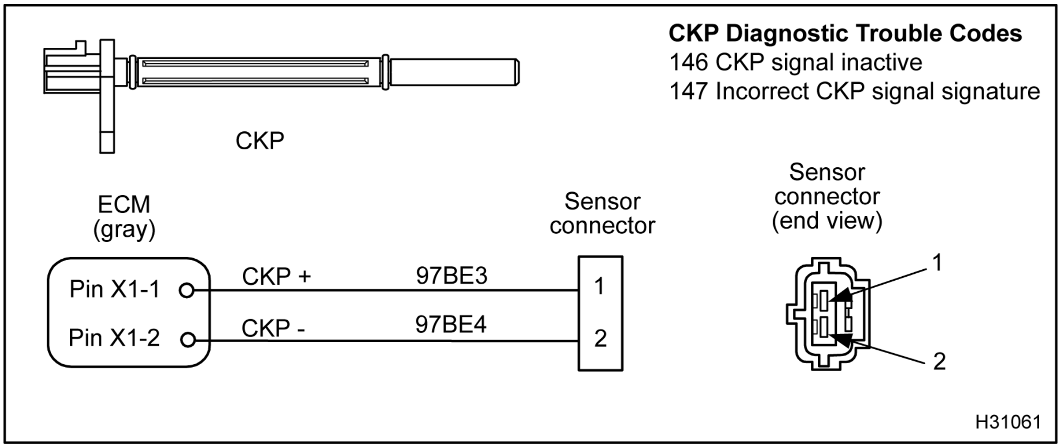



**Figure 408 CKP circuit diagram**

The ECM uses the CKP and CMP signal to calculate engine speed and position. The CKP sensor provides the ECM with a signal that indicates crankshaft speed and position. The CKP contains a permanent magnet that creates a magnetic field. The signal is created when the timing disk rotates and breaks the magnetic field created by the sensor. The ECM pins for the CKP sensor are CKP negative X1-2 and CKP positive X1-1.

**NOTE:** Engine will not operate without CKP signal.

**Fault / Detection Management**

An inactive CKP signal during cranking is detectable by the ECM. During engine cranking the ECM monitors the CMP signal and Injection Control Pressure (ICP) 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. An inactive CKP signal will cause a no start condition.

**CKP Diagnostic Trouble Codes (DTCs)**

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

**DTC 146**
**CKP signal inactive**

- DTC 146 is set by the ECM when CKP signal is not detected while the CMP signal is active or ICP has increased.
- DTC 146 can be set due to an open short to ground or voltage source in the CKP circuit. A failed CKP sensor can also set DTC 146.

**DTC 147**
**Incorrect CKP signal signature**

- DTC 147 is set by the ECM when the CKP signal has too few or many transitions per engine rotation.
- DTC 147 can be set due to an electrical noise in the CKP circuit or a failed CKP sensor.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Breakout Box

### CKP Pin-Point Diagnostics

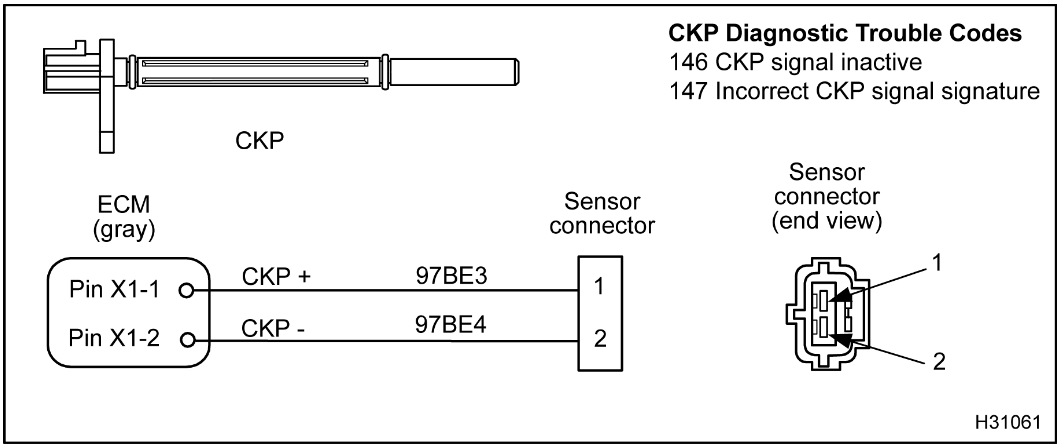



**Figure 409 CKP circuit diagram**

**Sensor and Circuit Resistance Check** (Check with breakout box connected [X1 only] to engine harness only and CKP sensor connected. Disconnect chassis connector 9260[1]. Inspect for bent pins or corrosion. **Note:** Set DMM to 4 kΩ range.)

| Test Point | Spec | Comment |
|---|---|---|
| X1–1 to X1–2 | 800 Ω to 1 kΩ | Resistance through sensor and complete circuit. If not within spec, do Sensor Resistance Check. If in spec, check for short to ground or open within wiring. |
| X1–1 to Pin A (9260) | 800 Ω to 1 kΩ | Resistance through sensor and complete circuit. If not within spec, do Sensor Resistance Check. If in spec, check for short to ground or open within wiring. |
| **Sensor Resistance Check** (Disconnect harness from sensor. **Note:** Test point to sensor only.) | | |
| 1 to 2 | 800 Ω to 1 kΩ | If within spec, check for short to ground or open within wiring.<br>If not within spec, replace sensor. |
| **Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect harness from sensor. Disconnect chassis connector 9260[1].) | | |
| X1–1 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |
| X1–2 to Pin A (9260) | < 5 kΩ | If > 5 kΩ, check for open circuit within wiring harness. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.)

| | | |
|---|---|---|
| X1–1 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| X1–2 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| **Harness Resistance Check** (Check with breakout box connected to engine harness only. Check from ECM to sensor harness connector.) | | |
| X1–1 to 2 | < 5 Ω | If > 5 Ω, check for open circuit. |
| X1–2 to 1 | < 5 Ω | If > 5 Ω, check for open circuit. |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. Refer to truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

| **Operational Checks for CKP Sensor** (Check with breakout box connected to ECM and engine harness.) | | | | |
|---|---|---|---|---|
| **Test Point** | **Engine Cranking** | **Low Idle** | **High Idle** | **Comment** |
| X1–1 to X1–6 | 130 Hz - 225 Hz @ 130–225 rpm | 650–700 Hz @ 700 rpm | 2.80 kHZ - 3.00 kHz @ 2950 rpm | Set DMM to DCmV-Hz |
| **NOTE:** If the tachometer or MasterDiagnostics® display no rpm signal, but both indicate CMP and CKP sensor activity, check the engine static timing. | | | | |

| **CKP Diagnostic Trouble Codes** |
|---|
| DTC 146 = CKP signal inactive (CMP signal active and ICP increased) |
| DTC 147 = Incorrect CKP signal signature |

**CMP Sensor (Camshaft Position)**

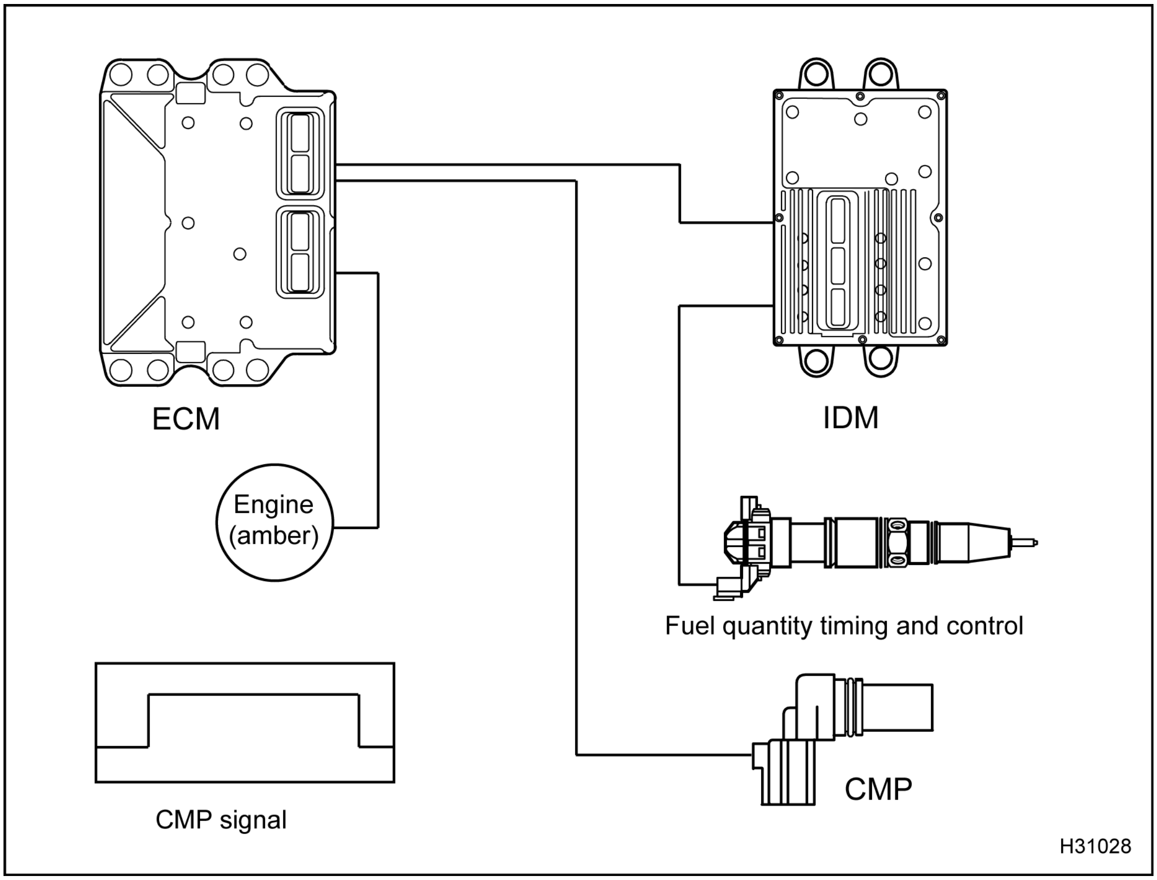



**Figure 410 Function diagram for the CMP sensor**

The function diagram for the CMP sensor includes the following:

- CMP sensor
- Electronic Control Module (ECM)
- Injector Drive Module (IDM)
- Fuel Injector
- ENGINE lamp (amber)

The CMP sensor provides the ECM with a signal that indicates camshaft position. As the cam rotates, the sensor identifies the position of the cam by locating a peg on the cam. The CMP is installed in the front cover, above and to the right of the water pump pulley.

Camshaft speed is calculated from the frequency of the CMP sensor signal. Diagnostic information on the CMP input signal is obtained by performing accuracy checks on signal levels, frequency, and duty cycle with software strategies.

**NOTE:** The short CMP sensor, used with International® DT 466, DT 570, and HT 570 diesel engines, is the Crankshaft Position (CKP) sensor used with other International® diesel engines.

### CMP Circuit Operation

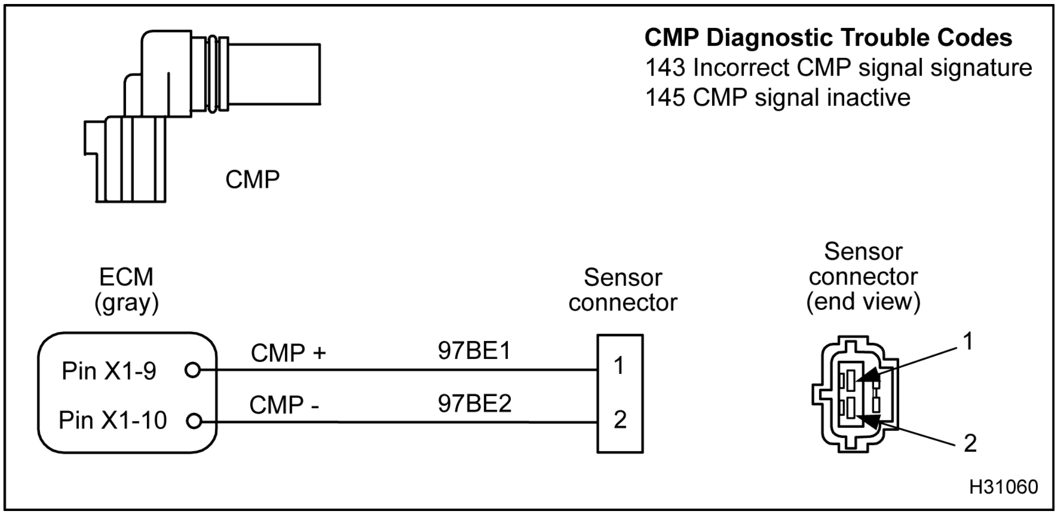



**Figure 411 CMP circuit diagram**

The ECM uses the CKP and CMP signal to calculate engine speed and position. The CMP sensor provides the ECM with a signal that indicates camshaft position. The CMP contains a permanent magnet which creates a magnetic field. The signal is created when the camshaft peg rotates past the sensor breaking the magnetic field. The ECM pins for the CMP sensor are CMP positive X1-9 and CMP negative X1-10.

**NOTE:** Engine will not operate without CMP signal.

### Fault Detection / Management

An inactive CMP signal during cranking is detectable by the ECM. During engine cranking the ECM monitors the CKP signal and Injection Control Pressure (ICP) to verify the engine is rotating. If the CMP signal is inactive during this time a DTC will be set. Electrical noise can also be detected by the ECM. When the level is sufficient to effect engine operation a corresponding DTC will be set. An inactive CMP signal will cause a no start condition.

### CMP Diagnostic Trouble Codes (DTCs)

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

**DTC 143**
**Incorrect CMP signal signature**

- DTC 143 is set by the ECM when the CMP transition occurs at the wrong CKP location.
- DTC 143 can be set due to a mistimed camshaft to crankshaft, electrical noise in the CMP circuit, or a failed CMP sensor.

**DTC 145**
**CMP signal inactive**

- DTC 145 is set by the ECM when CMP signal is not detected while CKP signal is active or ICP has increased.
- DTC 145 can be set due to an open, short to ground or open voltage source in the CMP circuit. A failed CMP sensor can cause DTC 145 to be set.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Breakout Box

### CMP Pin-Point Diagnostics

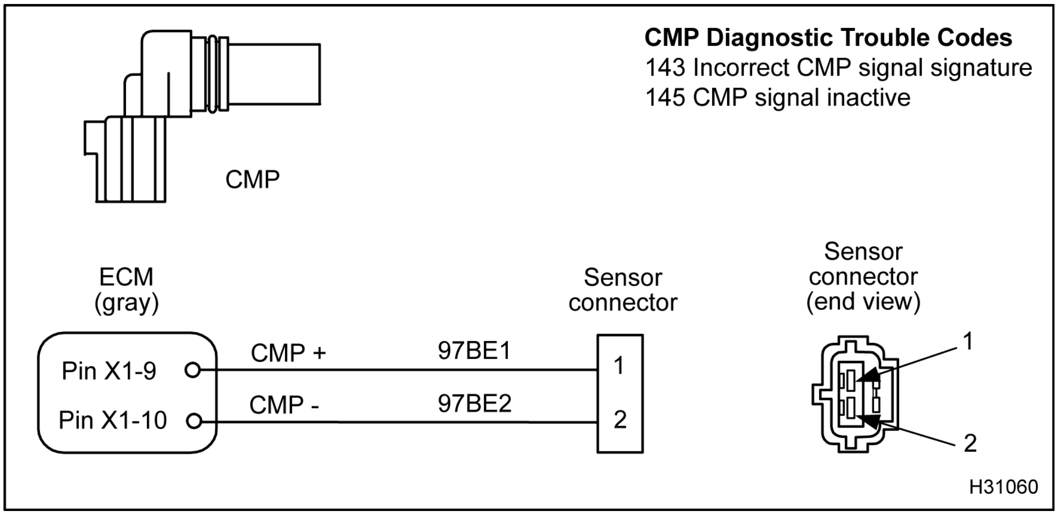



**Figure 412 CMP circuit diagram**

| Test Point | Spec | Comment |
|---|---|---|
| **Sensor and Circuit Resistance Check** (Check with breakout box connected [X1 only] to engine harness only and CMP sensor connected. Disconnect chassis connector 9260[1]. Inspect for bent pins or corrosion.) | | |
| X1–9 to X1–10 | 300 Ω to 400 Ω | Resistance through sensor and complete circuit. If not within spec, do Sensor Resistance Check. If in spec, check for short to ground or open within wiring. |
| X1–9 to Pin A (9260) | 300 Ω to 400 Ω | Resistance through sensor and complete circuit. If not within spec, do Sensor Resistance Check. If in spec, check for short to ground or open within wiring. |
| **Sensor Resistance Check** (Disconnect harness from sensor. **Note:** Test point to sensor only.) | | |
| 1 to 2 | 300 Ω to 400 Ω | If within spec, check for short to ground or open within wiring.<br>If not within spec, replace sensor. |
| **Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect harness from sensor. Disconnect chassis connector 9260[1].) | | |
| X1–9 to Pin A (9260) | > 500 Ω | If < 500 Ω, check for short to ground within wiring harness. |
| X1–10 to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open circuit within wiring harness. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

| | | |
|---|---|---|
| **Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.) | | |
| X1–9 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| X1–10 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| **Harness Resistance Check** (Check with breakout box connected to engine harness only. Check from ECM to sensor harness connector.) | | |
| X1–9 to 1 | < 5 Ω | If > 5 Ω, check for open circuit. |
| X1–10 to 2 | < 5 Ω | If > 5 Ω, check for open circuit. |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. Refer to truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

**Operational Checks for CMP Sensor** (Check with breakout box connected to ECM and engine harness.)

| Test Point | Engine Cranking | Low Idle | High Idle | Comment |
|---|---|---|---|---|
| X1–9 to X1–6 | 130 rpm to 225 rpm[2]@ 130 rpm to 225 rpm | 700 rpm[2]@ 700 rpm | 2950 rpm[2] @ 2950 rpm | Set DMM to DCmV-rpm[2] |

**NOTE:** If the tachometer or MasterDiagnostics® display no rpm signal, but both indicate CMP and CKP sensor activity, check the engine static timing.

**CMP Diagnostic Trouble Codes**

DTC 143 = Incorrect CMP signal signature

DTC 145 = CMP signal inactive

**EBP Sensor (Exhaust Back Pressure)**

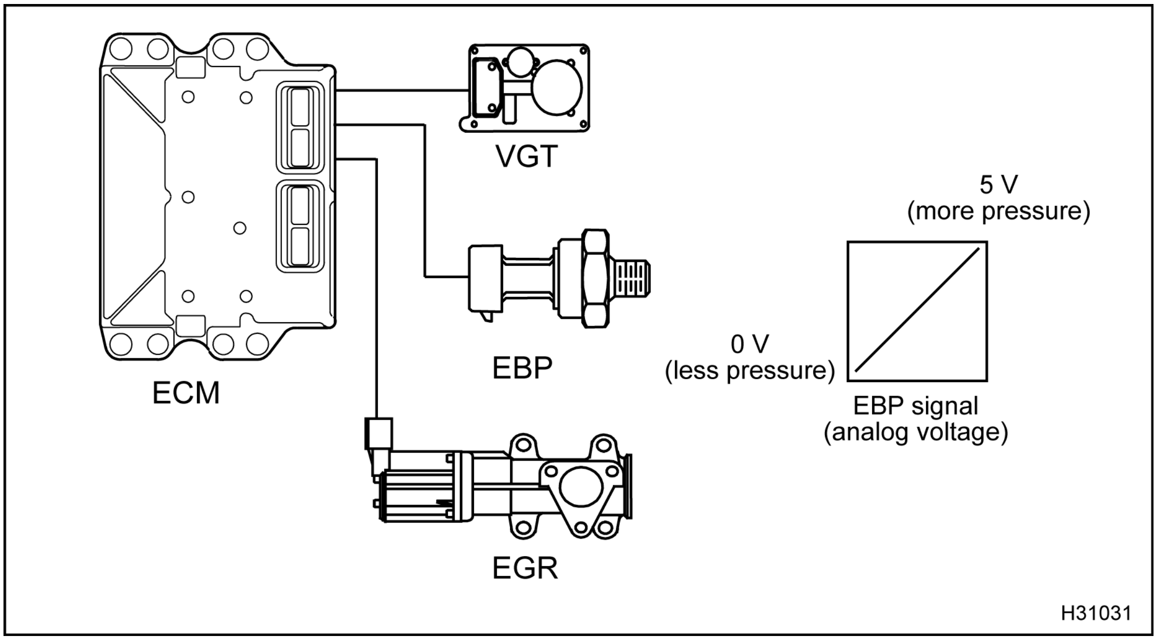



**Figure 413 Function diagram for the EBP sensor**

The function diagram for the EBP sensor includes the following:

- EBP sensor
- Electronic Control Module (ECM)
- Variable Geometry Turbocharger (VGT)
- Exhaust Gas Recirculation (EGR)

**Function**

The EBP sensor is a variable capacitance sensor installed in a bracket mounted on the water supply housing (Freon® compressor bracket). The ECM supplies a 5 V reference signal that the EBP sensor uses to produce a linear analog voltage that indicates pressure. The EBP sensor measures exhaust back pressure so that the ECM can control the VGT and EGR systems.

### EBP Circuit Operation

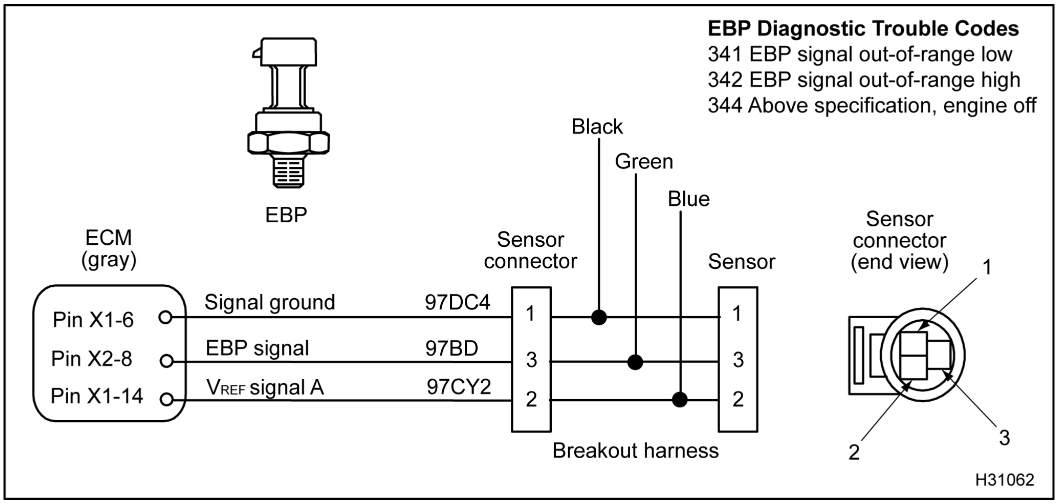



**Figure 414 EBP circuit diagram**

The EBP sensor is supplied with a 5 V reference voltage at Pin 2 from ECM Pin X1–14. The EBP sensor is grounded at Pin 1 from ECM Pin X1–6. The EBP sensor returns a variable voltage signal from Pin 3 to ECM Pin X2–8.

#### Fault Detection / Management

When the EBP signal voltage is detected out of range high or low, the ECM will cause the engine to ignore the EBP signal. The EGR valve will close and the ECM will rely on the VGT pre-programmed values.

#### EBP Diagnostic Trouble Codes (DTCs)

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

#### DTC 341
#### EBP signal out-of-range low

- DTC 341 is set by the ECM when the EBP signal is less than 0.039 V for more than 0.5 second.
- DTC 341 can be set due to an open or short to ground on the signal circuit, a failed EBP sensor or an open $V_{REF}$ circuit or $V_{REF}$ short to ground.
- When DTC 341 is active the amber ENGINE lamp is illuminated.

#### DTC 342
#### EBP signal out-of-range high

- DTC 342 is set by the ECM when the EBP signal is more than 4.9 V for more than 0.5 second.
- DTC 342 can be set due to a signal circuit shorted to $V_{REF}$ or B+, or a failed EBP sensor.
- When DTC 342 is active the amber ENGINE lamp is illuminated.

#### DTC 344
#### Above specification, engine off

- DTC 344 is set by the ECM when the exhaust back pressure is greater than expected with the key-on engine-off.
- DTC 344 can be set due to a plugged EBP sensor, a restriction in the tube leading to the sensor, an open signal ground, or a failed EBP sensor. To check for possible restriction, remove the sensor and tube and inspect for carbon deposits.
- When DTC 344 is active the amber ENGINE lamp is illuminated.

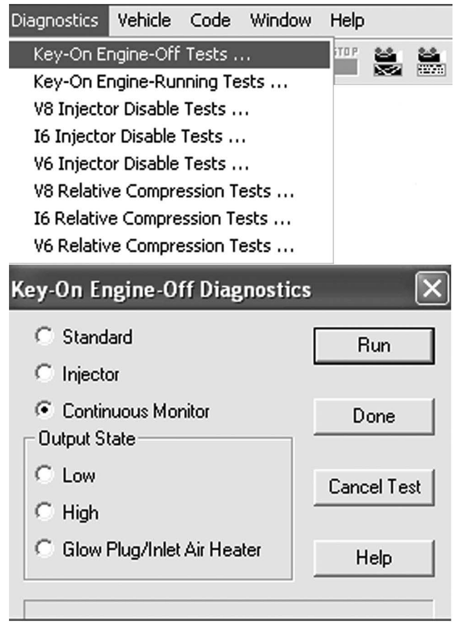
**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 500 Ohm Resistor Harness
- Breakout Box
- Breakout Harness
- Terminal Test Adapter Kit

**EBP Operational Diagnostics**

> **WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:**
>
> **Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.**

1. Using EST, open the D_ContinuousMonitor.ssn.




H31229

**Figure 415 Continuous Monitor Test**

2. To monitor signal voltage, run KOEO Continuous Monitor Test. For help, see “Continuous Monitor Test” in Section 3 (page 68).
3. Monitor EBP signal voltage. Verify an active DTC for the EBP circuit.
4. If code is active, do step 6 and 7 to check circuit for the EBP sensor using the following table.
   - Circuit Checks for EBP Sensor
5. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will display DTCs related to the condition.
6. Disconnect engine harness from pressure sensor.

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

7. Connect Pressure Sensor Breakout Harness to engine harness only.

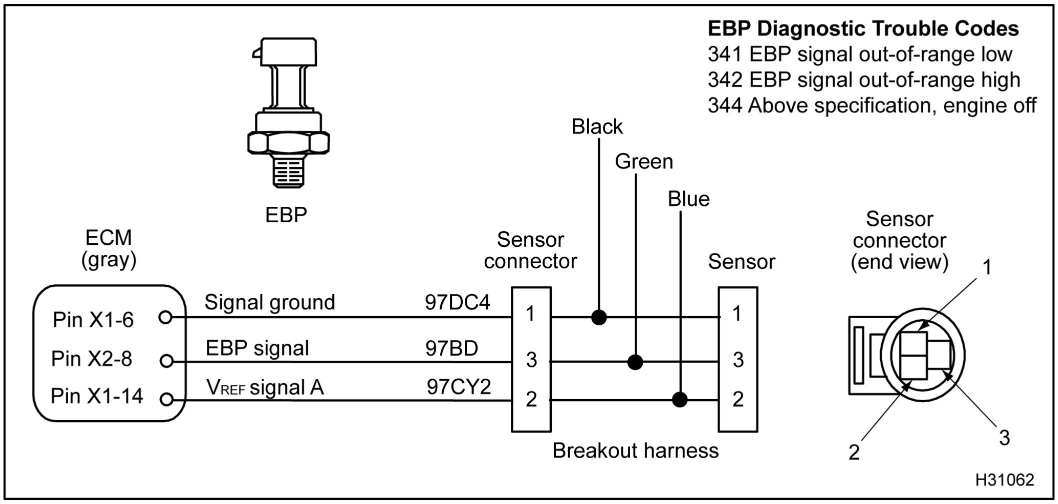



**Figure 416 EBP circuit diagram**

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Circuit Checks for EBP Sensor** (Use EST, DMM, breakout harness, and 500 Ohm Resistor Harness.)

| Test Condition | Spec | Checks |
|---|---|---|
| Sensor disconnected using EST | 0 V to 0.25 V | If > 0.25 V, check ground circuit for open or high resistance, check signal ground for short to $V_{REF}$ or B+. |
| Voltage from Pin 2 (Blue) to ground using DMM | 5 V ±0.5 V | If voltage > 5.5 V, check $V_{REF}$ for short to B+. If voltage is < 4.5 V, check $V_{REF}$ circuit for open or short to ground. |
| 500 Ohm Resistor Harness connected between Pin 3 (Green) and Pin 2 (Blue) of breakout harness. | 5 V | If voltage < 4.9 V, check signal circuit for open or short to ground.<br>— Disconnect connector 9260[1]. Measure resistance from Pin 3 to Pin A of connector 9260 (spec > 1 kΩ) to check for short to ground within wiring harness.<br>— Disconnect negative battery cable. Measure resistance from Pin 3 to ground cable to check for open in harness.<br>— Use a breakout box from Pin 3 to Pin X2–8 (spec < 5 Ω) to check for open in the harness. |
| Resistance from Pin 1 (Black) of breakout harness to ECM chassis ground Pin A of connector 9260 using DMM. | < 5 Ω | If resistance is > 5 Ω, check for open or high resistance between ECM and sensor connector. Use a breakout box and measure resistance from between Pin 1 and Pin X1–6 (spec < 5 Ω). |

**Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the EBP sensor.**

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

**EBP Pin-Point Diagnostics**

| | | |
|---|---|---|
| **Connector Voltage Checks to Ground** (Disconnect harness from sensor. Inspect for bent pins or corrosion. Connect breakout harness to engine harness only. Turn the ignition switch to ON.) | | |
| **Test Point** | **Spec** | **Comment** |
| 1 to gnd | 0 V to 0.25 V | Signal ground (no voltage expected). If > 0.25 V, check ground circuit for open or high resistance and check signal ground for short to $V_{REF}$ or B+. |
| 2 to gnd | 5 V ±0.5 V | If voltage is not to spec, $V_{REF}$ is open or shorted to ground. |
| 3 to gnd | 0 V to 0.25 V | If > 0.25 V, signal circuit is shorted to $V_{REF}$ or B+. |
| **Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Connect breakout harness to engine harness only. Disconnect chassis connector 9260[1].) | | |
| 1 to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open circuit. |
| 2 to Pin A (9260) | > 500 Ω | If < 500 Ω, check for short to ground within wiring harness. |
| 3 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

| | | |
|---|---|---|
| **Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.) | | |
| 1 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| 2 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| 3 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| **Harness Resistance Checks** (Connect breakout box [X1 and X2] to engine harness only. Connect breakout harness to engine harness only.) | | |
| X1–6 to 1 | < 5 Ω | If > 5 Ω, check for open ground wire. |
| X1–14 to 2 | < 5 Ω | If > 5 Ω, check for open $V_{REF}$ wire. |
| X2–8 to 3 | < 5 Ω | If > 5 Ω, check for open signal wire. |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

| **Operational Voltage Checks for EBP with Breakout Harness** (Check with breakout harness connected to sensor and engine harness.) | | |
|---|---|---|
| **Test Point** | **Voltage** | **Pressure** |
| 3 (Green) to 1 (Black) | 0.63 V | 0 kPa (0 psi) |
| 3 (Green) to 1 (Black) | 1.20 V | 55 kPa (8 psi) |
| 3 (Green) to 1 (Black) | 1.92 V | 124 kPa (18 psi) |
| **Operational Voltage Checks for EBP with Breakout Box** (Check with breakout box connected [X1 and X2 only] to the ECM and engine harness.) | | |
| X2–8 to X1–6 | 0.63 V | 0 kPa (0 psi) |
| X2–8 to X1–6 | 1.20 V | 55 kPa (8 psi) |
| X2–8 to X1–6 | 1.92 V | 124 kPa (18 psi) |
| **EBP Diagnostic Trouble Codes** | | |
| DTC 341 = Signal voltage was < 0.039 V for more than 0.5 second | | |
| DTC 342 = Signal voltage was > 4.9 V for more than 0.5 second | | |
| DTC 344 = Exhaust back pressure was > expected with key-on engine-off | | |

**ECI System (Engine Crank Inhibit)**

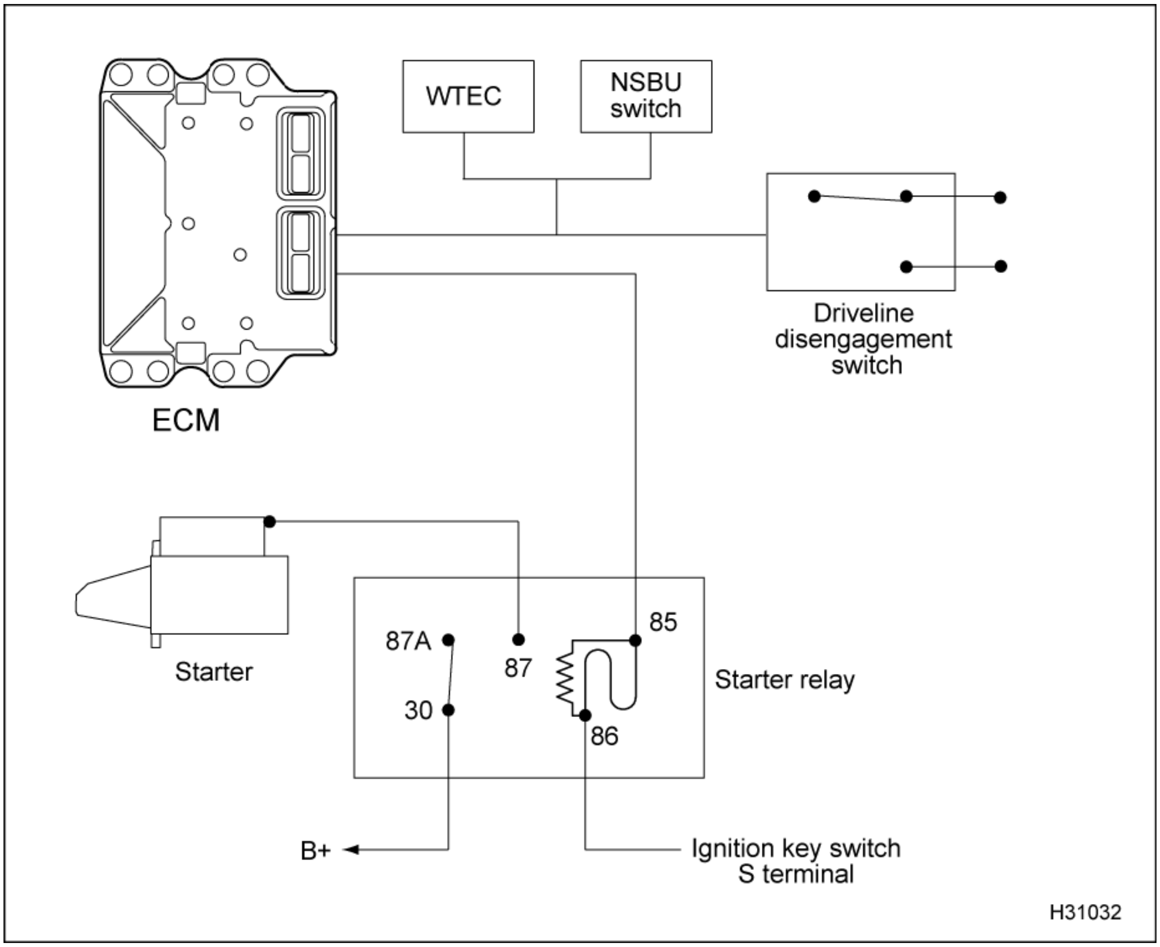



**Figure 417 Function diagram for ECI system**

The function diagram for the ECI system consists of the following.

- Electronic Control Module (ECM)
- Starter
- Starter relay
- World Transmission Electronically Controlled (WTEC)
- Neutral Start Backup Switch (NSBU)
- Driveline Disengagement Switch (DDS)

**Function**

The Engine Crank Inhibit (ECI) is a function of the ECM to control the operation of the starter. The ECM prevents engagement of the starter when the engine is running. This prevents damage to the starter pinion and ring gear. The transmission neutral safety switch or clutch switch prevents engagement of the starter when the transmission is in gear or when the clutch pedal is not depressed.

The engine starter relay controls battery voltage to the starter solenoid. The starter relay can also be controlled by an optional over crank thermocouple.

**Operation**

The ECM controls the starting system. The clutch switch or transmission neutral switch provide input to the ECM. Both switches prevent the starter from being engaged unless the transmission is in neutral or the clutch is depressed.

**Start Relay**

The engine starter relay controls voltage to the starter motor. Turning the ignition switch to start position supplies current to energize the relay at Pin 86. If the engine is not running and the driveline is not engaged, the ECM Pin X3–23 will enable the relay by suppling a ground circuit to Pin 85 of the relay. When the relay is closed, current passes through the relay to the pins on the starter solenoid.

Before troubleshooting, inspect circuit connectors for loose or damaged pins or wires. Wires and connections must be free of damage or corrosion. When connectors corrode, a white residue will be present and must be removed. Make sure the batteries are fully charged. To ensure accurate readings, check battery cables and grounds for clean and tight connections.

**Clutch Switch**

Manual transmissions use the clutch switch to supply a signal to the ECM indicating that the driveline is disengaged. A 12 V signal on the Driveline Disengagement Switch (DDS) circuit indicates that the clutch is disengaged. A 0 V signal indicates that the clutch is engaged.

**Neutral Switch**

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

**WTEC MD with Auto Neutral**

Allison MD World Transmission Electronically Controlled (WTEC) transmissions (with optional Auto Neutral) have a crank inhibit system with an additional relay. The relay inhibits cranking when the transmission is in auto neutral. Pin 6 of the transmission ECU controls 12 V to Pin 86 of the starter relay. Pin X3–8 of the ECM receives 12 V from the WTEC Auto Neutral relay when the transmission is shifted to neutral or auto neutral. Without the additional relay, the DDS input (Pin X3–8) allows cranking in auto neutral.

**Electronic Control Module (ECM)**

When the ECM recognizes that the engine is not running and the driveline is not engaged, the ECM will ground Pin X3–23. This provides a current path for the ECI relay to close when the Start switch is engaged or the starter button is depressed.

When the ECM recognizes that the engine is running or the driveline is engaged, the ECM will open Pin X3–23. This prevents the ECI relay from closing and the starter motor from engaging.

**Fault Detection / Management**

When the on demand Engine ON standard test is run, an open or short to ground can be detected on the coil side of the ECI relay.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Breakout Box
- 3-Banana Plug Harness
- 500 Ohm Resistor Harness
- Relay breakout harness

### ECI Circuit Diagnostics

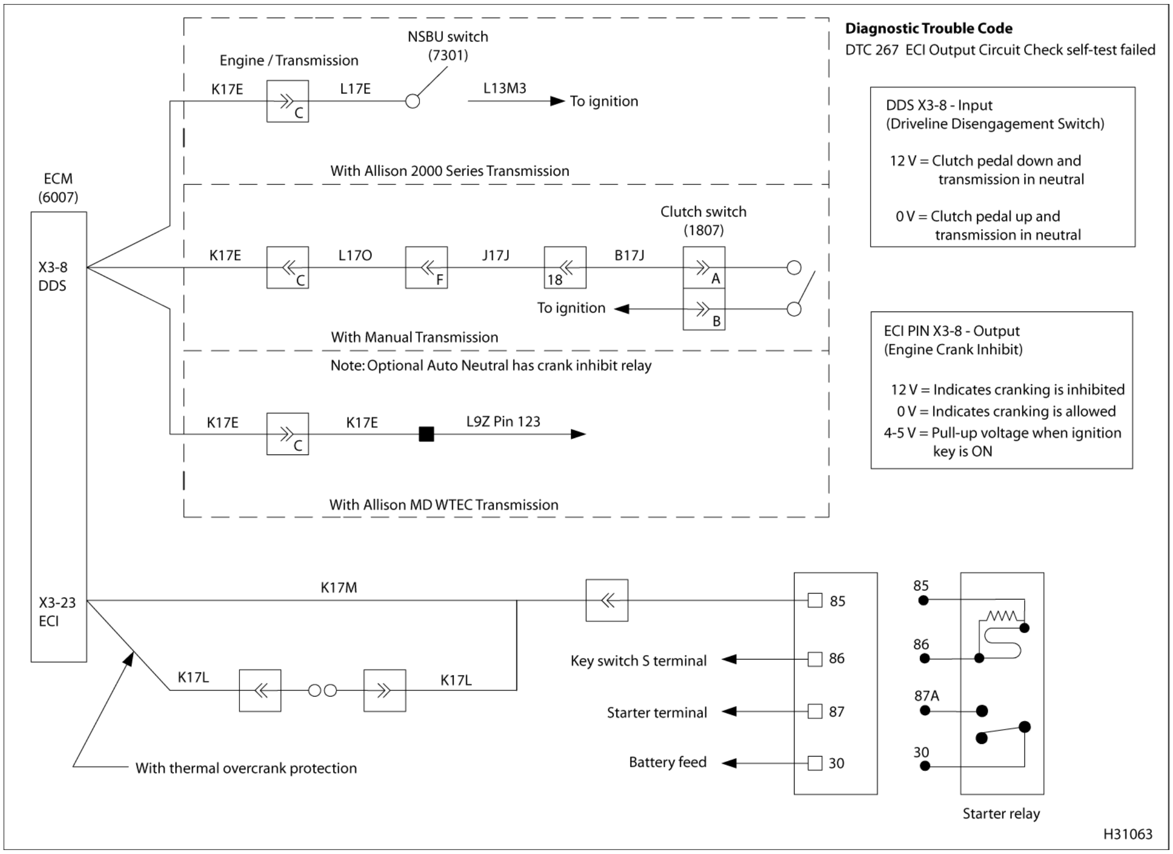



**Figure 418 ECI circuit diagram**

The ECI circuit requires the use of vehicle circuit diagrams. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**ECI Relay Voltage Checks** (Turn the ignition switch to ON. Check with ECI relay removed.)

| Test Point | Spec | Comment |
|---|---|---|
| 86 to gnd | 12 V ±1.5 V | Check with relay disconnected and starter switch (key or button) engaged. If no voltage present, troubleshoot ignition crank circuit. |
| 30 to gnd | 12 V ± 1.5 V | If no voltage is present, troubleshoot battery wiring. |
| 85 to gnd | 4 V to 5 V | ECM will pull circuit up to 4 V to 5 V with switch ON and go to 0 V when the clutch is depressed or transmission is in neutral. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:**

**When running the engine in the service bay, make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.**

ECI Circuit Test – With the transmission out of gear and the clutch depressed with wheels safely blocked, insert a harness between socket Pin 86 and 87 of the starter relay. If the engine cranks when the start switch is engaged, check for failed ECI relay or problems with the ECM or ECM wiring harness.

**ECI Chassis Circuit Checks** (Check with key-on engine-off, ECI relay installed, and breakout box connected.)

| Test Point | Spec | Comment |
|---|---|---|
| X3–8 to X3–7 | 0 V or 12 V | Manual Trans – 12 V with clutch pedal down, 0 V clutch pedal up. |
| | | Auto Trans – 12 V with trans in neutral, 0 V trans in gear. |
| X3–23 to X3–7 | 12 V ± 1.5 V | If no voltage is present with ignition switch in start position or start button pressed, troubleshoot battery wiring. |
| | 0 V to 0.6 V | At crank with clutch down or auto trans in neutral, if ECM Pin X3–8 is at 12 V and Pin X3–23 is not at 0 V to 0.6 V, check ECM programming. Cranking allowed. See truck *Electrical System Troubleshooting Guide* |
| | 4 V to 5 V | Pull up voltage from ECM with key-on engine-off or running: transmission in gear or clutch up. |

**ECL Sensor (Engine Coolant Level)**

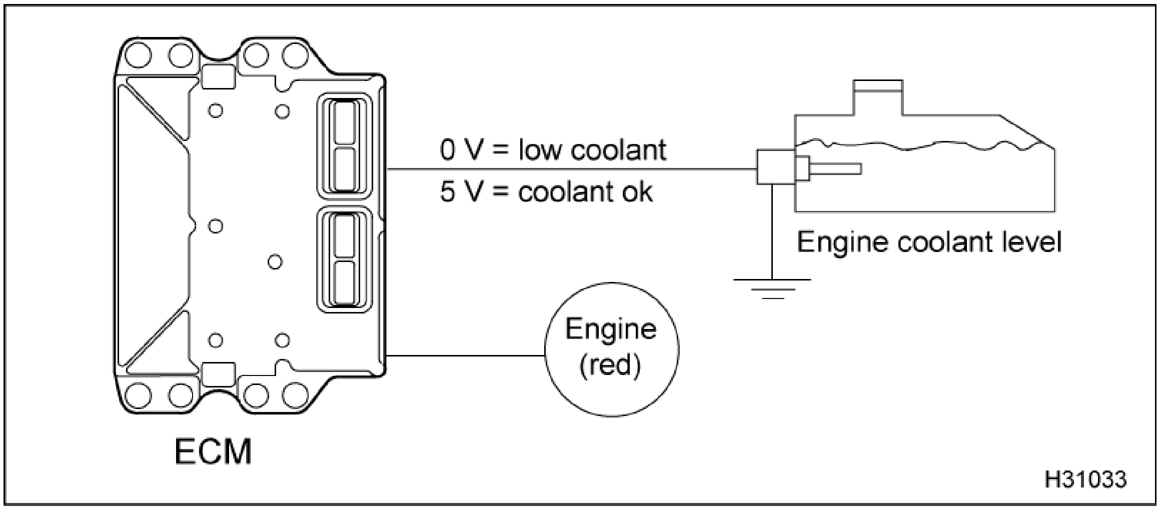



**Figure 419 Function diagram for the ECL system**

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.

The ECL system includes the Electronic Control Module (ECM) and the engine coolant tank with a coolant level sensor. The ECL switch is used in the plastic deaeration tank.

Coolant level monitoring is a customer programmable feature that can be programmed by the EST. The coolant level feature is operational if programmed for 3-way warning or 3-way protection. The feature can not be enabled if the ECM was not factory programmed for 3-way protection.

### ECL Circuit Operation

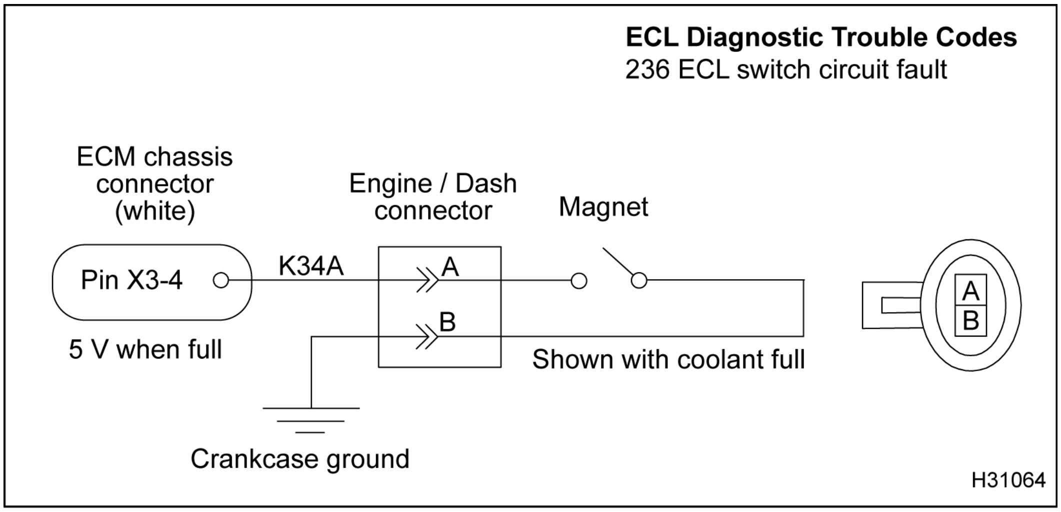



**Figure 420 ECL circuit diagram**

The coolant level sensor 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 V signal at ECM Pin X3–4. When the level is low, the switch will close and ECM Pin X3–4 will be 0 V.

### Fault Detection / Management

The ECM continuously monitors the ECL circuit for in-range faults. The ECM does not detect open or short circuits in the ECL system. When the ECM detects an in-range fault, DTC 236 will be set.

### ECL Diagnostic Trouble Codes (DTCs)

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

### DTC 236
### ECL switch circuit fault

- DTC 236 is set when the ECM detects an in-range fault voltage and the voltage is between 3.4 V and 4.3 V at ECM Pin X3–4 for more than 2.0 seconds.
- DTC 236 is set when a high resistance connection or intermittent short to ground in the circuit exists.
- DTC 236 will not illuminate the red ENGINE lamp. If the condition is intermittent, the DTC will be logged as inactive.

### Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Breakout Box

## ECL Pin-Point Diagnostics

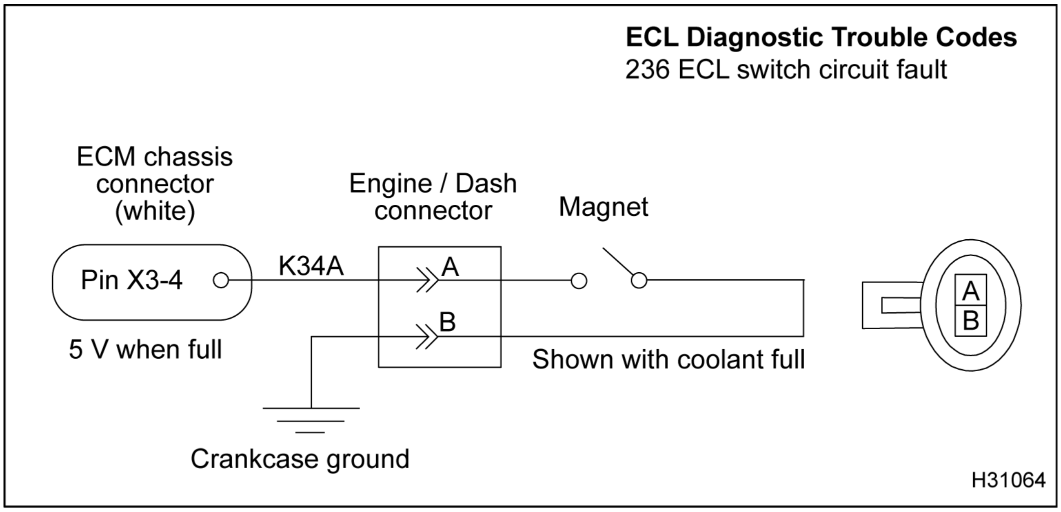



**Figure 421 ECL system circuit diagram**

The ECL circuit may require the use of vehicle circuit diagrams. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

| | | |
|---|---|---|
| **Coolant Level Sensor Connector** (Disconnect sensor from harness and turn the ignition switch to ON. Test with coolant level full.) **Note:** After removing connector, inspect for damaged pins, corrosion, or loose pins. Repair as required. | | |
| **Test Point** | **Spec** | **Comment** |
| A to gnd | 5 V ±0.5 V | If voltage < 5 V, check for open signal circuit or failed ECM. |
| B to gnd | 0 V | If voltage > 0 V, check for signal circuit shorted to another circuit |
| **Sensor Resistance Checks** (Disconnect sensor connector and measure across sensor) | | |
| A to B | > 1 kΩ | If < 1 kΩ, check for low coolant, failed sensor, or shorted sensor harness. |
| **Harness Resistance Checks** (Turn the ignition switch to OFF. Connect breakout box to chassis harness only. Disconnect sensor.) | | |
| B to gnd | < 5 Ω | If > 5 Ω, check for open ground wire |
| X3-4 to A | < 5 Ω | If > 5 Ω, check for open signal wire (breakout box connected) |
| **Operational Voltage Checks for ECL** (Check with breakout box connected and sensor connected. Turn the ignition switch to ON.) | | |
| X3-4 to X3-7 | 5 V | Voltage > 4.3 V with tank full. Voltage < 3.4 V with tank empty (use breakout box) |
| **ECL Diagnostic Trouble Codes** | | |
| DTC 236 = Signal voltage between 3.4 V and 4.3 V more than 2.0 seconds. | | |

### ECM / IDM Communications (Electronic Control Module / Injector Driver Module)

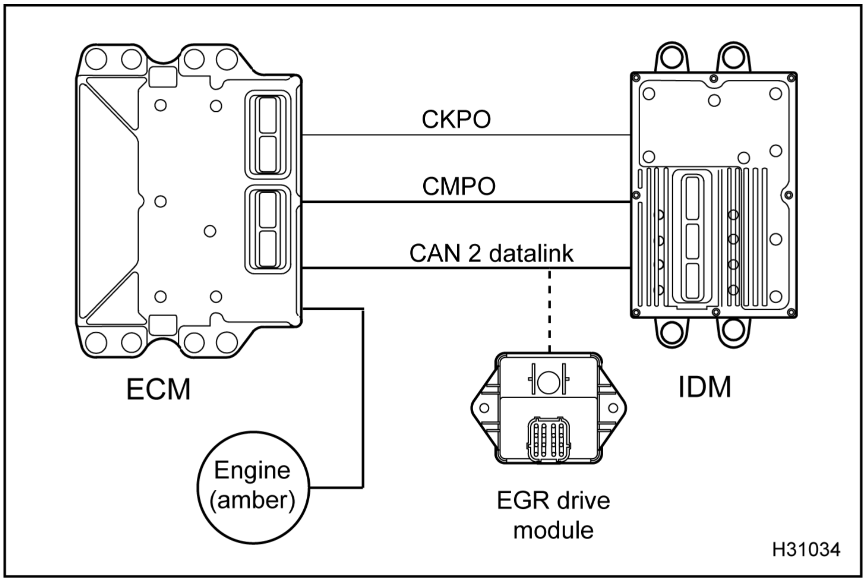



**Figure 422 Function diagram for the ECM / IDM communication system**

The function diagram for the ECM / IDM communication system includes the following:

- ECM
- IDM
- Exhaust Gas Recirculation (EGR) drive module
- Crankshaft Position Output (CKPO) signal
- Camshaft Position Output (CMPO) signal
- Controller Area Network (CAN 2) datalink
- ENGINE lamp (amber)

#### Function

The ECM provides two output channels to aid the IDM with engine speed and position signals. The CKPO and CMPO channels are in phase with the CKP and CMP signals received by the ECM.

The ECM and IDM are in continuous communication. The CKPO and CMPO signals are generated when the ECM switches these circuits to ground. The IDM uses these signals for engine speed and timing.

The CAN 2 datalink is a bidirectional communication line between the ECM, IDM, and EGR drive module. The ECM, IDM, and EGR drive module use the datalink to send operating strategies, sensor information, diagnostic demands, and Diagnostic Trouble Codes (DTCs).

**NOTE:** The engine will not operate without the CAN 2 datalink, CKPO, or CMPO signal.

### ECM / IDM Circuit Operation

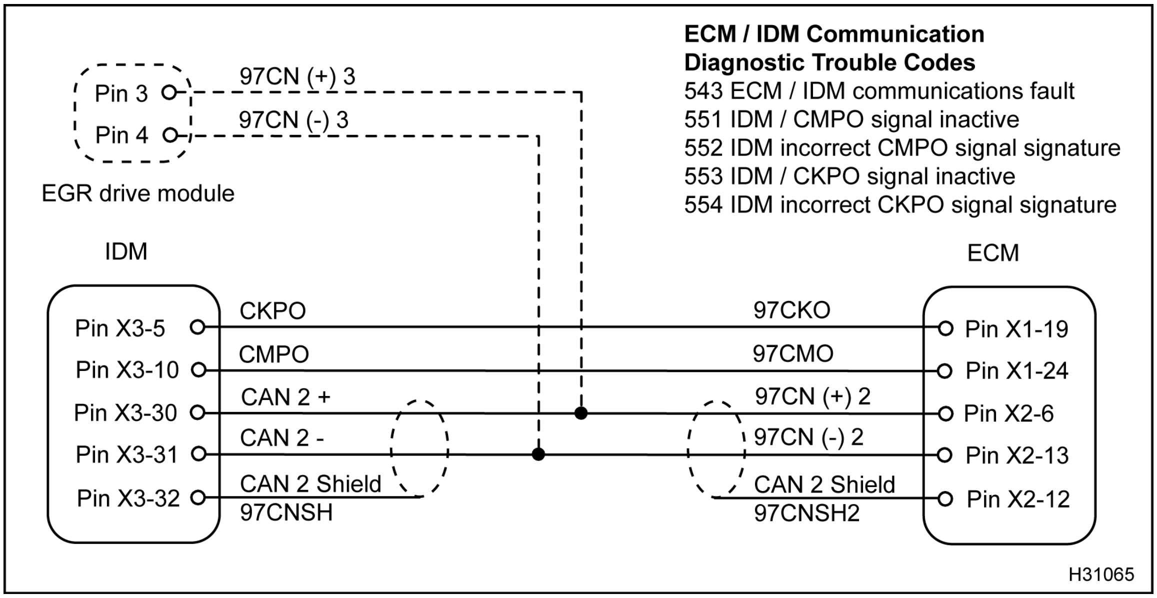



**Figure 423 ECM / IDM circuit diagram**

The ECM / IDM communication link consists of a series of interdependent signals that include the CKPO, CMPO, and the CAN 2 datalink.

The CKPO signal is a 0 V to 12 V signal that communicates (from ECM to IDM) the position of the crankshaft. The signal is used by the IDM to synchronize the injector firing sequence and is calculated from the signal generated from the CKP sensor. The ECM generates the CKPO signal by pulling down (switching to ground) a 12 V communication circuit in the IDM.

The CMPO signal is a 0 V to 12 V signal that communicates (from ECM to IDM) the position of the camshaft. The signal is used by the IDM to synchronize the injector firing sequence and is calculated from the signal generated from the CMP sensor. The ECM generates the CMPO signal by pulling down (switching to ground) a 12 V communication circuit in the IDM.

CAN 2 datalink is a J1939 high speed private communication datalink between the ECM, IDM, and EGR drive module. The ECM receives messages that include injector coil status, IDM calibration level, CMPO and CKPO DTCs, injector DTCs, IDM DTCs, and injector test results from the IDM. The IDM receives injector diagnostic commands, operation strategies, modes and conditions from the ECM.

**NOTE:** CAN 2 datalink is used only as communication between the ECM, IDM, and EGR drive module. There is no relation to the CAN 1 datalink that is used for communication with various processors on a vehicle.

### Fault Detection / Management

The ECM continuously monitors the IDM. When the ECM fails to receive required continuous communication from the IDM, the ECM will set a DTC.

### ECM / IDM Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

**DTC 543**
**ECM / IDM communications fault**

- DTC 543 is set by the ECM when the ECM is not communicating with the IDM.
- DTC 543 can be set when CAN 2 datalink J1939 between ECM and IDM is shorted to ground, $V_{REF}$, or battery or the circuit is open. If IDM power is low, DTC 543 can be set.
- When DTC 543 is active the amber ENGINE lamp is illuminated.

**NOTE:** If a no start condition exists with DTC 543 and 368 active, check the CAN 2 datalink wiring (EGR to ECM and IDM to ECM). See “EGR Actuator” (page 430) in this section. One of the CAN 2 datalink wires (CAN 2 positive or negative) is open, short to ground, or a short to power exists.

**DTC 551**
**IDM / CMPO signal inactive**

- DTC 551 is set by the ECM when no CMPO signal is present while the CKPO is active. DTC 551 can also be set when no CMPO/CKPO is present while the ECM reports it is in the run mode.
- DTC 551 can be set when the CMPO is open, shorted to ground, or shorted to a voltage source. DTC 551 can also be set if logic power is low.

**DTC 552**
**IDM incorrect CMPO signal signature**

- DTC 552 is set when the CMPO transition occurs at the wrong CKPO tooth.
- DTC 552 can be set due to electrical noise creating a miscount on CMP location.

**DTC 553**
**IDM / CKPO signal inactive**

- DTC 553 is set by the ECM when no CKPO signal is present while the CMPO is active. DTC 552 can also be set when no CMPO/CKPO is present while the ECM reports it is in the run mode.
- DTC 553 can be set when CKPO is open, shorted to ground, or shorted to a voltage source. DTC 553 can also be set if logic power is low.

**DTC 554**
**IDM incorrect CKPO signal signature**

- DTC 554 is set by the ECM when CKPO signal has too few or too many transitions per engine rotation.
- DTC 554 can be set due to electrical noise creating a miscount on CKP location.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Breakout Box
- Terminal Test Adapter Kit

### ECM / IDM Pin-Point Diagnostics

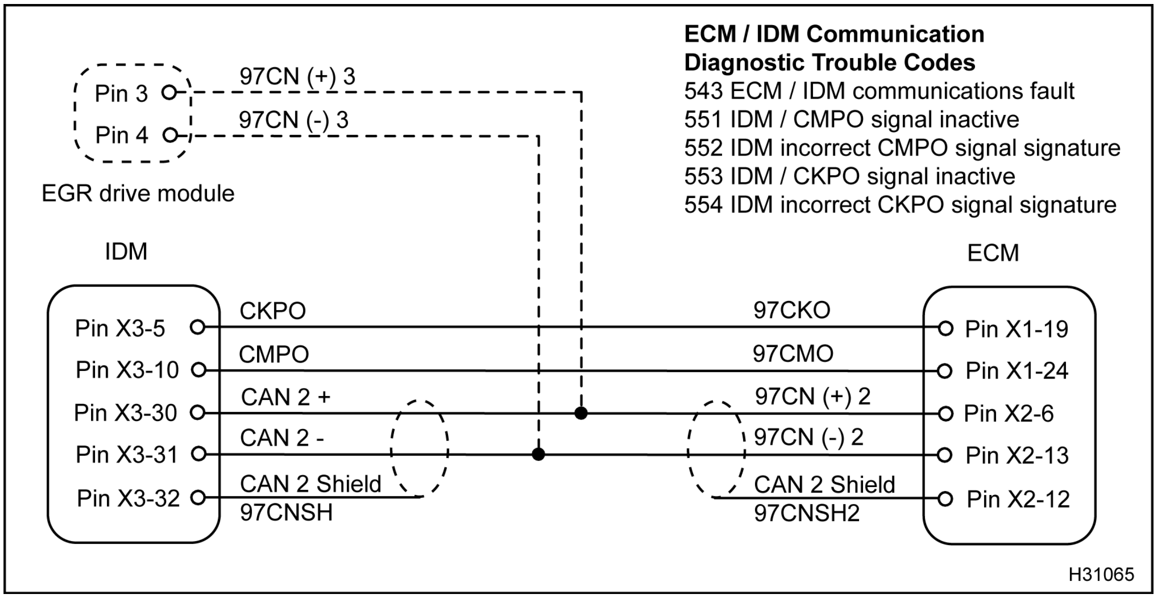



**Figure 424 ECM / IDM circuit diagram**

**CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting the connector or relay for the ECM and IDM. Failure to turn the switch to OFF will cause a voltage spike and damage to electrical components.**

**ECM Connector Voltage Checks to Chassis Ground** (Check with breakout box connected [X1 and X2] to engine harness only. Inspect for bent pins or corrosion. Turn the ignition switch to ON. **Note:** ECM is not connected. IDM output is checked through the wiring harness.)

| Test Point | Spec | Comment |
|---|---|---|
| X2–6 to gnd | 1 V to 4 V | Digital signal. If no voltage check for open or short to ground and do resistance checks to chassis ground, harness resistance checks, and resistance checks - IDM CAN2 checks. |
| X2–13 to gnd | 1 V to 4 V | Digital signal. If no voltage check for open or short to ground and do resistance checks to chassis ground, harness resistance checks, and resistance checks - IDM CAN2 checks. |
| X1–19 to gnd | 11 V to 12 V | If < 11 V to 12 V, check for open or short to ground. Check IDM power relay. |
| X1–24 to gnd | 11 V to 12 V | If < 11 V to 12 V, check for open or short to ground. Check IDM power relay. |
| X2–12 to gnd | 0 V | Ground, no voltage expected |

| | | |
|---|---|---|
| **Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Check with breakout box connected [X1 and X2] to engine harness only. Disconnect chassis connector 9260[1]. Inspect for bent pins or corrosion.) | | |
| X1–19 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground or internal IDM problem. Test with IDM connector X3 disconnected. If problem remains, repair or replace harness. If disconnect of X3 corrected problem, replace IDM. |
| X1–24 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground or internal IDM problem. Test with IDM connector X3 disconnected. If problem remains, repair or replace harness. If disconnect of X3 corrected problem, replace IDM. |
| X2–6 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground or internal IDM problem. Test with IDM connector X3 disconnected. If problem remains, repair or replace harness. If disconnect of X3 corrected problem, replace IDM. |
| X2–13 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground or internal IDM problem. Test with IDM connector X3 disconnected. If problem remains, repair or replace harness. If disconnect of X3 corrected problem, replace IDM. |
| X2–12 to Pin A (9260) | < 10 Ω | If > 10 Ω, check for open in harness. CAN 2 shield is grounded through IDM. If X3 is not connected to IDM, spec will be > 500 Ω. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

| | | |
|---|---|---|
| **Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Check with breakout box connected [X1 and X2] to engine harness only. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Use disconnected negative battery cable for ground test point.) | | |
| X1–19 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground or internal IDM problem. Test with IDM connector X3 disconnected. If problem remains, repair or replace harness. If disconnect of X3 corrected problem, replace IDM. |
| X1–24 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground or internal IDM problem. Test with IDM connector X3 disconnected. If problem remains, repair or replace harness. If disconnect of X3 corrected problem, replace IDM. |
| X2–6 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground or internal IDM problem. Test with IDM connector X3 disconnected. If problem remains, repair or replace harness. If disconnect of X3 corrected problem, replace IDM. |

| | | |
|---|---|---|
| X2–13 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground or internal IDM problem. Test with IDM connector X3 disconnected. If problem remains, repair or replace harness. If disconnect of X3 corrected problem, replace IDM. |
| X2–12 to gnd cable | < 10 Ω | If > 10 Ω, check for open in harness. CAN 2 shield is grounded through IDM. If X3 is not connected to IDM, spec will be > 500 Ω. |

**Harness Resistance Checks** (Turn the ignition switch to OFF. Check with breakout box connected [X1 and X2] to engine harness only. IDM checked at harness connector X3 using terminal test pins. IDM pins are numbered on the mating end of the connector.)

**NOTE:** Test points are from ECM to IDM.

| | | |
|---|---|---|
| ECM X1–19 to IDM X3–5 | < 5 Ω | If > 5 Ω, check for open in harness. |
| ECM X1–24 to IDM X3–10 | < 5 Ω | If > 5 Ω, check for open in harness. |
| ECM X2–6 to IDM X3–30 | < 5 Ω | If > 5 Ω, check for open in harness. |
| ECM X2–13 to IDM X3–31 | < 5 Ω | If > 5 Ω, check for open in harness. |
| ECM X2–12 to IDM X3–32 | < 5 Ω | If > 5 Ω, check for open in harness. |

**Resistance Checks – CAN 2 Datalink** (Turn the ignition switch to OFF. Connect breakout box to ECM and chassis harness.)

| | | |
|---|---|---|
| ECM X2–6 to gnd | 3 MΩ ±0.1 MΩ | If > spec, check for short to ground or another circuit. Check ECM and IDM separately.<br><br>If < spec, check for open circuit on CAN 2+. Check ECM and IDM separately. |
| ECM X2–13 to gnd | 3 MΩ ±0.1 MΩ | If > spec, check for short to ground or another circuit. Check ECM and IDM separately.<br><br>If < spec, check for open circuit on CAN 2+. Check ECM and IDM separately. |
| ECM X2–6 to X2–13 | 60 Ω | If > 60 Ω, check for open circuit on CAN 2+ and CAN 2-. Check ECM and IDM separately. Do Resistance Checks – ECM CAN 2 Circuit and Resistance Checks – IDM CAN 2. |
| ECM X2–12 to gnd | < 5 Ω | If > 5, check for open on CAN 2 shield (IDM Pin X3–32). Check ECM and IDM separately. Do Resistance Checks – ECM CAN 2 Circuit and Resistance Checks – IDM CAN 2. |

**Resistance Checks – ECM CAN 2 Circuit** (Remove ECM following procedure in the *Engine Service Manual*. Measure directly to ECM pins only.)

**NOTE:** Use ECM ground pins (X3–7 or X3–6) only for this test.

| | | |
|---|---|---|
| ECM X2–6 to gnd | 3.9 MΩ ±0.2 MΩ | If > spec, replace the ECM. |
| ECM X2–13 to gnd | 3.9 MΩ ±0.2 MΩ | If > spec, replace the ECM. |
| ECM X2–6 to X2–13 | 120 Ω | If > spec, replace the ECM. |

**IDM CAN 2 Checks** (Remove ECM following procedure in the *Engine Service Manual*. Measure directly to ECM pins only.)

**NOTE:** Use IDM ground pins (X3–1, X3–2, X3–3, X3–22, or X3–26) only for this test.

| | | |
|---|---|---|
| IDM X3–30 to gnd | 1.85 MΩ ±0.20 MΩ | If > spec, replace the IDM. |
| IDM X3–31 to gnd | 1.85 MΩ ±0.20 MΩ | If > spec, replace the IDM. |
| IDM X3–30 to X3–31 | 120 Ω | If > 120 Ω, replace the IDM. |
| IDM X3–32 to gnd | < 5 Ω | If > 5 Ω, replace the IDM. |
| IDM housing to gnd | < 5 Ω | If > 5 Ω, replace the IDM. |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. Refer to truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

**Operational Checks for CMPO and CKPO** (Check with breakout box connected to ECM and engine harness.)

| Test Point | Engine Cranking | Low Idle | High Idle | Comment |
|---|---|---|---|---|
| X1–24 to X1–6 | 130–225 rpm[2] @ 130–225 rpm | 700 rpm[2] @ 700 rpm | 2750 rpm [2] @ 2750 rpm | Set DMM to DC-rpm[2] |
| X1–19 to X1–6 | 130–225 Hz @ 130–225 rpm | 700 Hz @ 700 rpm | 2.75 kHZ to 3.00 kHz | Set DMM to DC-Hz |

**Diagnostic Trouble Codes**

DTC 543 = ECM / IDM communication fault

DTC 551 = IDM CMPO signal inactive

DTC 552 = IDM incorrect CMPO signal signature

DTC 553 = IDM CKPO signal inactive

DTC 554 = IDM incorrect CKPO signal signature

**ECM PWR (Electronic Control Module Power)**

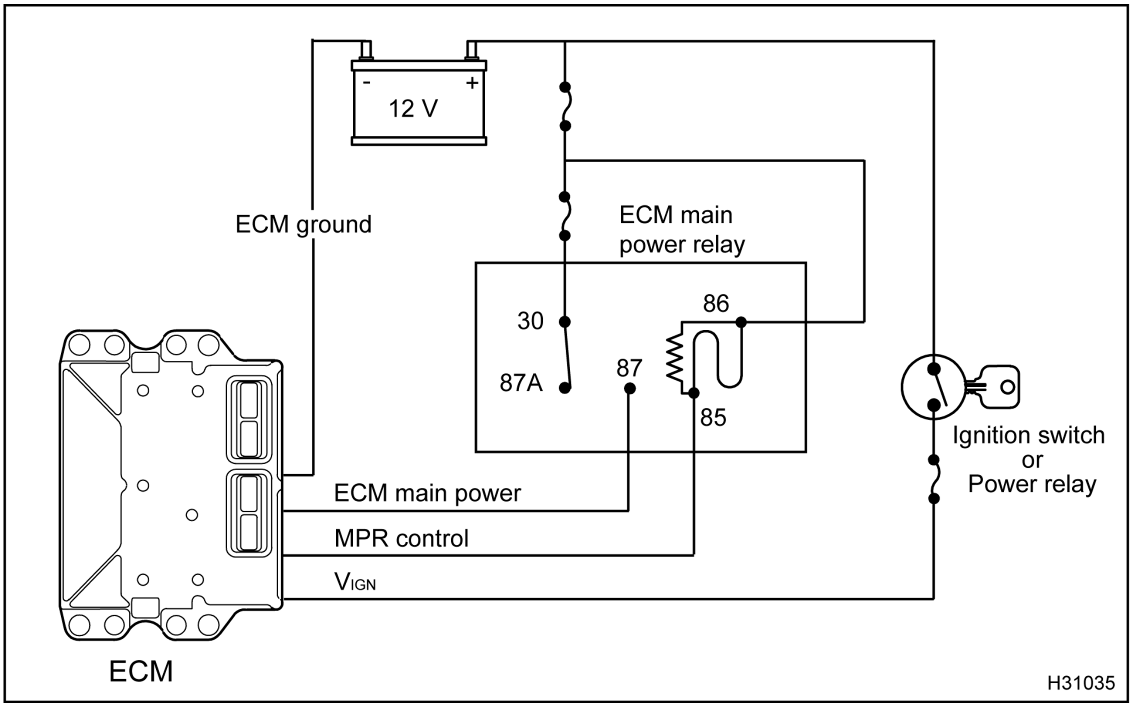



**Figure 425 Function diagram for the ECM PWR**

The function diagram for ECM PWR includes the following:

- ECM
- ECM main power relay
- Ignition switch or power relay
- Battery
- Fuses

**Function**

The Electronic Control Module (ECM) requires a 12 V power source to function correctly. The operating power is received from the vehicle batteries through the ECM main power relay contacts each time the ignition switch is turned ON.

When the ignition switch is turned ON, the ECM provides an internal ground to the coil side of the ECM main power relay. This closes the relay contacts and provides the ECM with necessary power.

**ECM PWR Circuit Operation**

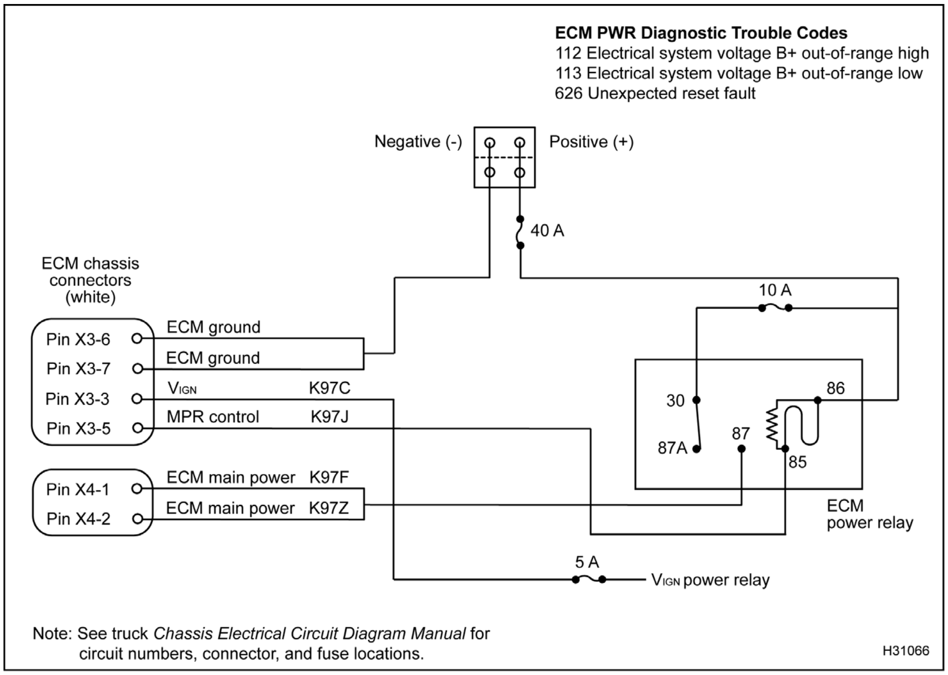



**Figure 426 ECM PWR circuit diagram**

The ECM is grounded to the battery negative terminal at ECM Pin X3-6 and X3-7.

The ECM receives $V_{IGN}$ power at Pin X3-3. The power signals the ECM to provide a ground path from Pin X3-5 to 85 to switch the ECM main power relay. Switching the relay provides power from the battery positive terminal through 2 fuses and relay contacts 30 and 87 to Pins X4-1 and X4-2. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**Fault Detection / Management**

The ECM internally monitors battery voltage. When the ECM continuously receives less than 7 V or more than 23 V, a Diagnostic Trouble Code (DTC) will be set.

**ECM PWR Diagnostic Trouble Codes (DTCs)**

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

**DTC 112**
**Electrical system voltage B+ out of range high**

- DTC 112 is set when the ECM detects an alternator output greater than 23 V at Pin X3–3 for more than 0.5 second.
- DTC 112 can be set when jump starting the engine and additional voltage is introduced. Incorrect external battery connections can cause the voltage increase.
- If the condition causing DTC 112 is intermittent, the code will change from active to inactive status. DTC 112 will not illuminate the amber ENGINE lamp.

**DTC 113**
**Electrical system voltage B+ out of range low**

- DTC 113 is set when the ECM detects less than 7.0 V at Pin X3–3 for more than 0.5 second.
- DTC 113 can be set by a inoperative alternator or ECM power relay, discharged batteries, or increased resistance in the battery feed circuits.
- If the condition causing DTC 113 is intermittent, the code will change from active to inactive status. DTC 113 will not illuminate the amber ENGINE lamp.

**DTC 626**
**Unexpected reset fault**

- DTC 626 is set when power is interrupted to the ECM. Loose or dirty connections at fuses, relay connections, and battery or ground cables can cause the ECM to power down.
- After circuit becomes intact, the ECM will reboot. Erratic engine performance can occur. Turning engine ignition switch OFF and then ON will cause the code to change from active to inactive status.
- When DTC 626 is active, monitor the voltage at ECM Pin X4–1 and X4–2. Examine for intermittent connections in the power feed wiring. The EST can be used to indicate DTCs and display the $V_{IGN}$ voltage measured by the ECM to Pin X3–3.
- DTC 626 will not illuminate the amber ENGINE lamp.

When DTC 112, 113, or 626 is active, see truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Breakout Box
- Relay Breakout Harness
- Terminal Test Adapter Kit

### ECM PWR Pin-Point Diagnostics

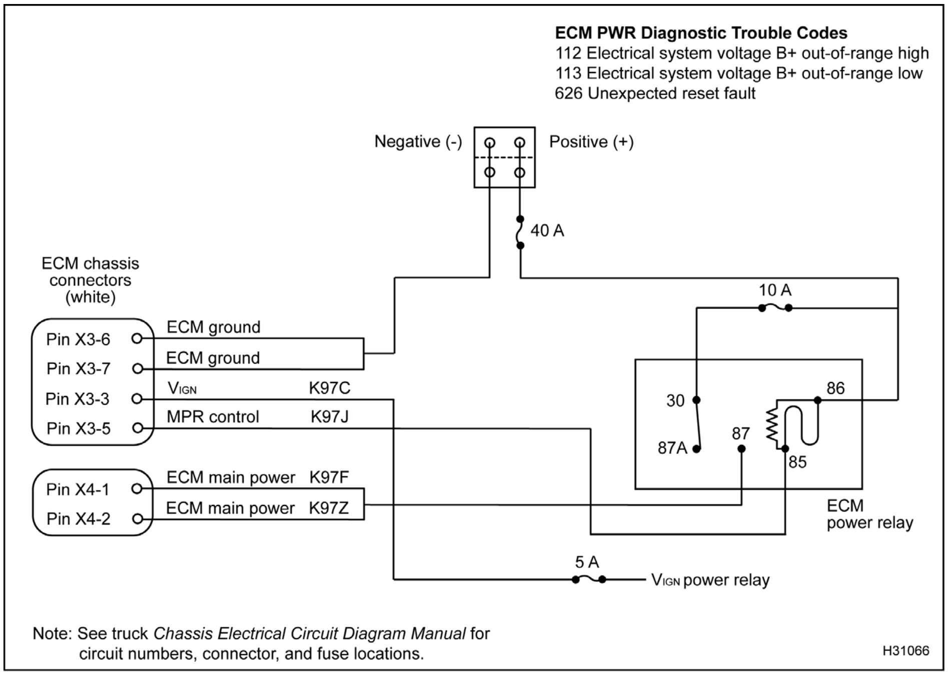



**Figure 427 ECM PWR circuit diagram**

The ECM PWR circuit requires the use of vehicle circuit diagrams. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

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

**Voltage Checks at ECM Power Relay Socket – Key-On Engine-Off** (Follow tests in order. Check with relay breakout harness connected to relay and power distribution center and turn the ignition switch on. Inspect for bent pins or corrosion.)

| Test Point | Spec | Comment |
|---|---|---|
| 86 to gnd | 12 V ±1.5 V | Continuous voltage. If no voltage, check power circuits from batteries through fuse. If fuse is blown, check for short to ground. If fuse is good, check for open between Pin 30 and B+. See truck *Chassis Electrical Circuit Diagram Manual* for relay and fuse locations. |
| 30 to gnd | 12 V ± 1.5 V | Continuous voltage. If no voltage, check fuses. If fuse is blown, check for short to ground. If fuse is good, check for open between Pin 30 and B+. See truck *Chassis Electrical Circuit Diagram Manual* for fuse and relay locations. |
| 85 to gnd | 0.06 V to 2 V | If > 2 V is present, check for open circuit between Pin X3–5 to Pin 85 on relay or $V_{IGN}$ circuit. See truck *Chassis Electrical Circuit Diagram Manual* for relay and fuse locations. |
| 87 to gnd | 12 V ±1.5 V | Continuous voltage. If previous test points are in spec and no voltage is present, replace relay. |

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

**Voltage Checks at ECM – Key-On Engine-Off** (Follow tests in order. Check with breakout box connected between chassis harness and ECM. Inspect for bent pins and corrosion.)

| Test Point | Spec | Comment |
|---|---|---|
| X3–3 to gnd | 12 V ±1.5 V | Power from ignition switch to ECM. If no voltage, see truck *Chassis Electrical Circuit Diagram Manual* for relay and fuse locations. |
| X3–6 to gnd | 0 V to 0.25 V | Ground – voltage reading indicates poor ground to battery. If voltage is present check for open or high resistance between battery (–) and ECM pins. |
| X3–7 to gnd | 0 V to 0.25 V | Ground – voltage reading indicates poor ground to battery. If voltage is present check for open or high resistance between battery (–) and ECM pins. |
| X3–5 to gnd | 0.06 V to 2 V | ECM grounds relay through internal transistor. If > 2 V is present, replace ECM. |
| X4–1 to gnd | 12 V ±1.5 V | Power from relay to ECM. If no voltage, check for open between X4–1 and 87 on ECM relay. See truck *Chassis Electrical Circuit Diagram Manual* for relay and fuse locations. |
| X4–2 to gnd | 12 V ±1.5 V | Power from relay to ECM. If no voltage, check for open between X4–2 and 87 on ECM relay. See truck *Chassis Electrical Circuit Diagram Manual* for relay and fuse locations. |

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

**Harness Resistance Checks – ECM to Main Power Relay** (Turn the ignition switch to OFF. Inspect for bent pins or corrosion. Connect relay breakout harness and breakout box to X3 and X4 chassis harness only.)

| Test Point | Spec | Comment |
|---|---|---|
| X3–5 to 85 (ECM relay) | < 5 Ω | If > 5 Ω, check connections for open between ECM and relay. See truck *Chassis Electrical Circuit Diagram Manual* for relay and fuse locations. |
| X4–1 to 87 (ECM relay) | < 5 Ω | If > 5 Ω, check connections for open between ECM and relay. See truck *Chassis Electrical Circuit Diagram Manual* for relay and fuse locations. |
| X4–2 to 87 (ECM relay) | < 5 Ω | If > 5 Ω, check connections for open between ECM and relay. See truck *Chassis Electrical Circuit Diagram Manual* for relay and fuse locations. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Harness Resistance Checks – Main Power Relay to Battery** (Turn the ignition switch to OFF. Disconnect negative battery cable. Disconnect harness from sensor. Inspect for bent pins or corrosion. Connect relay breakout harness.)

| | | |
|---|---|---|
| 30 (ECM relay) to B+ cable | < 5 Ω | If > 5 Ω, check connections for open between relay and positive battery cable. Check fuses. See truck *Chassis Electrical Circuit Diagram Manual* for relay and fuse locations. |
| 86 (ECM relay) to B+ cable | < 5 Ω | If > 5 Ω, check connections for open between relay and positive battery cable. Check fuse. See truck *Chassis Electrical Circuit Diagram Manual* for relay and fuse locations. |

**Harness Resistance Checks – ECM to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Inspect for bent pins or corrosion. Connect breakout box [X3 and X4] to chassis harness only.)

| | | |
|---|---|---|
| X3–6 to Pin A (9260) | < 5 Ω | If > 5 Ω, check connections to battery ground. See truck *Chassis Electrical Circuit Diagram Manual* for relay and fuse locations. |
| X3–7 to Pin A (9260) | < 5 Ω | If > 5 Ω, check connections to battery ground. See truck *Chassis Electrical Circuit Diagram Manual* for relay and fuse locations. |
| X3–3 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |
| X3–5 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |
| X4–1 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |
| X4–2 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Harness Resistance Checks – ECM to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.)

| | | |
|---|---|---|
| X3–6 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| X3–7 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| X3–3 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| X3–5 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| X4–1 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| X4–2 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |

| **Harness Resistance Checks – ECM to Ignition Power Relay** (Turn the ignition switch to OFF. Inspect for bent pins or corrosion. Connect relay breakout harness and breakout box [X3 and X4] to chassis harness only.) | | |
|---|---|---|
| X3–3 to 87 ($V_{IGN}$ - power relay) | < 5 Ω | If > 5 Ω, check connections or open between ECM and $V_{IGN}$ power relay. See truck *Chassis Electrical Circuit Diagram Manual* for relay and fuse locations. |

| **ECM PWR Diagnostic Trouble Codes** |
|---|
| DTC 112 = Internal voltage power out of range high > 23 V |
| DTC 113 = Internal voltage power out of range low < 7 V |
| DTC 626 = Unexpected reset fault |

[1] Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

### ECM Self Diagnostics (Electronic Control Module)

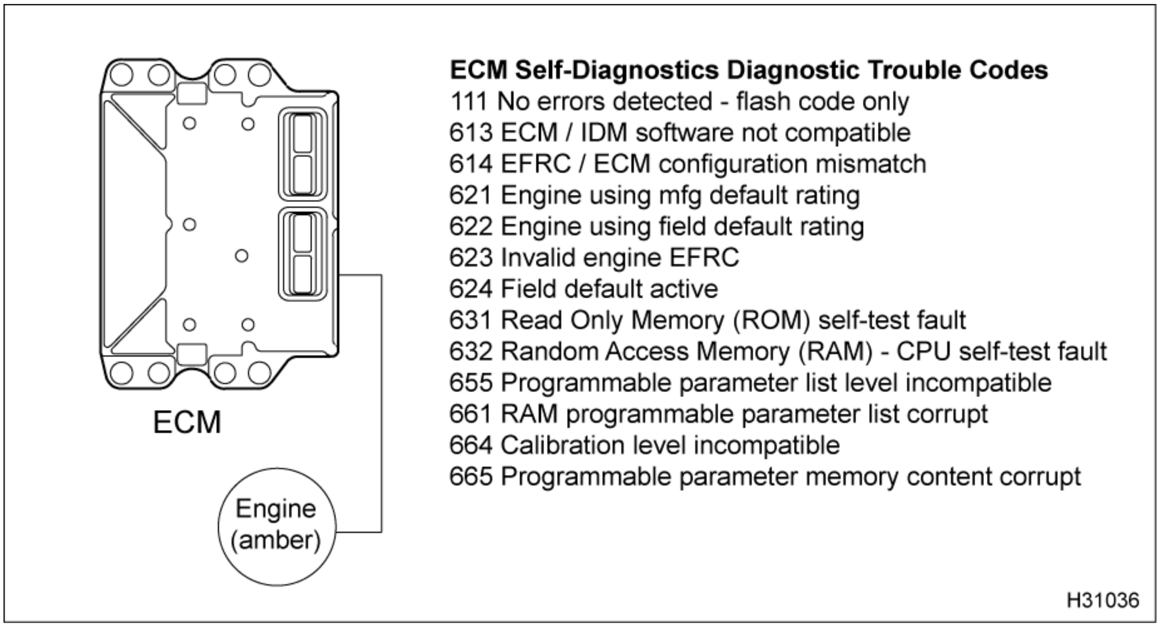



**Figure 428 Function diagram for the ECM**

The ECM does the following:

- Monitors and controls the engine operation and performance
- Enables Power Takeoff and cruise control
- Communicates engine and vehicle information to instrument cluster
- Enables electronically controlled transmission (for vehicles with feature)
- Enables diagnostic programming tools

**Fault Detection / Management**

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

When DTCs 613, 614, 621, 622, and 623 are set by the ECM, the amber ENGINE lamp will be illuminated.

**ECM Self Diagnostic Trouble Codes (DTCs)**

| **DTC 111 – No errors detected - flash code only** | |
|---|---|
| Condition: | No DTC conditions detected |
| Note: | Can only determine if ECM has detected continuous DTCs detected during an Output Circuit Check. DTCs generated during an On-Demand Test such as KOER Standard Test can only be accessed by an EST. |

| **DTC 613 – ECM / IDM software not compatible** | |
|---|---|
| Condition: | ECM / Injector Drive Module (IDM) software is incompatible |
| Symptoms: | Possible no start – low power |
| Possible Causes: | Field replacement ECM or IDM mismatch |
| Actions: | Program ECM or IDM. May require ECM or IDM replacement. |

| **DTC 614 – EFRC / ECM configuration mismatch** | |
|---|---|
| Condition: | Engine Family Rating Code (EFRC) / ECM configuration mismatch |
| Symptoms: | Possible hard start and no start or low power condition |
| Possible Causes: | Wrong EFRC selected for the ECM strategy programmed in the module. |
| Actions: | Check EFRC and verify that it matches the ECM strategy level. Reprogram the ECM or change the EFRC as required. |

| **DTC 621 – Engine using mfg default rating** | |
|---|---|
| Condition: | Manufacturing defaults selected. |
| Symptoms: | Very low power (25 hp). |
| Possible Causes: | Programmable parameters for the ECM were never programmed in module. (Usually occurs in new vehicle or new module). |
| Actions: | Program ECM. |

| **DTC 622 – Engine using field default rating** | |
|---|---|
| Condition: | Engine using field default rating. |
| Symptoms: | Low power (lowest rating in engine class) and vehicle features not working. |
| Possible Causes: | Programmable parameters for the ECM incorrectly programmed in module. |
| Actions: | Program ECM. |

| **DTC 623 – Invalid engine EFRC** | |
|---|---|
| Condition: | Invalid EFRC |
| Symptoms: | Possible hard start and no start or low power condition. |
| Possible Causes: | Wrong EFRC selected for the ECM strategy programmed in the module. |
| Actions: | Check the EFRC and verify that it matches the ECM strategy level. Reprogram the ECM or change the EFRC as necessary. |

| **DTC 624 – Field default active** | |
|---|---|
| Condition: | Field defaults active. |
| Symptoms: | Low power (lowest rating in engine class) and vehicle features not functioning. |
| Possible Causes: | Programmable parameters for the ECM incorrectly programmed in module. |
| Actions: | Program ECM |

| **DTC 631 – Read Only Memory (ROM) self-test fault** | |
|---|---|
| Condition: | ROM self-test fault |
| Symptoms: | No start. |
| Possible Causes: | Internal ECM problem. |
| Actions: | Replace the ECM. |

| **DTC 632 – Random Access Memory (RAM) - CPU self-test fault** | |
|---|---|
| Condition: | RAM Memory - CPU self-test fault. |
| Symptoms: | No start. |
| Possible Causes: | Internal ECM problem. |
| Actions: | Replace the ECM. |

| **DTC 655 – Programmable parameter list level incompatible** | |
|---|---|
| Condition: | Programmable parameter list level incompatible. |
| Symptoms: | No start or run in field defaults. |
| Possible Causes: | Programming problem or internal ECM problem. |
| Actions: | Program ECM. May require ECM replacement. |

| **DTC 661 – RAM programmable parameter list corrupt** | |
|---|---|
| Condition: | RAM programmable parameter list corrupt. |
| Symptoms: | No start or run in field defaults. |
| Possible Causes: | Internal ECM problem. |
| Actions: | Program ECM. May require ECM replacement. |

| **DTC 664 – Calibration level incompatible** | |
|---|---|
| Condition: | Calibration level incompatible. |
| Symptoms: | No start or run in field defaults. |
| Possible Causes: | Programmable problem or internal ECM problem. |
| Actions: | Program ECM |

| **DTC 665 – Programmable parameter memory content corrupt** | |
|---|---|
| Condition: | Programmable parameter memory content corrupt. |
| Symptoms: | No start or run in field defaults. |
| Possible Causes: | Internal ECM problem. |
| Actions: | Replace the ECM. |

**ECT Sensor (Engine Coolant Temperature)**

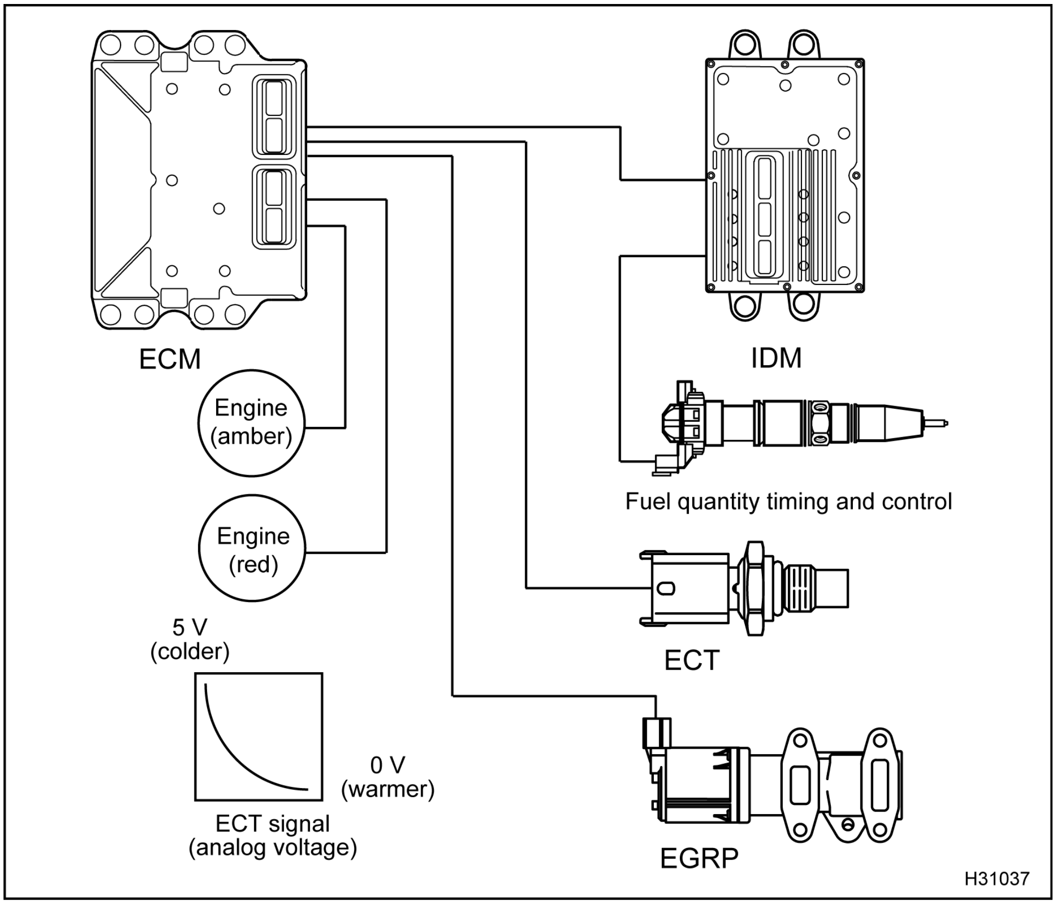



**Figure 429 Function diagram for the ECT sensor**

The function diagram for the ECT sensor includes the following:

- ECT sensor
- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR)
- Injector Drive Module (IDM)
- Fuel injector
- Variable Geometry Turbocharger (VGT)
- ENGINE lamp (amber and red)

**Function**

The ECT sensor is a thermistor sensor installed in the water supply housing (Freon® compressor bracket), right of the flat idler pulley assembly. The ECM supplies a 5 V reference signal which the ECT sensor uses to produce an analog voltage that indicates temperature.

The ECT sensor changes resistance when exposed to different temperatures. As the coolant temperature decreases, the resistance of the thermistor increases. This causes the signal voltage to increase. As the coolant temperature increases, the resistance of the thermistor decreases. This causes the signal voltage to decrease.

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

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

During engine operation, if the ECM recognizes that the ECT signal is greater or less than the expected value it will set a Diagnostic Trouble Code (DTC).

**Coolant Temperature Compensation**

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

The reduction in fuel delivery begins when ECT reaches approximately 107 °C (225 °F). A relatively rapid 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 may be disabled in emergency vehicles that require 100% power on demand.

**Engine Warning and Protection (EWPS)**

The 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 come on 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.

**ECT Circuit Operation**

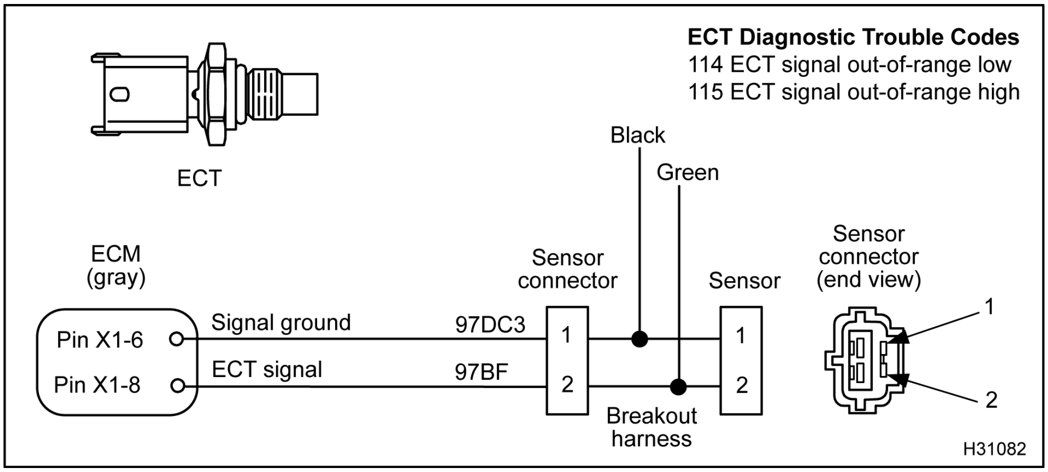



**Figure 430 ECT circuit diagram**

The ECT sensor is supplied with a 5 V reference voltage at Pin 2 from ECM Pin X1–8. The sensor is grounded at Pin 1 through the signal ground at the ECM Pin X1–6. As the coolant temperature increases or decreases, the sensor changes resistance and provides the coolant temperature signal voltage at the ECM. The signal voltage is monitored by the ECM to determine the temperature of the coolant.

**Fault Detection / Management**

The ECM continuously monitors the signal of the ECT sensor to determine if the signal is within an expected range. If the ECM detects an out of range high or low, the ECM will ignore the ECT signal and assume an engine coolant temperature of -20 °C (-4 °F) for starting and 82 °C (180 °F) for engine running conditions. When this occurs, the EWPS, CAP, IST, cold idle advance, and coolant temperature compensation features are disabled.

**ECT Diagnostic Trouble Codes (DTCs)**

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

**DTC 114**
**ECT signal out-of-range low**

- DTC 114 set by the ECM when the ECT signal is less than 0.127 V for more than 0.35 second.
- DTC 114 can set due to a short to ground in the signal circuit or a failed ECT sensor.
- When DTC 114 is active the amber ENGINE lamp is illuminated.

**DTC 115**
**ECT signal out-of-range high**

- DTC 115 set by the ECM when the ECT signal is more than 4.6 V for more than 0.35 second.
- DTC 115 can set due to an open signal or ground circuit, a short to a voltage source, or a failed ECT sensor.
- When DTC 115 is active the amber ENGINE lamp is illuminated.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 500 Ohm Resistor Harness
- Breakout Box
- Breakout Harness
- Terminal Test Adapter Kit

### ECT Operational Diagnostics

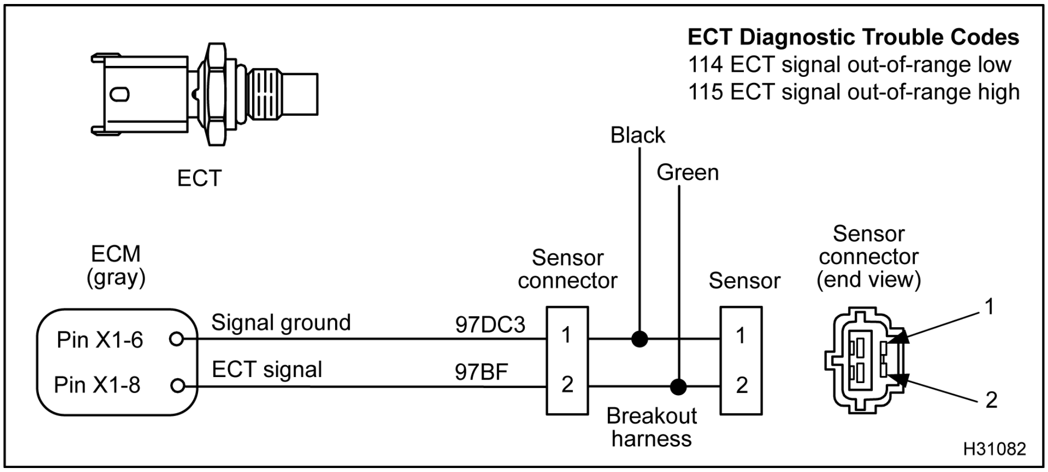



**Figure 431 ECT circuit diagram**

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:**

**Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.**

1. Using EST, open the D_ContinuousMonitor.ssn.

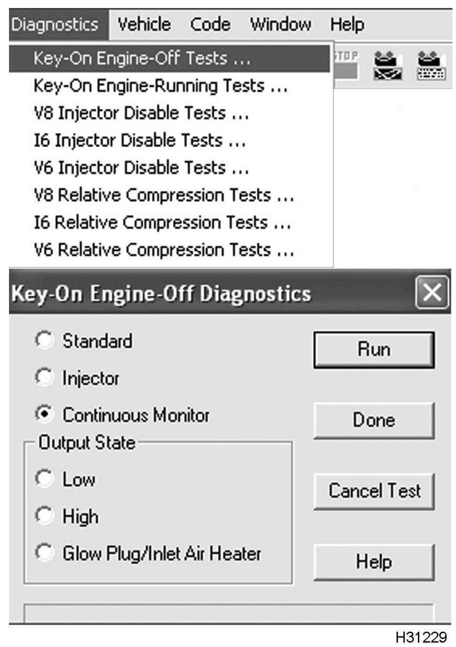



**Figure 432 Continuous Monitor Test**

2. To monitor signal voltage, run KOEO Continuous Monitor Test. For help, see “Continuous Monitor Test” in Section 3 (page 68).
3. Monitor ECT signal voltage. Verify an active DTC for the ECT circuit.

4. If code is active, do step 6 and 7 to check circuit for the ECT sensor using the following table.
   - Circuit Checks for ECT Sensor
5. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will display DTCs related to the condition.
6. Disconnect engine harness from temperature sensor.

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

7. Connect Temperature Sensor Breakout Harness to engine harness only.

**Circuit Checks for ECT Sensor** (Use EST, breakout harness, 3-Banana Plug Harness, and 500 Ohm Resistor Harness.)

| Test Condition | Spec | Checks |
|---|---|---|
| Sensor disconnected | > 4.6 V | If voltage < 4.6 V, check signal circuit for short to ground. |
| 3-Banana Plug Harness connected between Pin 2 (Green) and Pin 1 (Black) of breakout harness | 0 V | If voltage is > 0.127 V, check ground and signal circuit for open or high resistance. Use a breakout box and measure resistance from Pin 1 to Pin X1–6 and from Pin 2 to X1–8 (spec < 5 Ω). |
| 500 Ohm Resistor Harness connected between Pin 2 (Green) and Pin 1 (Black) of breakout harness | < 1.0 V | If voltage > 1.0 V, check signal circuit for short to $V_{REF}$, B+, or another sensor's signal voltage. |

**Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the ECT sensor.**

### ECT Pin-Point Diagnostics

| | | |
|---|---|---|
| **Connector Voltage Checks to Ground** (Disconnect harness from sensor. Inspect for bent pins or corrosion. Connect breakout harness to engine harness only. Turn the ignition switch to ON.) | | |
| **Test Point** | **Spec** | **Comment** |
| 2 to gnd | 4.6 V to 5.0 V | Pull up voltage, if no voltage or low, circuit is open, has high resistance, or short to ground |
| 1 to gnd | 0 V to 0.25 V | Voltage > 0.25 V, wire shorted to $V_{REF}$ or B+. |
| **Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect harness from sensor. Connect breakout harness to engine harness only. Disconnect chassis connector 9260[1].) | | |
| 1 to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open ground circuit. |
| 2 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for shorted signal to ground within wiring harness. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

| | | |
|---|---|---|
| **Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Connect breakout harness to engine harness only. Use disconnected negative battery cable for ground test point.) | | |
| 1 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| 2 to gnd cable | > 1 kΩ | If < 1 kΩ, check for signal short to ground. |
| **Harness Resistance Checks** (Connect breakout box to engine harness only. Disconnect harness from sensor. Connect breakout harness to engine harness only.) | | |
| X1–6 to 1 | < 5 Ω | If > 5 Ω, check for open ground wire |
| X1–8 to 2 | < 5 Ω | If > 5 Ω, check for open signal wire |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

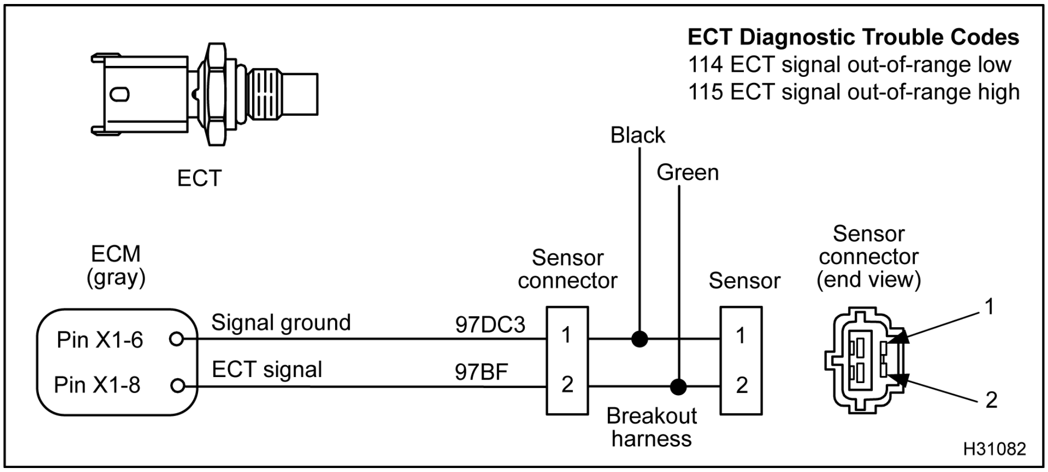



**Figure 433 ECT circuit diagram**

| Test Point | Coolant Temp | Resistance | Voltage |
|---|---|---|---|
| **Operational Voltage Checks for ECT Sensor with Breakout Harness** (Check with breakout harness connected to sensor and engine harness.) | | | |
| 2 (Green) to 1 (Black) | 108 °C (228 °F) | 1.605 kΩ | 0.37 V |
| 2 (Green) to 1 (Black) | 87.7 °C (190 °F) | 3 kΩ | 0.65 V |
| 2 (Green) to 1 (Black) | 0 °C (32 °F) | 91.1 kΩ | 3.86 V |
| 2 (Green) to 1 (Black) | –17.8 °C (0 °F) | 208 kΩ | 4.25 V |
| **Operational Voltage Checks for ECT Sensor with Breakout Box** (Check with breakout box connected [X-1 only] to ECM and engine harness.) | | | |
| X1–8 to X1–6 | 108 °C (228 °F) | 1.605 kΩ | 0.37 V |
| X1–8 to X1–6 | 87.7 °C (190 °F) | 3 kΩ | 0.65 V |
| X1–8 to X1–6 | 0 °C (32 °F) | 91.1 kΩ | 3.86 V |
| X1–8 to X1–6 | –17.8 °C (0 °F) | 208 kΩ | 4.25 V |

**ECT Diagnostic Trouble Codes**

DTC 114 = Signal voltage was < 0.127 V for more than 0.35 second.

DTC 115 = Signal voltage was > 4.6 V for more than 0.35 second.

DTC 316 = See “Engine Warning and Protection System” (page 459).

DTC 321 = See “Engine Warning and Protection System” (page 459).

DTC 322 = See “Engine Warning and Protection System” (page 459).

DTC 325 = See “Engine Warning and Protection System” (page 459).

**EFAN Control (Engine Fan Control)**

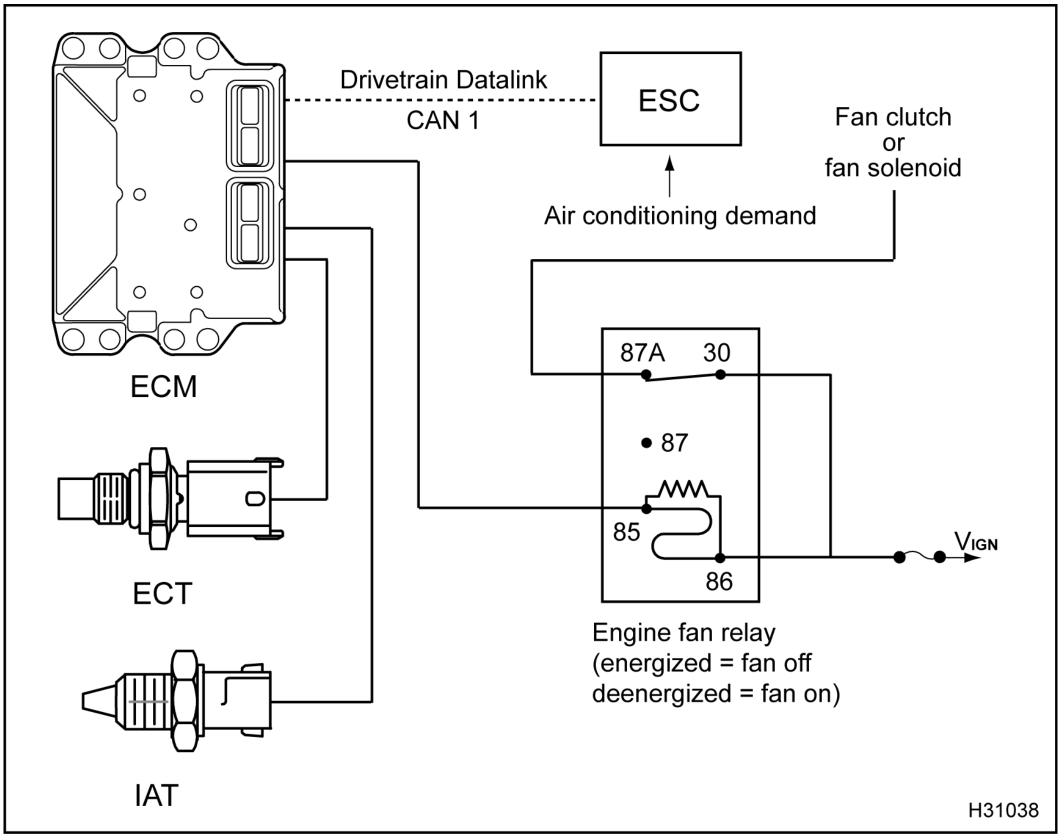



**Figure 434 Function diagram for EFAN**

The function diagram for EFAN includes the following:

- Electronic Control Module (ECM)
- Engine Coolant Temperature (ECT) sensor
- Intake Air Temperature (IAT) sensor
- Electronic System Controller (ESC)
- Engine fan relay

**Function**

The EFAN control provides ON/OFF control of the engine cooling system fan. The ECM can be programmed to set and monitor limits for engine coolant temperature, intake air temperature, engine mode selection (operating or diagnostic).

EFAN is accessible with the EST. Fan on and off temperature can be programmed by technician, but the mode of operation must be done by Tech Services.

The purpose of the engine fan control is to provide the correct logic to determine when the fan should be turned on or off by energizing/deenergizing the fan drive relay. The purpose of the engine fan is to allow a higher air flow for heat exchange between the radiator and the ambient air when needed.

**Engine Fan Control –** This parameter indicates to the on-board electronics whether or not the truck has the electronic engine fan control feature.
**AC Fan Activation –** This feature will allow fan activation through the ECM when requested from the ESC during AC operation.
**Disable –** Feature is turned off at all times.
**Fan On Temperature –** This parameter indicates the coolant temperature that the fan will be electronically activated.
**Fan Off Temperature –** This parameter indicates the coolant temperature that the fan will be electronically deactivated.

### Fan Clutch Circuit Operation

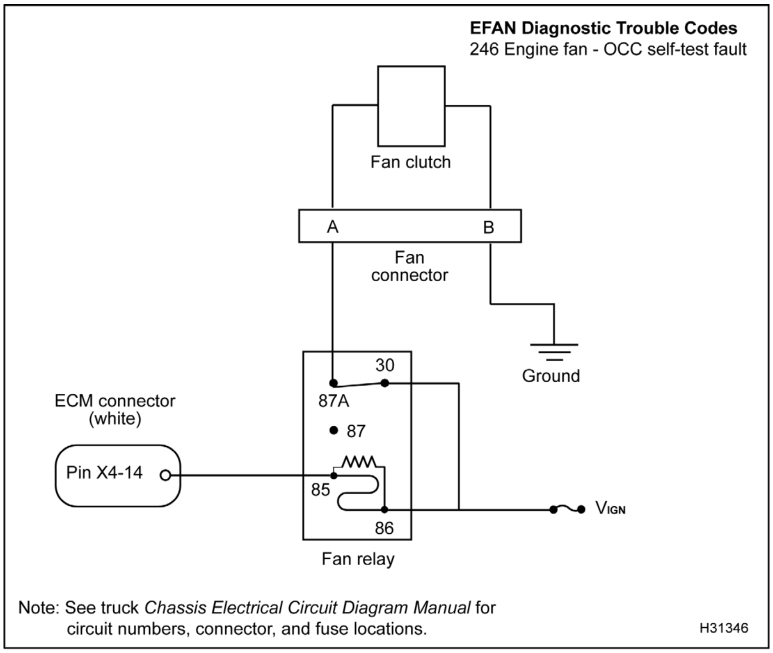



**Figure 435 Fan clutch circuit diagram**

The presence of electric current locks the fan clutch into place and allows fan activation and cooling.

When the fan needs to be activated, the ground is removed from ECM Pin X4–14. The coil side of the fan relay is deenergized causing the switch side to close, then sends 12 V from Pin 87A to the fan clutch. The fan clutch locks the fan in place when power is present at Pin 87A.

When fan needs to be deactivated, Pin X4–14 is grounded from the ECM. The coil side of the fan relay is energized, causing the switch side to open, and removes power from Pin 87A to the fan clutch. The fan clutch unlocks the fan when the power is removed from Pin 87A.

### Fault Detection / Management

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

**NOTE:** Before diagnosing, check that ECM is programmed correctly. Verify vehicle / application has an electronic fan.

### EFAN Diagnostic Trouble Codes (DTCs)

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

### DTC 246
### Engine Fan - OCC self-test fault

- DTC 246 is set by the ECM only during the KOEO Standard Test. During this test the ECM performs an output circuit test that momentarily enables the EFAN solenoid and measures the voltage drop across the relay

### Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Relay Breakout Harness

### Fan Clutch Pin-Point Diagnostics

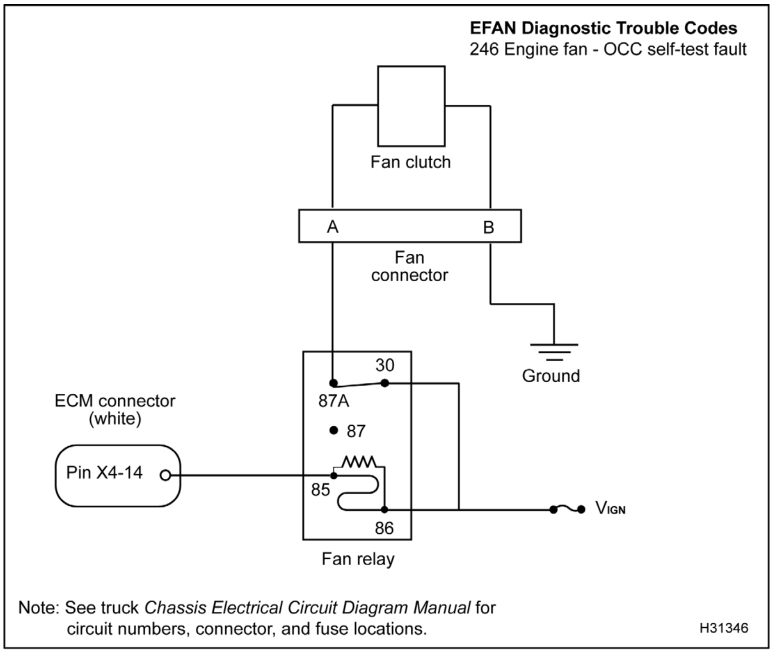



**Figure 436 Fan clutch circuit diagram**

| **Voltage Checks at Fan Connector** (Disconnect fan connector. Turn the ignition switch to ON.) | | |
|---|---|---|
| **Test Point** | **Spec** | **Comment** |
| KOEO | | |
| A to gnd | B+ ± 0.5 V | If < B+, check relay. Also check for an open circuit, short to ground, or short to voltage source. Do Output State Test - Voltage Check at Fan Connector. |
| B to gnd | 0 V to 0.25 V | If > 0.25 V, check for an open ground circuit or a short to voltage source. Do Harness Resistance Checks. |

| **Output State Test - Voltage Check at Fan Connector** (Disconnect fan connector. Turn the ignition switch to ON. Run the Output State Tests. For help, see "Diagnostic Software Operation" in Section 3 (page 68) for procedure to run the Low and High Output State Tests.) | | |
|---|---|---|
| **Test State/Point** | **Spec** | **Comment** |
| Output State Test - Low | | |
| A to gnd | 0 V to 0.25 V | If > 0.25 V, check relay. Also check for short to voltage source. |
| Output State Test - High | | |
| A to gnd | B+ ± 0.5 V | If < B+, check relay. Also check for an open circuit, short to ground, or a short to voltage source. Do Output State Test - Voltage Checks at Fan Relay. |

**Output State Test - Voltage Checks at Fan Relay** (Check with relay breakout harness connected with relay. Turn the ignition switch to ON. Run the Output State Tests. For help, see “Diagnostic Software Operation” in Section 3 (page 68) for procedure to run the Low and High Output State Tests.)

| Test State/Point | Spec | Comment |
|---|---|---|
| Output State Test - Low | | |
| 30 to gnd | B+ ± 0.5 V | If < B+, do Harness Resistance Checks. |
| 86 to gnd | B+ ± 0.5 V | If < B+, do Harness Resistance Checks. |
| 85 to gnd | 0 V to 0.25 V | If > 0.25 V, check for open circuit, short to voltage source, ECM programming, or failed ECM. Do Harness Resistance Checks. |
| 87 to gnd | B+ ± 0.5 V | If < B+, and previous checks (30, 86, 85 to gnd) are within specification, replace relay. |
| 87A to gnd | 0 V to 0.25 V | If > 0.25 V, and previous checks (30, 86, 85 to gnd) are within specification, but 87 to gnd is not within specification, replace relay. |
| Output State Test - High | | |
| 30 to gnd | B+ ± 0.5 V | If < B+, do Harness Resistance Checks. |
| 86 to gnd | B+ ± 0.5 V | If > B+, do Harness Resistance Checks. |
| 85 to gnd | B+ ± 0.5 V | If < B+, check for open circuit, ECM programming, or failed ECM. Do Harness Resistance Checks. |
| 87 to gnd | B+ ± 0.5 V | If > 0.25 V, and previous checks (30, 86, 85 to gnd) are within specification, replace relay. |
| 87A to gnd | B+ ± 0.5 V | If < B+, and previous checks (30, 86, 85 to gnd) are within specification, but 87 to gnd is not within specification, replace relay. |

**Output State Test - Voltage Checks at ECM** (Disconnect X3 and X4 from ECM. Connect breakout box X3 and X4 to ECM and wiring harness. Disconnect relay. Turn the ignition switch to ON. Run the Output State Tests. For help, see “Diagnostic Software Operation” in Section 3 (page 68) for procedure to run the Low and High Output State Tests.)

| | | |
|---|---|---|
| Output State Test - Low | | |
| X3–3 to X4–14 | B+ ± 0.5 V | If < B+, **verify that ECM is programmed correctly.** If ECM is programmed correctly, replace ECM. |
| Output State Test - High | | |
| X3–3 to X4–14 | 0 V to 0.25 V | If > 0.25 V, **verify that ECM is programmed correctly.** If ECM is programmed correctly, replace ECM. |

| **Harness Resistance Checks** (Turn the ignition switch to OFF. Disconnect fan. Remove relay and connect relay breakout harness. Connect breakout box X4 to chassis wiring harness only.) | | |
|---|---|---|
| X4–14 to 85 | < 5 Ω | If > 5 Ω, check for harness open between ECM and relay terminal. |
| 87A to A (fan) | < 5 Ω | If > 5 Ω, check for harness open between relay terminal and A (fan). |
| 30 to Fuse | < 5 Ω | If > 5 Ω, check for harness open between fuse and relay terminal. See truck *Chassis Electrical Circuit Diagram Manual* for fuse information. |
| 86 to Fuse | < 5 Ω | If > 5 Ω, check for harness open between fuse and relay terminal. See truck *Chassis Electrical Circuit Diagram Manual* for fuse information. |

## Fan Air Solenoid Circuit Operation

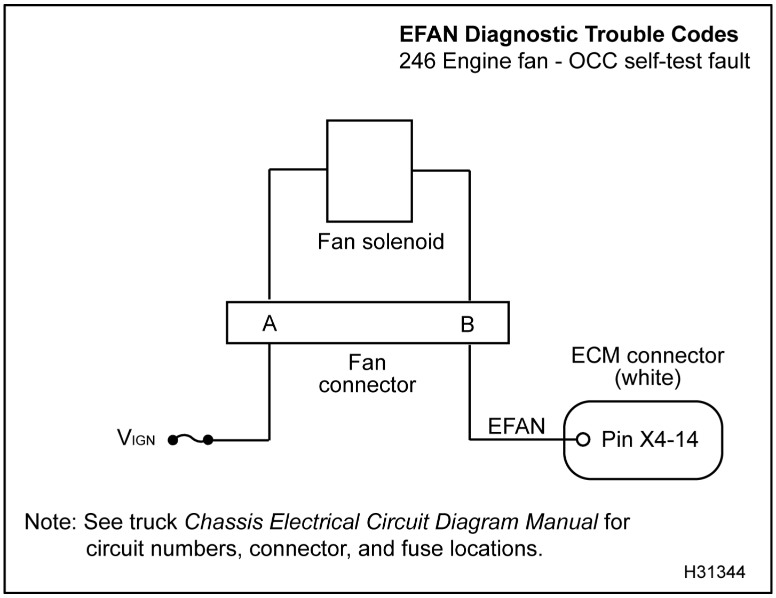



**Figure 437 Fan air solenoid circuit diagram**

The presence of air pressure locks the fan clutch into place and allows fan activation and cooling.

When the fan needs to be activated, the ground is removed from ECM Pin X4–14. The air fan solenoid is deenergized and stops the flow of compressed air to the fan clutch. The fan clutch locks the fan when compressed air is not present.

When the fan needs to be deactivated, Pin X4–14 is grounded from the ECM. The air fan solenoid is energized and allows compressed air to flow to the fan clutch. The fan clutch unlocks the fan when compressed air is present.

### Fault Detection / Management

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

**NOTE:** Before diagnosing, check that ECM is programmed correctly. Verify vehicle / application has an electronic fan.

### EFAN Diagnostic Trouble Codes (DTCs)

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

### DTC 246
### Engine Fan - OCC self-test fault

- DTC 246 is set by the ECM only during the KOEO Standard Test. During this test the ECM performs an output circuit test that momentarily enables the EFAN solenoid and measures the voltage drop across the relay

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)

**Fan Air Solenoid Pin-Point Diagnostics**

| **Voltage Checks at Fan Solenoid Connector** (Disconnect solenoid. Turn the ignition switch to ON.) | | |
|---|---|---|
| **Test Point** | **Spec** | **Comment** |
| KOEO | | |
| A to gnd | B+ ± 0.5 V | If < B+, check for open circuit. Do Harness Resistance Checks. |
| B to gnd | 0 V to 0.25 V | If > 0.25 V, check ECM programming or open circuit. |
| **Output State Test - Voltage Check at Fan Solenoid Connector** (Disconnect solenoid. Turn the ignition switch to ON. Run the Output State Tests. For help, see “Diagnostic Software Operation” in Section 3 (page 68) for procedure to run the Low and High Output State Tests.) | | |
| **Test State/Point** | **Spec** | **Comment** |
| Output State Test - Low | | |
| B+ to Pin B | B+ ± 0.5 V | If < B+, check ECM programming and check for open circuit. |
| Output State Test - High | | |
| B+ to Pin B | 0 V to 0.25 V | If > 0.25 V, check ECM programming and check for short to voltage source. |
| **Output State Test - Voltage Checks at ECM** (Disconnect X3 and X4 from ECM. Connect breakout box X3 and X4 to ECM and wiring harness. Turn the ignition switch to ON. Run the Output State Tests. For help, see “Diagnostic Software Operation” in Section 3 (page 68) for procedure to run the Low and High Output State Tests.) | | |
| Output State Test - Low | | |
| X3–3 to X4–14 | B+ ± 0.5 V | If < B+, **verify that ECM is programmed correctly.** If ECM is programmed correctly, replace ECM. |
| Output State Test - High | | |
| X3–3 to X4–14 | 0 V to 0.25 V | If > 0.25 V, **verify that ECM is programmed correctly.** If ECM is programmed correctly, replace ECM. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

| | | |
|---|---|---|
| **Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.) | | |
| A to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| B to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| **Harness Resistance Checks** (Turn the ignition switch to OFF. Disconnect solenoid. Connect breakout box X4 to chassis wiring harness only.) | | |
| X4–14 to B | < 5 Ω | If > 5 Ω, check for harness open between ECM and fan solenoid. |
| A to Fuse | < 5 Ω | If > 5 Ω, check for harness open between fuse and fan solenoid. See truck *Chassis Electrical Circuit Diagram Manual* for fuse information. |

**EFP Sensor (Engine Fuel Pressure – optional)**

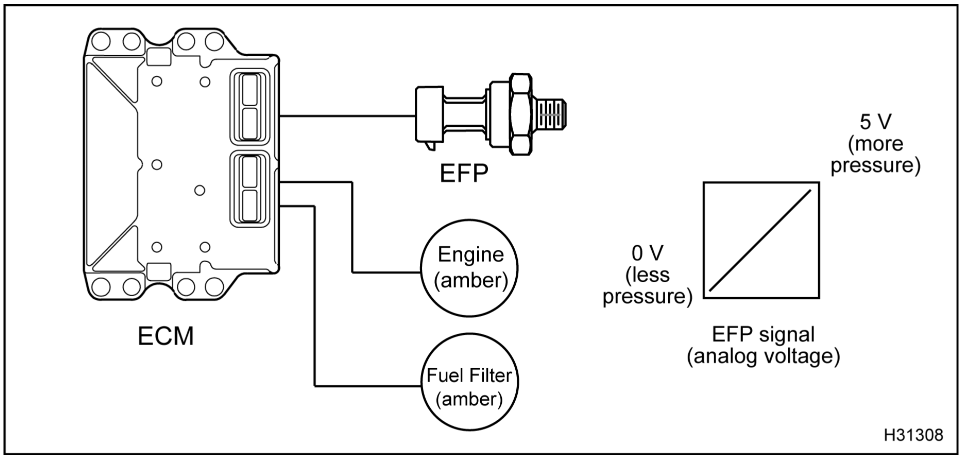



**Figure 438 Function diagram for the EFP sensor**

The function diagram for the EFP sensor includes the following:

- EFP sensor
- Electronic Control Module (ECM)
- ENGINE lamp (amber)
- FUEL FILTER lamp (amber)

**Function**

The EFP sensor is a variable capacitance sensor installed in the rear of the fuel filter assembly (crankcase side). The ECM supplies a 5 V reference signal which the EFP sensor uses to produce a linear analog voltage that indicates pressure. The ECM uses the EFP sensor signal to monitor engine fuel pressure and give an indication when the fuel filter needs to be changed.

**EFP Circuit Operation**

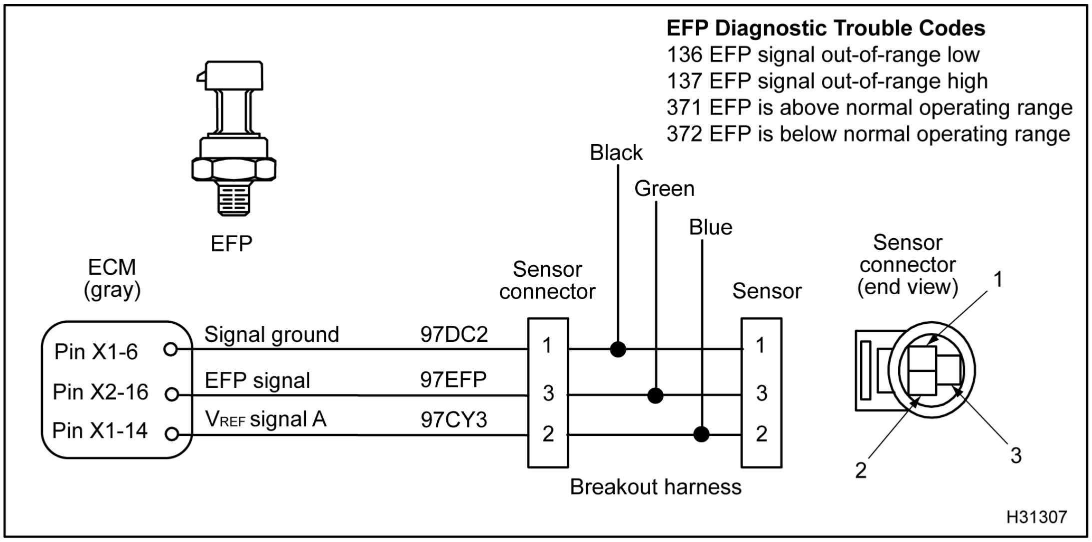



**Figure 439 EFP circuit diagram**

The EFP sensor is supplied with a 5 V reference voltage at Pin 2 from ECM Pin X1–14. The EFP sensor is grounded at Pin 1 from ECM Pin X1–6. The EFP sensor returns a variable voltage signal from Pin 3 to ECM Pin X2–16.

**Fault Detection / Management**

The ECM will ignore the EFP signal when the signal is detected to be out of range or an incorrect value is read.

**EFP Diagnostic Trouble Codes (DTCs)**

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

**DTC 136**
**EFP signal out-of-range low**

- DTC 136 is set by ECM when the EFP signal is less than 0.039 V for more than 0.35 second.
- DTC 136 can be set due to an open or short to ground on the signal circuit, a failed EFP sensor or an open $V_{REF}$ circuit or $V_{REF}$ short to ground.
- When DTC 136 is active the amber ENGINE lamp is not illuminated.

**DTC 137**
**EFP signal out-of-range high**

- DTC 137 is set by the ECM when the EFP signal is greater than 4.9 V for more than 0.35 second.
- DTC 137 can be set due to a signal circuit short to $V_{REF}$ or B+ or a failed EFP sensor.
- When DTC 137 is active the amber ENGINE lamp is not illuminated.

**DTC 371**
**EFP is above normal operating range**

- DTC 371 is set by ECM when measured fuel pressure is greater than expected pressure by 100 kPa (15 psi) for more than 60 seconds.
- DTC 371 can be set due to debris in fuel regulator valve, failed fuel regulator valve, open signal ground, $V_{REF}$ shorted to a voltage source greater than 5.5 V, bias high circuit, or failed EFP sensor.
- When DTC 371 is active the amber FUEL FILTER lamp will not illuminate

**DTC 372**
**EFP is below normal operating range**

- DTC 372 is set by ECM when measured fuel pressure is less than expected pressure by 103 kPa (15 psi) for more than 30 seconds.
- DTC 372 can be set due to dirty fuel filter element, fuel inlet restriction, debris in fuel tank, debris in fuel regulator valve, failed fuel regulator valve, failed fuel pump, bias low circuit, or failed EFP sensor. See “Fuel Pressure and Aerated Fuel” – Section 6.
- When DTC 372 is active the amber FUEL FILTER lamp is illuminated.

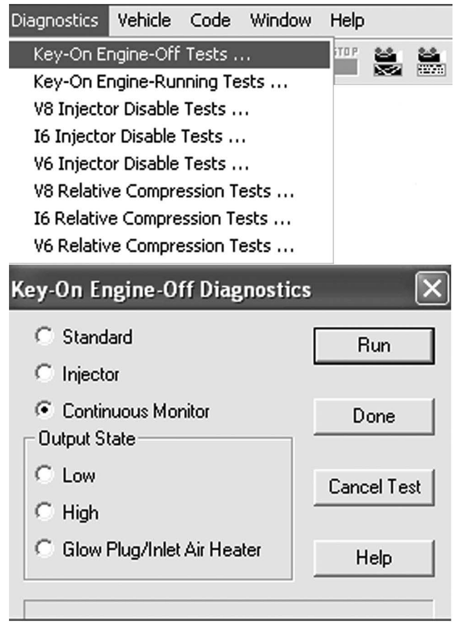
**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 500 Ohm Resistor Harness
- Breakout Box
- Breakout Harness
- Terminal Test Adapter Kit

**EFP Operational Diagnostics**

> **WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:**
>
> **Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.**

1. Using EST, open the D_ContinuousMonitor.ssn.



H31229

**Figure 440 Continuous Monitor Test**

2. To monitor signal voltage, run KOEO Continuous Monitor Test. For help, see “Continuous Monitor Test” in Section 3 (page 68).
3. Monitor EFP signal voltage. Verify an active DTC for the EFP circuit.
4. If code is active, do step 6 and 7 to check circuit for the EFP sensor using the following table.
   - Circuit Checks for EFP Sensor
5. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST display DTCs related to the condition.
6. Disconnect engine harness from pressure sensor.

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

7. Connect Pressure Sensor Breakout Harness to engine harness only.

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Circuit Checks for EFP Sensor** (Use EST, DMM, breakout harness, and 500 Ohm Resistor Harness.)

| Test Condition | Spec | Checks |
|---|---|---|
| Sensor disconnected using EST | 0 V | If voltage > 0.039 V, check signal circuit for short to $V_{REF}$ or B+. |
| Voltage from Pin 2 (Blue) to ground using DMM | 5 V ± 0.5 V | If voltage > 5.5 V, check $V_{REF}$ for short to B+. If voltage is < 4.5 V, check $V_{REF}$ for open or short to ground. |
| 500 Ohm Resistor Harness connected between Pin 3 (Green) and Pin 2 (Blue) of breakout harness using EST | 5 V | If voltage < 4.9 V, check signal circuit for open or short to ground.<br>— Disconnect connector 9260[1]. Measure resistance from Pin 3 to Pin A of connector 9260 (spec > 1 kΩ) to check for short to ground within wiring harness.<br>— Disconnect negative battery cable. Measure resistance from Pin 3 to ground cable to check for short to ground.<br>— Use a breakout box from Pin 3 to Pin X2–16 (spec < 5 Ω) to check for open in the harness. |
| Resistance from Pin 1 (Black) of breakout harness to ECM chassis ground (Pin A of connector 9260) using DMM | < 5 Ω | If resistance is > 5 Ω, check for open or high resistance between ECM and sensor connector. Use a breakout box and measure resistance from between Pin 1 and Pin X1–6 (spec < 5 Ω). |

**Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the EFP sensor.**

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

### EFP Pin-Point Diagnostics

**Connector Voltage Checks** (Disconnect harness from the sensor. Inspect for bent pins or corrosion. Connect breakout harness to engine harness only. Turn the ignition switch to ON.)

| Test Point | Spec | Comment |
|---|---|---|
| 1 to gnd | 0 V to 0.25 V | Signal ground (no voltage expected). If > 0.25 V, check ground circuit for open or high resistance and check signal ground for short to $V_{REF}$ or B+. |
| 2 to gnd | 5 V ± 0.5 V | If voltage is not to spec, $V_{REF}$ circuit is shorted to ground or B+. |
| 3 to gnd | 0 V to 0.25 V | If > 0.25 V, signal circuit is shorted to $V_{REF}$ or B+. |

**Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Connect breakout harness to engine harness only. Disconnect chassis connector 9260[1].)

| | | |
|---|---|---|
| 1 to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open circuit. |
| 2 to Pin A (9260) | > 500 Ω | If < 500 Ω, check for short to ground within wiring harness. |
| 3 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.)

| | | |
|---|---|---|
| 1 to gnd cable | < 500 Ω | If > 500 Ω, check for short to ground. |
| 2 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| 3 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |

**Harness Resistance Checks** (Connect breakout box [X1 and X2] to engine harness only. Connect breakout harness to engine harness only.)

| | | |
|---|---|---|
| X1–6 to 1 | < 5 Ω | If > 5 Ω, check for open ground wire |
| X1–14 to 2 | < 5 Ω | If > 5 Ω, check for open $V_{REF}$ wire |
| X2–16 to 3 | < 5 Ω | If > 5 Ω, check for open signal wire |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

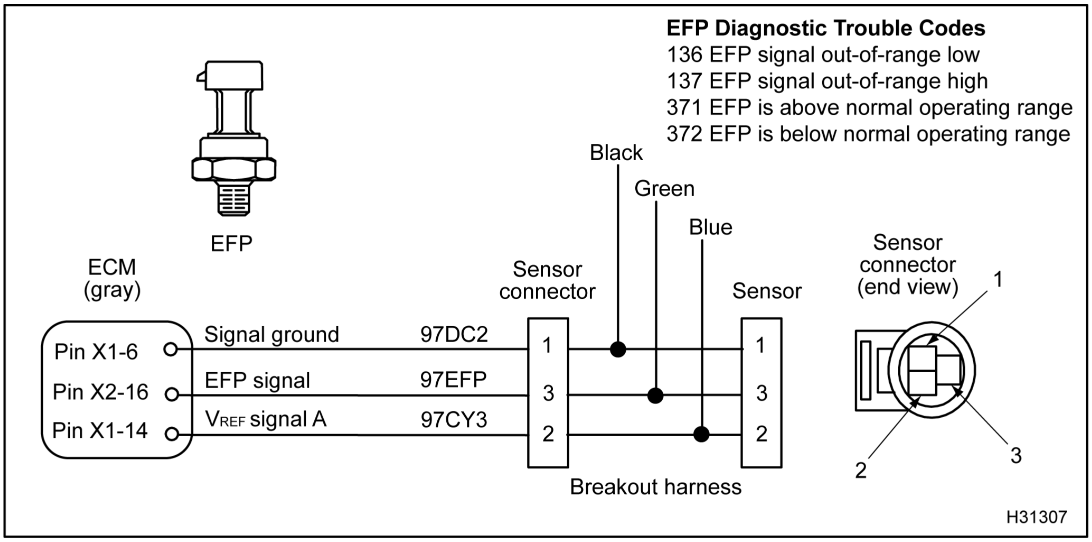



**Figure 441 EFP circuit diagram**

**Operational Voltage Checks for EFP Sensor with Breakout Harness** (Check with breakout harness connected to sensor and engine harness.)

| Test Point | EST voltage readings: Signal to ground | Spec | Comment |
|---|---|---|---|
| 3 (Green) to 1 (Black) | 0.66 V | 5 kPa (0.75 psi) | Voltage with key-on engine-off. |
| 3 (Green) to 1 (Black) | 1.65 V | 138 kPa (20 psi) | |
| 3 (Green) to 1 (Black) | 3.13 V | 345 kPa (50 psi) | |
| 3 (Green) to 1 (Black) | 4.1 V | 483 kPa (70 psi) | |

**Operational Voltage Checks for EFP Sensor with Breakout Box** (Check with breakout box connected [X1 and X2 only] to the ECM and engine harness.)

| | | | |
|---|---|---|---|
| X2–3 to X1–6 | 0.66 V | 5 kPa (0.75 psi) | Voltage with key-on engine-off. |
| X2–3 to X1–6 | 1.65 V | 138 kPa (20 psi) | |
| X2–3 to X1–6 | 3.13 V | 345 kPa (50 psi) | |
| X2–3 to X1–6 | 4.1 V | 483 kPa (70 psi) | |

**EFP Diagnostic Trouble Codes**

DTC 136 = Signal voltage was < 0.039 V for more than 0.35 second

DTC 137 = Signal voltage was > 4.9 V for more than 0.35 second

DTC 371 = Measured fuel pressure was greater than expected pressure by 100 kPa (15 psi) for more than 60 seconds.

DTC 372 = Measured fuel pressure was greater than expected pressure by 103 kPa (15 psi) for more than 30 seconds.

**Operational Voltage Checks for EFP Sensor without Breakout Harness** (Check with breakout box connected [X1 and X2 only] to the ECM and engine harness.)

| Test Point | EST voltage readings: Signal to ground | Spec | Checks |
|---|---|---|---|
| X2–3 to X1–6 | 0.66 V | 5 kPa (0.75 psi) | Voltage with key-on engine-off. |
| X2–3 to X1–6 | 1.65 V | 138 kPa (20 psi) | Voltage with key-on engine-off. |
| X2–3 to X1–6 | 3.13 V | 345 kPa (50 psi) | Voltage with key-on engine-off. |
| X2–3 to X1–6 | 4.1 V | 483 kPa (70 psi) | Rated speed, full load |

**EFP Diagnostic Trouble Codes**

DTC 136 = Signal voltage was < 0.039 V for more than 0.35 second

DTC 137 = Signal voltage was > 4.9 V for more than 0.35 second

DTC 371 = Engine fuel pressure is above normal operating range

DTC 372 = Engine fuel pressure is below normal operating range

**EGR Actuator (Exhaust Gas Recirculation)**

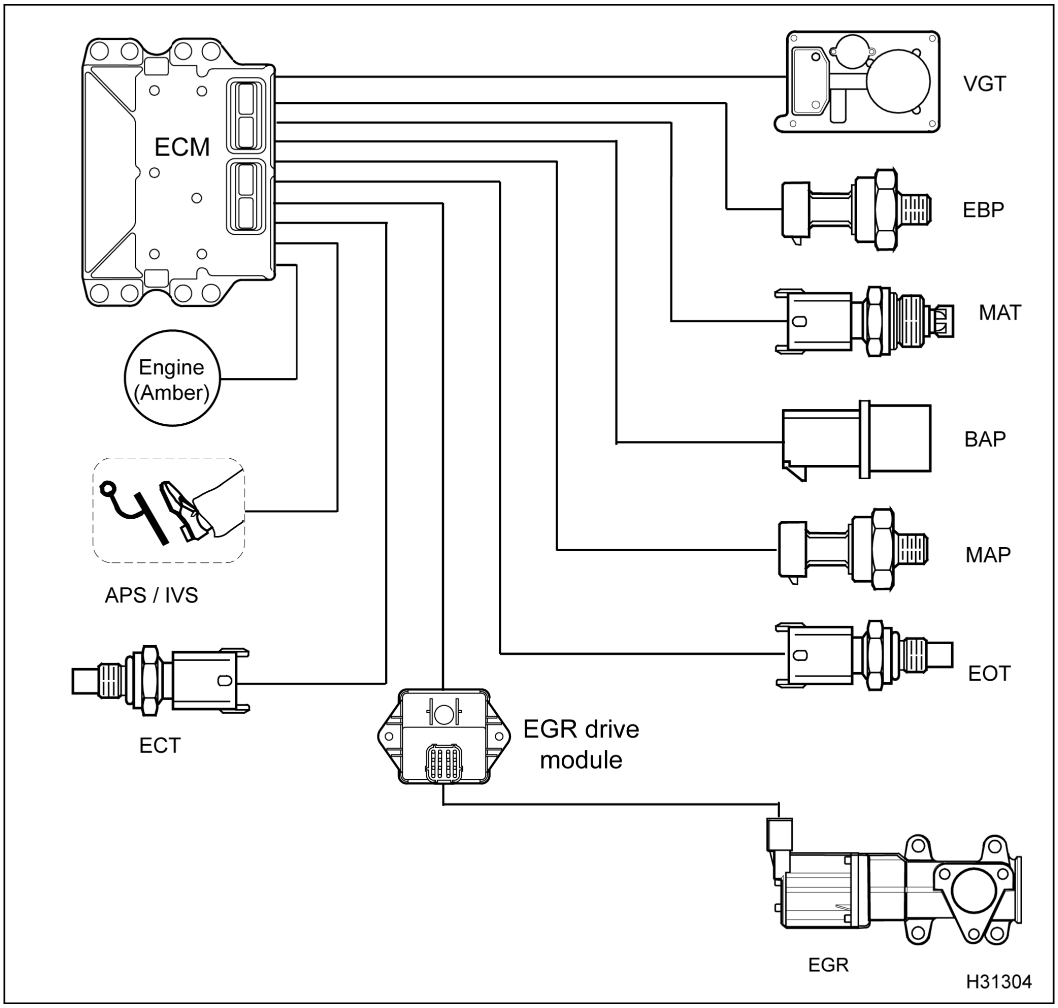



**Figure 442 Function diagram for the EGR actuator**

The function diagram for the EGR actuator includes the following:

- Electronic Control Module (ECM)
- Variable Geometry Turbocharger (VGT) actuator
- Accelerator Position Sensor (APS)
- EGR actuator with position sensors
- EGR drive module
- Exhaust Back Pressure (EBP) sensor
- Manifold Absolute Temperature (MAT) sensor
- Barometric Absolute Pressure (BAP) sensor
- Engine Coolant Temperature (ECT) sensor
- Engine Oil Temperature (EOT) sensor
- Manifold Absolute Pressure (MAP) sensor
- ENGINE lamp (amber)

**Function**

The EGR actuator consists of three major components, a valve, an actuator motor, and Integrated Circuit (IC). The IC has three Hall effect position sensors to monitor valve movement. The EGR actuator is located at the front of the engine on the mixer duct.

The EGR drive module controls the EGR actuator and is located on the left side of the engine on the ECM and Injector Driver Module (IDM).

The EGR actuator is a variable position valve that controls the amount of exhaust entering the intake system. The ECM uses sensor input from the BAP, EBP, MAT, MAP, APS, EOT, ECT, and VGT control to calculate the desired position of the EGR actuator. The EGR drive module receives the desired EGR actuator position from the ECM across the CAN 2 datalink to activate the valve for exhaust gas recirculation. The EGR drive module provides feedback to the ECM on the valve position. The EGR drive module interprets the ECM command and sends the command using three pulse width modulated signals to the valve actuator.

The system is closed loop control using the EGR position signals. The EGR drive module provides a 9 V supply and ground to the IC in the motor of the valve. When the EGR drive module directs the valve to move, the IC with three Hall effect sensors provides the EGR drive module with the valve position signals. The EGR drive module interprets the three signals to determine valve position and sends the information back to the ECM.

**EGR Circuit Operation**

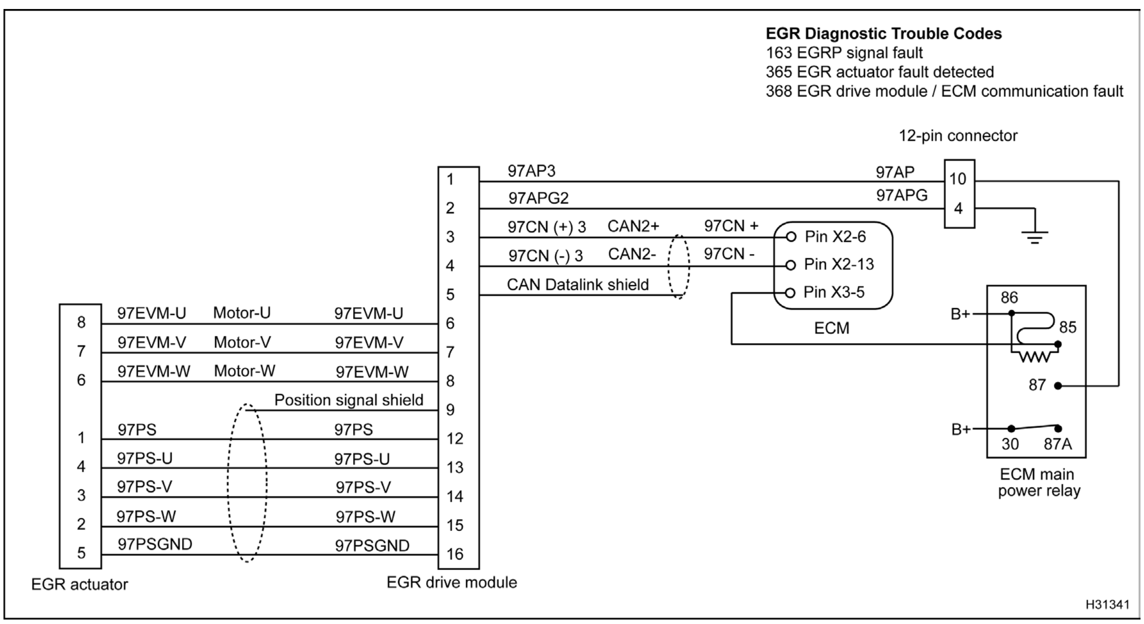



**Figure 443 EGR circuit diagram**

The EGR drive module is supplied 12 V to Pin 1 from the ECM main power relay through Pin 10 of the 12-pin connector. Ground is supplied to Pin 2 from battery ground through Pin 4 of the 12-pin connector.

The ECM sends the desired position to the EGR drive module across the CAN 2 datalink. CAN 2 positive is ECM Pin X2-6 to EGR drive module Pin 3. CAN 2 negative is ECM Pin X2-13 to EGR drive module Pin 4.

The EGR drive module provides a 9 V supply to the IC from Pin 12 to Pin 1 of the EGR actuator. The EGR drive module provides ground to the IC from Pin 16 to Pin 5 of the EGR actuator. The IC in the EGR actuator produces the following valve position signals:

- Position U – EGR actuator Pin 4 to EGR drive module Pin 13
- Position V – EGR actuator Pin 3 to EGR drive module Pin 14
- Position W – EGR actuator Pin 2 to EGR drive module Pin 15

Depending on desired valve position from the ECM signal and position feedback signal from the IC, the EGR drive module drives the 3 phase DC motor to move the valve to the proper position using the following pulse width modulated signals:

- Motor U - EGR drive module Pin 6 to EGR actuator Pin 8
- Motor V - EGR drive module Pin 7 to EGR actuator Pin 7
- Motor W - EGR drive module Pin 8 to EGR actuator Pin 6

The EGR drive module provides two shields to suppress electrical noise. One shield is for the CAN 2 datalink (EGR drive module Pin 5). The other shield is for the valve position sensor signals used by the EGR drive module to monitor position (EGR drive module Pin 9).

**Fault Detection / Management**

The EGR drive module constantly monitors the EGR actuator. When an EGR control error is detected, the EGR drive module sends a message to the ECM, a DTC is set, and the amber ENGINE lamp is illuminated.

**EGR Diagnostic Trouble Codes (DTCs)**

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

**DTC 163**
**EGRP signal fault**

- DTC 163 is set by the ECM when the EGR drive module detects a position signal failure.
- DTC 163 can be set due to an open or short to ground on the position sensor signal power supply circuit, an open ground circuit, an open or short to ground on any of the position signal circuits, or a failed IC.
- When DTC 163 is active the amber ENGINE lamp is illuminated.

**DTC 365**
**EGR actuator fault detected**

- DTC 365 is set by the ECM when the EGR drive module detects an EGR actuator fault.
- DTC 365 can be set due to an open, short to ground, short to a power source on any of the motor signal circuits, failure of EGR actuator motor, or a stuck valve assembly.
- When DTC 365 is active the amber ENGINE lamp is illuminated.

**DTC 368**
**EGR drive module/ECM communication fault**

- DTC 368 is set by the ECM when CAN 2 datalink communications are not received from EGR drive module.
- DTC 368 can be set for the EGR drive module due to the following conditions:

  If engine starts and runs, the DTC is specific to the EGR drive module and ECM communications. The following are possible causes:

  - An open or short to ground on the power circuit exists.

  - An open or short to power on the ground circuit exists.

  - CAN 2 positive and CAN 2 negative are both open or high resistance exists.

  When CAN communication is not present from the EGR drive module, the ECM sends 100 percent EGR position to the EST.

  If a no start condition exists with DTC 368 and 543 active, check the CAN 2 wiring (EGR to ECM and IDM to ECM). See “ECM / IDM Communications” (page 389). One of the CAN 2 datalink wires (CAN 2 positive or negative) is open, short to ground, or short to power exists.
- When DTC 368 is active the amber ENGINE lamp is illuminated.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- EGR Valve Breakout Harness
- 12–pin Breakout Harness
- Breakout Box
- Terminal Test Adapter Kit

## EGR Pin-Point Diagnostics

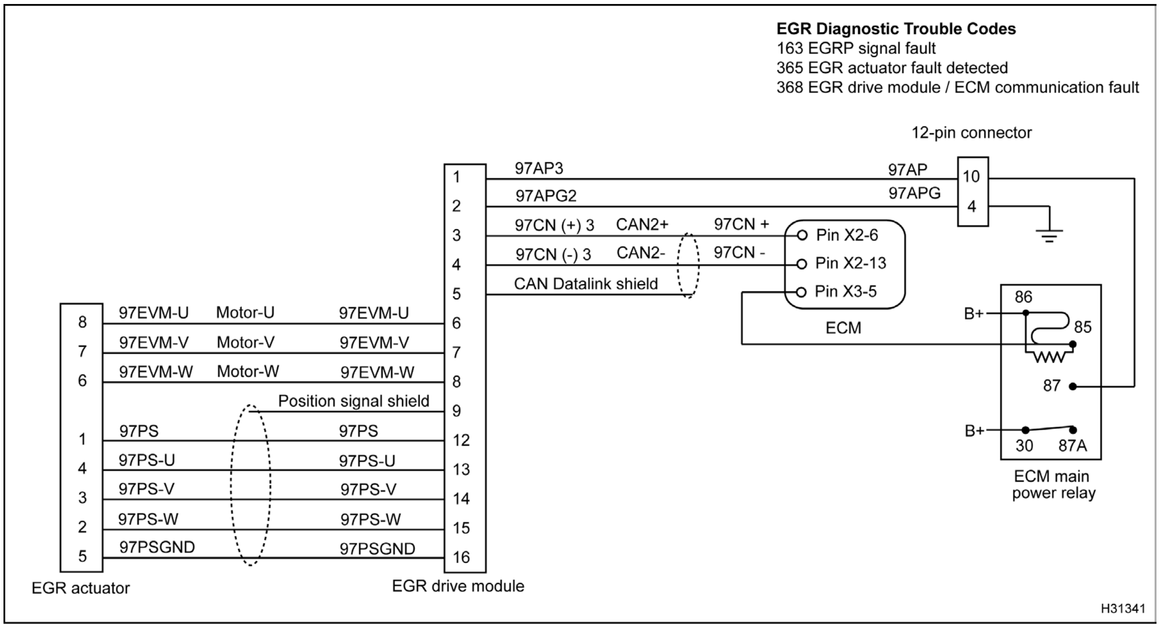
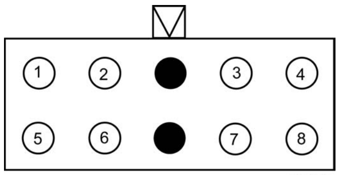



**Figure 444 EGR circuit diagram**

**EGR Actuator Connector Pins**

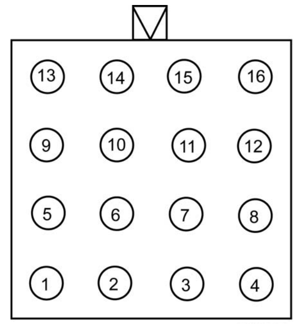



H31342

**NOTE:** Harness connectors shown with mating end view.

| Pin | |
|---|---|
| 1 | Position sensor power |
| 2 | Position sensor W |
| 3 | Position sensor V |
| 4 | Position sensor U |
| 5 | Position sensor ground |
| 6 | Motor W |
| 7 | Motor V |
| 8 | Motor U |

**EGR Drive Module Connector Pins**




H31343

| Pin | | Pin | |
|---|---|---|---|
| 1 | Power | 9 | Ground shield |
| 2 | Ground | 10 | Not used |
| 3 | CAN high | 11 | Not used |
| 4 | CAN low | 12 | Position sensor power |
| 5 | CAN shield | 13 | Position sensor U |
| 6 | Motor U | 14 | Position sensor V |
| 7 | Motor V | 15 | Position sensor W |
| 8 | Motor W | 16 | Position sensor ground |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing service bay diagnostics on engine or vehicle.**

**CAUTION: To avoid engine damage, *use utmost care* when:**

1. **Disconnecting harness from EGR actuator or EGR drive module.**
2. **Inserting Terminal Test Adapter probe into connector to test for specifications.**
3. **Connecting harness to EGR actuator or EGR drive module.**

**Failure to use care when disconnecting, testing, or connecting components may result in damaged or bent connector pins.**

**EGR Actuator Harness Connector Voltage Checks** (Disconnect harness from actuator. Connect breakout harness. Turn the ignition switch to ON.)

| Test Point | Spec | Comment |
|---|---|---|
| 1 to gnd | 8 V to 11 V | If not in spec, check for an open, short to ground or short to voltage source. |
| 2 to gnd | 5 V ± 0.5 V | If not in spec, check for an open, short to ground or short to voltage source. |
| 3 to gnd | 5 V ± 0.5 V | If not in spec, check for an open, short to ground or short to voltage source. |
| 4 to gnd | 5 V ± 0.5 V | If not in spec, check for an open, short to ground or short to voltage source. |
| 5 to gnd | 0 V | If not in spec, check for a short to voltage source. |
| 6 to gnd | 0 V | If not in spec, check for a short to voltage source. |
| 7 to gnd | 0 V | If not in spec, check for a short to voltage source. |
| 8 to gnd | 0 V | If not in spec, check for a short to voltage source. |

| | | |
|---|---|---|
| **EGR Actuator Resistance Checks Only** (Turn the ignition switch to OFF. Disconnect harness from actuator. Connect breakout harness to actuator only. **Note:** Ensure DMM and leads are zeroed.) | | |
| 1 to 2 | > 1 kΩ | If < 1 kΩ, short to sensor power exists. |
| 1 to 3 | > 1 kΩ | If < 1 kΩ, short to sensor power exists. |
| 1 to 4 | > 1 kΩ | If < 1 kΩ, short to sensor power exists. |
| 1 to 5 | > 1 kΩ | If < 1 kΩ, short to sensor power exists. |
| 5 to 2 | > 1 kΩ | If < 1 kΩ, short to sensor power exists. |
| 5 to 3 | > 1 kΩ | If < 1 kΩ, short to sensor power exists. |
| 5 to 4 | > 1 kΩ | If < 1 kΩ, short to sensor power exists. |
| 6 to 7 | 2.1 Ω ±0.5 Ω | If not in spec, replace actuator. |
| 6 to 8 | 2.1 Ω ±0.5 Ω | If not in spec, replace actuator. |
| 7 to 8 | 2.1 Ω ±0.5 Ω | If not in spec, replace actuator. |
| **EGR Actuator Harness Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect harness from actuator. Connect breakout harness to engine harness only. Disconnect chassis connector 9260[1].) | | |
| 1 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 2 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 3 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 4 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 5 to Pin A (9260) | < 5 Ω | If > 5 Ω, an open circuit exists or high resistance. Specification is based on 4300 chassis. For other applications, see *Chassis Electrical Circuit Diagram Manual* for complete chassis ground circuit information. |
| 6 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 7 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 8 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**EGR Actuator Harness Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect harness from actuator. Disconnect negative battery cable. Connect breakout harness to engine harness only. Use disconnected negative battery cable for ground test point.)

| | | |
|---|---|---|
| 1 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 2 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 3 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 4 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 5 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. Specification is based on 4300 chassis. For other applications, see *Chassis Electrical Circuit Diagram Manual* for complete chassis ground circuit information. |
| 6 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 7 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 8 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

**⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing service bay diagnostics on engine or vehicle.**

**CAUTION: To avoid engine damage, *use utmost care* when:**

1. **Disconnecting harness from EGR actuator or EGR drive module.**
2. **Inserting Terminal Test Adapter probe into connector to test for specifications.**
3. **Connecting harness to EGR actuator or EGR drive module.**

**Failure to use care when disconnecting, testing, or connecting components may result in damaged or bent connector pins.**

**EGR Drive Module Connector Voltage Checks** (Disconnect harness from the EGR drive module. Turn the ignition switch to ON.)

| Test Point | Spec | Comment |
|---|---|---|
| 1 to gnd | 9 V to 16 V | If not in spec, check for an open, short to ground, or short to voltage source. |
| 2 to gnd | 0 V | If not in spec, check for a short to voltage source. |
| 3 to gnd | 1 V to 4 V | Digital signal. See "ECM / IDM Communications" (page 389). |
| 4 to gnd | 1 V to 4 V | Digital signal. See "ECM / IDM Communications" (page 389). |
| 5 to gnd | 0 V | If not in spec, check for a short to voltage source. |
| 6 to gnd | 0 V | If not in spec, check for a short to voltage source. |
| 7 to gnd | 0 V | If not in spec, check for a short to voltage source. |
| 8 to gnd | 0 V | If not in spec, check for a short to voltage source. |
| 9 to gnd | 0 V | If not in spec, check for a short to voltage source. |
| 12 to gnd | 0 V | If not in spec, check for a short to voltage source. |
| 13 to gnd | 0 V | If not in spec, check for a short to voltage source. |
| 14 to gnd | 0 V | If not in spec, check for a short to voltage source. |
| 15 to gnd | 0 V | If not in spec, check for a short to voltage source. |
| 16 to gnd | 0 V | If not in spec, check for a short to voltage source. |

| **Resistance Checks – EGR Drive Module Only** (Turn the ignition switch to OFF. Disconnect harness from EGR drive module. Measure at EGR drive module pins.) | | |
|---|---|---|
| 1 to 2 | > 50 Ω | If < 50 Ω, short to ground exists. |
| 2 to 3 | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 2 to 4 | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 2 to 5 | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 2 to 6 | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 2 to 7 | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 2 to 8 | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 2 to 9 | < 5 Ω | If > 5 Ω, an open circuit or high resistance exists. |
| 2 to 12 | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 2 to 13 | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 2 to 14 | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 2 to 15 | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 2 to 16 | < 5 Ω | If > 5 Ω, an open circuit or high resistance exists. |
| 9 to 16 | < 5 Ω | If > 5 Ω, an open circuit or high resistance exists. |
| 12 to 16 | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 13 to 16 | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 14 to 16 | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 15 to 16 | > 1 kΩ | If < 1 kΩ, short to ground exists. |

| **EGR Drive Module Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect harness from EGR drive module and disconnect chassis connector 9260[1].) | | |
|---|---|---|
| 1 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 2 to Pin A (9260) | < 5 Ω | If > 5 Ω, an open circuit or high resistance exists. Specification is based on 4300 chassis. For other applications, see *Chassis Electrical Circuit Diagram Manual* for complete chassis ground circuit information. |
| 3 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 4 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 5 to Pin A (9260) | < 5 Ω | If > 5 Ω, an open circuit or high resistance exists. Specification is based on 4300 chassis. For other applications, see *Chassis Electrical Circuit Diagram Manual* for complete chassis ground circuit information. |
| 6 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 7 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 8 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 9 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 12 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 13 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 14 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 15 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 16 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, short to ground exists. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**EGR Drive Module Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable and harness from EGR drive module. Use disconnected negative battery cable for ground test point.)

| Test Point | Spec | Comment |
|---|---|---|
| 1 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 2 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. Specification is based on 4300 chassis. For other applications, see *Chassis Electrical Circuit Diagram Manual* for complete chassis ground circuit information. |
| 3 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 4 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 5 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. Specification is based on 4300 chassis. For other applications, see *Chassis Electrical Circuit Diagram Manual* for complete chassis ground circuit information. |
| 6 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 7 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 8 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 9 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 12 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 13 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 14 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 15 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |
| 16 to gnd | > 1 kΩ | If < 1 kΩ, short to ground exists. |

| | | |
|---|---|---|
| **Harness Resistance Checks from EGR Drive Module to EGR Actuator** (Turn the ignition switch to OFF. Disconnect harness from EGR drive module and EGR actuator. **NOTE:** Test points are EGR drive module to EGR actuator.) | | |
| Pin 6 to Pin 8 | < 5 Ω | If > 5 Ω, open circuit or high resistance to MTR U. |
| Pin 7 to Pin 7 | < 5 Ω | If > 5 Ω, open circuit or high resistance to MTR V. |
| Pin 8 to Pin 6 | < 5 Ω | If > 5 Ω, open circuit or high resistance to MTR W. |
| Pin 12 to Pin 1 | < 5 Ω | If > 5 Ω, open circuit or high resistance to position sensor power. |
| Pin 13 to Pin 4 | < 5 Ω | If > 5 Ω, open circuit or high resistance to position sensor U. |
| Pin 14 to Pin 3 | < 5 Ω | If > 5 Ω, open circuit or high resistance to position sensor V. |
| Pin 15 to Pin 2 | < 5 Ω | If > 5 Ω, open circuit or high resistance to position sensor W. |
| Pin 16 to Pin 5 | < 5 Ω | If > 5 Ω, open circuit or high resistance to position sensor ground. |

[1] Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

> **WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing service bay diagnostics on engine or vehicle.**

**Harness Resistance Checks from EGR Drive Module to 12–pin Connector** (Turn the ignition switch to OFF. Disconnect harness at EGR drive module and 12–pin connector.)

| Test Point | Spec | Comment |
|---|---|---|
| Pin 1 to Pin 10 | < 5 Ω | If > 5 Ω, open circuit or high resistance to actuator power. |
| Pin 2 to Pin 4 | < 5 Ω | If > 5 Ω, open circuit or high resistance to actuator ground. |
| **Harness Resistance Checks from EGR Drive Module to ECM** (Turn the ignition switch to OFF. Disconnect harness at EGR drive module and ECM connector X2. Connect breakout box X2 to engine harness only.) | | |
| Pin 3 to Pin X2–6 | < 5 Ω | If > 5 Ω, open circuit or high resistance to CAN 2 positive. |
| Pin 4 to Pin X2–13 | < 5 Ω | If > 5 Ω, open circuit or high resistance to CAN 2 negative. |

| |
|---|
| **EGR Actuator Diagnostic Trouble Codes (DTCs)** |
| DTC 163 = EGR drive module detects position signal fault. |
| DTC 365 = EGR drive module detects actuator fault. |
| DTC 368 = ECM did not receive EGR drive module communication for more than one second. |

**EOP Sensor (Engine Oil Pressure)**

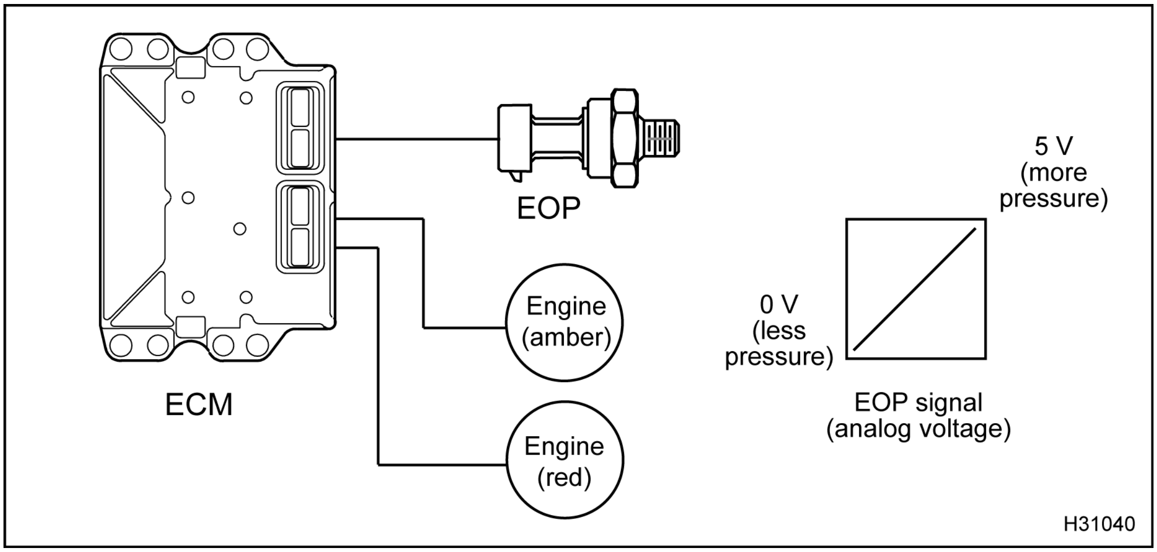



**Figure 445 Function diagram for the EOP sensor**

The function diagram for the EOP sensor includes the following:

- EOP sensor
- Electronic Control Module (ECM)
- ENGINE lamp (amber and red)

**Function**

The EOP sensor is a variable capacitance sensor installed in the left side of the crankcase below and left of the fuel filter housing. The ECM supplies a 5 V reference signal which the EOP sensor uses to produce a linear analog voltage that indicates oil pressure.

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

### EOP Circuit Operation

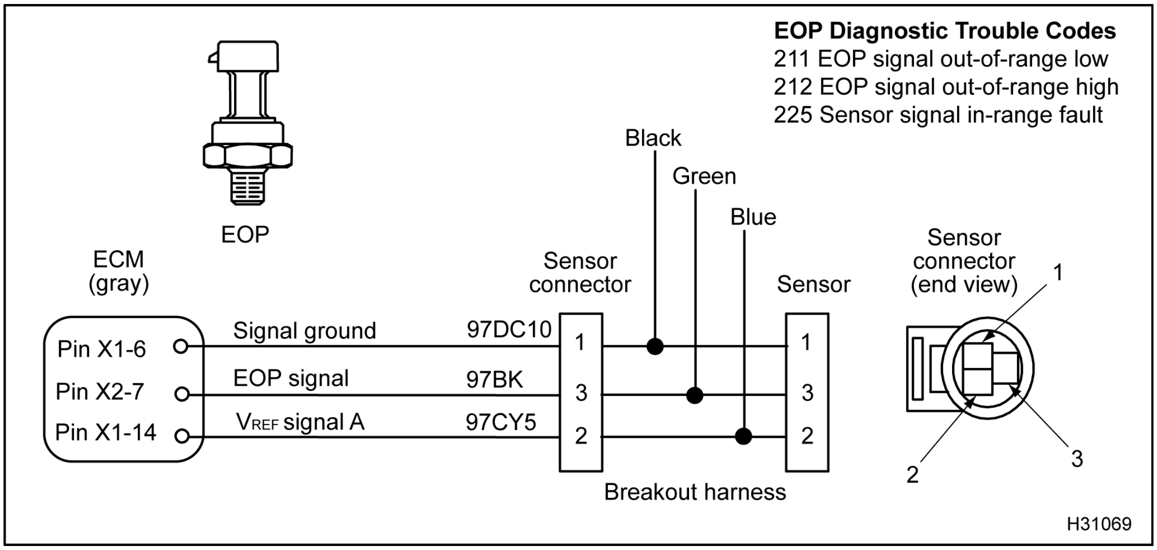



**Figure 446 EOP circuit diagram**

The EOP sensor is supplied with a 5 V reference voltage at Pin 2 from ECM Pin X1–14. The EOP sensor is grounded at Pin 1 from ECM Pin X1–6. The EOP sensor returns a variable voltage signal from Pin 3 to ECM Pin X2–7.

### Fault Detection / Management

When the EOP signal voltage is detected out of range high or low, the ECM will cause the engine to ignore the EOP signal and disable the EWPS.

### EOP Diagnostic Trouble Codes (DTCs)

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

**DTC 211**
**EOP signal out-of-range low**

- DTC 211 is set by the ECM when the EOP signal is less than 0.039 V for more than 0.35 second.
- DTC 211 can be set due to an open or short to ground on the signal circuit, a failed ICP sensor or an open $V_{REF}$ circuit or $V_{REF}$ short to ground.
- When DTC 211 is active the amber ENGINE lamp is illuminated.

**DTC 212**
**EOP signal out-of-range high**

- DTC 212 is set by the ECM when the EOP signal is greater than 4.9 V for more than 0.35 second.
- DTC 212 can be set due to signal circuit short to $V_{REF}$ or B+, or a failed EOP sensor.
- When DTC 212 is active the amber ENGINE lamp is illuminated.

**DTC 225**
**EOP sensor signal in-range fault**

- DTC 225 is set by the ECM when the EOP signal voltage is greater than 207 kPa (30 psi) for 8 seconds or more with the ignition key-on engine-off.
- DTC 225 can be set due to an open signal ground, $V^{REF}$ shorted to voltage source above 5.5 V, biased circuit, failed EOP sensor.
- When DTC 225 is active the amber ENGINE lamp is illuminated.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 500 Ohm Resistor Harness
- Breakout Box
- Breakout Harness
- Terminal Test Adapter Kit

**EOP Operational Diagnostics**

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:**

**Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.**

1. Using EST, open the D_ContinuousMonitor.ssn.

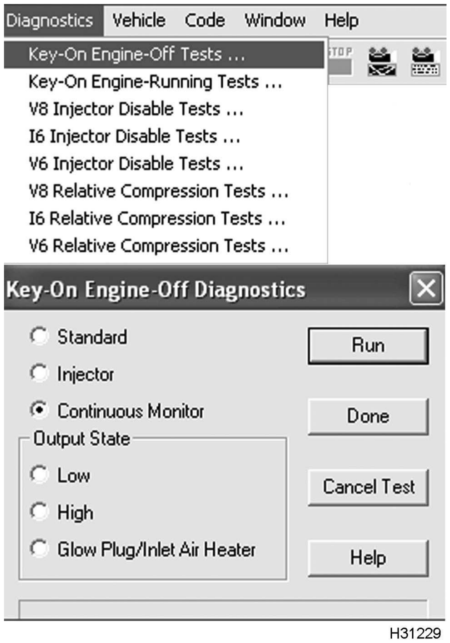



**Figure 447 Continuous Monitor Test**

2. To monitor signal voltage, run KOEO Continuous Monitor Test. For help, see “Continuous Monitor Test” in Section 3 (page 68).
3. Monitor EOP signal voltage. Verify an active DTC for the EOP circuit.
4. If code is active, do step 6 and 7 to check circuit for the EOP sensor using the following table.
   - Circuit Checks for EOP Sensor
5. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will display DTCs related to the condition.
6. Disconnect engine harness from pressure sensor.

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

7. Connect Pressure Sensor Breakout Harness to engine harness only.

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Circuit Checks for EOP Sensor** (Use EST, DMM, breakout harness, and 500 Ohm Resistor Harness.)

| Test Condition | Spec | Checks |
|---|---|---|
| Sensor disconnected using EST | 0 V | If voltage > 0.039 V, check signal circuit for short to $V_{REF}$ or B+. |
| Voltage from Pin 2 (Blue) to ground using DMM | 5 V ± 0.5 V | If voltage > 5.5 V, check $V_{REF}$ for short to B+. If voltage is < 4.5 V, check $V_{REF}$ circuit for open or short to ground. |
| 500 Ohm Resistor Harness connected between Pin 3 (Green) and Pin 2 (Blue) of breakout harness | 5 V | If voltage < 4.9 V, check signal circuit for open or short to ground.<br>— Disconnect connector 9260[1]. Measure resistance from Pin 3 to Pin A of connector 9260 (spec > 1 kΩ) to check for short to ground within wiring harness.<br>— Disconnect negative battery cable. Measure resistance from Pin 3 to ground cable to check for short to ground.<br>— Use a breakout box from Pin 3 to Pin X2–7 (spec < 5 Ω) to check for open in the harness. |
| Resistance from Pin 1 (Black) of breakout harness to ECM chassis ground Pin A of connector 9260 using DMM | < 5 Ω | If resistance is > 5 Ω, check for open or high resistance between ECM and sensor connector. Use a breakout box and measure resistance from between Pin 1 and Pin X1–6 (spec < 5 Ω). |

Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the EOP sensor.

[1] Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

### EOP Pin-Point Diagnostics

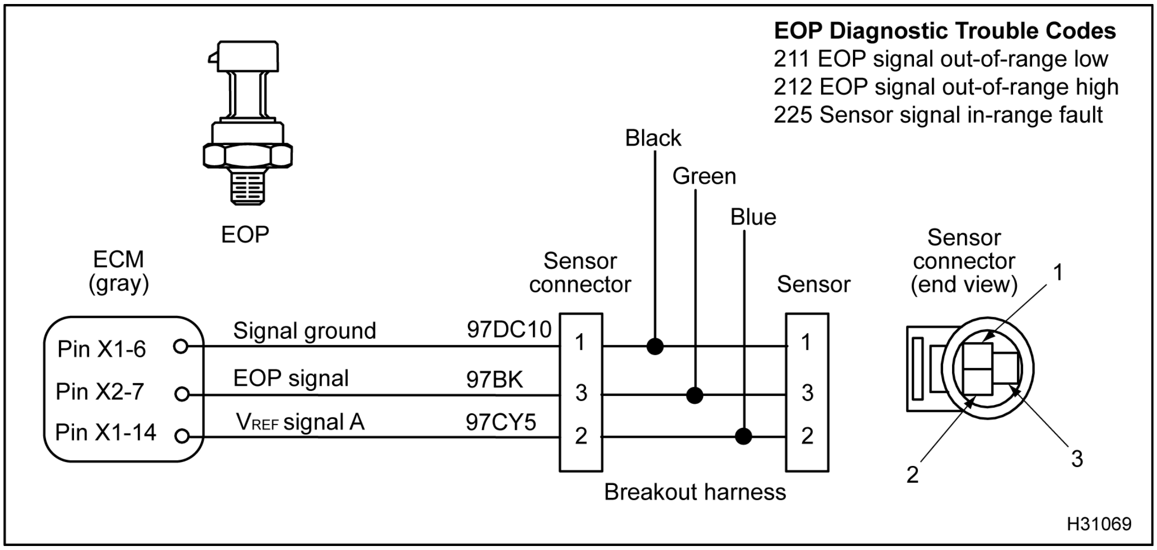



**Figure 448 EOP circuit diagram**

| Test Point | Spec | Comment |
|---|---|---|
| **Connector Voltage Checks to Ground** (Disconnect harness from sensor. Inspect for bent pins or corrosion. Connect breakout harness to engine harness only. Turn the ignition switch to ON.) | | |
| **Test Point** | **Spec** | **Comment** |
| 1 to gnd | 0 V to 0.25 V | Signal ground (no voltage expected). If > 0.25 V, check ground circuit for open or high resistance and check signal ground for short to $V_{REF}$ or B+. |
| 2 to gnd | 5 V ± 0.5 V | If voltage is not to spec, $V_{REF}$ circuit is shorted to ground, shorted to B+, or open. |
| 3 to gnd | 0 V to 0.25 V | If > 0.25 V, signal circuit is shorted to $V_{REF}$ or B+. |
| **Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Connect breakout harness to engine harness only. Disconnect chassis connector 9260[1].) | | |
| 1 to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open circuit. |
| 2 to Pin A (9260) | > 500 Ω | If < 500 Ω, check for short to ground within wiring harness. |
| 3 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

| | | |
|---|---|---|
| **Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.) | | |
| 1 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| 2 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| 3 to gnd cable | > 1 kΩ | If < 1 kΩ , check for short to ground. |
| **Harness Resistance Checks** (Connect breakout box [X1 and X2] to engine harness only. Connect breakout harness to engine harness only.) | | |
| X1–6 to 1 | < 5 Ω | If > 5 Ω, check for open ground wire. |
| X1–14 to 2 | < 5 Ω | If > 5 Ω, check for open $V_{REF}$ wire. |
| X2–7 to 3 | < 5 Ω | If > 5 Ω, check for open signal wire. |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

| Test Point | Voltage | Pressure | Comment |
|---|---|---|---|
| **Operational Voltage Checks for EOP Sensor with Breakout Harness** (Check with breakout harness connected to sensor and engine harness.) | | | |
| 3 (Green) to 1 (Black) | 0.89 V | 34 kPa (5 psi) | Pressure will vary with engine speed and temperature. |
| 3 (Green) to 1 (Black) | 1.15 V | 69 kPa (10 psi) | Pressure will vary with engine speed and temperature. |
| 3 (Green) to 1 (Black) | 2.40 V | 241 kPa (35 psi) | Pressure will vary with engine speed and temperature. |
| 3 (Green) to 1 (Black) | 3.61 V | 414 kPa (60 psi) | Pressure will vary with engine speed and temperature. |
| **Operational Voltage Checks for EOP Sensor with Breakout Box** (Check with breakout box connected [X1 and X2] to ECM and engine harness.) | | | |
| X2–7 to X1–6 | 0.89 V | 34 kPa (5 psi) | Pressure will vary with engine speed and temperature. |
| X2–7 to X1–6 | 1.15 V | 69 kPa (10 psi) | Pressure will vary with engine speed and temperature. |
| X2–7 to X1–6 | 2.40 V | 241 kPa (35 psi) | Pressure will vary with engine speed and temperature. |
| X2–7 to X1–6 | 3.61 V | 414 kPa (60 psi) | Pressure will vary with engine speed and temperature. |

**EOP Diagnostic Trouble Codes**

DTC 211 = Signal voltage was < 0.039 V for more than 0.35 second

DTC 212 = Signal voltage was > 4.9 V for more than 0.35 second

DTC 225 = Engine oil pressure was > 207 kPa (30 psi) for more than 8 seconds with key-on engine-off

DTC 313 = See “Engine Warning and Protection System” (page 459).

DTC 314 = See “Engine Warning and Protection System” (page 459).

**EOT Sensor (Engine Oil Temperature)**

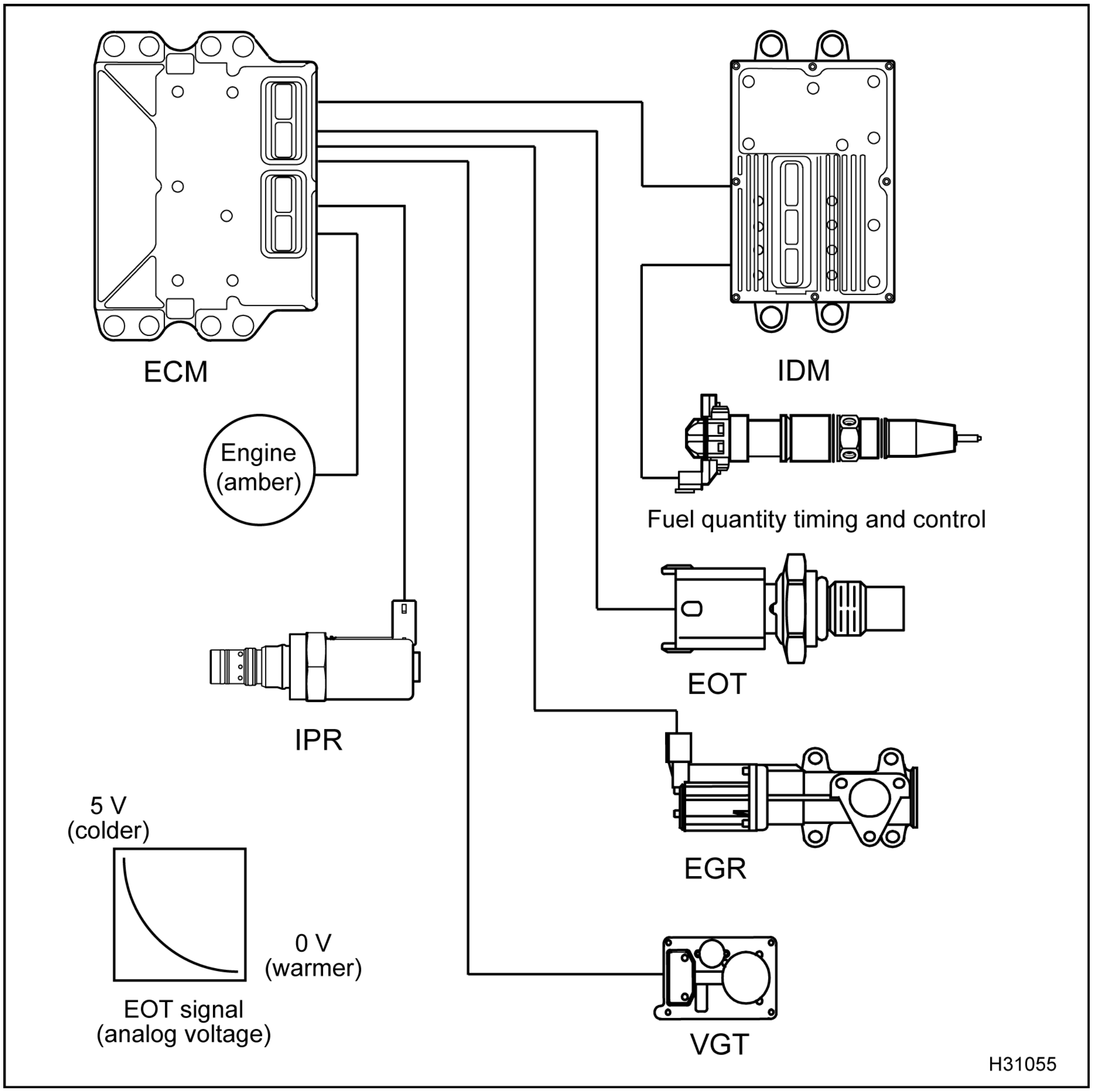



**Figure 449 Function diagram for the EOT sensor**

The function diagram for the EOT sensor includes the following:

- EOT sensor
- Electronic Control Module (ECM)
- Injection Driver Module (IDM)
- Fuel injector
- Exhaust Gas Recirculation Position (EGR)
- Variable Geometry Turbocharger (VGT)
- Injection Pressure Regulator (IPR)
- ENGINE lamp (amber)

**Function**

The EOT sensor is a thermistor sensor installed in the rear of the front cover, left of the high-pressure oil pump assembly. The ECM supplies a 5 V reference signal which the EOT sensor uses to produce an analog voltage that indicates temperature.

The EOT changes resistance when exposed to different temperatures. As oil temperature decreases, the resistance of the thermistor increases. This causes the signal voltage to increase. As oil temperature increases, the resistance of the thermistor decreases. This causes the signal voltage to decrease.

The EOT sensor provides a feedback signal to the ECM indicating engine oil temperature. The ECM monitors the EOT signal to control fuel quantity and timing throughout the operating range of the engine. The EOT signal allows the ECM to compensate for oil viscosity variations due to temperature changes in the operating environment, ensuring that adequate power and torque are available for all operating conditions. During engine operation, if the ECM recognizes that the EOT signal is greater or less than the expected value it will set a DTC.

### 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.

### EOT Circuit Operation

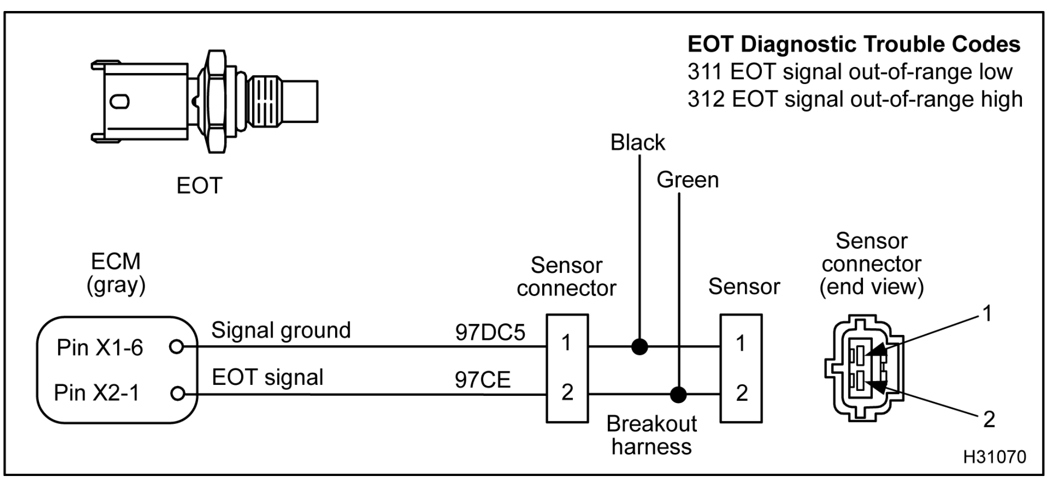



**Figure 450 EOT circuit diagram**

The EOT sensor is supplied with a 5 V reference voltage at Pin 2 from ECM Pin X2–1. The sensor is grounded at Pin 1 through the signal ground at ECM Pin X1–6. As the oil temperature increases or decreases, the sensor changes resistance and provides the oil temperature signal voltage at the ECM. The signal voltage is monitored by the ECM to determine the temperature of the oil.

**Fault Detection / Management**

The ECM continuously monitors the signal of the EOT sensor to determine if the signal is within an expected range. If the ECM detects an out of range high or low, the ECM will ignore the EOT signal and assume an engine oil temperature of –20 °C (–4 °F) for starting and 100 °C (212 °F) for engine running conditions.

## EOT Diagnostic Trouble Codes (DTCs)

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

**DTC 311**
**EOT signal out-of-range low**

- DTC 311 is set by the ECM when the EOT signal is less than 0.2 V for more than 0.35 second.
- DTC 311 can be set due to a sensor signal wire short to ground or a failed EOT sensor.
- When DTC 311 is active the amber ENGINE lamp is illuminated.

**DTC 312**
**EOT signal out-of-range high**

- DTC 312 is set by the ECM when the EOT signal is greater than 4.78 V for more than 0.35 second.
- DTC 312 can be set due to a signal or ground circuit open, a short to a voltage source, or a failed EOT sensor.
- When DTC 312 is active the amber ENGINE lamp is illuminated.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 500 Ohm Resistor Harness
- Breakout Box
- Breakout Harness
- Terminal Test Adapter Kit

## EOT Operational Diagnostics

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:**

**Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.**

1. Using EST, open the D_ContinuousMonitor.ssn.

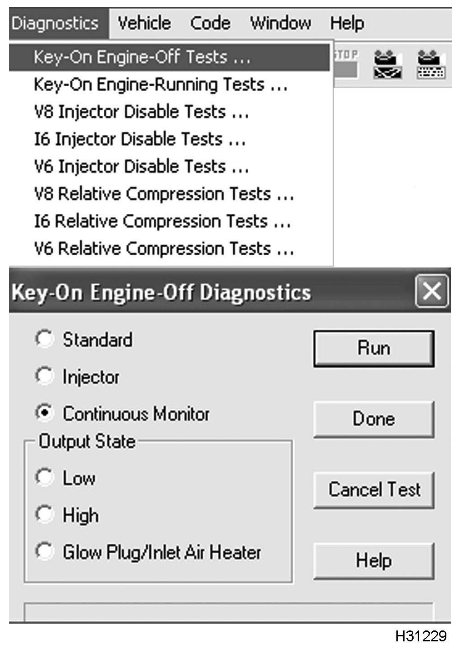



**Figure 451 Continuous Monitor Test**

2. To monitor signal voltage, run KOEO Continuous Monitor Test. For help, see “Continuous Monitor Test” in Section 3 (page 68).
3. Monitor EOT signal voltage. Verify an active DTC for the EOT circuit.
4. If code is active, do step 6 and 7 to check circuit for the EOT sensor using the following table.
    - Circuit Checks for EOT Sensor
5. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will display DTCs related to the condition.

6. Disconnect engine harness from temperature sensor.

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

7. Connect Temperature Sensor Breakout Harness to engine harness only.

**Circuit Checks for EOT Sensor** (Use EST, breakout harness, 3-Banana Plug Harness, and 500 Ohm Resistor Harness.)

| Test Condition | Spec | Checks |
|---|---|---|
| Sensor disconnected | > 4.78 V | If voltage < 4.78 V, check signal circuit for short to ground. |
| 3-Banana Plug Harness connected between Pin 2 (Green) and Pin 1 (Black) of breakout harness | 0 V | If voltage is > 0.2 V, check ground and signal circuit for open or high resistance. Use a breakout box and measure resistance from Pin 1 to Pin X1–6 and from Pin 2 to X2–1 (spec < 5 Ω). |
| 500 Ohm Resistor Harness connected between Pin 2 (Green) and Pin 1 (Black) of breakout harness | < 1.0 V | If voltage > 1.0 V, check signal circuit for short to $V_{REF}$, B+, or another sensor's signal voltage. |

**Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the EOT sensor.**

**EOT Pin-Point Diagnostics**

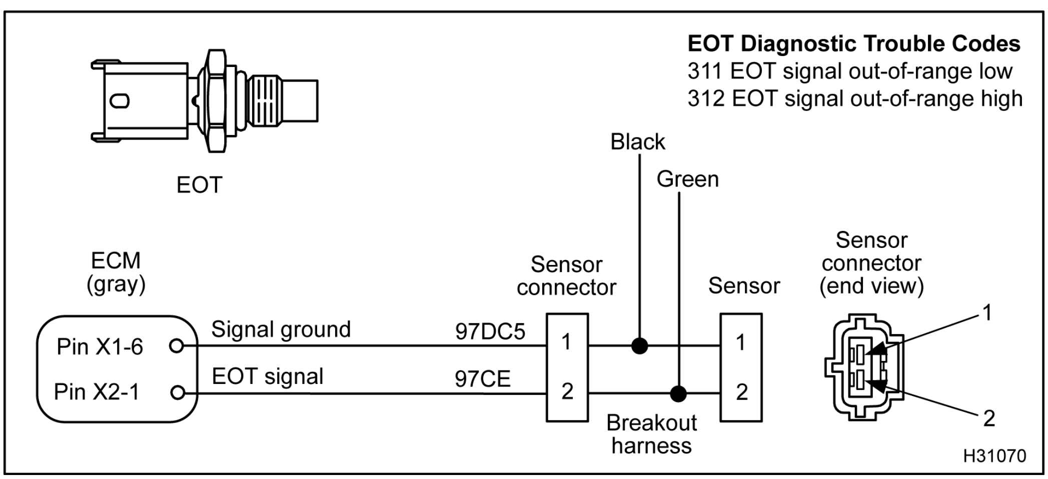



**Figure 452 EOT circuit diagram**

| Test Point | Spec | Comment |
|---|---|---|
| **Connector Voltage Checks to Ground** (Disconnect harness from sensor. Inspect for bent pins or corrosion. Connect breakout harness to engine harness only. Turn the ignition switch to ON.) | | |
| 2 to gnd | 4.8 V to 5.0 V | Pull up voltage, if low or no voltage, circuit has open, high resistance, or short to ground. |
| 1 to gnd | 0 V to 0.25 V | If > 0.25 V, signal ground wire is shorted to $V_{REF}$ or B+. |
| **Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect harness from sensor. Connect breakout harness to engine harness only. Disconnect chassis connector 9260[1].) | | |
| 1 to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open circuit. |
| 2 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |

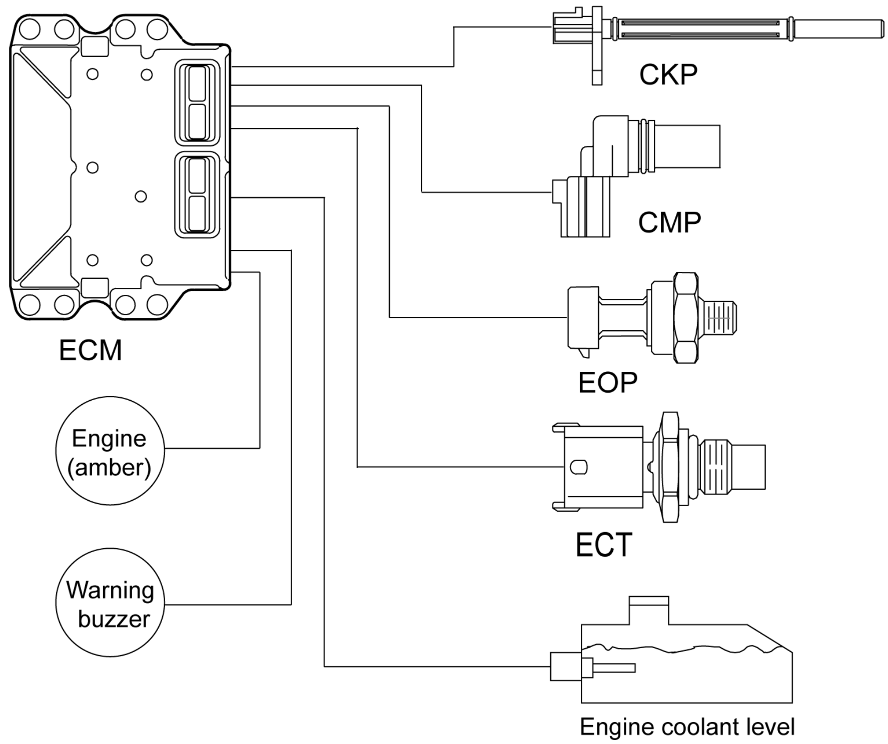
**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

| | | |
|---|---|---|
| **Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Connect breakout harness to engine harness only. Use disconnected negative battery cable for ground test point.) | | |
| 1 to gnd cable | > 500 Ω | If < 500 Ω , check for short to ground. |
| 2 to gnd cable | > 1 kΩ | If < 1 kΩ, check for signal short to ground. |
| **Harness Resistance Checks** (Connect breakout box to engine harness only.) | | |
| X1–6 to 1 | < 5 Ω | If > 5 Ω, check for open ground wire |
| X2–1 to 2 | < 5 Ω | If > 5 Ω, check for open signal wire |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

| **Operational Voltage Checks for EOT Sensor with Breakout Harness** (Check with breakout harness connected to sensor and engine harness. Connect breakout harness to engine harness only.) | | | |
|---|---|---|---|
| **Test Point** | **Temp** | **Resistance** | **Voltage** |
| 2 (Green) to 1 (Black) | 0 °C (32 °F) | 91.1 kΩ | 4.348 V |
| 2 (Green) to 1 (Black) | 20 °C (68 °F) | 35.5 kΩ | 3.782 V |
| 2 (Green) to 1 (Black) | 100 °C (212 °F) | 2.0 k Ω | 0.819 V |
| **Operational Voltage Checks for EOT Sensor with Breakout Box** (Check with breakout box [X1 and X2 only] connected to the ECM and engine harness.) | | | |
| X2–1 to X1–6 | 0 °C (32 °F) | 91.1 kΩ | 4.348 V |
| X2–1 to X1–6 | 20 °C (68 °F) | 35.5 kΩ | 3.782 V |
| X2–1 to X1–6 | 100 °C (212 °F) | 2.0 kΩ | 0.819 V |
| **EOT Diagnostic Trouble Codes** | | | |
| DTC 311 = Signal voltage was < 0.2 V for more than 0.35 second | | | |
| DTC 312 = Signal voltage was > 4.78 V for more than 0.35 second | | | |

### EWPS (Engine Warning and Protection System)




**EWPS Diagnostic Trouble Codes**

313 Engine oil pressure below warning level
314 Engine oil pressure below critical level
315 Engine speed above warning level
316 Engine coolant temperature unable to reach command set point
321 Engine coolant temperature above warning level
322 Engine coolant temperature above critical level
323 Engine coolant level below warning/critical level
325 Power reduced, matched to cooling system performance

H34009

**Figure 453 Function diagram for the EWPS**

**Function**

The EWPS safeguards the engine from undesirable operating conditions to prevent engine damage and to prolong engine life. When a warning condition is detected, the on-board electronics will illuminate the red ENGINE lamp.

When a critical engine condition is detected, the on-board electronics will shut the engine down if the protection feature has been enabled. The critical engine condition will be recorded by a logging feature that records the event in engine hours and odometer readings. After the engine has shutdown, the engine may be restarted for a thirty second run time.

There are four options of EWPS:

- Standard
- 2–way warning
- 3–way warning
- 3–way protection

**EWPS Operational Diagnostics**

The EWPS includes the following features:

**EWPS mode –** This parameter indicates to the on-board electronics the desired mode of operation for the engine warning and protection feature.

**Standard warning (rpm, ECT) –** Engine overspeed and overheat are provided as the default operating mode. No engine shutdown is available.

**2–way warning (rpm, ECT, EOP) –** Engine overspeed, overheat, and low oil pressure are monitored in the engine warning operating mode. No engine shutdown is available.

**3–way warning (rpm, ECT, EOP, ECL) –** Engine overspeed, overheat, low oil pressure, and low coolant level are monitored in the engine warning operating mode. No engine shutdown is available.

**3-way Protection (rpm, ECT, EOP, ECL) –** Engine overspeed, overheat, low oil pressure, and low coolant level are monitored in the engine protection operating mode. Engine shutdown is available when a critical engine condition is detected. Critical engine conditions include overheat, low oil pressure and low coolant level.

**ECT Warning Temperature –** This parameter indicates when an engine overheat condition warrants the red ENGINE lamp to be illuminated and the warning buzzer to be activated.

**ECT Critical Temperature –** This parameter indicates when an engine overheat condition warrants an engine shutdown. The event logging feature will log when this event has occurred in both engine hours and odometer readings.

**EOP RPM Boundary 1 –** This parameter indicates the rpm range that engine oil pressure level 1 is used for the loss of engine oil pressure detection.

**EOP RPM Boundary 2 –** This parameter indicates the rpm range that engine oil pressure level 2 is used for the loss of engine oil pressure detection.

**EOP RPM Boundary 3 –** This parameter indicates the rpm range that engine oil pressure level 3 is used for the loss of engine oil pressure detection.

**EOP Warning Level 1 –** This parameter indicates when a loss of engine oil pressure warrants the red ENGINE lamp to be illuminated and the warning buzzer to be activated.

**EOP Warning Level 2 –** This parameter indicates when a loss of engine oil pressure condition warrants the red ENGINE lamp to be illuminated and the warning buzzer to be activated.

**EOP Warning Level 3 –** This parameter indicates when a loss of engine oil pressure condition warrants the red ENGINE lamp to be illuminated and the warning buzzer to be activated.

**EOP Critical Level 1 –** This parameter indicates when a loss of engine oil pressure condition warrants an engine shutdown. The event logging feature will log when this event has occurred in both engine hours and odometer readings.

**EOP Critical Level 2 –** This parameter indicates when a loss of engine oil pressure condition warrants an engine shutdown. The event logging feature will log when this event has occurred in both engine hours and odometer readings.

**EOP Critical Level 3 –** This parameter indicates when a loss of engine oil pressure condition warrants an engine shutdown. The event logging feature will log when this event has occurred in both engine hours and odometer readings.

**EWPS Diagnostic Trouble Codes (DTCs)**

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

**DTC 323**
**ECT below warning/critical level**

- DTC 323 is set by the ECM when coolant is low. When the EWPS mode is 3-way protection and DTC 323 is active, the engine will shutdown. The ECM will log the engine hours and odometer reading at the time of occurrence. After the shutdown, the engine can be restarted for thirty seconds. When the coolant has returned to correct levels, DTC 323 will become inactive.

**NOTE:** If coolant level is correct, see "ECL Sensor" (page 386). An ECL signal shorted to ground can cause DTC 323.

**DTC 321**
**ECT above warning level**

- DTC 321 is set by the ECM when the engine coolant temperature is above 110 °C (230 °F). The ECM illuminates the red ENGINE lamp and sounds the audible alarm. When the temperature drops below 110 °C (230 °F) the DTC will become inactive. For diagnostics, see "Engine Symptoms Diagnostics" – Section 4 (page 101).
- For high altitude applications (103 kPa [15 psi] radiator cap), DTC 321 is set by the ECM when the engine coolant temperature is above 113 °C (235 °F). When the temperature drops below 113 °C (235 °F) the DTC will become inactive.

**DTC 322**
**ECT above critical level**

- DTC 322 is set by the ECM when the engine coolant temperature is above 112 °C (234 °F). The ECM illuminates the red ENGINE lamp and sounds the audible alarm. When the temperature drops below 112 °C (234 °F) the DTC will become inactive. For diagnostics, see "Engine Symptoms Diagnostics" – Section 4 (page 101).
- For high altitude applications (103 kPa [15 psi] radiator cap), DTC 321 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 325**
**Power reduced, matched to cooling system performance**

- DTC 325 is set by the ECM when the cooling system temperature exceeds 107 °C (225 °F). At this temperature the ECM will reduce the fuel delivered to the engine. When the temperature drops below 107 °C (225 °F) the DTC will become inactive and the engine will return to normal operation.

  For each Celsius degree of temperature the fuel will be reduced by 6 percent. For each Fahrenheit degree of temperature the fuel will be reduced by 3 percent. This reduces the heat produced by the engine and reduces the burden on the cooling system. The vehicle speed will also be reduced and allow the operator to downshift and increase the efficiency of the cooling system. As the temperature is reduced, the compensation level is reduced until the temperature drops below 107 °C (225 °F) and normal operation is resumed.

  For high altitude applications (103 kPa [15 psi] radiator cap), as the temperature is reduced, the compensation level is reduced until the temperature drops below 111 °C (232 °F) and normal operation is resumed.

  DTC 325 does not illuminate the ENGINE warning lamp.

**DTC 316**
**ECT unable to reach commanded set point**

**NOTE:** DTC 316 only indicates the engine has not been able to reach operating temperature. It does not indicate an electronic fault.

- DTC 316 is set if the engine does not reach operating temperature. DTC 316 will only be set with engines that have Cold Ambient Protection (CAP) strategy enabled. DTC 316 is set after the engine has run for more than 120 minutes and has not exceeded 66 °C (151 °F) for engine coolant temperature. DTC 316 can be cleared with the EST.

- DTC 316 can be set due to any of the following conditions:
  - Extended idle time
  - Cold ambient temperatures (may require use of winter front)
  - Thermostat stuck in open position
  - Incorrectly plumbed cooling system (thermostat bypassed)
  - Auxiliary heater cores cooling off engine (school bus application)
  - Fan clutch locked on

**DTC 313**
**EOP below warning level**

- DTC 313 is set by the ECM when the oil pressure has dropped below the warning level. The specification for the warning level is:
  - 34 kPa (5 psi) @ 700 rpm
  - 69 kPa (10 psi) @ 1400 rpm
  - 138 kPa (20 psi) @ 2000 rpm

  The ECM illuminates the red ENGINE lamp and sounds an audible alarm. For diagnostics, see “Engine Symptoms Diagnostics” – Section 4 (page 101).
- DTC 313 can be set due to a failed EOP sensor sending an incorrect signal. To confirm this, compare actual oil pressure to the reading on the data list of the EST. Low oil pressure due to inoperative mechanical components will also set DTC 313.

**DTC 314**
**EOP below critical level**

- DTC 314 is set by the ECM when the oil pressure has dropped below the critical level. The specification for the critical level is:
  - 14 kPa (2 psi) @ 700 rpm
  - 83 kPa (12 psi) @ 1400 rpm
  - 152 kPa (22 psi) @ 2000 rpm

  The ECM flashes the red ENGINE lamp and sounds an audible alarm. See “Engine Symptoms Diagnostics” – Section 4 (page 101).
- DTC 314 can be set due to a failed EOP sensor sending an incorrect signal. To confirm this, compare actual oil pressure to the reading on the data list of the EST. Low oil pressure due to inoperative mechanical components will also set DTC 313.

**DTC 315**
**Engine speed above warning level**

- DTC 315 is set by the ECM when the engine rpm has exceeded 3400 rpm.
- DTC 315 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 315 is active the amber ENGINE lamp is illuminated. The engine hours and miles of the last two over speed occurrences will be recorded in the engine event log.

**IAH System (Inlet Air Heater)**

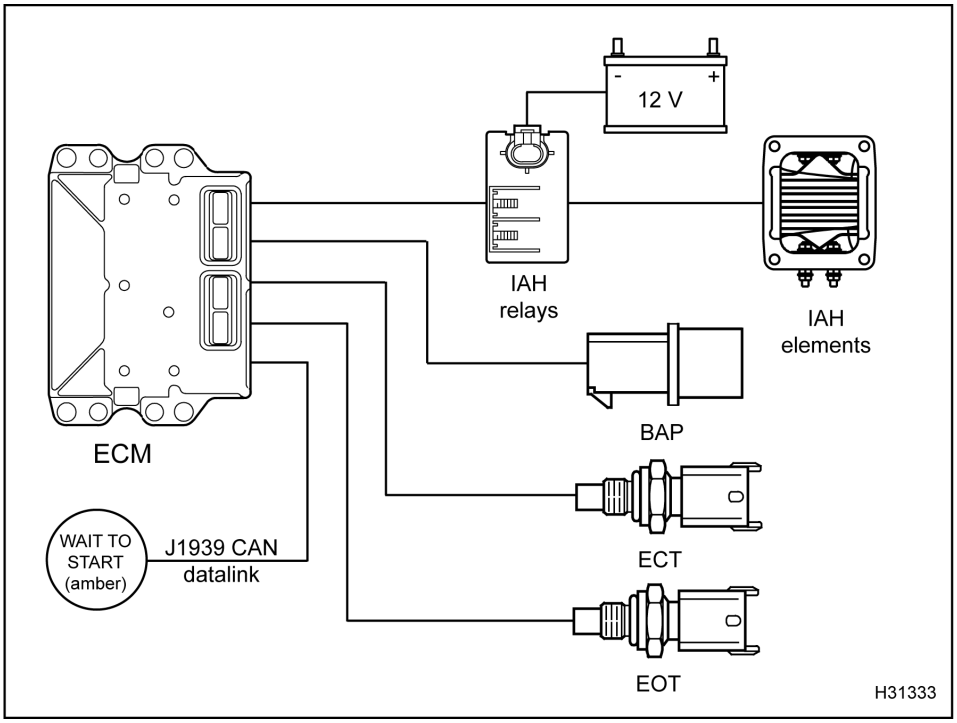



**Figure 454 Function diagram for the IAH system**

The function diagram for the IAH system includes the following:

- IAH relays
- IAH relay connectors
- IAH elements
- Electronic Control Module (ECM)
- Barometric Absolute Pressure (BAP) sensor
- Engine Coolant Temperature (ECT) sensor
- Engine Oil Temperature (EOT) sensor
- Battery
- WAIT TO START lamp (amber)

**Function**

The Inlet Air Heater (IAH) system warms the incoming air supply prior to cranking to aid cold engine starting and reduce white smoke during warm-up.

The ECM is programmed to energize the IAH elements through the IAH relays while monitoring certain programmed conditions for engine coolant temperature, engine oil temperature, and atmospheric pressure.

The ECM monitors battery voltage and uses readings from the ECT, EOT, and BAP sensor to determine the amount of time that the WAIT TO START lamp is on, as well as the activation of the IAH system. The WAIT TO START lamp indicates when the IAH relays are activated and the elements are heating. The IAH system on-time can vary between zero seconds to forty-five seconds, depending on the ECT, EOT, and BAP sensor readings.

IAH elements are activated for a longer time period if the engine is cold or the barometric pressure is low (high altitude).

The engine is ready to start when the WAIT TO START lamp is turned off by the ECM.

**NOTE:** The WAIT TO START lamp on-time is independent from the IAH system on-time.

### IAH Circuit Operation

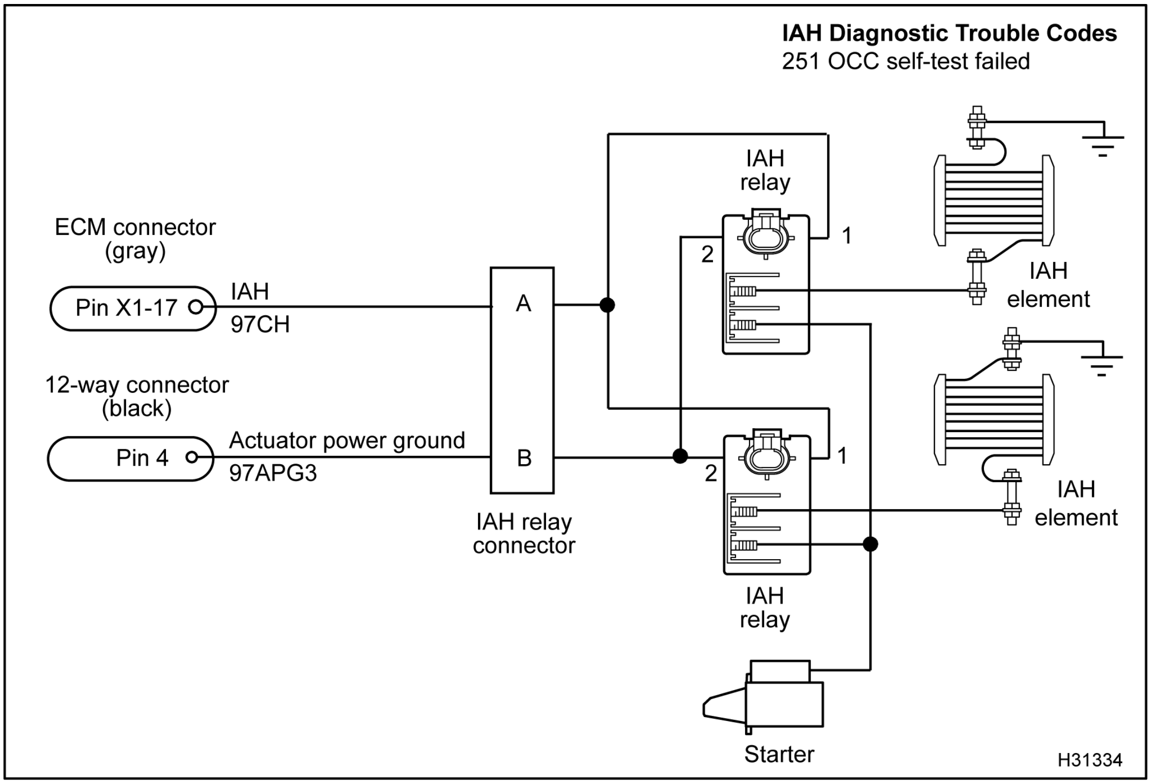



**Figure 455 IAH circuit diagram**

The IAH control system operation is dependent upon the ECT, EOT, BAP, and battery voltage. The IAH relays are activated by power supplied by the ECM through Pin X1–17 to circuit 97CH. The IAH relays are grounded through circuit 97APG3, Pin 4 on the 12-pin connector, and to negative battery terminal. Power is supplied to the switch side of the IAH relays from the starter motor. When the IAH relay is energized, power is supplied to the IAH elements that are grounded through the intake manifold.

The WAIT TO START lamp time is transmitted over the CAN 1 datalink. See truck *Chassis Electrical Circuit Diagram Manual* .

#### 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 will be set.

#### IAH Diagnostic Trouble Codes (DTCs)

#### DTC 251
#### IAH OCC self-test failed

- DTC 251 is set by the ECM when the OCC test has failed after the KOEO Standard Test has been run.
- DTC 251 can be set when a poor connection, an open or short to ground in the relay control circuit, or failed relay exists.

**NOTE:** For initial calibrations:

- If the system voltage is less than 13 volts, DTC 251 may become active.
- If the system is functioning properly, disregard DTC 251.

Later calibrations and current hardware levels do not support DTC 251.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- 12-pin Breakout Harness
- Breakout Box
- Amp Clamp

**IAH Pin-Point Diagnostics**

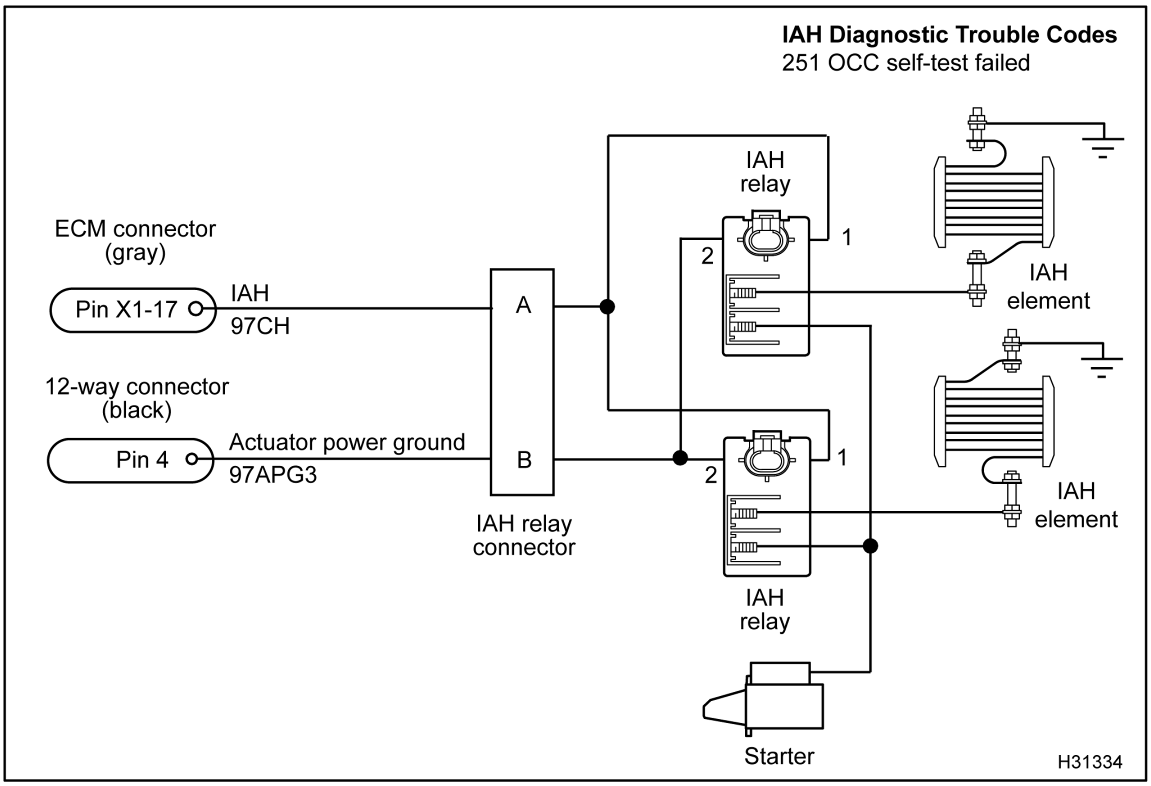



**Figure 456 IAH circuit diagram**

**Voltage Check at Element – Output State Test** (Turn the ignition switch to ON. Run Glowplug / Inlet Air Heater Output State Test. For help, see “Inlet Air Heater Output State Test” in Section 3 (page 68).)

| Test Point | Spec | Comment |
|---|---|---|
| Element terminal 1 to gnd | B+ | If < B+, check relay and circuit for element 1. Do Voltage Checks (page 467) and Harness Resistance Check (page 467).<br>If equal to B+, do Amperage Draw Check. |
| Element terminal 2 to gnd | B+ | If < B+, check relay and circuit for element 2. Do Voltage Checks (page 467) and Harness Resistance Check (page 467).<br>If equal to B+, do Amperage Draw Check. |

**NOTE:** When a single IAH circuit fails, suspect that circuit only. If both elements or circuits do not have voltage, verify the ECM programming. If the ECM programming is correct, do Actuator Voltage Checks at ECM (page 467) , Harness Resistance Checks – Relay to ECM (page 468), and Harness Resistance Check – Relay to 12–pin Connector (page 468).

**Amperage Draw Check** (Secure AMP Clamp around element feed wire. Turn the ignition switch to ON. Run Glowplug / Inlet Air Heater Output State Test. For help, see “Inlet Air Heater Output State Test” in Section 3 (page 68).)

| | | |
|---|---|---|
| Element 1 | 125 A ±30 A | If not within specification, do Element Continuity Check and Harness Resistance Checks (page 467). |
| Element 2 | 125 A ±30 A | If not within specification, do Element Continuity Check and Harness Resistance Checks (page 467). |

**Element Continuity Check** (Turn the ignition switch to OFF. Disconnect harness from element post. Inspect for corrosion.)

| | |
|---|---|
| Element terminal 1 to gnd | If continuity is not present, check element for carbon build-up, corrosion, or open circuit. |
| Element terminal 2 to gnd | If continuity is not present, check element for carbon build-up, corrosion, or open circuit. |

| | | |
|---|---|---|
| **Harness Resistance Check – Element to Relay** (Turn the ignition switch to OFF. Disconnect harness from element terminal. Check for corrosion. Trace wiring harness from element to IAH relay. Ensure the correct relay terminal is being tested.) | | |
| Element terminal 1 to relay output terminal 1 | < 5 Ω | If > 5 Ω, check for a corroded terminal or an open circuit. |
| Element terminal 2 to relay output terminal 2 | < 5 Ω | If > 5 Ω, check for a corroded terminal or an open circuit. |
| **Voltage Check at Relays – Battery Feed Wires (Starter)** | | |
| Relay 1: Battery feed terminal to gnd | B+ | If < B+, check for dead battery, open in IAH harness, or open in truck battery harness. |
| Relay 2: Battery feed terminal to gnd | B+ | If < B+, check for dead battery, open in IAH harness, or open in truck battery harness. |
| **Voltage Check at Relays – Output (Output State Test)** (Turn the ignition switch to ON. Run Glowplug / Inlet Air Heater Output State Test. For help, see “Inlet Air Heater Output State Test” in Section 3 (page 68).) | | |
| Relay 1: Relay output post to gnd | B+ | If < B+, check for dead battery, open IAH harness, open in truck battery harness, faulty IAH relay, ECM for IAH programming, or open relay control circuit from ECM. |
| Relay 2: Relay output post to gnd | B+ | If < B+, check for dead battery, open IAH harness, open in truck battery harness, faulty IAH relay, ECM for IAH programming, or open relay control circuit from ECM. |
| **Actuator Control Voltage Check at Relay Connection** (Disconnect control wiring from relay. Turn the ignition switch ON. Run the Glow Plug / Air Heater Output State Test. For help, see “Inlet Air Heater Output State Test” in Section 3 (page 68).) | | |
| Element 1: A to gnd | B+ | If < B+, do Actuator Control Voltage Check at ECM (page 467). |
| Element 1: A to B | B+ | If < B+, do Harness Resistance Check – Relay to 12-pin Connector. (page 468). |
| Element 2: A to gnd | B+ | If < B+, do Actuator Control Voltage Check at ECM (page 467). |
| Element 2: A to B | B+ | If < B+, do Harness Resistance Check – Relay to 12-pin Connector. (page 468). |
| **NOTE:** If both relays are < B+, check wiring back to the ECM and 12-pin connector. Verify ECM programming. The Glowplug / IAH parameter should be option 2 (IAH). | | |
| **Actuator Control Voltage Check at ECM** (Connect breakout box [X1 only] to ECM. Turn the ignition switch to on. Run the Glow Plug / Inlet Air Heater Output State Test. For help, see “Inlet Air Heater Output State Test” in Section 3 (page 68).) | | |
| Output State Test High | | |
| X1–17 to gnd | B+ | If < B+, and ECM is programmed correctly, replace the ECM. |
| Output State Test Low | | |
| X1–17 to gnd | 0 V | If > 0.25 V, and ECM is programmed correctly, replace the ECM. |

**Harness Resistance Check – Relay to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect control wiring from relay.)

| | | |
|---|---|---|
| Relay 1: A to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |
| Relay 1: B to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open circuit. Specification is based on 4300 chassis. For other applications, see *Chassis Electrical Circuit Diagram Manual* for complete chassis ground circuit information. |
| Relay 2: A to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |
| Relay 2: B to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open circuit. Specification is based on 4300 chassis. For other applications, see *Chassis Electrical Circuit Diagram Manual* for complete chassis ground circuit information. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Harness Resistance Check – Relay to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect control wiring from relay. Use disconnected negative battery cable for ground test point.)

| | | |
|---|---|---|
| Relay 1: A to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| Relay 1: B to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. Specification is based on 4300 chassis. For other applications, see *Chassis Electrical Circuit Diagram Manual* for complete chassis ground circuit information. |
| Relay 2: A to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| Relay 2: B to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. Specification is based on 4300 chassis. For other applications, see *Chassis Electrical Circuit Diagram Manual* for complete chassis ground circuit information. |

**Harness Resistance Check – Relay to ECM** (Turn the ignition switch to OFF. Connect breakout box [X1 only] to engine harness.)

| | | |
|---|---|---|
| Relay 1: Pin A to X1–17 | < 5 Ω | If > 5 Ω, check for open in circuit. |
| Relay 2: Pin A to X1–17 | < 5 Ω | If > 5 Ω, check for open in circuit. |

**Harness Resistance Check – Relay to 12–pin Connector** (Turn the ignition switch to OFF. Connect 12–pin breakout harness to engine harness only.)

| | | |
|---|---|---|
| Relay 1: Pin B to Pin 4 (12-pin) | < 5 Ω | If > 5 Ω, check for open in control wire. |
| Relay 2: Pin B to Pin 4 (12-pin) | < 5 Ω | If > 5 Ω, check for open in control wire. |

**IAH Diagnostic Trouble Codes (DTCs)**

DTC 251 = OCC self-test failed

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. Refer to truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

**IAT Sensor (Intake Air Temperature)**

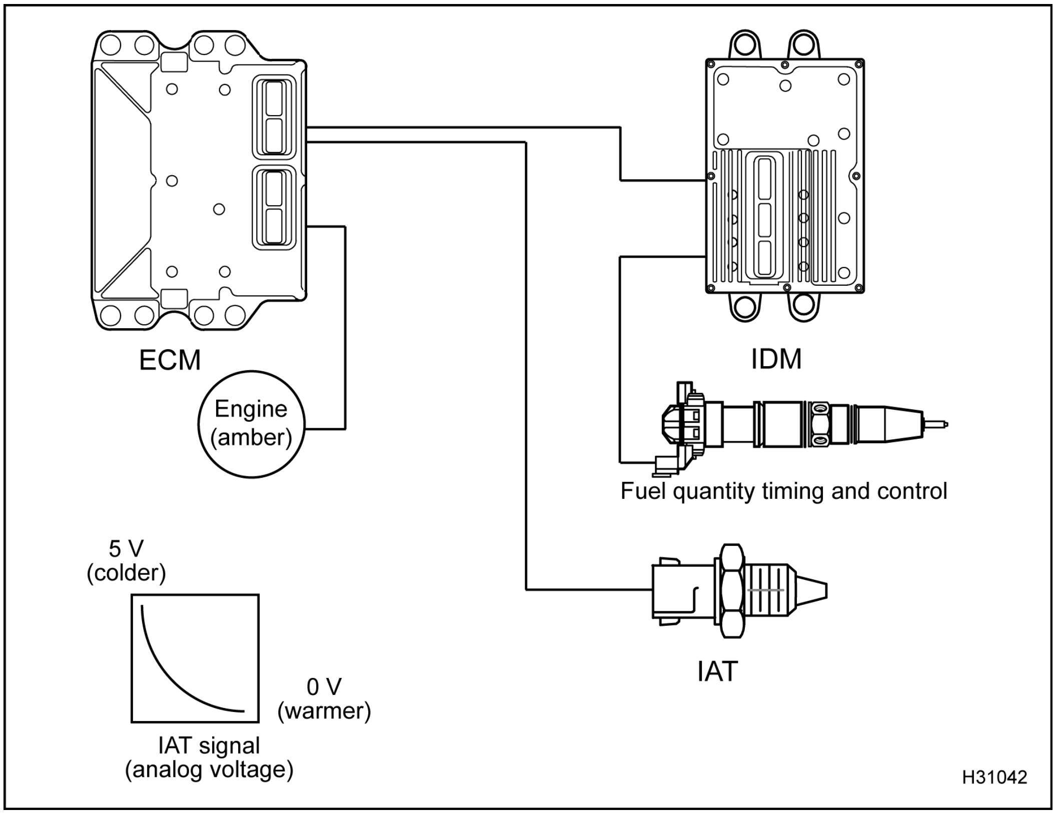



**Figure 457 Function diagram for the IAT sensor**

The function diagram for the IAT sensor includes the following:

- IAT sensor
- Electronic Control Module (ECM)
- Fuel injector
- ENGINE lamp (amber)

### Function

The Intake Air Temperature (IAT) sensor is a thermistor sensor that is chassis mounted on the air filter housing. The ECM supplies a 5 V reference signal which the IAT sensor uses to produce an analog voltage that indicates the intake air temperature. The IAT sensor changes resistance when exposed to different temperatures. As air temperature decreases, the resistance of the thermistor increases. This causes the signal voltage to increase. As air temperature increases, the resistance of the thermistor decreases. This causes the signal voltage to decrease.

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 continuous monitoring by the IAT sensor limits smoke emissions.

### IAT Circuit Operation

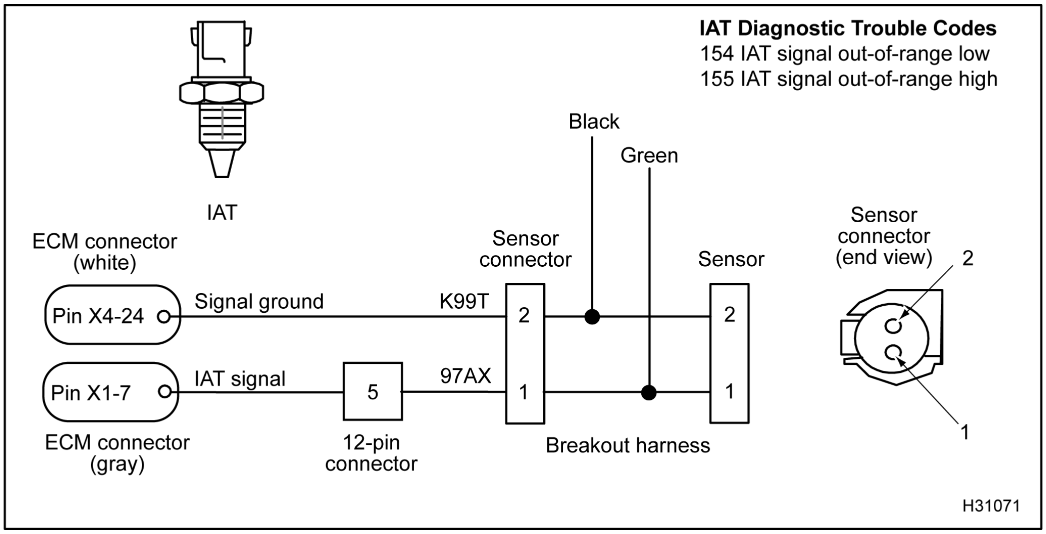



**Figure 458 IAT circuit diagram**

The IAT sensor is supplied with a 5 V reference signal at Pin 1 through 12–pin connector (Pin 5) from ECM Pin X1–7. The sensor is grounded at Pin 2 through the signal ground at ECM Pin X4–24. As the air temperature increases or decreases, the sensor changes resistance and provides the air temperature signal voltage at the ECM. The signal voltage is monitored by the ECM to determine the intake air temperature.

#### Fault Detection / Management

When the ECM detects an IAT signal out of range high or low, the ECM will ignore the IAT signal and assume an ambient temperature of 25 °C (77 °F).

#### IAT Diagnostic Trouble Codes (DTCs)

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp on the vehicle dash.

#### DTC 154
#### IAT signal out-of-range low

- DTC 154 is set by the ECM if signal voltage is less than 0.127 V for more than 0.35 second.
- DTC 154 can be set due to a short to ground in the signal circuit or a failed IAT sensor.
- When DTC 154 is active, the amber ENGINE lamp is illuminated.

#### DTC 155
#### IAT signal out-of-range high

- DTC 155 is set by the ECM if signal voltage is more than 4.6 V for more than 0.35 second.
- DTC 155 can set due to an open signal or ground circuit, a short to a voltage source, or a failed IAT sensor.
- When DTC 155 is active, the amber ENGINE lamp is illuminated.

#### Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 500 Ohm Resistor Harness
- Breakout Box
- Breakout Harness
- Terminal Test Adapter Kit

### IAT Operational Diagnostics

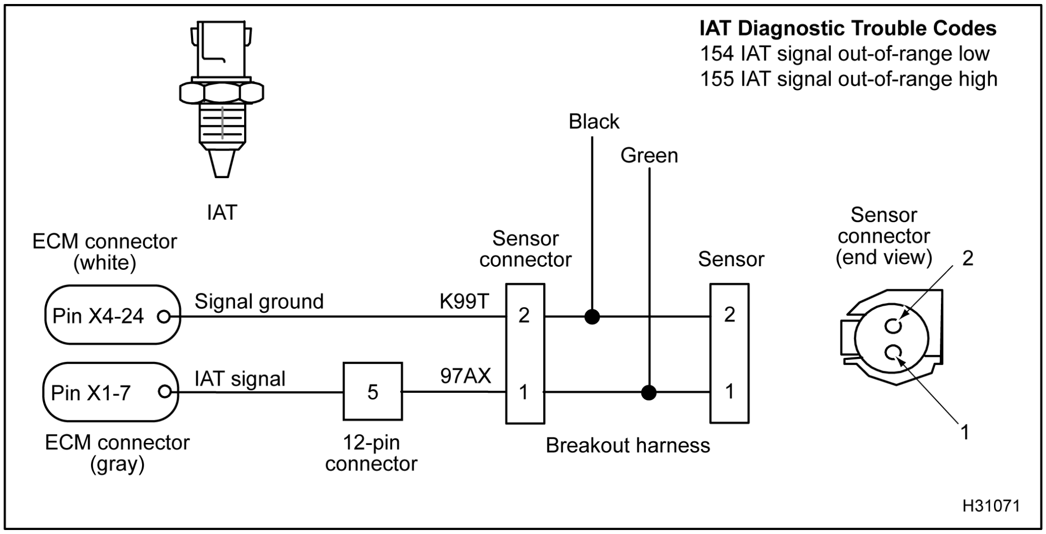



**Figure 459 IAT circuit diagram**

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:**

**Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.**

1. Using EST, open the D_ContinuousMonitor.ssn.

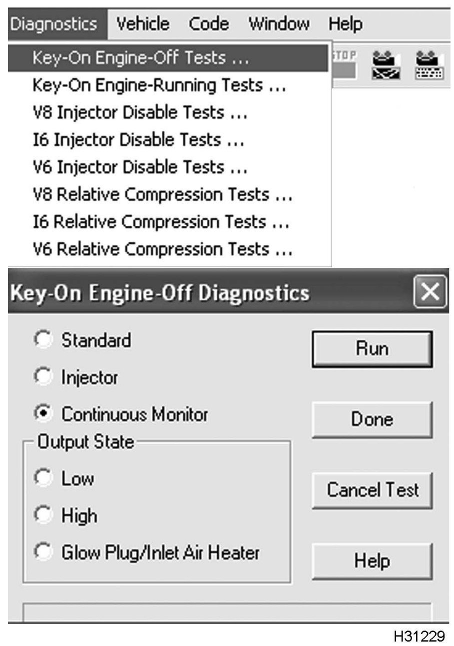



**Figure 460 Continuous Monitor Test**

2. To monitor signal voltage, run KOEO Continuous Monitor Test. For help, see “Continuous Monitor Test” in Section 3 (page 68).
3. Monitor IAT signal voltage. Verify an active DTC for the IAT circuit.

4. If code is active, do step 6 and 7 to check circuit for the IAT sensor using the following table.
   - Circuit Checks for IAT Sensor
5. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will display DTCs related to the condition.
6. Disconnect chassis harness from temperature sensor.

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

7. Connect Temperature Sensor Breakout Harness to engine harness only.

**Circuit Checks for IAT Sensor** (Use EST, breakout harness, 3-Banana Plug Harness, and 500 Ohm Resistor Harness.)

| Test Condition | Spec | Checks |
|---|---|---|
| Sensor disconnected | > 4.6 V | If voltage < 4.6 V, check signal circuit for short to ground. |
| 3-Banana Plug Harness connected between Pin 1 (Green) and Pin 2 (Black) of breakout harness | 0 V | If voltage is > 0.127 V, check ground and signal circuit for open or high resistance. Use a breakout box and measure resistance from Pin 2 to Pin X4–24 and from Pin 1 to X1–7 (spec < 5 Ω). |
| 500 Ohm Resistor Harness connected between Pin 1 (Green) and Pin 2 (Black) of breakout harness | < 1.0 V | If voltage > 1.0 V, check signal circuit for short to $V_{REF}$, B+, or another sensor's signal voltage. |

**Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the IAT sensor.**

### IAT Pin-Point Diagnostics

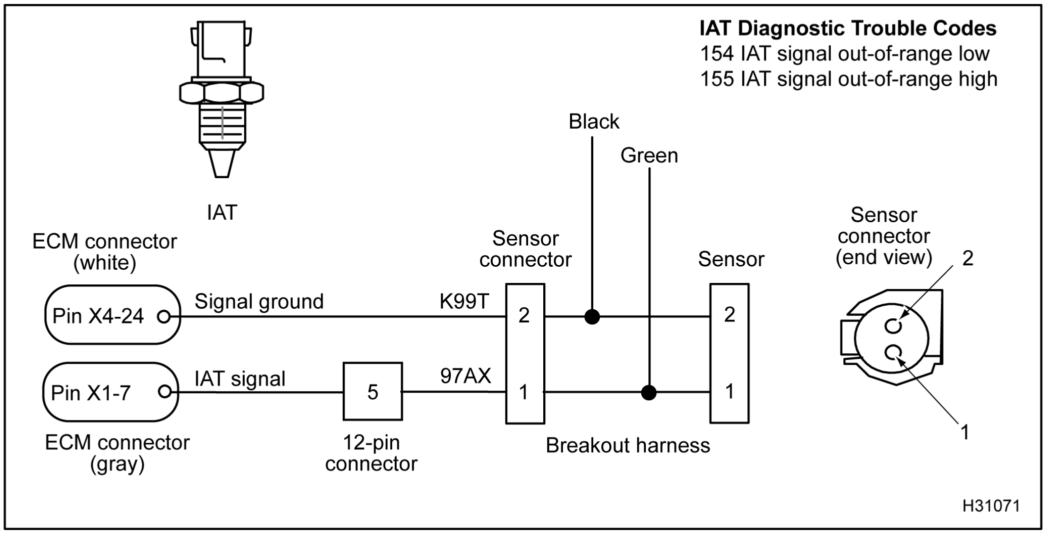



**Figure 461 IAT circuit diagram**

| Test Point | Spec | Comment |
|---|---|---|
| **Connector Voltage Checks to Ground** (Disconnect harness from sensor. Inspect for bent pins or corrosion. Connect breakout harness to engine harness only. Turn the ignition switch to ON.) | | |
| **Test Point** | **Spec** | **Comment** |
| 2 to gnd | 0 V to 0.25 V | Signal ground (No voltage expected). If > 0.25 V, signal wire is shorted to $V_{REF}$ or B+. |
| 1 to gnd | 4.6 V to 5.0 V | Pull up voltage, if no voltage, circuit has open, high resistance, or short to ground. |
| **Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect harness from sensor. Connect breakout harness to engine harness only. Disconnect chassis connector 9260[1].) | | |
| 2 to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open circuit. |
| 1 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

| | | |
|---|---|---|
| **Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Connect breakout harness to engine harness only. Use disconnected negative battery cable for ground test point.) | | |
| 2 to gnd cable | > 500 Ω | If < 500 Ω , check for short to ground. |
| 1 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| **Harness Resistance Checks** (Connect breakout box to engine harness [X1 only] and chassis harness [X4 only].) | | |
| X4–24 to 2 | < 5 Ω | If > 5 Ω, check for open ground wire. |
| X1–7 to 1 | < 5 Ω | If > 5 Ω, check for open signal wire. |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

| **Operational Voltage Checks for IAT Sensor with Breakout Harness** (Check with breakout harness connected to sensor and engine harness.) | | | |
|---|---|---|---|
| **Test Point** | **Temp** | **Resistance** | **Voltage @ Resistance** |
| 2 (Black) to 1 (Green) | 0 °C (32 °F) | 91.1 kΩ | 3.846 V |
| 2 (Black) to 1 (Green) | 20 °C (68 °F) | 35.5 kΩ | 3.041 V |
| 2 (Black) to 1 (Green) | 100 °C (212 °F) | 2.0 kΩ | 0.446 V |
| **Operational Voltage Checks for IAT Sensor with Breakout Box** (Check with breakout box connected [X1 and X4 only] to the ECM and engine harness.) | | | |
| X4–24 to X1–7 | 0 °C (32 °F) | 91.1 kΩ | 3.846 V |
| X4–24 to X1–7 | 20 °C (68 °F) | 35.5 kΩ | 3.041 V |
| X4–24 to X1–7 | 100 °C (212 °F) | 2.0 kΩ | 0.446 V |
| **IAT Diagnostic Trouble Codes** | | | |
| DTC 154 = Signal voltage was < 0.127 V for more than 0.35 second | | | |
| DTC 155 = Signal voltage was > 4.6 V for more than 0.35 second | | | |

**ICP Sensor (Injection Control Pressure)**

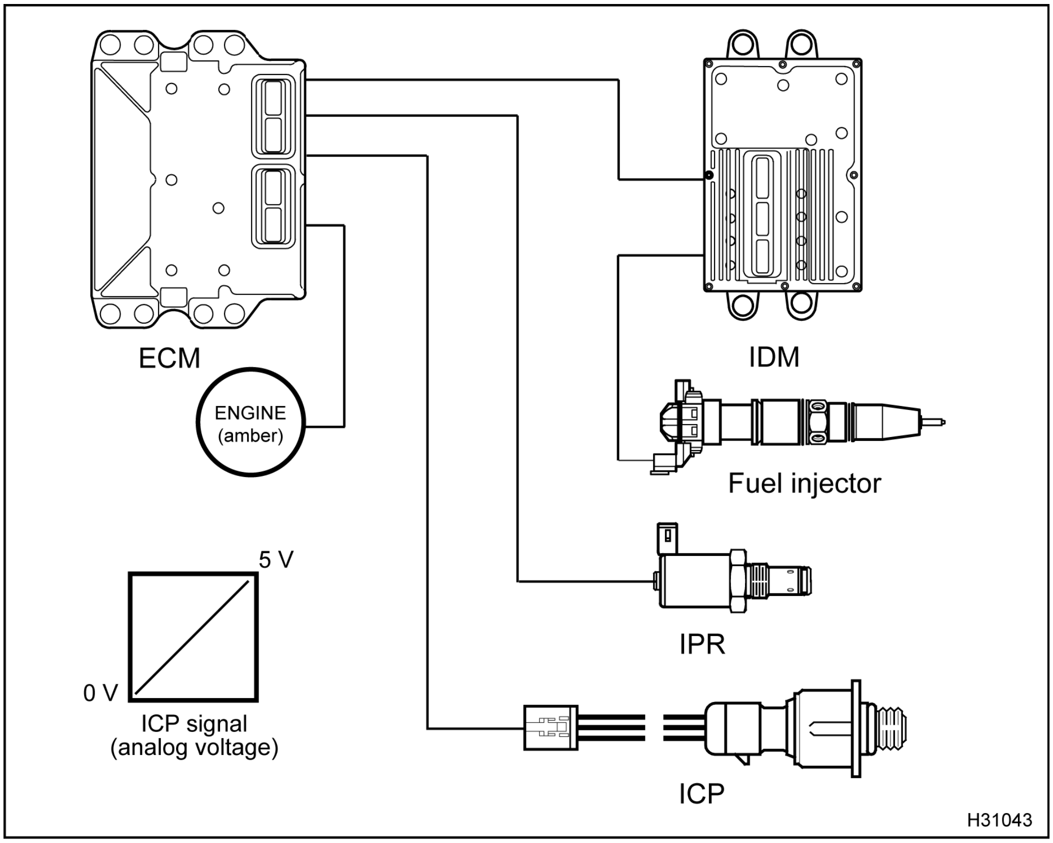



**Figure 462 Function diagram for the ICP sensor**

The function diagram for the ICP sensor includes the following:

- ICP sensor
- Electronic Control Module (ECM)
- Injector Drive Module (IDM)
- Fuel injector
- Injection Pressure Regulator (IPR)
- ENGINE lamp (amber)

**Function**

The ICP sensor is a Micro Strain Gauge (MSG) sensor. The ICP sensor is under the valve cover, forward of the No. 6 fuel injector in the high-pressure oil rail. The engine harness connection on the valve cover gasket for the ICP sensor is left of the No. 6 injector connector. The ECM supplies a 5 V reference signal which the ICP sensor uses to produce a linear analog voltage that indicates pressure.

The ICP sensor provides a feedback signal to the ECM indicating injection control pressure. The ECM monitors ICP as the engine is operating to modulate the IPR. This is a closed loop function which means the ECM continuously monitors and adjusts for ideal ICP determined by conditions such as load, speed, and temperature.

The ECM monitors the ICP signal to determine if the performance of the hydraulic system is satisfactory. During engine operation, if the ECM recognizes that the ICP signal is greater or less than the value that the IPR is trying to achieve the ECM will set a DTC and illuminate the amber ENGINE lamp.

The ICP signal from the ECM is one of the signals the IDM uses to command the correct injector timing.

### ICP Circuit Operation

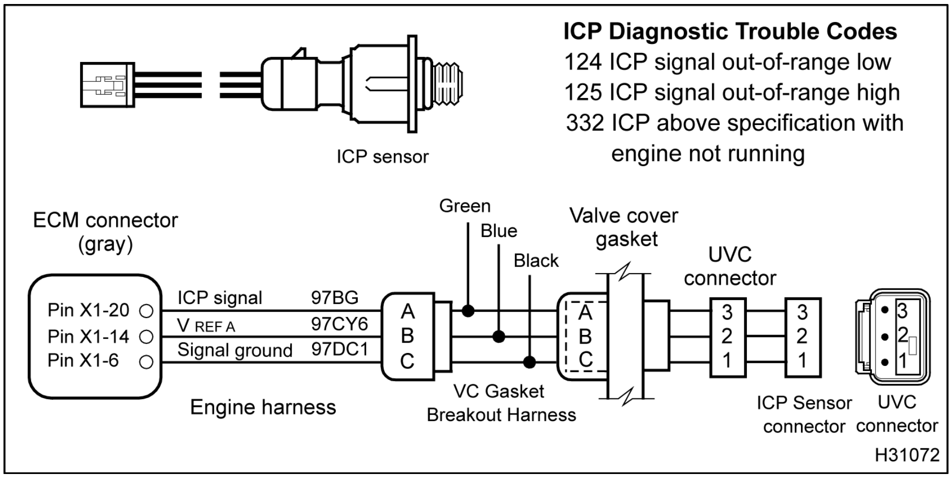



**Figure 463 ICP circuit diagram**

The ICP sensor is supplied a 5 V reference signal at Pin 2 through valve cover gasket Pin B from ECM Pin X1–14. The ICP sensor is supplied a signal ground at Pin 1 through valve cover gasket Pin C from ECM Pin X1–6. The ECM monitors the ICP signal from sensor Pin 3 through valve cover gasket Pin A to ECM Pin X1–20.

#### Fault Detection / Management

The ECM continuously monitors the signal of the ICP sensor to determine if the signal is within an expected range. If the ECM detects a voltage greater or less than expected, the ECM will set a DTC, illuminate the amber ENGINE lamp, ignore the ICP sensor signal, and use a preset value based on engine operating conditions.

#### ICP Diagnostic Trouble Codes (DTCs)

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamps.

#### DTC 124
#### ICP signal out-of-range low

- DTC 124 is set by the ECM if signal voltage is less than 0.039 V for more than 0.1 second.
- DTC 124 can be set due to an open or short to ground on the signal circuit, a failed ICP sensor or an open $V_{REF}$ circuit or $V_{REF}$ short to ground.
- When DTC 124 is active the amber ENGINE lamp is illuminated.

#### DTC 125
#### ICP signal out-of-range high

- DTC 125 is set by the ECM if the signal voltage is greater than 4.9 V for more than 0.1 second.
- DTC 125 can be set due to a signal circuit shorted to $V_{REF}$ or B+, or a failed ICP sensor.
- When DTC 125 is active the amber ENGINE lamp is illuminated.

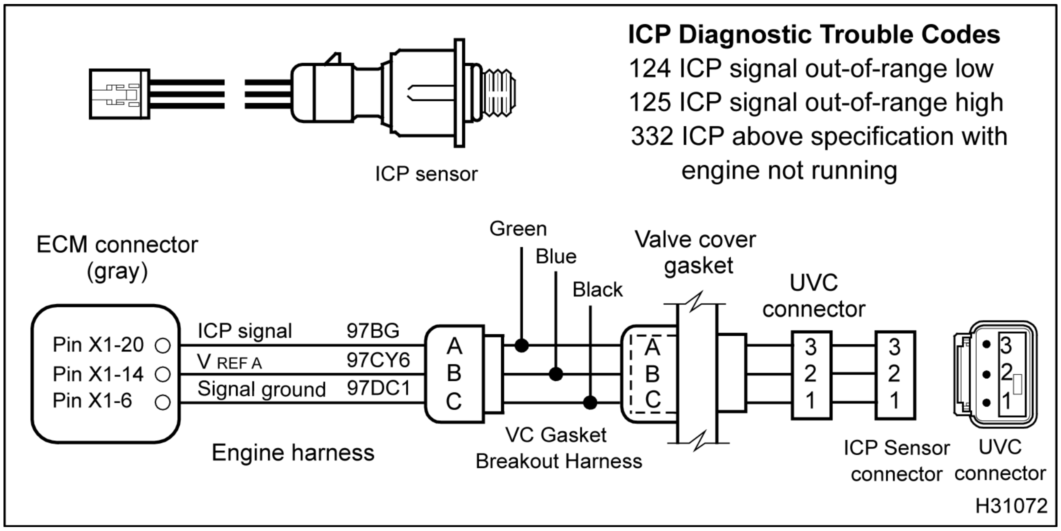
**DTC 332**
**ICP above specification with engine not running**

- DTC 332 is set by the ECM, if the voltage signal from the ICP sensor is greater than expected with the key-on engine-off. If the ECM sets DTC 332, the ECM will ignore the ICP signal and operate the IPR with fixed values based on engine operating conditions.
- DTC 332 can be caused by an open signal ground, $V_{REF}$ shorted to voltage source greater than 5.5 V, a biased circuit, a failed ICP sensor, or a momentary loss of either the CMP or CKP signal.
- When DTC 332 is active the amber ENGINE lamp is illuminated.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 500 Ohm Resistor Harness
- VC Gasket Breakout Harness
- UVC Pressure Breakout Harness
- Breakout Box
- Terminal Test Adapter Kit

### ICP Operational Diagnostics




> **WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:**
>
> **Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.**

1. Using EST, open the D_ContinuousMonitor.ssn.

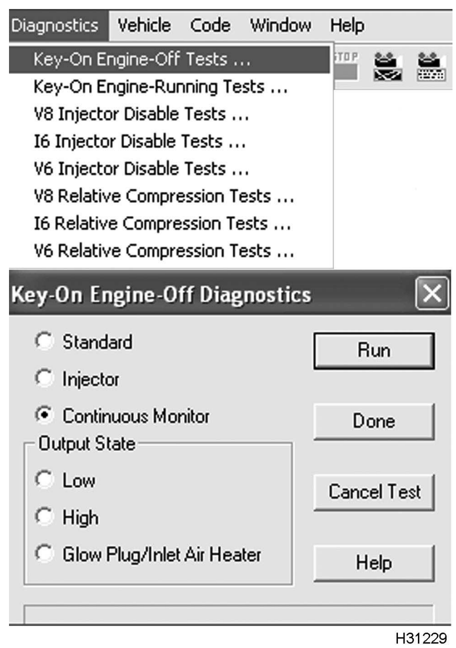



**Figure 465 Continuous Monitor Test**

2. To monitor signal voltage, run KOEO Continuous Monitor Test.
3. Monitor ICP signal voltage. Verify an active DTC for the ICP circuit.

4. If code is active, do step 6 and 7 to check circuit for the ICP sensor using the following tables.
   - Circuit Checks for ICP Sensor – ECM to Valve Cover Gasket Connector
   - Circuit Checks for ICP Sensor – ECM to ICP Sensor
5. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST display DTCs related to the condition.
6. Disconnect engine harness from valve cover gasket connector.

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

7. Connect VC Gasket Breakout Harness to engine harness only.

### ICP Operational Diagnostics

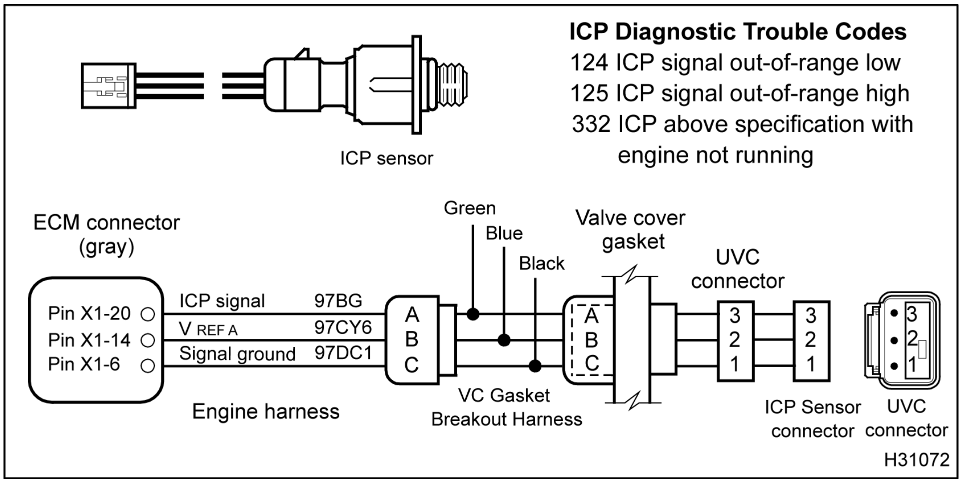



**Figure 466 ICP circuit diagram with VC Gasket Breakout Harness**

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Circuit Checks for ICP – ECM to Valve Cover Connector** (Use EST, DMM, 500 Ohm Resistor Harness, and VC Gasket Breakout Harness connected to engine harness only.)

| Test Condition | Spec | Checks |
|---|---|---|
| Harness disconnected from valve cover gasket connector using EST | 0 V | If voltage > 0.039 V, check ICP signal for short to $V_{REF}$ or B+. |
| Voltage from Pin B (Blue) of VC Gasket Breakout Harness to ground using DMM | 5 V ±0.5 V | If voltage > 5.5 V, check $V_{REF}$ for short to B+. If voltage is < 4.5 V, check $V_{REF}$ for open or short to ground. |
| 500 Ohm Resistor Harness connected between Pin A (Green) and Pin B (Blue) of VC Gasket Breakout Harness using EST | 5 V | If voltage < 4.9 V, check ICP signal for open or short to ground.<br>— Disconnect connector 9260[1]. Measure resistance from Pin A to Pin A of connector 9260 (spec > 1 kΩ) to check for short to ground within wiring harness.<br>— Disconnect negative battery cable. Measure resistance from Pin A (spec > 1 kΩ) to ground cable to check for short to ground.<br>— Use a breakout box to measure resistance from X1-20 to Pin A (spec < 5 Ω) to check for open circuit. |
| Resistance from Pin C (Black) of VC Gasket Breakout Harness to ECM chassis ground (Pin A of connector 9260) using DMM. | < 5 Ω | If resistance is > 5 Ω, check for open or high resistance between ECM and VC Gasket Breakout Harness connector. Use a breakout box to measure resistance from X1-6 to Pin C (spec < 5 Ω). |

Connect engine harness to valve cover gasket connector. Use the EST to clear DTCs. If test results are to spec for all test conditions, but an active code remains, remove valve cover and check between valve cover gasket connector and ICP sensor. (See Circuit Checks for ICP Sensor – ECM to ICP Sensor.)

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

### ICP Operational Diagnostics

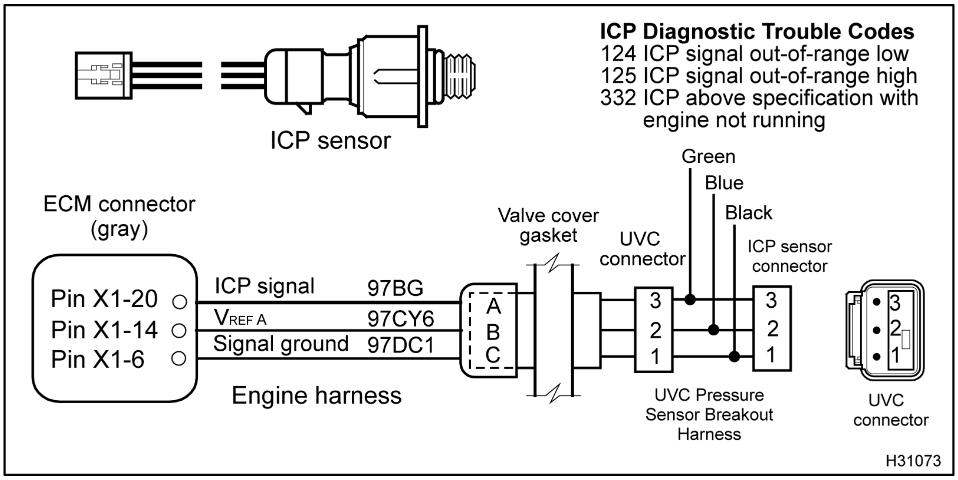



**Figure 467 ICP circuit diagram with UVC Pressure Sensor Breakout Harness**

**Circuit Checks for ICP Sensor – ECM to ICP Sensor** (If Circuit Checks for ICP Sensor – ECM to Valve Cover Gasket Connector are complete and test results are to specification for all test conditions, but an active code remains, remove valve cover following procedure in the *Engine Service Manual*. Use EST, DMM, 500 Ohm Resistor Harness, and UVC Pressure Sensor Breakout Harness to UVC connector only.)

| Test Condition | Spec | Checks |
|---|---|---|
| ICP sensor connector removed from UVC connector using EST | 0 V | If voltage > 0.039 V, check ICP signal for short to $V_{REF}$ or B+. |
| Voltage from Pin 2 (Blue) of UVC Pressure Sensor Breakout Harness to ground using DMM. | 5 V ± 0.5 V | If voltage > 5.5 V, check $V_{REF}$ for short to B+. If voltage is < 4.5 V, check $V_{REF}$ for open or short to ground. |
| 500 Ohm Resistor Harness connected between Pin 3 (Green) and Pin 2 (Blue) of UVC Pressure Sensor Breakout Harness using EST | 5 V | If voltage < 4.9 V, check ICP signal for open or short to ground.<br>— Disconnect connector 9260[1]. Measure resistance from Pin 3 to Pin A of connector 9260 (spec > 1 kΩ) to check for short to ground within wiring harness.<br>— Disconnect negative battery cable. Measure resistance from Pin A to ground cable to check for short to ground.<br>— Use a breakout box to measure resistance from X1-20 to Pin 3 (spec < 5 Ω) to check for open circuit. |
| Resistance from Pin 1 (Black) of UVC Pressure Sensor Breakout Harness to ECM chassis ground ECM chassis ground (Pin A of connector 9260) using DMM using DMM. | < 5 Ω | If resistance is > 5 Ω, check for open or high resistance between ECM and UVC connector. Use a breakout box to measure resistance from X1-6 to Pin 1 (spec < 5 Ω). |

Connect ICP sensor to UVC connection. Use the EST to clear DTCs. If test results are to spec for all test conditions, but an active code remains, replace sensor.

**NOTE:** If all tests are to specification, but DTCs return after valve cover is torqued down, replace the valve cover gasket.

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

### ICP Pin-Point Diagnostics (ECM to valve cover gasket connector)

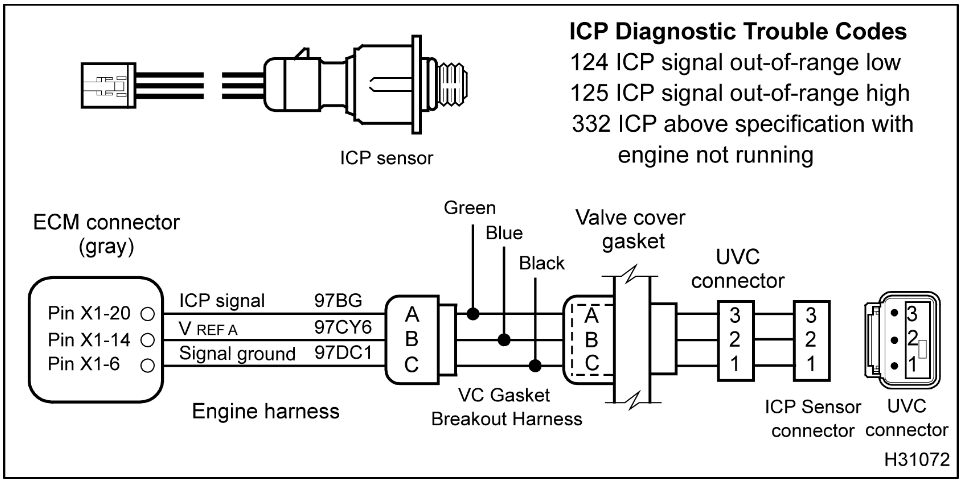



**Figure 468 ICP circuit diagram with VC Gasket Breakout Harness**

| Test Point | Spec | Comment |
|---|---|---|
| **Connector Voltage Checks to Ground** (Disconnect engine harness from valve cover gasket connector and connect VC Gasket Breakout Harness to engine harness only. Turn the ignition switch to ON.) | | |
| **Test Point** | **Spec** | **Comment** |
| A to gnd | 0 to 0.25 V | If > 0.25 V, signal circuit is shorted to $V_{REF}$ or B+. |
| B to gnd | 5 V ± 0.5 V | If voltage is not to spec, $V_{REF}$ is shorted to ground, shorted to B+, or open. |
| C to gnd | 0 V to 0.25 V | Signal ground (no voltage expected). If > 0.25 V, check ground circuit for open or high resistance and check signal ground for short to $V_{REF}$ or B+. |
| **Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect harness from valve cover gasket connector. Connect VC Gasket Breakout Harness to engine harness only. Disconnect chassis connector 9260[1].) | | |
| A to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |
| B to Pin A (9260) | > 500 Ω | If < 500 Ω, check for short to ground within wiring harness. |
| C to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open circuit. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

| Test Point | Spec | Comment |
|---|---|---|
| **Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.) | | |
| A to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| B to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| C to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| **Harness Resistance Checks** (Connect breakout box [X1] to engine harness only. Connect VC Gasket Breakout Harness to engine harness only.) | | |
| X1–20 to A | < 5 Ω | If > 5 Ω, check for open ICP signal. |
| X1–14 to B | < 5 Ω | If > 5 Ω, check for open $V_{REF}$. |
| X1–6 to C | < 5 Ω | If > 5 Ω, check for open ground. |

1 Connector 9260 is a 2-wire connector usually in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

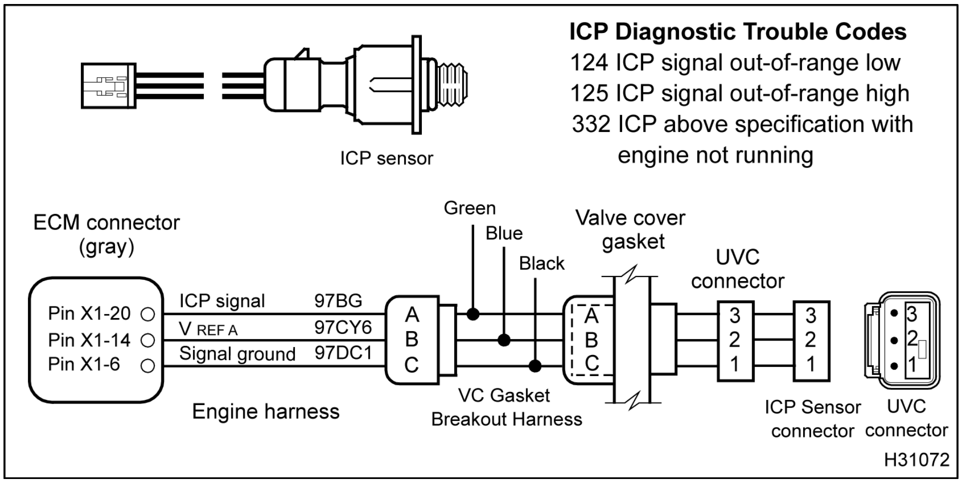



**Figure 469 ICP circuit diagram with VC Gasket Breakout Harness**

**Operational Voltage Checks for ICP Sensor with VC Gasket Breakout Harness** (These checks are done if an EST is not available and the valve cover is not removed. Check with VC Gasket Breakout Harness connected to valve cover gasket connector and engine harness.)

| Test Point | EST voltage readings: Signal to ground | Spec | Checks |
|---|---|---|---|
| A to C | 0.15 V to 0.3 V | 0 kPa (0 psi) | Atmospheric pressure with key-on engine-off |
| A to C | See Performance Specifications. | | Minimum at engine cranking speed |
| A to C | See Performance Specifications. | | Low idle, no load |
| A to C | See Performance Specifications. | | High idle, no load |
| A to C | See Performance Specifications. | | Rated speed, full load |

**Operational Voltage Checks for ICP Sensor with Breakout Box** (Check with breakout box [X-1] connected to ECM and engine harness.)

| | | | |
|---|---|---|---|
| X1–20 to X1–6 | 0.15 V to 0.3 V | 0 kPa (0 psi) | Atmospheric pressure with key-on engine-off |
| X1–20 to X1–6 | See Performance Specifications. | | Minimum at engine cranking speed |
| X1–20 to X1–6 | See Performance Specifications. | | Low idle, no load |
| X1–20 to X1–6 | See Performance Specifications. | | High idle, no load |
| X1–20 to X1–6 | See Performance Specifications. | | Rated speed, full load |

**ICP Diagnostic Trouble Codes**

DTC 124 = Signal voltage was < 0.039 V for more than 0.1 second

DTC 125 = Signal voltage was > 4.9 V for more than 0.1 second

DTC 332 = Signal voltage was > 1.625 V, key-on engine-off 7.99 kPa (1160 psi)

### ICP Pin-Point Diagnostics (ECM to ICP Sensor– valve cover removed)

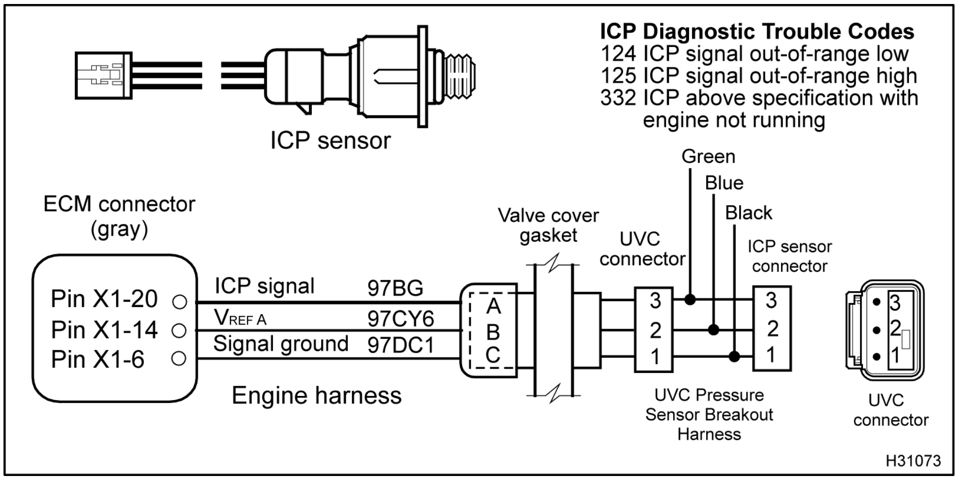



**Figure 470 ICP circuit diagram with UVC Pressure Sensor Breakout Harness**

| | | |
|---|---|---|
| **Connector Voltage Checks to Ground with Valve Cover Removed** (Disconnect sensor from UVC connector and connect UVC Pressure Sensor Breakout Harness to UVC connector only. Turn the ignition switch to ON.) | | |
| **Test Point** | **Spec** | **Comment** |
| 1 to gnd | 0 V to 0.25 V | Signal ground (no voltage expected). If > 0.25 V, check ground circuit for open or high resistance and check for short to $V_{REF}$ or B+. |
| 2 to gnd | 5 V ± 0.5 V | If voltage is not to spec, $V_{REF}$ circuit is shorted to ground, shorted to B+, or open. |
| 3 to gnd | 0 V to 0.25 V | If voltage > 0.25 V, signal circuit is shorted to $V_{REF}$ or B+. |
| **Connector Resistance Checks to ECM Chassis Ground with Valve Cover Removed** (Turn the ignition switch to OFF. Disconnect sensor from UVC connector. Disconnect chassis connector 9260[1]. Connect UVC Pressure Sensor Breakout Harness to UVC connector only.) | | |
| 1 to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open circuit. |
| 2 to Pin A (9260) | > 500 Ω | If < 500 Ω, check for short to ground within wiring harness. |
| 3 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

| | | |
|---|---|---|
| **Connector Resistance Checks to Chassis Ground with Valve Cover Removed** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.) | | |
| 1 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| 2 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| 3 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| **Harness Resistance Checks With Valve Cover Removed** (Connect breakout box [X1] to engine harness only. Connect UVC Pressure Sensor Breakout Harness to UVC connector only.) | | |
| X1–6 to 1 | < 5 Ω | If > 5 Ω, check for open ground. |
| X1–14 to 2 | < 5 Ω | If > 5 Ω, check for open $V_{REF}$. |
| X1–20 to 3 | < 5 Ω | If > 5 Ω, check for open ICP signal. |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

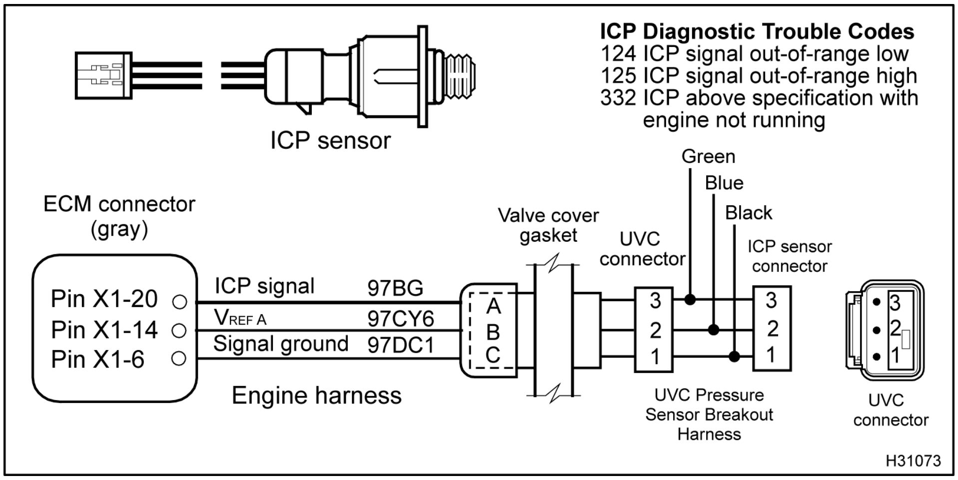



**Figure 471 ICP circuit diagram with UVC Pressure Sensor Breakout Harness**

**Operational Voltage Checks for ICP Sensor with UVC Pressure Sensor Breakout Harness** (Check with UVC Pressure Sensor Breakout Harness connected to UVC connector and sensor.)

**NOTE:** These check are done only if an EST is not available. Do not use this method to measure ICP while the engine is running.

| Test Point | EST voltage readings: Signal to ground | Spec | Checks |
|---|---|---|---|
| 3 to 1 | 0.15 V to 0.3 V | 0 psi (0 kPa) | Atmospheric pressure with key-on engine-off |
| 3 to 1 | See Performance Specifications. | | Minimum at engine cranking speed |

**ICP Diagnostic Trouble Codes**

DTC 124 = Signal voltage was < 0.039 V for more than 0.1 second

DTC 125 = Signal voltage was > 4.9 V for more than 0.1 second

DTC 332 = Signal voltage was > 1.625 V, key-on engine-off 7.99 kPa (1160 psi)

### ICP System (Injection Control Pressure)

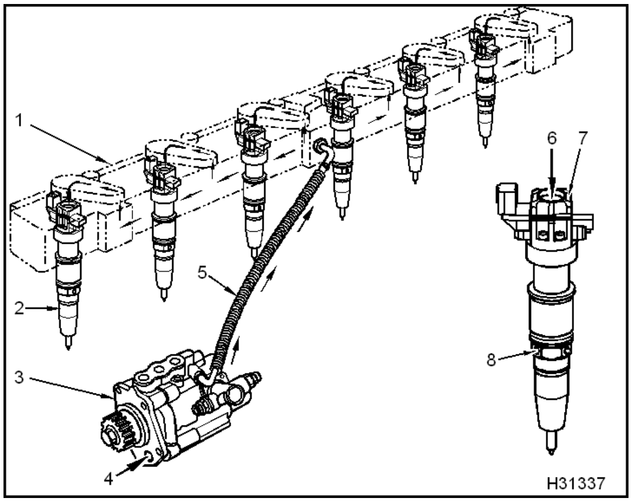



**Figure 472 Function diagram for the ICP system**

1. High-pressure oil manifold assembly
2. Fuel injector
3. High-pressure pump assembly
4. Oil inlet (lube oil)
5. High-pressure oil hose
6. High-pressure oil inlet (injector)
7. Oil exhaust port (2)
8. Fuel inlet (4)

The ICP system additionally consists of the following subsystems and components:

- Electronic Control Module (ECM)
- Injection Pressure Regulator (IPR)
- Injection Control Pressure (ICP) sensor
- Engine lubrication system
- Cylinder head passage
- High-pressure hydraulic pump
- High-pressure oil hose
- Associated wiring
- Diamond Logic® engine brake (optional)

### Function

The function of the ICP system is to develop, maintain, and control the high-pressure injection control pressure to provide the force to actuate the injectors and provide fuel to the engine.

### ICP System Operation

### Fault Detection / Management

The Diagnostic Trouble Codes (DTCs) associated with this system may indicate an electrical or electronic control system failure, but **will most likely indicate a mechanical or hydraulic problem with the ICP system.**

The ECM continuously monitors the ICP in the system to assure the control system is providing the proper control pressure at all times. If the oil pressure feedback provided by the ICP sensor does not meet ECM desired values, the ECM will set a DTC, illuminate the amber engine lamp and control the operation of the ICP system by calculating the correct oil pressure for all engine operating conditions until the system is diagnosed and repaired.

The ECM monitors the injection control pressure developed while the engine is cranking. When pressure does not develop in an expected time frame, the ECM will set a DTC. The DTC will aid in identifying and diagnosing the hard start and no start condition.

The EST 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 and evaluates system performance. When the test concludes, if a performance issue has been detected, the ECM will set a DTC for that system condition.

When an ICP fault is detected, the ECM will default to open loop of IPR control and the Electronic Service Tool (EST) will display N/A on ICP data. ICP desired will indicate default pressure.

### ICP System Diagnostic Trouble Codes (DTCs)

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

**NOTE:** Repair all injector, sensor, and actuator DTCs before doing ICP diagnostic checks and tests. See "Injection Control Pressure (ICP) System Components and High-Pressure Oil Flow" – Section 1 (page 27) for additional information.

**NOTE:** Engine brake components need to be considered during ICP diagnostics. See "Injection Control Pressure (ICP) System Components and High-Pressure Oil Flow" – Section 1 (page 27) for additional information.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, when performing ICP system checks and tests – comply with the following:**

- **Read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.**
- **When running the engine in the service bay, make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.**
- **Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.**

**DTC 331 – ICP above system working range**

DTC 331 is set by the ECM when the injection control pressure is above normal working range of 30 MPa (4351 psi) for 1.5 seconds. DTC 331 can be an indicator of a problem in the mechanical injection control pressure system, wiring, or ICP sensor.

When DTC 331 is active, the ECM will ignore feedback from the ICP sensor and control the IPR valve from programmed default values. The amber ENGINE lamp will be illuminated when DTC 331 is active.

Possible causes for DTC 331 include the following:

- Debris in engine
- Incorrect grade of oil
- Inoperative, stuck or plugged inlet on the IPR valve
- IPR control wire shorted to ground
- ICP sensor or circuit causing signal to be biased high

| Checks and Tests | Comment |
|---|---|
| Check oil level and quality. | Check oil level and for contamination, debris, and correct API classification. |
| Check active and inactive DTCs. | Repair any ICP sensor codes. See “ICP Sensor” (page 477). |
| Do ICP Operational Voltage Checks. | Check KOEO pressure sensor value and voltage. See “ICP Sensor” (page 477). |
| Do IPR Pin-Point Diagnostics. | See “IPR” (page 517). |
| Do the KOEO Standard Test. | Test will verify IPR valve circuit continuity. See “Performance Diagnostics” – Section 6 (page 213). |
| Do KOER Standard Test and Injection Control Pressure Test. | See “Performance Diagnostics” – Section 6 (page 213). |

**DTC 333 – ICP above/below desired level**

DTC 333 indicates an injection control system response time fault and may be set during normal engine operation through the continuous monitor function or during the KOER Standard Test.

DTC 333 is set by the ECM when the measured pressure does not match the pressure expected by the ECM. DTC 333 will be set if the measured value is less than or greater than 3 MPa (435 psi) of desired injection control pressure for a period greater than 7 seconds.

When DTC 333 is active, the ECM will ignore feedback from the ICP sensor and control the IPR valve from programmed default values. The amber ENGINE lamp will be illuminated when DTC 333 is active.

Possible causes for DTC 333 include the following:

- Low oil level in crankcase
- High oil level in crankcase
- Contaminated engine oil
- Debris in engine oil
- Aerated engine oil
- Trapped air in the ICP system (particularly after an injector or high-pressure pump replacement)
- Intermittent IPR valve wiring connection. Inspect engine wiring harness connector and IPR valve terminal for corrosion. Inspect terminal for bent or pushed back pins.
- Inoperative or stuck injection pressure regulator
- Leaks in ICP system
- Leaks in Brake Control Pressure (BCP) system or failed brake shut-off valve
- Problem with ICP sensor or sensor circuit, incorrect sensor, system biased high or low
- Inoperative high-pressure hydraulic pump

| Checks and Tests | Comment |
|---|---|
| Check repair history – Determine if trapped air caused by ICP system disassembly. | If ICP system was serviced, vehicle should be operated 20 miles to validate system performance |
| Check oil level and quality. | Check oil level, API classification. Inspect for debris. If contamination is suspected, check oil filter element. |
| Check active and inactive DTCs. | Repair any ICP sensor codes. See “ICP Sensor” (page 477). |
| Do ICP Operational Voltage Checks. | Check KOEO pressure sensor values and voltage. See “ICP Sensor” (page 477). |
| Do IPR Pin-Point Diagnostics. | See “IPR” (page 517). |
| Do KOEO Standard Test. | Test will verify IPR circuit continuity. See “Performance Diagnostics” – Section 6 (page 213). |
| Do KOER Standard Test. | Test will verify major ICP system failure. See “Performance Diagnostics” – Section 6 (page 213). |
| Do KOER Continuous Monitor Test (intermittent DTC detected). | When running test, wiggle wires on ICP sensor, IPR valve, and all pass through connectors while engine is running. |

| | |
|---|---|
| Do Injection Control Pressure Test. | Verify if oil is aerated at high idle. See "Performance Diagnostics" – Section 6 (page 213). |
| Test ICP system for leaks. | See "Hard Start and No Start Diagnostics" – Section 5 (page 145). |

**DTC 334 – ICP unable to achieve set point in time (poor performance)**

DTC 334 indicates an injection control system response time fault and may be set during normal engine operation through the continuous monitor function or during the KOER Standard Test.

DTC 334 compares measured ICP to desired ICP and looks for a large pressure difference of 9.5 MPa (1378 psi) for a period of 3 seconds.

When DTC 334 is active, the ECM ignores the ICP sensor and controls the IPR valve operation from programmed default values.

Possible causes for DTC 334 include the following:

- Low oil level in crankcase
- High oil level in crankcase
- Contaminated engine oil
- Debris in engine oil
- Aerated engine oil
- Trapped air in the ICP system (particularly after an injector or high-pressure pump replacement)
- Intermittent IPR valve wiring connection. Inspect engine wiring harness connector and IPR valve terminal for corrosion. Inspect terminal for bent or pushed back pins.
- Inoperative or stuck injection pressure regulator
- Leaks in ICP system
- Problem with ICP sensor or sensor circuit, incorrect sensor, system biased high or low
- Inoperative high-pressure hydraulic pump

| **Checks and Tests** | **Comment** |
|---|---|
| Check repair history – Determine if trapped air caused by ICP system disassembly. | If ICP system was serviced, vehicle should be operated 20 miles to validate system performance |
| Check oil level and quality. | Check oil level, API classification. Inspect for debris. If contamination is suspected, check oil filter element. |
| Check active and inactive DTCs. | Repair any ICP sensor codes. See"ICP Sensor" (page 477). |
| Do ICP Operational Voltage Checks. | Check KOEO pressure sensor value and voltage. See "ICP Sensor" (page 477). |
| Do IPR Pin-Point Diagnostics. | Test will verify IPR circuit continuity. See "IPR" (page 517). |
| Do KOEO Standard Test. | Test will verify IPR circuit continuity. See "Performance Diagnostics" – Section 6 (page 213). |
| Do KOER Standard Test. | Test will verify major ICP system failure. See "Performance Diagnostics" – Section 6 (page 213). |

| | |
|---|---|
| Do KOER Continuous Monitor Test (intermittent DTC detected). | When running test, wiggle wires on ICP sensor, IPR valve, and all pass through connectors while engine is running. |
| Do Injection Pressure Control Test. | Verify if oil is aerated at high idle. See “Performance Diagnostics” – Section 6 (page 213). |
| Test ICP system for leaks. | See “Hard Start and No Start Diagnostics” – Section 5 (page 145). |

**DTC 335 – ICP unable to build pressure during cranking**

DTC 335 is set after the ECM detects 8 to 10 seconds of engine cranking with less than 3.5 MPa (508 psi) of ICP. Engine cranking speed must be greater than 130 rpm before diagnostic trouble code detection can begin.

Engine cranking time varies with engine temperature.

**NOTE:** If DTC becomes active during Relative Compression Test, ignore and clear DTC.

Possible causes for DTC 335 include the following:

- Low oil level in crankcase
- No lube oil pressure or lube oil delivery (reservoir empty or not filling)
- Trapped air in the ICP system (particularly after an injector or high-pressure pump replacement)
- Leaks in ICP system
- Leaks in BCP system or failed brake shut-off valve
- Inoperative or stuck injection pressure regulator
- Intermittent IPR valve wiring connection. Inspect engine wiring harness connector and IPR valve terminal for corrosion. Inspect terminal for bent or pushed back pins.
- Loose high-pressure hydraulic pump gear
- Inoperative high-pressure hydraulic pump

| Checks and Tests | Comment |
|---|---|
| Visual inspection | Verify ICP sensor and IPR wiring is connected. Check for oil leaks. Verify if system has been recently serviced (air entrapment). If ICP system was serviced, vehicle should be operated 20 miles to validate system performance. |
| Check oil level and pressure. | Inspect engine oil for debris. Verify lube oil pressure and delivery during engine cranking. Verify delivery by collecting oil from lube oil pressure tap. See “Hard Start and No Start Diagnostics” – Section 5 (page 145). |
| Check active and inactive DTCs. | Repair any ICP, CKP, or CMP sensor codes first. See“ICP Sensor” (page 477), “CKP Sensor” (page 365), and “CMP Sensor” (page 370) . |
| Do KOEO Standard Test. | Test will verify IPR valve circuit continuity. See “Hard Start and No Start Diagnostics” – Section 5 (page 145). |
| Do KOER Continuous Monitor Test. | When engine is running, enable test, wiggle wires on ICP sensor, IPR valve, and all pass through connectors. If DTC is set, or engine dies, check codes and inspect wires at connection point. |
| Do ICP pressure test. | Test will verify if oil is aerated at high idle. See “Performance Diagnostics” – Section 6 (page 213). |
| Test ICP system for leaks. | See “Hard Start and No Start Diagnostics” – Section 5 (page 145). |
| Do IPR Pin-Point Diagnostics. | See “IPR” (page 517). |

**IDM PWR (Injection Driver Module Power)**

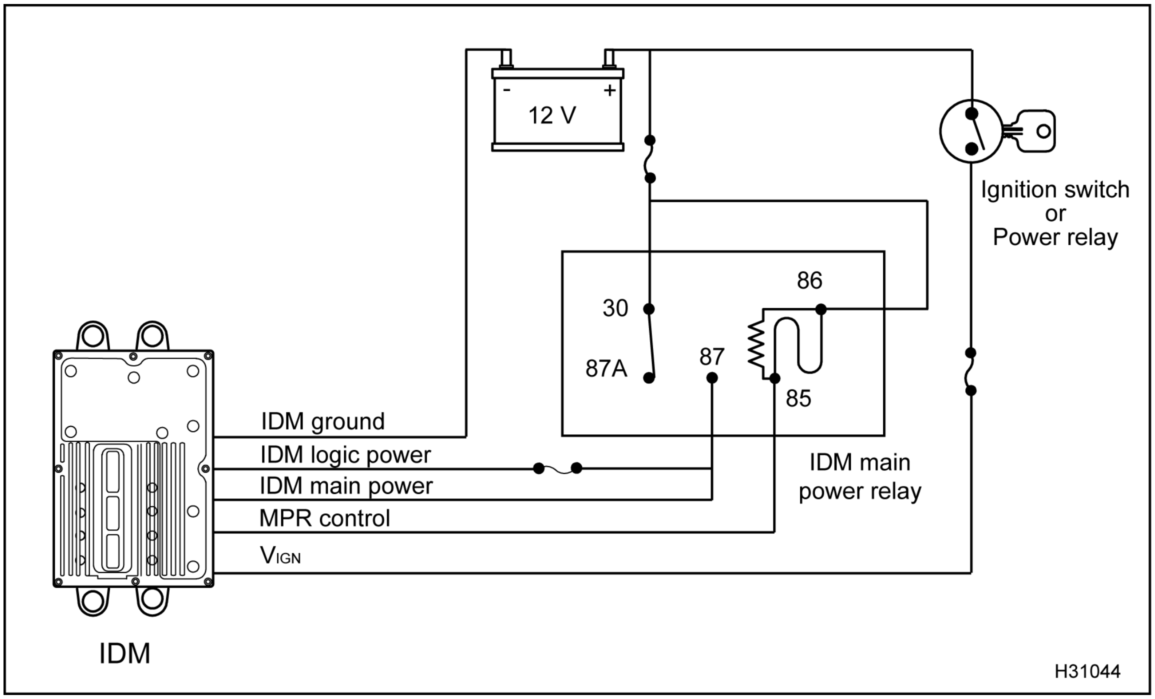



**Figure 473 Function diagram for the IDM PWR supply**

The function diagram for the IDM PWR includes the following:

- IDM
- IDM main power relay
- Ignition switch or power relay
- Battery
- Fuses

**Function**

The Injector Drive Module (IDM) requires a 12 V power source. The operating power is received from the vehicle batteries through the IDM main power relay contacts each time the ignition switch is turned ON.

When the ignition is turned ON, the IDM provides an internal ground to the coil side of the IDM main power relay. This closes the relay contacts and provides the IDM with necessary power.

### IDM PWR Circuit Operation

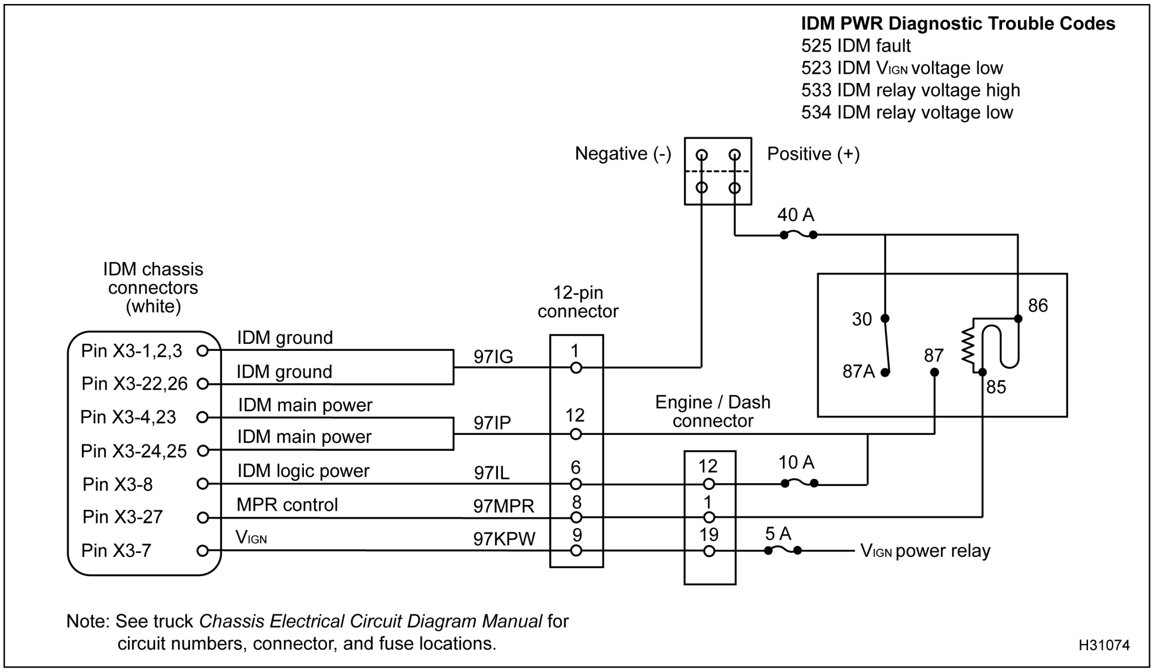



**Figure 474 IDM PWR circuit diagram**

The IDM is grounded to the battery negative terminal at IDM Pins X3-1, X3-2, X3-3, X3-22 and X3-26.

The IDM receives $V_{IGN}$ power at Pin X3-7. The power signals the IDM to provide a ground path from Pin X3-27 to 85 to switch the IDM main power relay. Switching the relay provides power from the battery positive terminal through a fuse and relay contacts 30 and 87 to Pins X3-4, X3-23, X3-24 and X3-25. Switching the relay also supplies power through a fuse to Pin X3–8 logic power. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

#### Fault Detection / Management

The IDM internally monitors battery voltage. When the IDM continuously receives less than 7 V or more than 16 V a Diagnostic Trouble Code (DTC) will be set.

#### IDM PWR Diagnostic Trouble Codes (DTCs)

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

#### DTC 525
#### IDM fault

- DTC 525 is set by the ECM when there is an internal IDM failure. When DTC 525 is set, replace the IDM.
- When DTC 525 is active the amber ENGINE lamp is illuminated.

#### DTC 523
#### IDM $V_{IGN}$ voltage low

- DTC 523 is set by the ECM when the voltage from $V_{IGN}$ is less than 7 V.
- DTC 523 can be set due to poor connections between the IDM Pin X3-7 and the $V_{IGN}$.
- DTC 523 will not illuminate the amber ENGINE lamp

**DTC 533**
**IDM relay voltage high**

- DTC 533 is set by the ECM when the voltage from the IDM power relay exceeds 16 V.
- DTC 533 can be set due to an alternator voltage output of 16 V or more. DTC 533 can also be set when jump starting the engine or incorrect external battery connections exist.
- DTC 533 will not illuminate the amber ENGINE lamp.

**DTC 534**
**IDM relay voltage low**

- DTC 534 is set by the ECM when the voltage from the IDM main power relay is less than 7 V.
- DTC 534 can be set due to a poor connections between relay and batteries, poor connections between relay and IDM, a blown fuse, or a failed IDM main power relay, discharged batteries or increased resistance in the battery feed circuits.
- DTC 534 will not illuminate the amber ENGINE lamp.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Breakout Box
- Relay Breakout Harness
- 12–pin Breakout Harness
- Terminal Test Adapter Kit

## IDM PWR Pin-Point Diagnostics

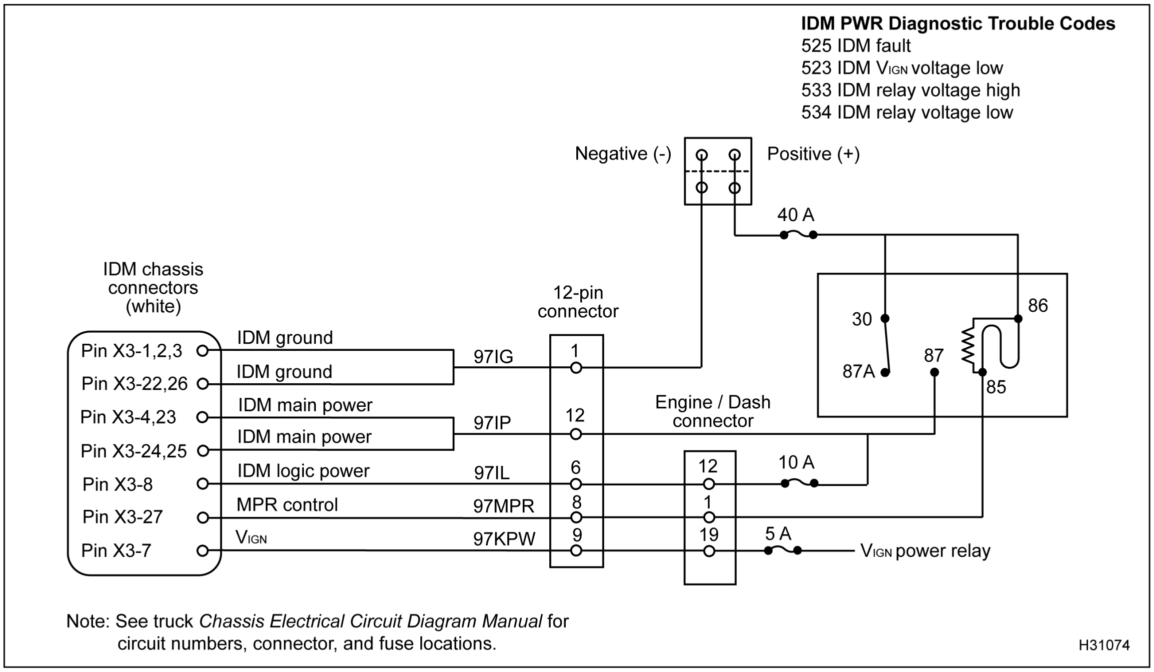



**Figure 475 IDM PWR circuit diagram**

The IDM PWR circuit requires the use of vehicle circuit diagrams. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

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

**Voltage Checks at IDM Power Relay Socket – Key-On Engine-Off** (Follow tests in order. Check with relay breakout harness connected to relay and power distribution center and turn the ignition switch on. If all tests are in spec, proceed to 12–pin voltage checks.)

| Test Point | Spec | Comment |
|---|---|---|
| 86 to gnd | 12 V ±1.5 V | Continuous voltage. If no voltage, check power circuits from battery or fuse. If fuse is blown, check for short to ground. If fuse is good, check for open between Pin 86 and B+. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| 30 to gnd | 12 V ± 1.5 V | Continuous voltage. If no voltage, check power circuits from battery or fuse. If fuse is blown, check for short to ground. If fuse is good, check for open between Pin 30 and B+. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| 85 to gnd | 0.06 V to 2 V | If > 2 V, check for open circuit between IDM Pin X3-27 to Pin 85 on relay or $V_{IGN}$ circuit – continue with 12–pin voltage checks. |
| 87 to gnd | 12 V ±1.5 V | Continuous voltage. If previous test points are in spec and no voltage is present, replace relay. |

### 12–Pin Breakout Harness

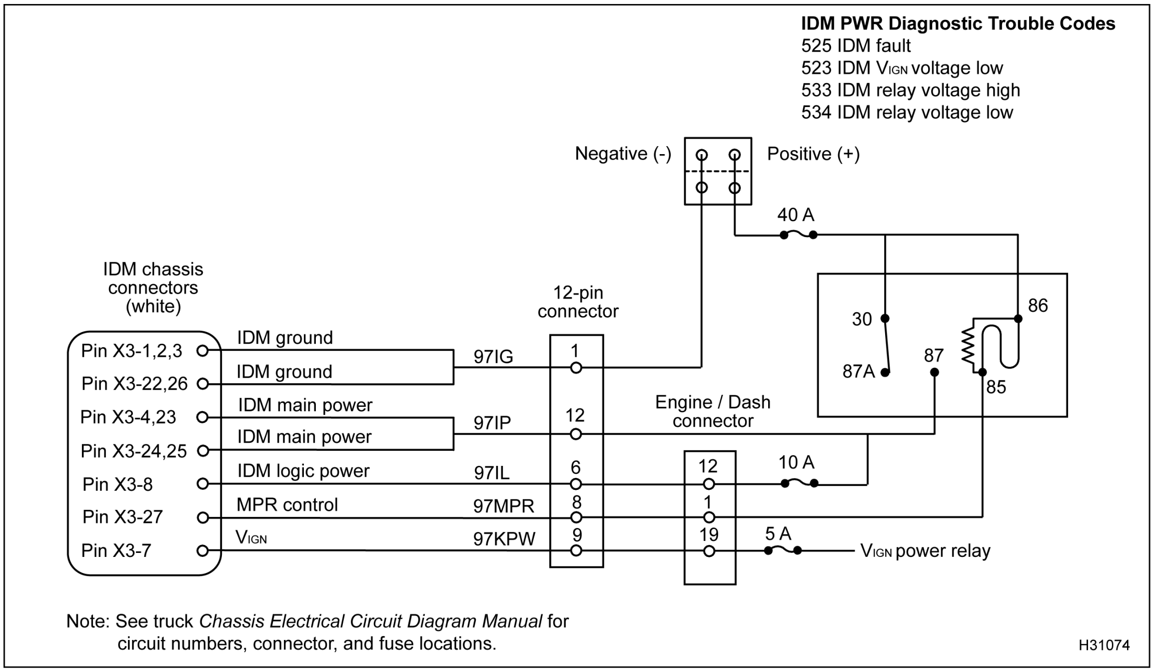



**Figure 476 IDM PWR circuit diagram**

**CAUTION: To avoid engine damage, turn the ignition switch to OFF before removing IDM relay or disconnecting any connectors supplying power to the IDM. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.**

**Voltage Checks at 12-pin Connector – Key-On Engine-Off** (Check with breakout harness connected to engine harness and chassis harness at 12–pin connector, IDM relay installed, and key-on engine-off. Follow tests in order. Inspect for bent pins or corrosion.)

| Test Point | Spec | Comment |
|---|---|---|
| 9 to gnd | 12 V ±1.5 V | Power from ignition switch to IDM. If no voltage, see truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| 8 to gnd | 0.06 V to 2 V | IDM MPR – 12–pin connector. If > 2 V, check for open circuit between IDM Pin X3–27 to Pin 8. |
| 12 to gnd | 12 V ±1.5 V | IDM power from relay Pin 87. If no voltage, check from Pin 12 to Pin 87 on relay for open or short to ground. |
| 6 to gnd | 12 V ±1.5 V | IDM logic power from relay Pin 87 with fuse. If fuse is blown, check for short to ground. If fuse is good, check for open circuit between fuse to Pin 6. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| 1 to gnd | 0 V to 0.25 V | Ground – voltage reading indicates poor ground to battery. If voltage is present check for open or high resistance between battery (–) and IDM pins. |

**CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting the connector or relay for the IDM. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.**

**Voltage Checks at IDM – Key-On Engine-Off** (Check with IDM power relay installed. Disconnect IDM X3 connector. Ground Pin X3–27 using Terminal Test Pin Adapter and harness to activate relay and check at harness connector. Inspect for bent pins or corrosion.)

| Test Point | Spec | Comment |
|---|---|---|
| IDM X3–7 to gnd | 12 V ± 1.5 V | Power from ignition switch to IDM. If no voltage, see truck *Chassis Electrical Circuit Diagram Manual*. |
| IDM X3–1 to gnd | 0 V to 0.25 V | Ground – voltage reading indicates poor ground to battery. See truck *Chassis Electrical Circuit Diagram Manual*. |
| IDM X3–2 to gnd | 0 V to 0.25 V | Ground – voltage reading indicates poor ground to battery. See truck *Chassis Electrical Circuit Diagram Manual*. |
| IDM X3–3 to gnd | 0 V to 0.25 V | Ground – voltage reading indicates poor ground to battery. See truck *Chassis Electrical Circuit Diagram Manual*. |
| IDM X3–22 to gnd | 0 V to 0.25 V | Ground – voltage reading indicates poor ground to battery. See truck *Chassis Electrical Circuit Diagram Manual*. |
| IDM X3–26 to gnd | 0 V to 0.25 V | Ground – voltage reading indicates poor ground to battery. See truck *Chassis Electrical Circuit Diagram Manual*. |
| IDM X3–27 to gnd | 0 V to 0.25 V | IDM grounds relay through internal transistor. Expect 0 V with X3–27 grounded. If voltage is present, check Terminal Test Pin Adapter and jumper. |
| IDM X3–8 to gnd | 12 V ± 1.5 V | Power from relay to IDM. If no voltage, check fuses. If a fuse is blown, check for short to ground. If fuses are good, check for open circuit between 87 and X3–8. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–4 to gnd | 12 V ± 1.5 V | Power from relay to IDM. If no voltage, check for open between Pin X3–4 and 87 on IDM relay. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–23 to gnd | 12 V ± 1.5 V | Power from relay to IDM. If no voltage, check for open between Pin X3–23 and 87 on IDM relay. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3– 24 to gnd | 12 V ± 1.5 V | Power from relay to IDM. If no voltage, check for open between Pin X3–24 and 87 on IDM relay. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–25 to gnd | 12 V ± 1.5 V | Power from relay to IDM. If no voltage, check for open between Pin X3–25 and 87 on IDM relay. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Harness Resistance Checks – Main Power Relay to Battery** (Turn the ignition switch to OFF. Disconnect negative battery cable. Disconnect harness from sensor. Inspect for bent pins or corrosion. Connect relay breakout harness.)

| | | |
|---|---|---|
| 30 (IDM relay) to B+ cable | < 5 Ω | If > 5 Ω, check connections for open between relay and positive battery cable. Check fuses. See truck *Chassis Electrical Circuit Diagram Manual* for relay and fuse locations. |
| 86 (IDM relay) to B+ cable | < 5 Ω | If > 5 Ω, check connections for open between relay and positive battery cable. Check fuse. See truck *Chassis Electrical Circuit Diagram Manual* for relay and fuse locations. |

**CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting the connector relay for the IDM. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.**

**Harness Resistance Checks – IDM to Main Power Relay** (Turn the ignition switch to OFF. Inspect for bent pins or corrosion. Connect relay breakout harness and use Terminal Test Adapter Kit to test.)

| | | |
|---|---|---|
| IDM X3–4 to 87 | < 5 Ω | If > 5 Ω, check connection from IDM to relay. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–23 to 87 | < 5 Ω | If > 5 Ω, check connection from IDM to relay. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–24 to 87 | < 5 Ω | If > 5 Ω, check connection from IDM to relay. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–25 to 87 | < 5 Ω | If > 5 Ω, check connection from IDM to relay. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–8 to 87 | < 5 Ω | If > 5 Ω, check connection from IDM through fuse to relay. |
| IDM X3–27 to 85 | < 5 Ω | If > 5 Ω, check connection from IDM to relay. |

**CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting the connector relay for the IDM. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.**

**Harness Resistance Checks – IDM to IDM Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1] and IDM X3 harness. IDM harness connector end is numbered at mating end. Use the Terminal Test Adapter Kit to test.)

| Test Point | Spec | Comment |
|---|---|---|
| IDM X3–1 to Pin A (9260) | < 5 Ω | If > 5 Ω, check connection to battery ground. See truck*Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–2 to Pin A (9260) | < 5 Ω | If > 5 Ω, check connection to battery ground. See truck*Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–3 to Pin A (9260) | < 5 Ω | If > 5 Ω, check connection to battery ground. See truck*Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–22 to Pin A (9260) | < 5 Ω | If > 5 Ω, check connection to battery ground. See truck*Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–26 to Pin A (9260) | < 5 Ω | If > 5 Ω, check connection to battery ground. See truck*Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–4 to Pin A (9260) | > 900 Ω | If < 900 Ω, check for short to ground within wiring harness. |
| IDM X3–23 to Pin A (9260) | > 900 Ω | If < 900 Ω, check for short to ground within wiring harness. |
| IDM X3–24 to Pin A (9260) | > 900 Ω | If < 900 Ω, check for short to ground within wiring harness. |
| IDM X3–25 to Pin A (9260) | > 900 Ω | If < 900 Ω, check for short to ground within wiring harness. |
| IDM X3–8 to Pin A (9260) | > 900 Ω | If < 900 Ω, check for short to ground within wiring harness. |
| IDM X3–27 to Pin A (9260) | > 900 Ω | If < 900 Ω, check for short to ground within wiring harness. |
| IDM X3–7 to Pin A (9260) | > 900 Ω | If < 900 Ω, check for short to ground within wiring harness. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Harness Resistance Checks – IDM to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1] Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.)

| Test Point | Spec | Comment |
|---|---|---|
| IDM X3–1 to gnd cable | < 5 Ω | If > 5 Ω, check connection to battery ground. See truck*Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–2 to gnd cable | < 5 Ω | If > 5 Ω, check connection to battery ground. See truck*Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–3 to gnd cable | < 5 Ω | If > 5 Ω, check connection to battery ground. See truck*Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–22 to gnd cable | < 5 Ω | If > 5 Ω, check connection to battery ground. See truck*Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–26 to gnd cable | < 5 Ω | If > 5 Ω, check connection to battery ground. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| IDM X3–4 to gnd cable | > 900 Ω | If < 900 Ω, check for short to ground. |
| IDM X3–23 to gnd cable | > 900 Ω | If < 900 Ω, check for short to ground. |
| IDM X3–24 to gnd cable | > 900 Ω | If < 900 Ω, check for short to ground. |
| IDM X3–25 to gnd cable | > 900 Ω | If < 900 Ω, check for short to ground. |
| IDM X3–8 to gnd cable | > 900 Ω | If < 900 Ω, check for short to ground. |
| IDM X3–27 to gnd cable | > 900 Ω | If < 900 Ω, check for short to ground. |
| IDM X3–7 to gnd cable | > 900 Ω | If < 900 Ω, check for short to ground. |

**Harness Resistance Checks – IDM to Ignition Power Relay** (Turn the ignition switch to OFF. Inspect for bent pins or corrosion. Connect relay breakout harness and breakout box to [X3 and X4] to chassis harness only.)

| | | |
|---|---|---|
| X3–7 to 87 ($V_{IGN}$ - power relay) | < 5 Ω | If > 5 Ω, see truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. Check connections in circuit. |

| IDM PWR Diagnostic Trouble Codes |
|---|
| DTC 525 = IDM fault |
| DTC 523 = IDM $V_{IGN}$ voltage low |
| DTC 533 = IDM relay voltage high |
| DTC 534 = IDM relay voltage low |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

**INJ Circuits (Injector Drive)**

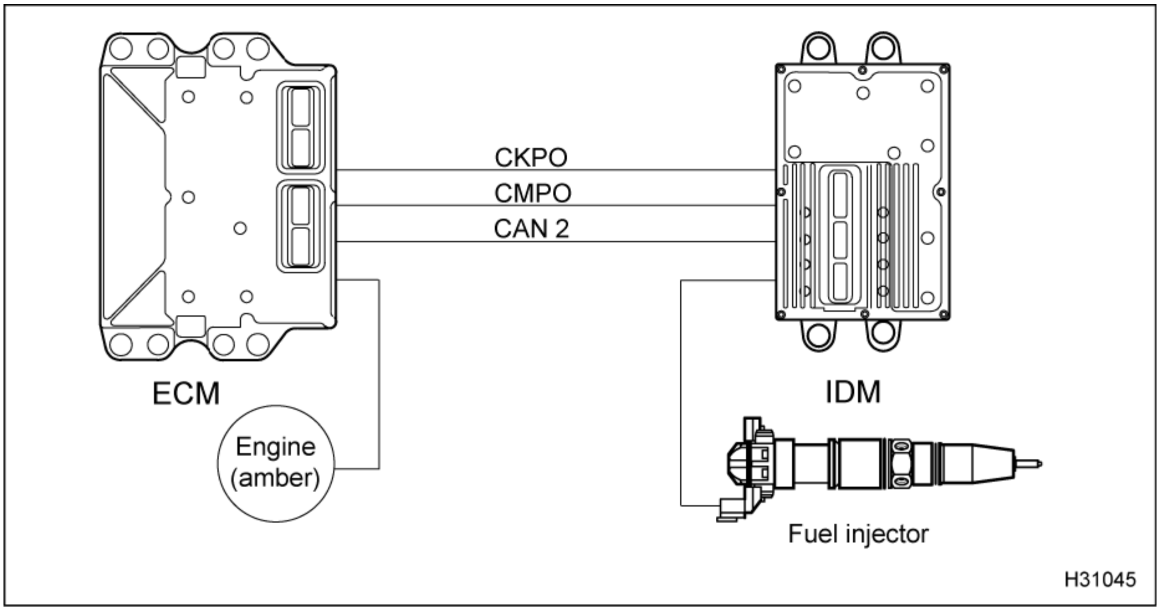



**Figure 477 Function diagram for the INJ circuit**

The function diagram for INJ circuit includes the following:

- Injectors
- Electronic Control Module (ECM)
- Injector Driver Module (IDM)
- Controller Area Network (CAN 1) link
- Camshaft Position Output (CMPO) signal
- Crankshaft Position Output (CKPO) signal

**Function**

The IDM is used to control the injectors. The IDM receives CMPO and CKPO signals and fueling information via CAN from the ECM. The IDM calculates injection timing and injector actuation time based on the fuel quantity requested for any engine operation condition.

**INJ Circuit Operation**

When a coil needs to be energized the IDM turns on both the high and low side driver.

**High Side Drive Output**

The IDM regulates the current at an average of 20 A. When the current reaches 24 A the IDM shuts off the high side driver. When the current drops to 16 A the IDM 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 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 internal to the ECM.

**Fault Detection / Management**

When the engine is running, the IDM can detect individual injector coil open and shorts to ground or battery. A KOEO Injector Test allows the operator to enable all injector coils when the engine is off to verify circuit operation. When the IDM detects a fault, Diagnostic Trouble Codes (DTCs) are transmitted over the CAN 2 line between the ECM and IDM.

The IDM transmits a high and low side drive output to the injectors. The high side output supplies the injectors with a power supply of 48 V DC at 20 A. The low side output supplies a return circuit to each injector coil.

The injectors are under the valve covers. Each injector has a close and open coil. The IDM continuously monitors the amount of time (rising time) taken by each coil to draw 20 A. The time is compared to calibrated values and the IDM determines if a circuit or injector fault exists. Each injector has 6 failure modes and 3 DTCs. A failure can occur on the open or close coil circuit.

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

### INJ Diagnostic Trouble Codes (DTCs)

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp. The last digit in the injector DTC corresponds to the cylinder where a fault has been detected.

**DTC 421-426**
**High side to low side open**

- DTC 421–426 is set by the ECM when the rising time is too long for the open or close coil. DTC 421–426 usually indicates a harness or coil is open.
- DTC 421–426 does not set the amber ENGINE lamp.

**DTC 431-436**
**High side shorted to low side**

- DTC 431–436 is set by the ECM when the rising time to 20 A is short, but not zero for the open or close coil. DTC 431–436 usually indicates an internally shorted coil.
- DTC 431–436 does not set the amber ENGINE lamp.

**DTC 451-456**
**High side short to ground or $V_{BAT}$**

- DTC 451–456 is set by the ECM when the rising time to 20 A is zero for the open or close coil. DTC 451–458 usually indicates the harness or coil is shorted to ground.
- DTC 451–456 does not set the amber ENGINE lamp.

**Tools**

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

### INJ Pin-Point Diagnostics

**WARNING: To avoid serious personal injury or possible death, do not perform voltage checks with the engine running. Injector solenoid operating voltage of 48 V DC @ 20 A is present on injector circuits.**

**CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting the connector or relay for the IDM. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.**

Before doing injector diagnostic testing:

1. Turn the ignition switch to OFF.
2. Disconnect IDM connectors (X1 and X2).

All tests are checked at harness end. Pin numbers are marked on all connector mating ends. After checking resistance through injector coils and resistance to chassis ground, if tests are within specification and DTC is active, replace the injector.

**NOTE:** Only diagnose injectors with active DTCs.

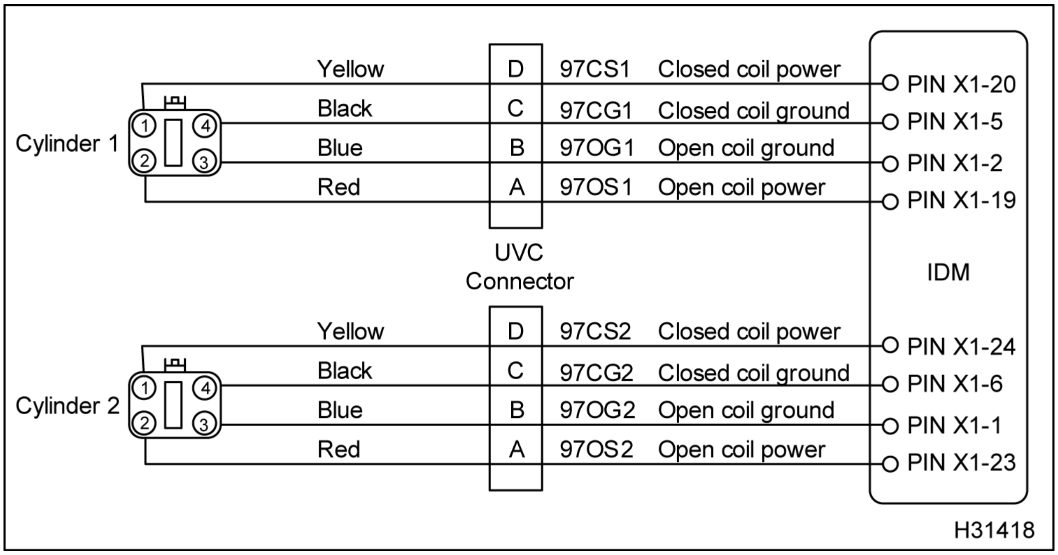



**Figure 478 Cylinder 1 and 2 circuit diagram**

**Injector Cylinder 1**

| Test Point | Spec | Comment |
|---|---|---|
| X1–2 to X1–19 | 0.7 Ω to 1.5 Ω | If > 1.5 Ω, check for open or high resistance between IDM and injector, or open injector coil |
| X1–2 to gnd, X1–19 to gnd | > 1 kΩ | If < 1 kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If > 1 kΩ, the short is in the injector. |
| X1–5 to X1–20 | 0.7 Ω to 1.5 Ω | If > 1.5 Ω, check for open or high resistance between IDM and injector, or open injector coil. |
| X1–5 to gnd, X1–20 to gnd | > 1 kΩ | If < 1 kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If > 1 kΩ, the short is in the injector. |

**Injector Cylinder 2**

| Test Point | Spec | Comment |
|---|---|---|
| X1–1 to X1–23 | 0.7 Ω to 1.5 Ω | If > 1.5 Ω, check for open or high resistance between IDM and injector, or open injector coil |
| X1–1 to gnd, X1–23 to gnd | > 1 kΩ | If < 1 kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If > 1 kΩ, the short is in the injector. |
| X1–6 to X1–24 | 0.7 Ω to 1.5 Ω | If > 1.5 Ω, check for open or high resistance between IDM and injector, or open injector coil |
| X1–6 to gnd, X1–29 to gnd | > 1 kΩ | If < 1 kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If > 1 kΩ, the short is in the injector. |

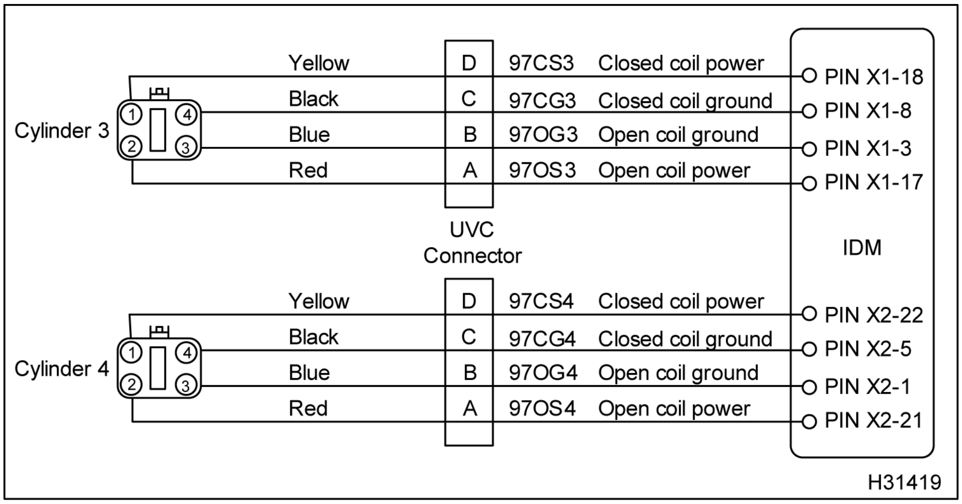



**Figure 479 Cylinder 3 and 4 circuit diagram**

**Injector Cylinder 3**

| Test Point | Spec | Comment |
|---|---|---|
| X1–17 to X1–3 | 0.7 Ω to 1.5 Ω | If > 1.5 Ω, check for open or high resistance between IDM and injector, or open injector coil. |
| X1–17 to gnd, X1–3 to gnd | > 1 kΩ | If < 1 kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If > 1 kΩ, the short is in the injector. |
| X1–18 to X1–8 | 0.7 Ω to 1.5 Ω | If > 1.5 Ω, check for open or high resistance between IDM and injector, or open injector coil |
| X1–18 to gnd, X1–8 to gnd | > 1 kΩ | If < 1 kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If > 1 kΩ, the short is in the injector. |

**Injector Cylinder 4**

| Test Point | Spec | Comment |
|---|---|---|
| X2–1 to X2–21 | 0.7 Ω to 1.5 Ω | If > 1.5 Ω, check for open or high resistance between IDM and injector, or open injector coil |
| X2–1 to gnd, X2–21 to gnd | > 1 kΩ | If < 1 kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If > 1 kΩ, the short is in the injector. |
| X2–5 to X2–22 | 0.7 Ω to 1.5 Ω | If > 1.5 Ω, check for open or high resistance between IDM and injector, or open injector coil |
| X2–5 to gnd, X2–22 to gnd | > 1 kΩ | If < 1 kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If > 1 kΩ, the short is in the injector. |

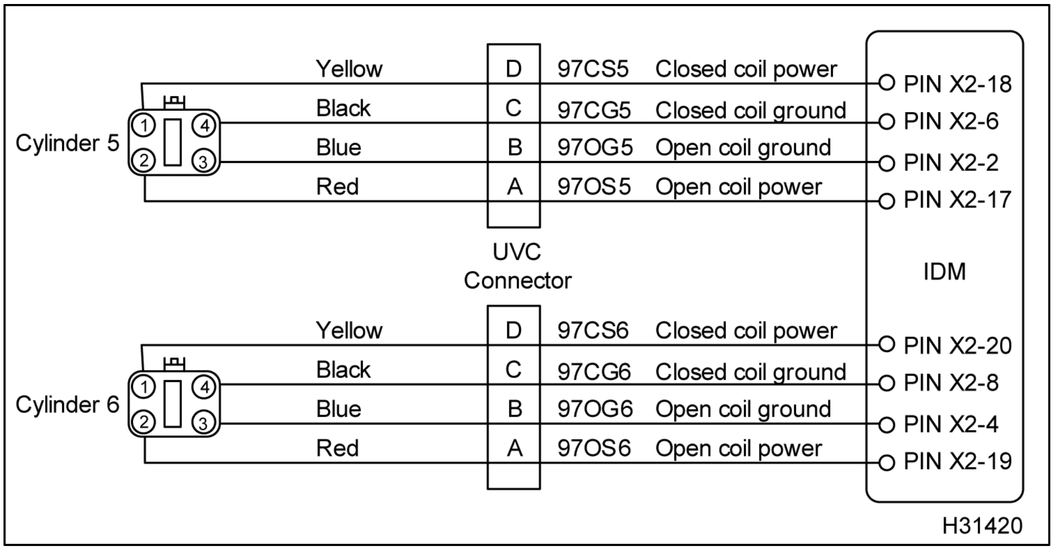



**Figure 480 Cylinder 5 and 6 circuit diagram**

**Injector Cylinder 5**

| Test Point | Spec | Comment |
|---|---|---|
| X2–2 to X2–17 | 0.7 Ω to 1.5 Ω | If > 1.5 Ω, check for open or high resistance between IDM and injector, or open injector coil |
| X2–2 to gnd, X2–17 to gnd | > 1 kΩ | If < 1 kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If > 1 kΩ, the short is in the injector. |
| X2–6 to X2–18 | 0.7 Ω to 1.5 Ω | If > 1.5 Ω, check for open or high resistance between IDM and injector, or open injector coil |
| X2–6 to gnd, X2–18 to gnd | > 1 kΩ | If < 1 kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If > 1 kΩ, the short is in the injector. |

**Injector Cylinder 6**

| Test Point | Spec | Comment |
|---|---|---|
| X2–4 to X2–19 | 0.7 Ω to 1.5 Ω | If > 1.5 Ω, check for open or high resistance between IDM and injector, or open injector coil |
| X2–4 to gnd, X2–19 to gnd | > 1 kΩ | If < 1 kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If > 1 kΩ, the short is in the injector. |
| X2–8 to X2–20 | 0.7 Ω to 1.5 Ω | If > 1.5 Ω, check for open or high resistance between IDM and injector, or open injector coil |
| X2–8 to gnd, X2–20 to gnd | > 1 kΩ | If < 1 kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If > 1 kΩ, the short is in the injector. |

**IPR (Injection Pressure Regulator)**

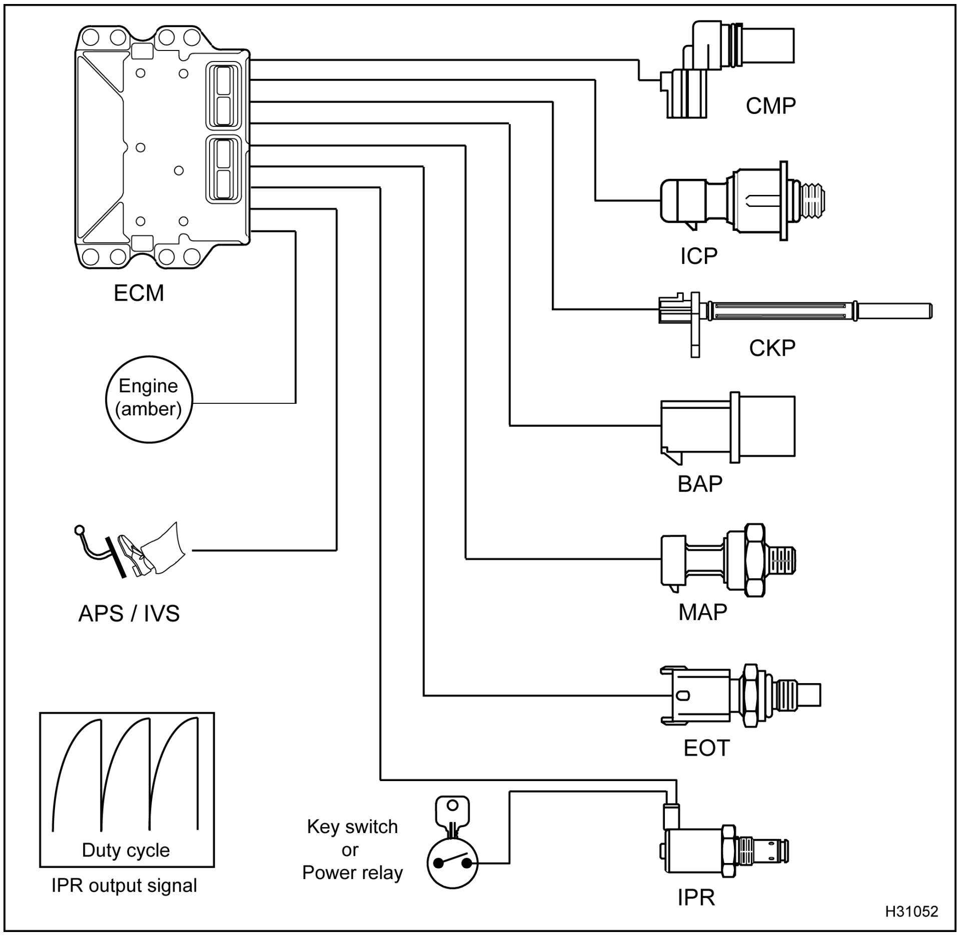



**Figure 481 Function diagram for the IPR**

The function diagram for the IPR includes the following:

- IPR
- Engine Oil Temperature (EOT) sensor
- Injection Control Pressure (ICP) sensor
- Manifold Absolute Pressure (MAP) sensor
- Barometric Absolute Pressure (BAP) sensor
- Camshaft Position (CMP) sensor
- Crankshaft Position (CKP) sensor
- Accelerator Position / Idle Validation (APS/IVS) sensor
- Electronic Control Module (ECM)

**Function**

The IPR valve controls oil pressure in the high-pressure injection control system that actuates the injectors. The IPR valve consists of a solenoid, poppet, and a spool valve assembly. The IPR is mounted in the body of the high-pressure pump. The ECM regulates ICP 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 and maintains pressure in the ICP system or vents pressure to the oil sump through the front cover.

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

### IPR Circuit Operation

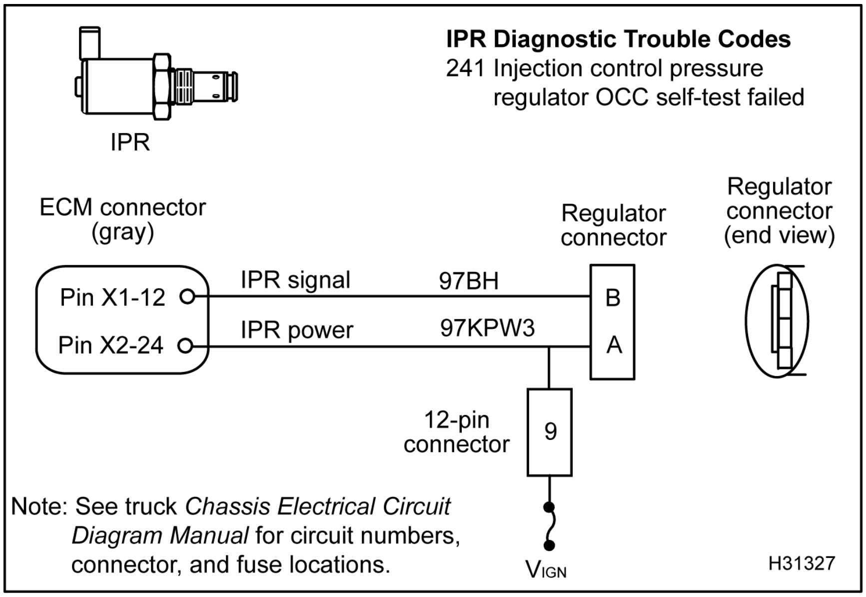



**Figure 482 IPR circuit diagram**

The IPR valve is supplied with voltage at Pin A of the IPR connector through 12–pin connector (Pin 9) from $V_{IGN}$. The control of the injection control system is gained by the ECM grounding Pin B of the IPR valve through Pin X1-12 of the ECM. Precise control is gained by varying the percentage of ON/OFF time of the IPR solenoid. A high duty cycle indicates a high amount of injection control pressure is being commanded. A low duty cycle indicates less pressure being commanded.

#### 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 be set. When the engine is running, the ECM can detect if the injection control pressure is equal to the desired pressure. When the measured injection control pressure does not compare to the desired pressure, the ECM will ignore the measured ICP signal and controls the engine with the desired value.

#### IPR Diagnostic Trouble Codes (DTCs)

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

#### DTC 241
#### IPR OCC self-test failed

- DTC 241 is set by the ECM when the Output Circuit Check (OCC) test has failed after the KOEO Standard Test has been run.
- DTC 241 can be set when a poor connection to the IPR solenoid or inoperative IPR coil exists.
- When DTC 241 is active the engine will not run and the amber ENGINE lamp will not be illuminated.

#### Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Breakout Box
- Actuator Breakout Harness
- Terminal Test Adapter Kit

**IPR Pin-Point Diagnostics**

The IPR circuit requires the use of vehicle circuit diagrams. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**IPR Voltage Checks** (Disconnect regulator connector. Connect breakout harness to engine harness only. Turn the ignition switch to ON.)

| Test Point | Spec | Comment |
|---|---|---|
| A to gnd | B+ | IPR power from $V_{IGN}$ – If no voltage, check from fuse to IPR connector. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. |
| B to gnd | 0 V to 0.25 V | If > 0.25 V, control wire is shorted to $V_{REF}$ or B+. |
| **Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Connect breakout harness to engine harness only. Disconnect chassis connector 9260[1].) | | |
| 1 to Pin A (9260) | > 1 kΩ | Resistance to chassis ground. If < 1 kΩ, check for short to ground in circuit (check with fuse removed) |
| 2 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground |
| **Harness Resistance Checks - 12-pin Connector to IPR Connector** (Turn the ignition switch to OFF. Connect 12- pin breakout harness to engine harness only. Connect actuator breakout harness to engine harness only. Check with fuse removed.) | | |
| Pin 9 to A | < 5 Ω | If > 5 Ω check for open circuit. |
| **Harness Resistance Checks - IPR Circuit Including Regulator** (Turn the ignition switch to OFF. Connect Breakout Box X1 to engine harness only. Connect engine harness to IPR. Check with fuse remove.) | | |
| X1-12 to fuse | 5 Ω to 20 Ω | Resistance through entire IPR circuit including regulator. If not within specification do Actuator Resistance Check. |
| **Actuator Resistance Checks** (Turn the ignition switch to OFF. Disconnect the connector from the IPR, connect breakout harness to IPR only. Check resistance through the IPR only.) | | |
| A to B | 5 Ω to 20 Ω | Resistance through IPR coil only. If not within specification replace IPR. |
| **IPR Diagnostic Trouble Codes** | | |
| DTC 241 = Output Circuit Check detected during KOEO Standard Test, indicates high or low resistance in circuit. | | |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

**IST System (Idle Shutdown Timer)**

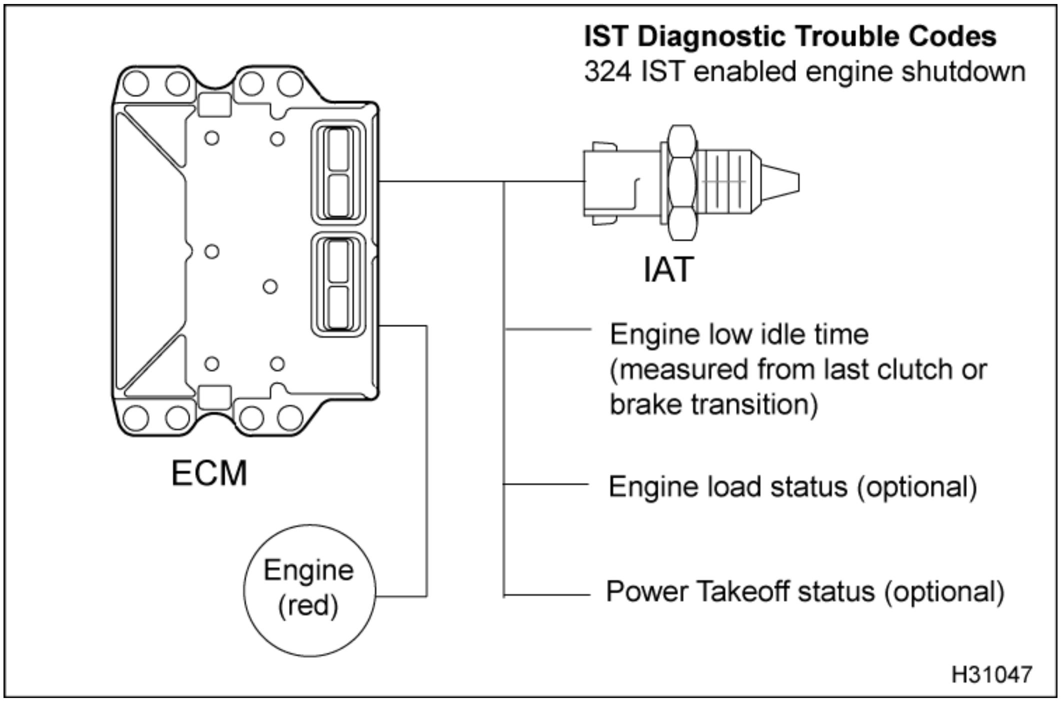



**Figure 483 Function diagram for the IST system**

The function diagram for the IST system includes the following:

- Electronic Service Tool (EST)
- Intake Air Temperature (IAT) sensor
- ENGINE lamp (red)

### IST Operation

The IST is an optional feature that allows the ECM to shutdown the engine when an extended idle condition occurs. The idle timer can be programmed for the customer to automatically shut the engine down for idle times that range from 2 to 120 minutes.

Before engine shutdown, the red ENGINE lamp will illuminate. The lamp will flash for 30 seconds to warn the operator the engine is approaching shutdown. Idle time is measured from last clutch or brake pedal transition. The engine must be out of gear for the IST to work.

The IST feature can be programmed to operate at specific ambient air temperatures, allowing engine operation in cold or hot weather. Power Takeoff (PTO) applications can be programmed to disable the IST feature for load levels or when PTO features are active.

The resets for the IST include:

- PTO is active.
- Engine speed is not at idle speed (700 rpm).
- Vehicle movement or a Vehicle Speed Sensor (VSS) fault is detected.
- Engine coolant operating temperature is below 60 °C (140 °F).
- Ambient air temperature is below 16 °C (60 °F) or above 44 °C (110 °F).
- Brake pedal movement or a brake switch fault is detected.
- Clutch pedal is depressed or a fault for the clutch pedal switch is detected (manual transmissions, if equipped with clutch switch).
- Shift selector is moved from neutral or park (automatic transmissions).

The IST feature provides several advantages when enabled. Reduced emissions, fuel consumption, and engine wear are all direct results from the IST strategy.

There are four states of the IST electronic operation.

- **Idle shutdown timer** indicates to the on-board electronics that the vehicle has the following features:
  - OFF – turned off at all times.
  - PTO available – allows prolonged engine idle shutdown when engine is in low idle and PTO is disabled.
  - No engine load – allows prolonged engine idle shutdown when engine is in low idle / no load condition.
  - Tamper proof – prohibits operator over-ride.
- **Idle shutdown time** indicates the programmed value of engine idle time before engine will shutdown.
- **Maximum ambient intake air temperature** indicates maximum value of ambient intake air temperature programmed to shutdown engine. This feature prevents engine shutdown due to air conditioner usage.
- **Minimum ambient intake air temperature** – indicates minimum value of ambient intake air temperature programmed to shutdown engine. This feature prevents engine shutdown due to cold ambient temperature.

**Fault Detection / Management**

The IST feature is internal to the ECM. The subsystems that contribute to the IST strategy have their own fault codes. The fault code for the IST is not a system diagnostic trouble code. The IST fault code is only set to indicate that the IST has been activated and the engine has shutdown.

**IST Diagnostic Trouble Codes (DTCs)**

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

**DTC 324**
**IST enabled engine shutdown**

- DTC 324 is set by the ECM when the engine has been shutdown due to exceeding the programmed idle time criteria. The IST feature must be enabled for DTC 324 to be displayed.

**NOTE:** DTC 324 does not indicate any system or circuit DTCs. Diagnostic checks are not required for DTC 324.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

### MAP Sensor (Manifold Absolute Pressure)

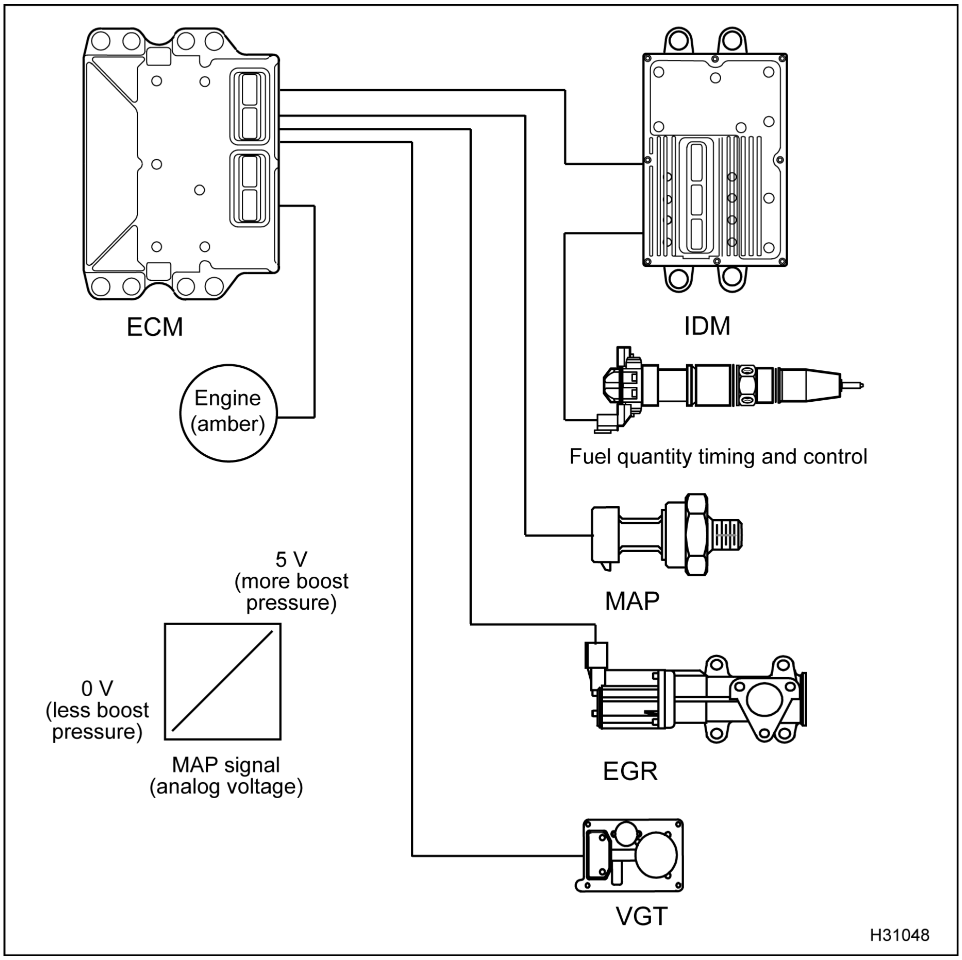



**Figure 484 Function diagram for the MAP sensor**

The function diagram for the MAP sensor includes the following:

- MAP sensor
- Electronic Control Module (ECM)
- Injector Drive Module (IDM)
- Exhaust Gas Recirculation (EGR)
- Variable Geometry Turbocharger (VGT)
- Fuel injector
- ENGINE lamp (amber)

**Function**

The MAP sensor is a variable capacitance sensor installed left of the MAT sensor in the intake manifold. The ECM supplies a 5 V reference signal which the MAP sensor uses to produce a linear analog voltage that indicates pressure. The ECM uses the MAP sensor signal to assist in the calculation of the EGR and VGT duty percentage. The ECM monitors the MAP signal to determine intake manifold (boost) pressure. From this information the ECM can optimize control of fuel rate and injection timing for all engine operating conditions.

**MAP Circuit Operation**

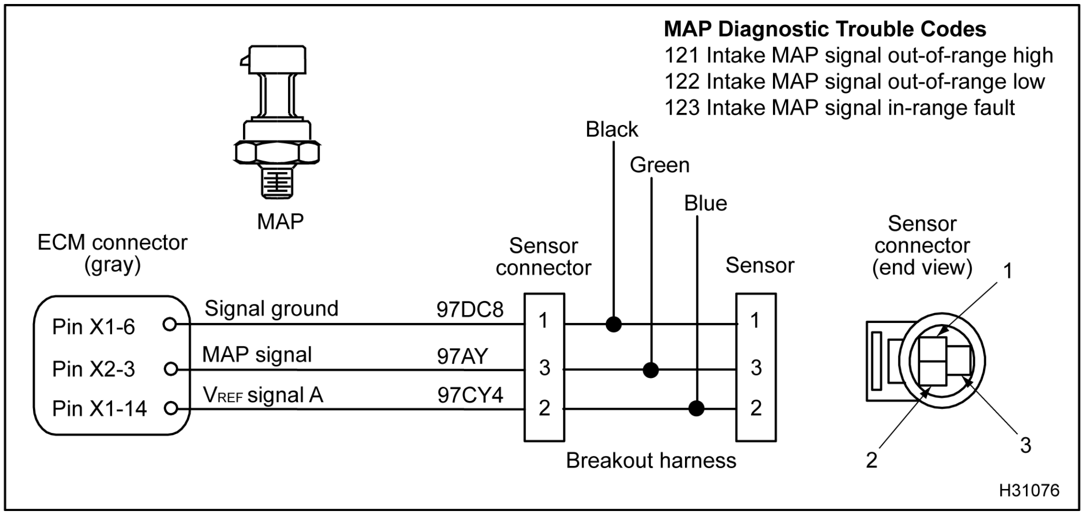



**Figure 485 MAP circuit diagram**

The MAP sensor is supplied with a 5 V reference voltage at Pin 2 from ECM Pin X1–14. The MAP sensor is grounded at Pin 1 from ECM Pin X1–6. The MAP sensor returns a variable voltage signal from Pin 3 to ECM Pin X2–3.

### Fault Detection / Management

The ECM will ignore the MAP signal when the signal is detected to be out of range or an incorrect value is read. The engine will continue to operate based on estimated values.

### MAP Diagnostic Trouble Codes (DTCs)

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

### DTC 121
### Intake MAP signal out-of-range high

- DTC 121 is set by the ECM when the MAP signal is greater than 4.9 V for more than 0.4 second.
- DTC 121 can be set due to a signal circuit short to $V_{REF}$ or B+ or a failed MAP sensor.
- When DTC 121 is active the amber ENGINE lamp is illuminated.

### DTC 122
### Intake MAP signal out-of-range low

- DTC 122 is set by ECM when the MAP signal is less than 0.039 V for more than 0.4 second.
- DTC 122 can be set due to an open or short to ground on the signal circuit, a failed MAP sensor or an open $V_{REF}$ circuit or $V_{REF}$ short to ground.
- When DTC 122 is active the amber ENGINE lamp is illuminated.

### DTC 123
### Intake MAP signal in-range fault

- DTC 123 is set by ECM when the MAP signal is greater than 115 kPa (17 psi) absolute at low idle.
- DTC 123 can be set due to a restricted or plugged sensor inlet, open signal ground, $V_{REF}$ shorted to voltage source above 5.5 V, biased circuit, or a failed MAP sensor.
- When DTC 123 is active the amber ENGINE lamp is illuminated.

### Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 500 Ohm Resistor Harness

- Breakout Box
- Breakout Harness
- Terminal Test Adapter Kit

**MAP Operational Diagnostics**

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:**

**Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.**

1. Using EST, open the D_ContinuousMonitor.ssn.

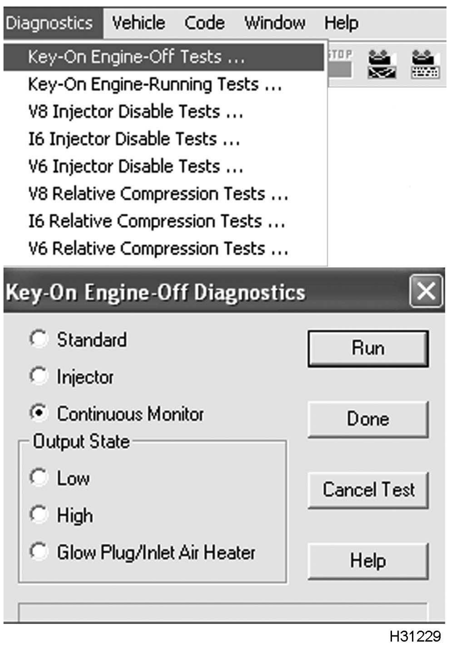



**Figure 486 Continuous Monitor Test**

2. To monitor signal voltage, run KOEO Continuous Monitor Test. For help, see “Continuous Monitor Test” in Section 3 (page 68).
3. Monitor MAP signal voltage. Verify an active DTC for the MAP circuit.
4. If code is active, do step 6 and 7 to check circuit for the MAP sensor using the following table.
   - Circuit Checks for MAP Sensor
5. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will display DTCs related to the condition.
6. Disconnect engine harness from pressure sensor.

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

7. Connect Pressure Sensor Breakout Harness to engine harness only.

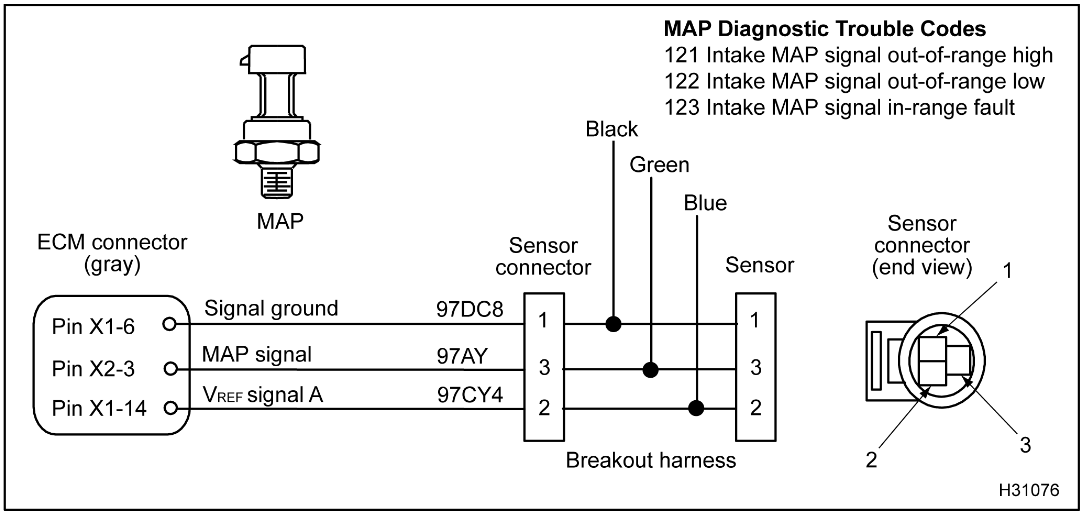



**Figure 487 MAP circuit diagram**

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Circuit Checks for MAP Sensor** (Use EST, DMM, breakout harness, and 500 Ohm Resistor Harness.)

| Test Condition | Spec | Checks |
|---|---|---|
| Sensor disconnected using EST | 0 V | If voltage > 0.039 V, check signal circuit for short to $V_{REF}$ or B+. |
| Voltage from Pin 2 (Blue) to ground using DMM | 5 V ±0.5 V | If voltage > 5.5 V, check $V_{REF}$ for short to B+. If voltage is < 4.5 V, check $V_{REF}$ for open or short to ground. |
| 500 Ohm Resistor Harness connected between Pin 3 (Green) and Pin 2 (Blue) of breakout harness using EST. | 5 V | If voltage < 4.9 V, check signal circuit for open or short to ground.<br>— Disconnect connector 9260[1]. Measure resistance from Pin 3 to Pin A of connector 9260 (spec > 1 kΩ) to check for short to ground within wiring harness.<br>— Disconnect negative battery cable. Measure resistance from Pin 3 to ground cable to check for short to ground.<br>— Use a breakout box from Pin 3 to Pin X2–8 (spec < 5 Ω) to check for open in the harness. |
| Resistance from Pin 1 (Black) of breakout harness to Pin A of connector 9260 using DMM | < 5 Ω | If resistance is > 5 Ω, check for open or high resistance between ECM and sensor connector. Use a breakout box and measure resistance from between Pin 1 and Pin X1–6 (spec < 5 Ω). |

**Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the MAP sensor.**

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

### MAP Pin-Point Diagnostics

| Test Point | Spec | Comment |
|---|---|---|
| **Connector Voltage Checks to Ground** (Disconnect harness from sensor. Inspect for bent pins or corrosion. Connect breakout harness to engine harness only. Turn the ignition switch to ON.) | | |
| 1 to gnd | 0 V to 0.25 V | Signal ground (no voltage expected). If > 0.25 V, check ground circuit for open or high resistance and check signal ground for short to $V_{REF}$ or B+. |
| 2 to gnd | 5 V ± 0.5 V | If voltage is not to spec, $V_{REF}$ circuit is shorted to ground, shorted to B+, or open. |
| 3 to gnd | 0 V to 0.25 V | If > 0.25 V, signal circuit is shorted to $V_{REF}$ or B+. |
| **Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Connect breakout harness to engine harness only. Disconnect chassis connector 9260[1].) | | |
| 1 to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open circuit. |
| 2 to Pin A (9260) | > 500 Ω | If < 500 Ω, check for short to ground within wiring harness. |
| 3 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

| Test Point | Spec | Comment |
|---|---|---|
| **Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.) | | |
| 1 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| 2 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| 3 to gnd cable | > 1 kΩ | If < 1 kΩ , check for short to ground. |
| **Harness Resistance Checks** (Connect breakout box to engine harness [X1 and X2 only] and breakout harness to engine harness only.) | | |
| X1–6 to 1 | < 5 Ω | If > 5 Ω, check for open ground wire. |
| X1–14 to 2 | < 5 Ω | If > 5 Ω, check for open $V_{REF}$ wire. |
| X2–3 to 3 | < 5 Ω | If > 5 Ω, check for open signal wire. |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

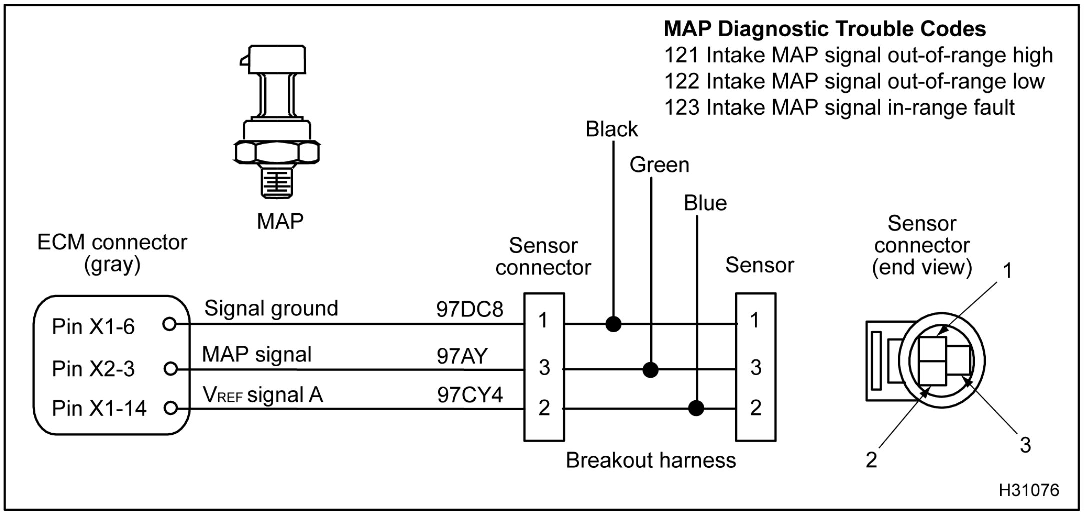



**Figure 488 MAP circuit diagram**

| | | | |
|---|---|---|---|
| **Operational Voltage Checks for MAP Sensor with Breakout Harness** (Check with breakout harness connected to sensor and engine harness.) | | | |
| **Test Point** | **EST voltage readings: Signal to ground** | **Spec** | **Comment** |
| 3 (Green) to 1 (Black) | 0.92 V | 0 kPa (psi) | Voltage with key-on engine-off. Atmospheric pressure dependent on altitude and BAP pressure. |
| 3 (Green) to 1 (Black) | 1.73 V | 55 kPa (8 psi) | |
| 3 (Green) to 1 (Black) | 2.72 V | 129 kPa (18 psi) | |
| 3 (Green) to 1 (Black) | 3.71 V | 193 kPa (28 psi) | |
| 3 (Green) to 1 (Black) | See appropriate performance specification below. | | Rated speed, full load |
| **Operational Voltage Checks for MAP Sensor with Breakout Box** (Check with breakout box connected [X1 and X2 only] to the ECM and engine harness.) | | | |
| X2–3 to X1–6 | 0.92 V | 0 kPa (psi) | Voltage with key-on engine-off. Atmospheric pressure dependent on altitude and BAP pressure. |
| X2–3 to X1–6 | 1.73 V | 55 kPa (8 psi) | |
| X2–3 to X1–6 | 2.72 V | 129 kPa (18 psi) | |
| X2–3 to X1–6 | 3.71 V | 193 kPa (28 psi) | |
| X2–3 to X1–6 | See appropriate performance specification below. | | Rated speed, full load |
| “DT 466 Performance Specifications” – Appendix A (page 619) | | | |
| “DT 570 and HT 570 Performance Specifications – Appendix B (page 643) | | | |
| **MAP Diagnostic Trouble Codes** | | | |
| DTC 121 = Signal voltage was > 4.9 V for more than 0.4 second | | | |
| DTC 122 = Signal voltage was < 0.039 V for more than 0.4 second | | | |
| DTC 123 = Detected boost signal voltage was > 115 kPa (17 psi) absolute at low idle. | | | |

### MAT Sensor (Manifold Air Temperature)

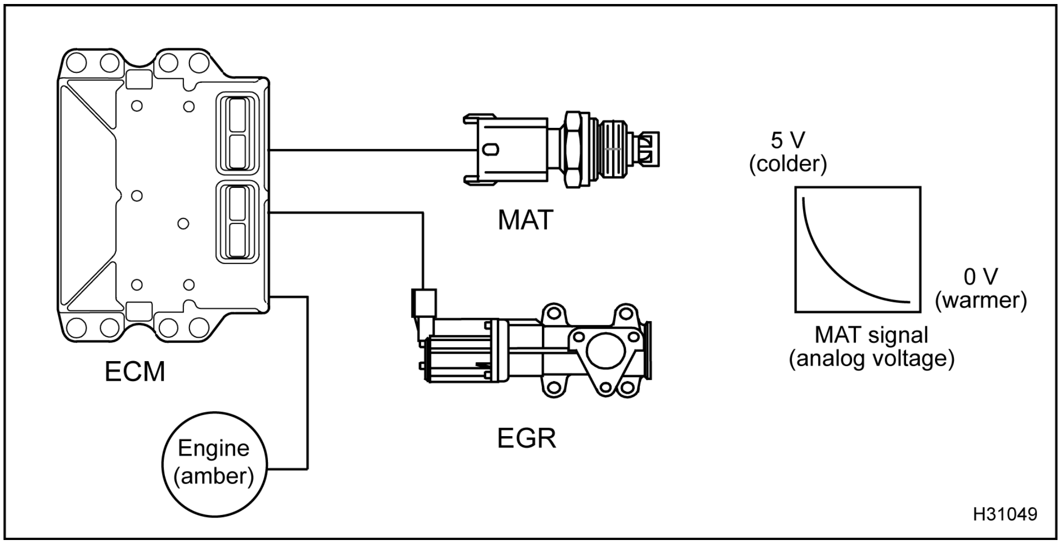



**Figure 489 Function diagram for the MAT sensor**

The function diagram for the MAT sensor includes the following:

- MAT sensor
- Exhaust Gas Recirculation (EGR)
- Electronic Control Module (ECM)
- ENGINE lamp (amber)

#### Function

The MAT sensor is a thermistor sensor installed right of the MAP sensor in the intake manifold. The ECM supplies a 5 V reference signal which the MAT sensor uses to produce an analog voltage that indicates temperature. The MAT sensor changes resistance when exposed to different temperatures. As air temperature decreases, the resistance of the thermistor increases. This causes the signal voltage to increase. As air temperature increases, the resistance of the thermistor decreases. This causes the signal voltage to decrease.

The MAT sensor provides a feedback signal to the ECM indicating manifold air temperature. The ECM monitors the MAT signal to determine if the temperature is satisfactory. During engine operation, if the ECM recognizes that the MAT signal is greater or less than the expected value it will set a Diagnostic Trouble Code (DTC).

### MAT Circuit Operation

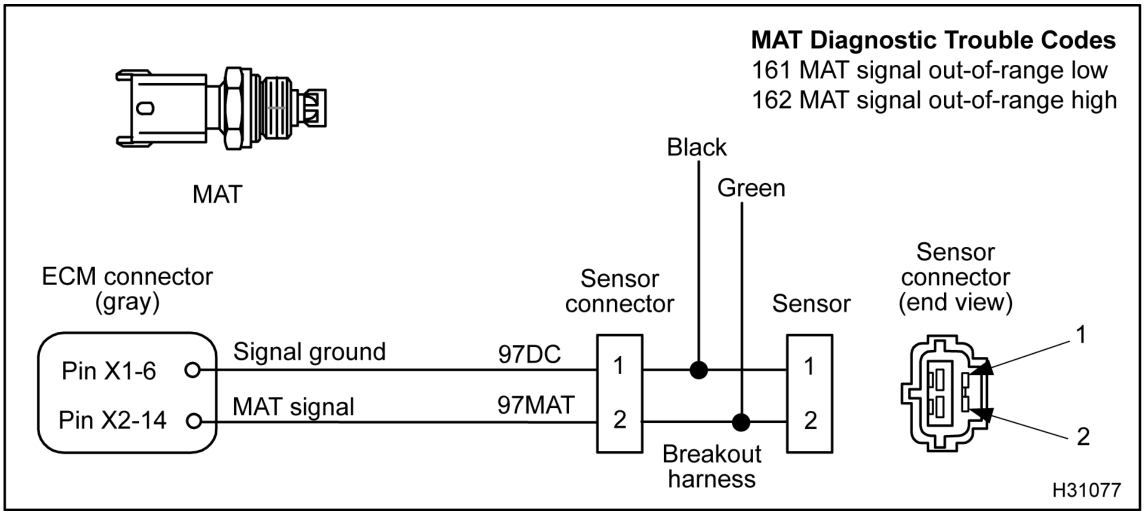



**Figure 490 MAT circuit diagram**

The MAT sensor is supplied with a 5 V reference voltage at Pin 2 from ECM Pin X2–14. The sensor is grounded at Pin 1 through the signal ground at ECM Pin X1–6. As the air temperature increases or decreases, the sensor changes resistance and provides the air temperature signal voltage at the ECM. The signal voltage is monitored by the ECM to determine the temperature of the air.

#### Fault Detection / Management

The ECM continuously monitors the signal of the MAT sensor to determine if the signal is within an expected range. If the ECM detects the signal voltage is greater or less than expected, the ECM will set a DTC.

#### MAT Diagnostic Trouble Codes (DTCs)

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

#### DTC 161
#### MAT signal out-of-range low

- DTC 161 is set by the ECM when the signal voltage is less than 0.098 V for more than 0.35 second.
- DTC 161 can be set due to a short to ground in the signal circuit or a failed MAT sensor.
- When DTC 161 is active the amber ENGINE lamp is illuminated.

#### DTC 162
#### MAT signal out-of-range high

- DTC 162 is set by ECM when the signal voltage is greater than 4.58 V for more than 0.35 second.
- DTC 162 can be set due to an open signal or ground circuit , short to a voltage source, or a failed MAT sensor.
- When DTC 162 is active the amber ENGINE lamp is illuminated.

#### Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- 3-Banana Plug Harness
- 500 Ohm Resistor Harness
- Breakout Box
- Breakout Harness
- Terminal Test Adapter Kit

**MAT Operational Diagnostics**

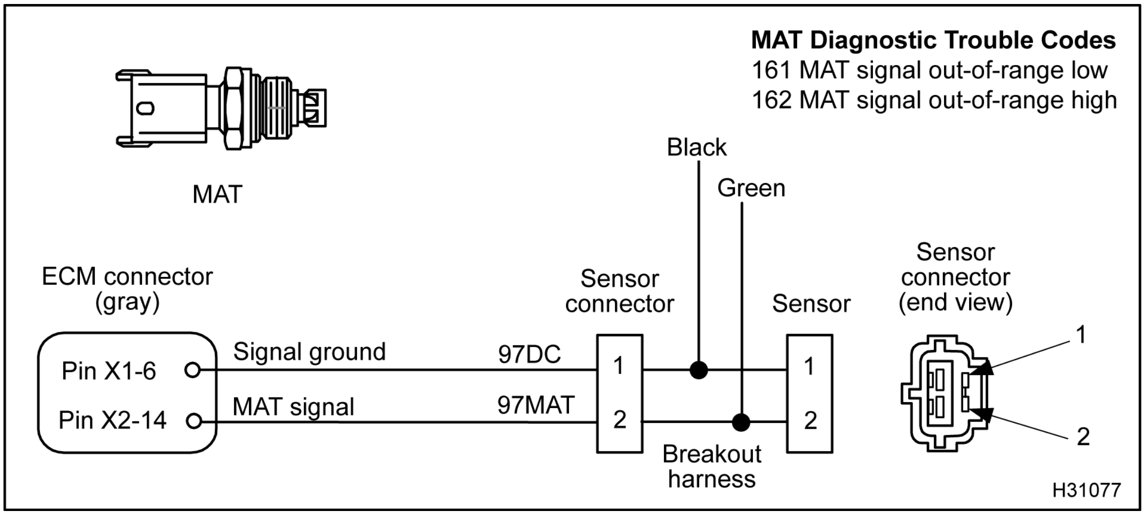



**Figure 491 MAT circuit diagram**

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:**

**Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.**

1. Using EST, open the D_ContinuousMonitor.ssn.

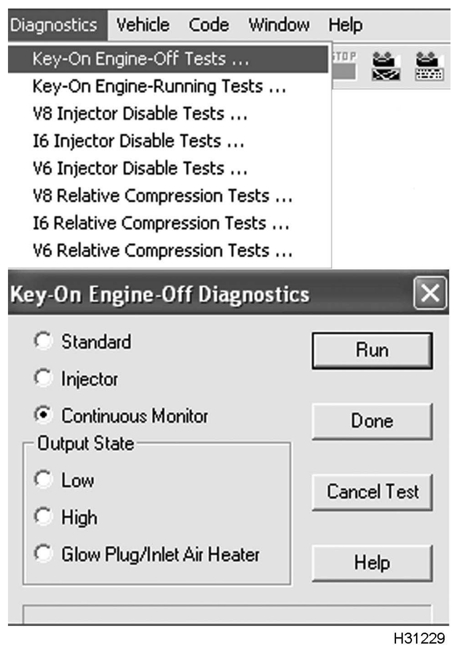



**Figure 492 Continuous Monitor Test**

2. To monitor signal voltage, run KOEO Continuous Monitor Test. For help, see “Continuous Monitor Test” in Section 3 (page 68).
3. Monitor MAT signal voltage. Verify an active DTC for the MAT circuit.

4. If code is active, do step 6 and 7 to check circuit for the MAT sensor using the following table.
   - Circuit Checks for MAT Sensor
5. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will display DTCs related to the condition.
6. Disconnect engine harness from temperature sensor.

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

7. Connect Temperature Sensor Breakout Harness to engine harness only.

**Circuit Checks for MAT Sensor** (Use EST, breakout harness, 3-Banana Plug Harness, and 500 Ohm Resistor Harness.)

| Test Condition | Spec | Checks |
|---|---|---|
| Sensor disconnected | > 4.58 V | If voltage < 4.58 V, check signal circuit for short to ground. |
| 3-Banana Plug Harness connected between Pin 2 (Green) and Pin 1 (Black) of breakout harness | 0 V | If voltage is > 0.098 V, check ground and signal circuit for open or high resistance. Use a breakout box and measure resistance from Pin 1 to Pin X1–6 and from Pin 2 to X2–14 (spec < 5 Ω). |
| 500 Ohm Resistor Harness connected between Pin 2 (Green) and Pin 1 (Black) of breakout harness | < 1.0 V | If voltage > 1.0 V, check signal circuit for short to $V_{REF}$, B+, or another sensor's signal voltage. |

**Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the MAT sensor.**

**MAT Pin-Point Diagnostics**

| Test Point | Spec | Comment |
|---|---|---|
| **Connector Voltage Checks to Ground** (Disconnect harness from sensor. Inspect for bent pins or corrosion. Connect breakout harness to engine harness only. Turn the ignition switch to ON.) | | |
| 1 to gnd | 0 V to 0.25 V | If > 0.25 V, signal wire is shorted to $V_{REF}$ or battery. |
| 2 to gnd | 4.6 V to 5 V | Pull up voltage. If no voltage, circuit has open or high resistance or short to ground. |
| **Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect harness from sensor. Connect breakout harness to engine harness only. Disconnect chassis connector 9260[1].) | | |
| 1 to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open circuit. |
| 2 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground within wiring harness. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

| | | |
|---|---|---|
| **Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Connect breakout harness to engine harness only. Use disconnected negative battery cable for ground test point.) | | |
| 1 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| 2 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| **Harness Resistance Checks** (Connect breakout box [X1 and X2 only] to engine harness. Connect breakout harness to engine harness only.) | | |
| X1–6 to 1 | < 5 Ω | If > 5 Ω, check for open ground wire. |
| X2–14 to 2 | < 5 Ω | If > 5 Ω, check for open signal wire. |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. See truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

| **Operational Voltage Checks for MAT Sensor with Breakout Harness** (Check with breakout harness connected to sensor and engine harness.) | | | |
|---|---|---|---|
| **Test Point** | **Temp** | **Resistance** | **Voltage @ Resistance** |
| 2 (Green) to 1 (Black) | 0 °C (32 °F) | 93.8 kΩ | 4.36 V |
| 2 (Green) to 1 (Black) | 15 °C (59 °F) | 47.6 kΩ | 4.0 V |
| 2 (Green) to 1 (Black) | 40 °C (104 °F) | 15.8 kΩ | 2.98 V |
| 2 (Green) to 1 (Black) | 100 °C (212 °F) | 2.3 kΩ | 0.93 V |
| **Operational Voltage Checks for MAT Sensor with Breakout Box** (Check with breakout box connected [X1 and X2 only] to the ECM and engine harness.) | | | |
| X2–14 to X1–6 | 0 °C (32 °F) | 93.8 kΩ | 4.36 V |
| X2–14 to X1–6 | 15 °C (59 °F) | 47.6 kΩ | 4.0 V |
| X2–14 to X1–6 | 40 °C (104 °F) | 15.8 kΩ | 2.98 V |
| X2–14 to X1–6 | 100 °C (212 °F) | 2.3 kΩ | 0.93 V |
| **MAT Diagnostic Trouble Codes** | | | |
| DTC 161 = Signal voltage was < 0.098 V for more than 0.35 second | | | |
| DTC 162 = Signal voltage was > 4.58 V for more than 0.35 second | | | |

**RSE (Radiator Shutter Enable)**

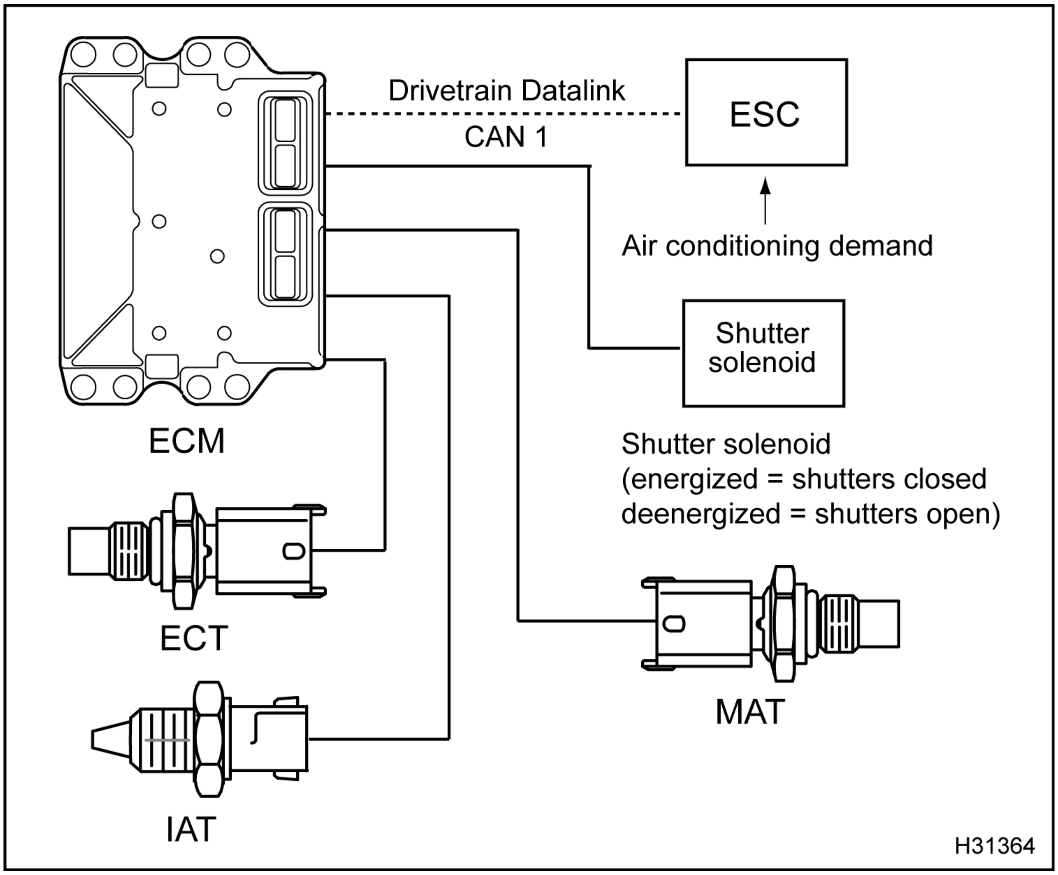



**Figure 493 Function diagram for the RSE**

The function diagram for the RSE includes the following:

- Electronic Control Module (ECM)
- Intake Air Temperature (IAT) sensor
- Engine Coolant Temperature (ECT) sensor
- Manifold Air Temperature (MAT) sensor
- Shutter solenoid
- Electronic System Controller (ESC)
- Drivetrain Datalink (CAN 1)

**Function**

The Radiator Shutter Enable (RSE) feature provides the correct logic to open or close the radiator shutters (energize or de-energize a solenoid). Closing the shutters will keep the engine warm during cold weather operation. This provides faster warm up of the passenger cab and enables faster windshield defrosting.

### RSE Circuit Operation

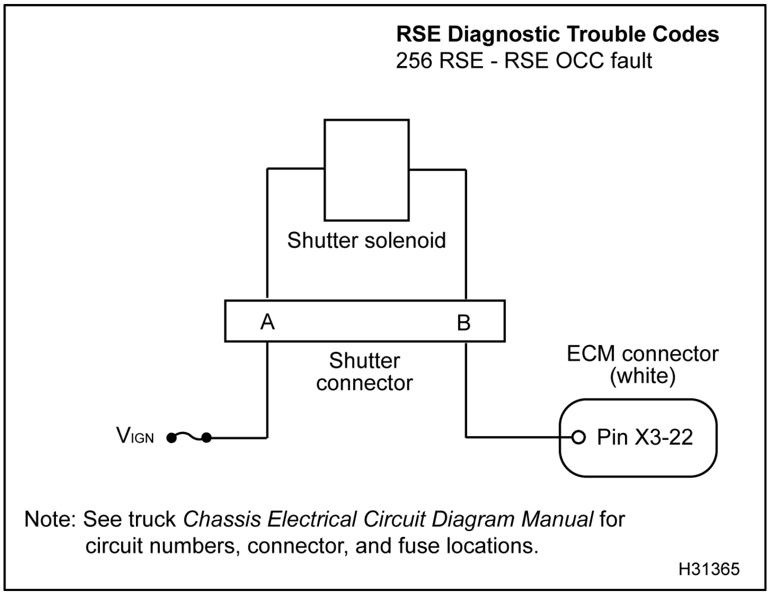



**Figure 494 RSE circuit diagram**

The RSE circuit provides control to open or close the radiator shutters (energize or deenergize a solenoid). Radiator shutters keep the engine warm during cold weather operation. When the ignition switch is ON, power is available to the shutter solenoid.

The shutters **will close when all** of the following conditions exist:

- MAT is less than 37 °C (99 °F)
- IAT is less than 7 °C (45 °F)
- ECT is less than 80 °C (176 °F)
- No transmission retarder request is present
- No engine fan request is present

The shutters **will open when any** of the following conditions exist:

- MAT is greater than 60 °C (140 °F)
- IAT is greater than 12 °C (54 °F)
- ECT is greater than 87 °C (189 °F)

  (**Note:** ECT is customer programmable)
- Transmission retarder request is present
- Engine fan request is present

The shutters will not close again until all closed conditions exist:

The ECM controls the shutter solenoid by providing a path to ground for the solenoid coil. When the shutters need to be activated, Pin X3–22 is grounded from the ECM. When the shutters need to be deactivated, the ground is removed from ECM Pin X3–22.

If all pin-point diagnostic tests are in specification, and the shutters are not operating in accordance with parameters, contact International® Technical Services.

### Fault Detection / Management

An open or short to ground in the RSE 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 will be set.

### RSE Diagnostic Trouble Codes (DTCs)

### DTC 256
### RSE OCC fault

- DTC 256 is set by the ECM when the OCC test has failed after the KOEO Standard Test has been run.
- DTC 256 can be set when a poor connection, an open or short to ground in the relay control circuit, or failed relay exists.
- When DTC 256 is active the amber ENGINE lamp is illuminated.

### Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)

### RSE Pin-Point Diagnostics

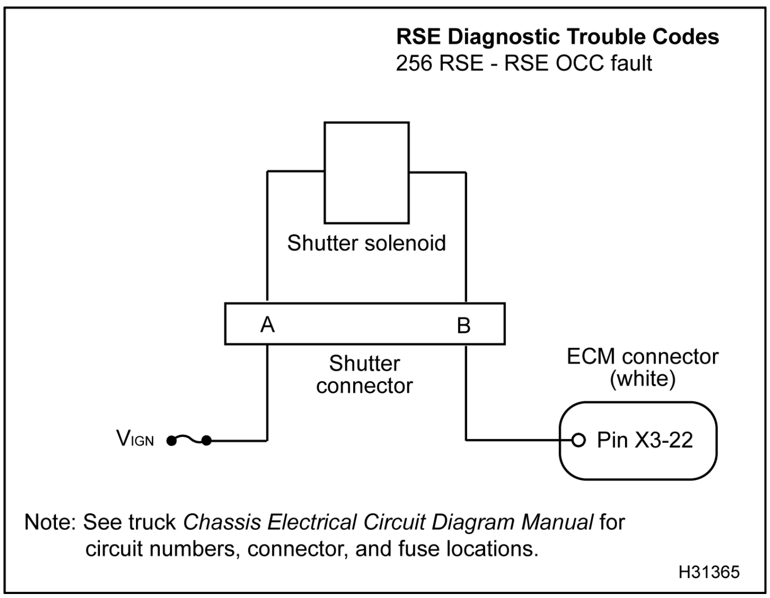



**Figure 495 RSE circuit diagram**

The RSE circuit requires the use of vehicle circuit diagrams. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**Voltage Checks at Solenoid Connector** (Disconnect solenoid. Turn the ignition switch to ON.)

| Test Point | Spec | Comment |
|---|---|---|
| KOEO | | |
| A to gnd | B+ ± 0.5 V | If < B+, check for open circuit. Do Harness Resistance Checks. |
| B to gnd | 0 V to 0.25 V | If > 0.25 V, check ECM programming or open circuit. |

**Output State Test - Voltage Check at Shutter Connector** (Disconnect solenoid. Turn the ignition switch to ON. Run the Output State Tests. For help, see “Diagnostic Software Operation” in Section 3 (page 68) for procedure to run the Low and High Output State Tests.)

| Test State/Point | Spec | Comment |
|---|---|---|
| Output State Test - Low | | |
| B+ to Pin B | B+ ± 0.5 V | If < B+, check ECM programming and check for open circuit. |
| Output State Test - High | | |
| B+ to Pin B | 0 V to 0.25 V | If > 0.25 V, check ECM programming and check for short to voltage source. |

**RSE Solenoid Continuity Check** (Turn the ignition switch to OFF. Disconnect solenoid.)

| | | |
|---|---|---|
| B to gnd | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| A to gnd | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| B to A | 10 Ω to 30 Ω | Expected coil resistance for solenoid. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect negative battery cable. Disconnect solenoid. Use disconnected negative battery cable for ground test point.)

| | | |
|---|---|---|
| A to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| B to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |

**Harness Resistance Checks** (Turn the ignition switch to OFF. Disconnect solenoid. Connect breakout box X3 to chassis wiring harness only.)

| | | |
|---|---|---|
| X3–22 to B | < 5 Ω | If > 5 Ω, check for harness open between ECM and fan solenoid. |
| A to Fuse | < 5 Ω | If > 5 Ω, check for harness open between fuse and fan solenoid. See truck *Chassis Electrical Circuit Diagram Manual* for fuse information. |

| | | |
|---|---|---|
| **Output State Test - Voltage Checks at ECM** (Disconnect X3 and X4 from ECM. Connect breakout box X3 only to ECM and wiring harness. Turn the ignition switch to ON. Run the Output State Tests. For help, see "Diagnostic Software Operation" in Section 3 (page 68) for procedure to run the Low and High Output State Tests.) | | |
| Output State Test - Low | | |
| X3–3 to X3–22 | B+ ± 0.5 V | If < B+, **verify that ECM is programmed correctly.** If ECM is programmed correctly, replace ECM. |
| Output State Test - High | | |
| X3–3 to X3–22 | 0 V to 0.25 V | If > 0.25 V, **verify that ECM is programmed correctly.** If ECM is programmed correctly, replace ECM. |
| **Operational Voltage Check to Shutter Solenoid** (Check with solenoid connected and breakout box connected. **Note:** This test should only be done when no DTCs are present. Monitor engine parameters and voltage at ECM X3–22 while engine is running.) | | |
| X3–3 to X3–22 | B+ ± 0.5 V | The solenoid is energized and the shutters are closed.<br>• MAT is less than 37 °C (99 °F)<br>• IAT is less than 7 °C (45 °F)<br>• ECT is less than 80 °C (176 °F)<br>• No transmission retarder request is present<br>• No engine fan request is present |
| X3–3 to X3–22 | 0 V to 0.25 V | The solenoid is deenergized and the shutters are open.<br>• MAT is greater than 60 °C (140 °F)<br>• IAT is greater than 12 °C (54 °F)<br>• ECT is greater than 87 °C (189 °F)<br>• Transmission retarder request is present<br>• Engine fan request is present |
| **RSE Diagnostic Trouble Codes** | | |
| DTC 256 = Output Circuit Check detected during KOEO Standard Test, indicates high or low resistance in circuit. | | |

**SCCS (Speed Control Command Switches)**

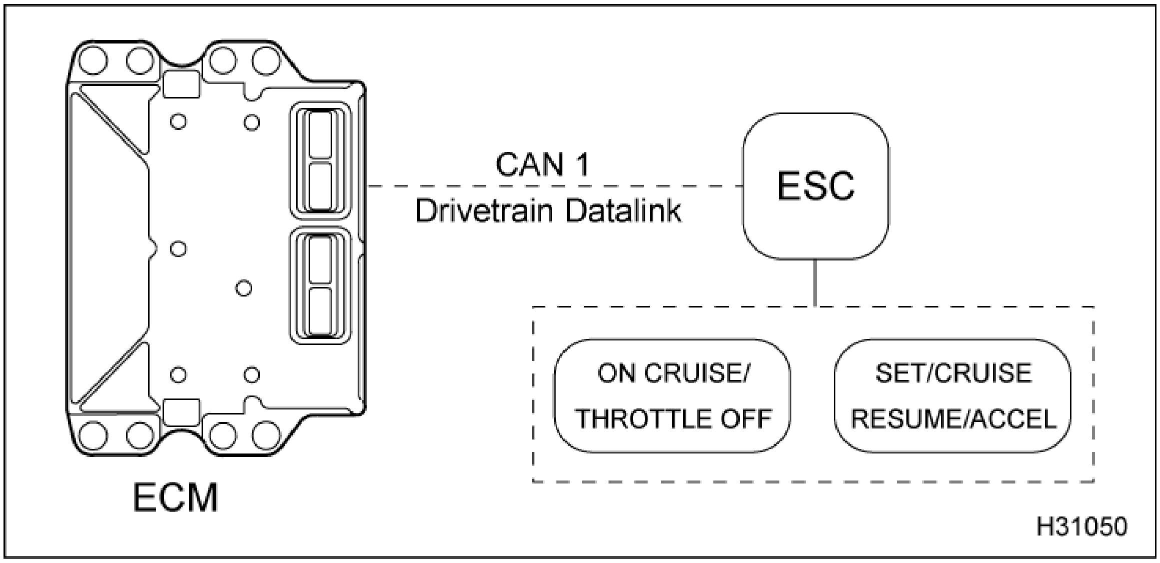



**Figure 496 Function diagram for the SCCS**

The function diagram for the SCCS includes the following:

- Electronic System Controller (ESC)
- Electronic Control Module (ECM)
- Steering wheel cruise control switches

**Cruise Control**

The ECM will control engine speed to maintain a constant road speed with cruise control. Pressing the set switch when the vehicle is at the desired speed with the CRUISE switch in the on position activates the cruise control. Speed is increased or decreased by pressing ACCEL/CRUISE switches. The cruise control is deactivated by pressing the off switch, applying the brake pedal, clutch pedal, or on vehicles equipped with automatic transmissions, by placing the transmission in neutral.

**Power Takeoff (PTO) Control**

Engine speed can be controlled by the SCCS switches if the PTO option has been programmed into the ECM and the vehicle is stationary. Variable as well as preset speeds are available depending on ECM programming. The PTO function is turned on by pressing the cruise switch on. Pressing the SET/CRUISE or RESUME/ACCEL switches will increase or decrease engine speed depending on PTO programming.

**SCCS Circuit Operation**

Cruise control allows the ECM to control the engines power delivery to maintain a constant vehicle speed. The speed set point is determined by the operator and the cruise high and low set points are programmed in the ECM. The minimum engine speed that the cruise control can be engaged is programmed in the ECM.

Cruise control features are enabled as follows:

| | |
|---|---|
| Cruise ON/OFF button: | ON enables and OFF disables the cruise control functions. |
| SET / CRUISE: | If the cruise is enabled but a speed is not set, pressing the SET/CRUISE switch will select the current vehicle speed as the set speed.<br><br>If the cruise is enabled and a speed is set, pressing the SET/CRUISE switch will cause the vehicle speed to decrease. |
| RESUME / ACCEL: | If the cruise is enabled, but has been deactivated by applying the brake or clutch, pressing the RESUME/ACCEL switch will cause the vehicle speed to resume to the last set speed.<br><br>If the cruise is enabled and active, pressing the RESUME/ACCEL switch will cause the vehicle speed to accelerate. |

**In-Cab PTO**

In-Cab PTO has three different modes of operation. These modes are selected by programming the ECM In-Cab PTO Mode. These modes are:

- In-Cab Preset
- In-Cab Variable
- In-Cab Mobile

**In-Cab Preset**

In-Cab Preset is selected by programming the ECM programmable parameters for In-Cab Mode to In-Cab Preset. This allows the operator to select one of two programmed values for engine speed. To operate, press the ON/OFF switch to the ON position. Then press either the SET/CRUISE or RESUME/ACCEL switch. This will cause the engine speed to run at the value programmed into PTO Set Speed.

Pressing the off switch, brake pedal, clutch pedal, placing the automatic transmission in gear, or a signal from the Vehicle Speed Sensor (VSS) (unless programmed for Mobile operation), will deactivate the PTO speed control. PTO speed control will not be functional if the VSS signal is in fault.

**In-Cab Variable**

In-Cab Variable is selected by programming the ECM Programmable Parameters for In-Cab Mode to In-Cab Variable. This option allows the operator to set the engine speed to a desired value. The control module will then maintain this speed over varying load conditions up to the engines rated power in the selected speed range.

To enable, press the ON/OFF switch to the ON position. Speed may be adjusted two ways. First the operator may adjust the engine speed with the accelerator and then press the SET/CRUISE switch. Second, the operator may press the RESUME/ACCEL to increase engine speed incrementally or press the SET/CRUISE switch to decrease the engine speed.

Engine set speed will be limited to the value programmed in the ECM for Maximum PTO speed.

Pressing the OFF switch, brake pedal, clutch pedal, placing the automatic transmission in gear, or a signal from the VSS, (unless programmed for Mobile operation), will deactivate the PTO speed control. PTO speed control will not be functional if the VSS signal is in fault.

**In-Cab Mobile**

In-Cab Mobile is selected by programming the ECM programmable parameters for the In-Cab mode to In-Cab Mobile. This allows the operator to use the engine speed control the same as In-Cab Variable, however, in this mode the vehicle can be moving while the mode is active. See In-Cab Variable for more details. The maximum speed of the vehicle is programmable up to 20 mph. This mode is the same as In-Cab Variable, however, a speed signal will not disable the speed control until the programmed maximum speed is exceeded.

**Remote PTO**

Remote PTO can be enabled by two means, Remote Preset and Remote Variable. Operation of the speed control depends on which signal is enabled.

**Remote Preset**

When in the preset mode, the set switch will cause the engine to run at the programmed set speed. The RESUME/ACCEL switch will allow the engine to run at the programmed resume speed.

With the remote preset enabled, the speed is adjusted as with In-Cab preset. See In-Cab preset for more details.

Turning the ON/OFF switch OFF, depressing the brake pedal, clutch pedal, placing the automatic transmission in gear, or a signal from the VSS will deactivate the PTO speed control. However, the programmed option of PTO Operation Disable will prevent the clutch and brake signals from interrupting the PTO speed control, as well as cause the Accelerator Position Sensor (APS) to be inoperative. PTO speed control will not be functional if the VSS signal is in fault.

**Remote Variable**

Enabling the remote variable signal allows for the engine speed to be adjusted to the desired level. Pressing the RESUME / ACCEL switch will cause the engine speed to increase, pressing the SET/CRUISE switch will cause the engine speed to decrease.

With remote variable enabled the speed is adjusted as with In-Cab Variable.

Opening the switch to Pin X3–20, pressing the ON/OFF switch to OFF, depressing the brake or clutch pedal or placing the automatic transmission in gear, or a signal from the VSS will deactivate the PTO speed control. However the programmed option of PTO Operation Disable will prevent the clutch and brake signals from interrupting the PTO speed control, as well as cause the APS to be inoperative. PTO speed control will not be functional if the VSS signal is in fault.

**PTO Speed Ramp Rate**

The rate at which the speed of the engine will change will depend on load conditions and on a programmed value called PTO speed ramp rate. A higher value will cause the engine to change speed more quickly.

**Tools**

- EST with INTUNE and MasterDiagnostics® software
- EZ-Tech® interface cable
- *Electrical System Troubleshooting Guide* (truck manual)
- Electrical Circuit Diagrams (truck manual)

**Fault Detection / Management**

The ECM does not monitor the SCCS system for faults. There are no Diagnostic Trouble Codes (DTCs) for this system.

**Diagnostics**

If the engine does not respond to the cruise control switches, use INTUNE to monitor cruise switch input to the ESC. If the switch state does not change when the cruise controls are pressed, diagnose the cruise switch circuits using the *Electrical System Troubleshooting Guide*. If the ESC is receiving the cruise switch input, use MasterDiagnostics® to view the cruise switch state. If the switch state does not change as the switch is pressed, verify communication exists between the ECM and the ESC (does the ECM respond to other ESC inputs). If the switch state does change, verify that other conditions do not exist that would stop or delay the reaction to the input. Examples include:

- rpm below minimum
- rpm above maximum
- Road speed below minimum / Road speed above maximum
- Brake pedal depressed
- Clutch / driveline disengaged

The EST can be used to monitor the status of the PTO controls. Comparing the data list reading to actual operation will indicate if the controls are operating correctly. Using the menu option of programmable parameters the programming can be verified to be sure the ECM is programmed correctly for the application. Also the data list can be used to monitor the parameters that cause interruption of PTO speed control.

### Tachometer Output Circuit

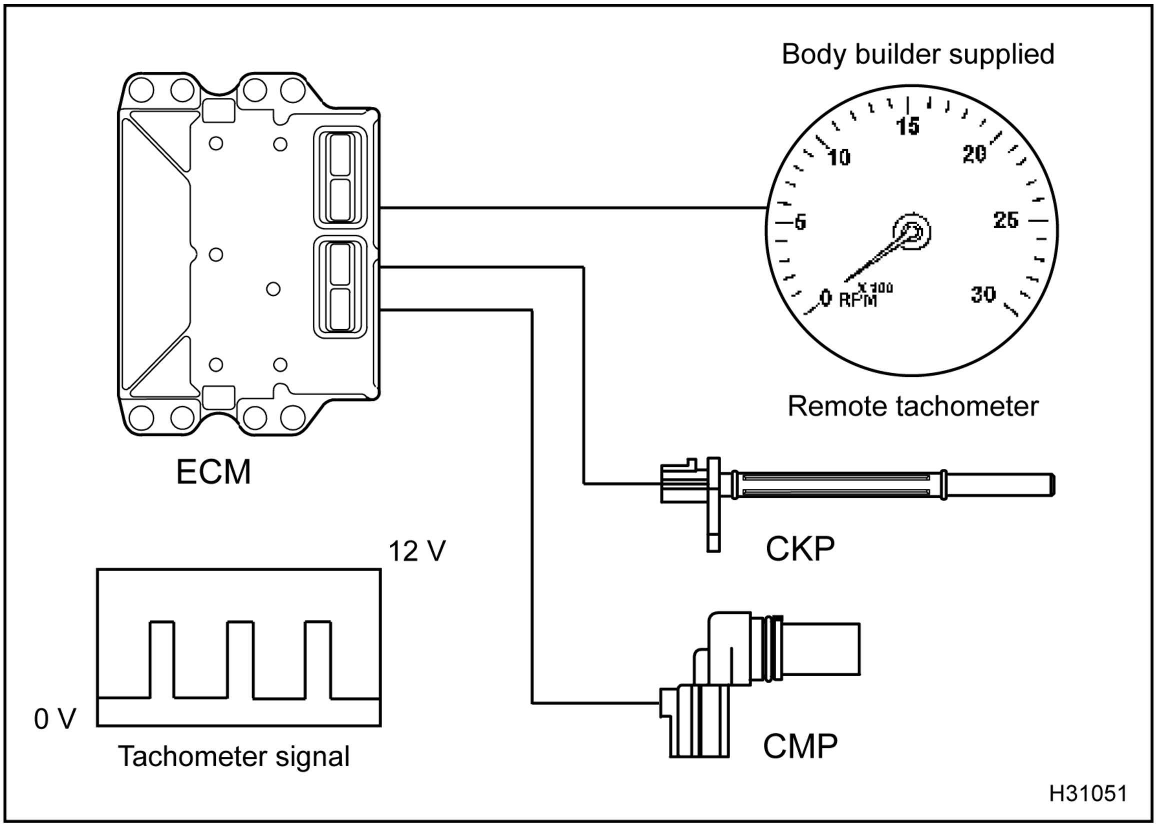



**Figure 497 Function diagram for the tachometer output circuit**

The function diagram for the tachometer output circuit consists of the following:

- Remote tachometer
- Electronic Control Module (ECM)
- Camshaft Position (CMP) sensor
- Crankshaft Position (CKP) sensor

The ECM provides an output for a remote tachometer with a 0 V to 12 V 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).

#### Tachometer Input Signal

The ECM receives a signal from the CMP sensor and calculates engine speed (rpm). The ECM sends the calculated engine speed as a digital buffered TACH signal from the ECM connector to the owner installed tachometer.

#### Tachometer Diagnostic Trouble Codes (DTCs)

DTCs are not available for communication between the ECM and the remote tachometer.

**Tachometer Pin-Point Diagnostics**

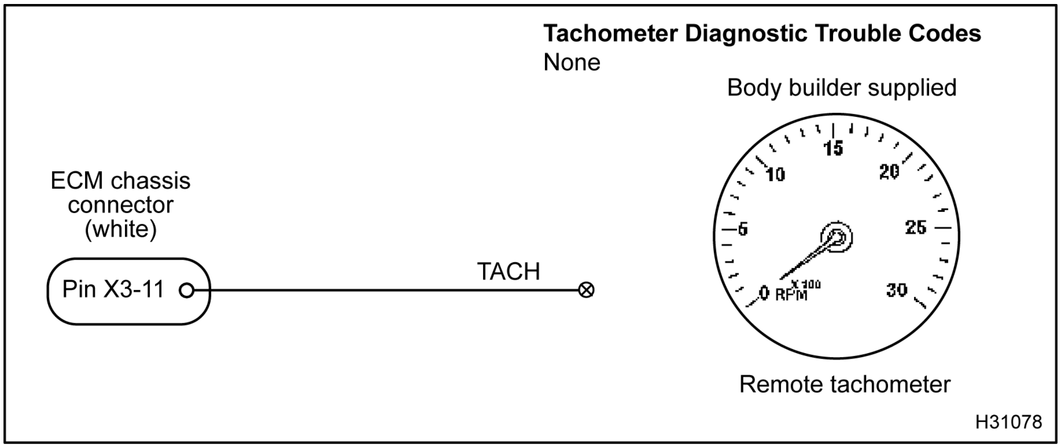



**Figure 498 Tachometer circuit diagram**

| Test Point | Spec | Signal | Comment |
|---|---|---|---|
| **Key-On Engine-Off Voltage Checks at ECM** (Check with key-on engine-off and breakout box connected [X3 only] to ECM and chassis harness.) | | | |
| X3–11 to X3–7 | 12 V ±1.5 V | TACH | The signal is pulled up by the ECM with the key-on engine-off. |
| **Connector Checks to Ground at ECM** (Check with key-on engine-off and breakout box connected [X3 only] to ECM and chassis harness.) | | | |
| X3–11 to X3–7 | > 1 kΩ | TACH | If < 1 kΩ, check for short to ground either through the harness or internal ECM. Disconnect the ECM from the breakout box and measure to ground again. If short is still present, repair harness. |
| **Harness Resistance Checks** (Check with key-on engine-off and breakout box connected [X3 only] to ECM and chassis harness.) | | | |
| X3–11 to tach | < 5 Ω | TACH | Resistance from ECM connector to TACH input – Optional owner / operator tach. |
| **Key-On Engine-Running Signal Checks – TACH** (Check with key-on engine-off and breakout box connected [X3 only] to ECM and chassis harness.) | | | |
| X3–11 to X3–7 | 140–700 Hz | | Tach signal from the ECM is a frequency that is engine rpm divided 5. Multiply frequency by 5 to calculate rpm. |
| **NOTE:** The instrument cluster tachometer does not use these outputs. See truck *Electrical System Troubleshooting Guide*. | | | |

### VGT Actuator (Variable Geometry Turbocharger)

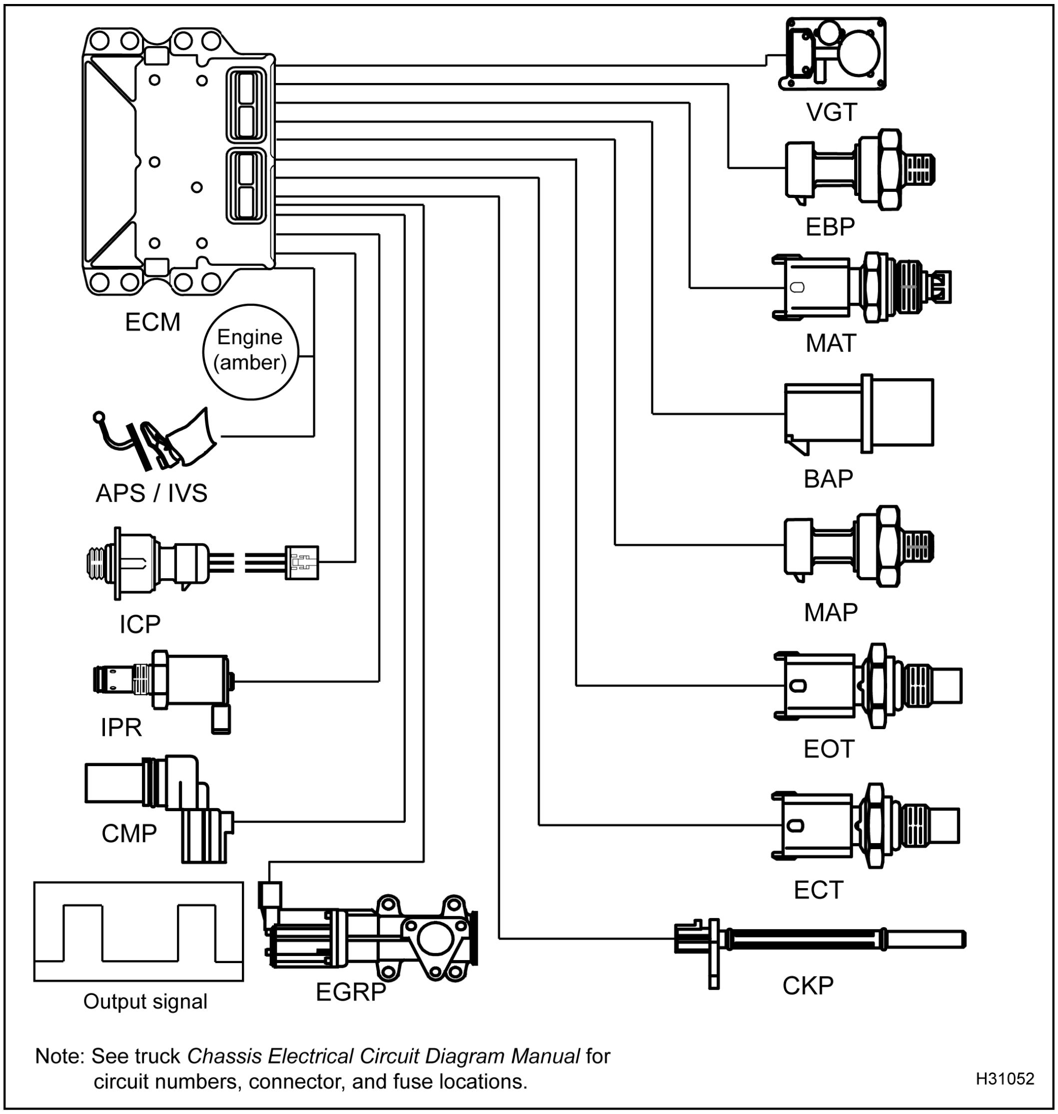



**Figure 499 Function diagram for the VGT actuator**

The function diagram for the VGT actuator includes the following:

- VGT actuator
- Electronic Control Module (ECM)
- Accelerator Pedal Position sensor and Idle Validation Switch (APS/IVS)
- Barometric Absolute Pressure (BAP) sensor
- Camshaft Position (CMP) sensor
- Crankshaft Position (CKP) sensor
- Engine Coolant Temperature (ECT) sensor
- Exhaust Gas Recirculation (EGR)
- Engine Oil Temperature (EOT) sensor
- Exhaust Back Pressure (EBP) sensor
- Injection Control Pressure (ICP) sensor
- Injection Pressure Regulator (IPR)
- Manifold Absolute Pressure (MAP) sensor
- Manifold Air Temperature (MAT) sensor

- ENGINE lamp (amber)

**Function**

The VGT actuator is a control module that contains a microchip and a DC motor. The VGT actuator is located below the turbocharger. The microchip operates a DC motor which rotates a crank lever controlling the vane position in the turbine housing. The position of the vanes is based off the pulse width modulated signal sent from the ECM.

Actuator control for the vane position is achieved by setting a pulse width modulated signal from the ECM in response to the following:

- Engine speed
- Desired fuel quantity
- Boost (manifold air pressure)
- Exhaust back pressure and altitude

**VGT Circuit Operation**

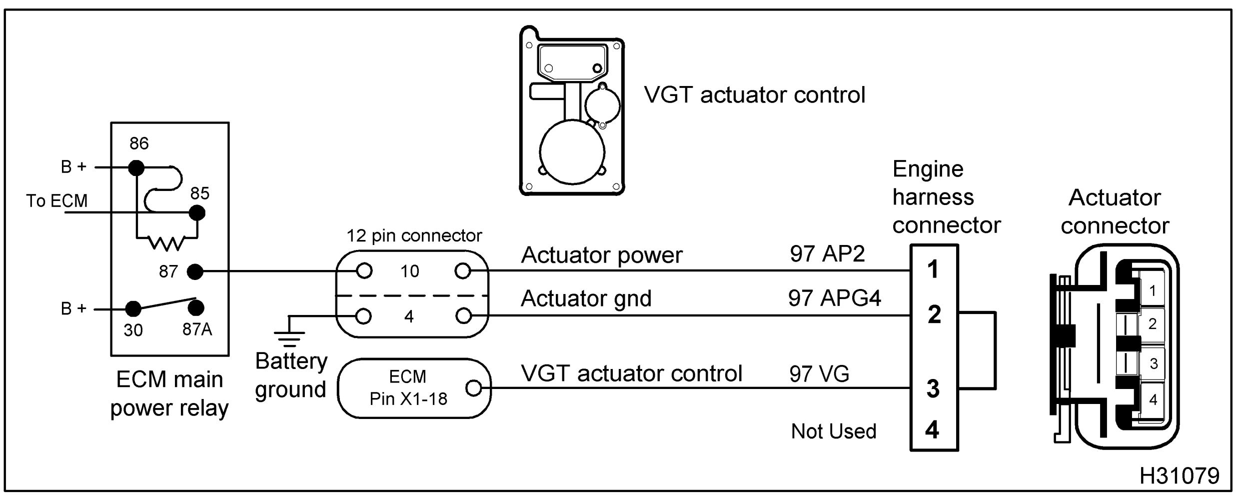



**Figure 500 VGT circuit diagram**

The VGT actuator receives power at Pin 1, through the 12-pin connector Pin 10, from the ECM main power relay Pin 87. Ground for the VGT actuator is supplied at Pin 2, through the 12-pin connector Pin 4 from battery ground. The ECM controls the VGT actuator by sending a pulse width modulated signal from the ECM, Pin X1-18 to the actuator harness connector Pin 3.

The VGT actuator is controlled by varying the percentage of ON/OFF time of the VGT actuator control signal to control module. A high duty cycle indicates a high amount of exhaust back pressure is being commanded. A low duty cycle indicates less pressure being commanded.

**Fault Detection / Management**

When the engine is running, the ECM can detect if exhaust back pressure equals the desired pressure. When measured exhaust back pressure does not equal the desired pressure, the ECM will ignore the EBP sensor signal and use a preset value based on engine operating conditions.

If the VGT actuator is suspect, use the EST to run the Output State Test Low. See “Diagnostic Software Operation” in Section 3 (page 68). Check crank lever operation during this test.

**VGT Diagnostic Trouble Codes (DTCs)**

There are no specific DTCs relating to the wiring or Output Circuit Check (OCC) for the VGT actuator. When diagnosing the air management system, VGT wiring and operation can be tested with the following checks.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Turbo Breakout Harness
- 12-pin Breakout Harness
- Breakout Box
- Terminal Test Adapter Kit
- 500 Ohm Resistor Harness

## VGT Pin-Point Diagnostics

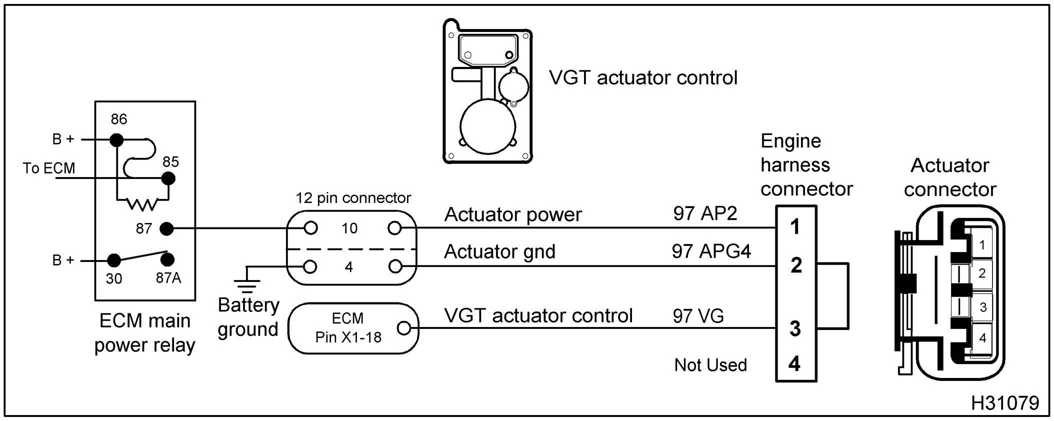



**Figure 501 VGT circuit diagram**

**NOTE:** Turn the ignition switch to OFF before disconnecting engine wiring harness connectors from components.

See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**Actuator Control Voltage Check** (Disconnect actuator harness from engine harness. Connect Turbo Breakout Harness to engine and actuator harness. Turn the ignition switch to ON.)

| Test Point | Spec | Comment |
|---|---|---|
| 1 to 2 | B+ ± 0.5 V | If < B+, continue with next test point, 1 to chassis gnd.<br>If equal to B+, check test point 3 to gnd (KOEO). |
| 1 to chassis gnd | B+ ± 0.5 V | If equal to B+, but 1 to 2 did not equal B+, check for high resistance or open in ground circuit. Do Harness Resistance Checks – ECM to ECM Chassis Ground (page 561).<br>If < B+, disconnect the actuator harness from Turbo Breakout Harness and retest.<br>• If < B+, do 12-pin Actuator Power Voltage Check (page 557).<br>• If equal to B+, the concern is either high resistance in wiring or the VGT actuator. Do Harness Resistance Checks (page 561) to confirm integrity of wiring. See truck *Chassis Electrical Circuit Diagram Manual*.<br>If integrity of wiring is confirmed to be in good condition, replace VGT actuator. |

| | | |
|---|---|---|
| 2 to chassis gnd | 0 V to 0.25 V | If > 0.25 V disconnect the actuator harness and retest.<br>• If > 0.25 V, do 12-pin Actuator Power Voltage Check (page 557).<br>• If < 0.25 V, the concern is either high resistance in wiring or the VGT actuator. Do Harness Resistance Checks (page 561) to confirm integrity of wiring. See truck *Chassis Electrical Circuit Diagram Manual*.<br>If integrity of wiring is confirmed to be in good condition, replace VGT actuator. |
| 3 to gnd (KOEO) | DMM set to V - DC[1]<br>DMM set to Duty Cycle[2] | If test point 1 to 2 is to specification and no voltage or duty cycle is measured, disconnect actuator harness. Connect 500 Ohm Resistor Harness between Pin 3 and Pin 2. Retest by measuring across Pin 3 and Pin 2.<br>• If after retesting and values are not to specifications, do Actuator Control Voltage Check at ECM (page 558).<br>• If values are to specifications, the concern is either high resistance in the wiring or the VGT actuator. Do Harness Resistance Checks (page 561) to confirm integrity of wiring.<br>If integrity of wiring is confirmed to be in good condition, replace VGT actuator. |

[1] Values are calibration dependent. See “DT 466 Performance Specifications” – Appendix A (page 619) or “DT 570 and HT 570 Performance Specifications – Appendix B (page 643).

[2] Use the EST with MasterDiagnostics® software to view VGT duty cycle with key-on engine-off. When using the Fluke 88 DMM, measurement is typically within 2% of what MasterDiagnostics® reads.

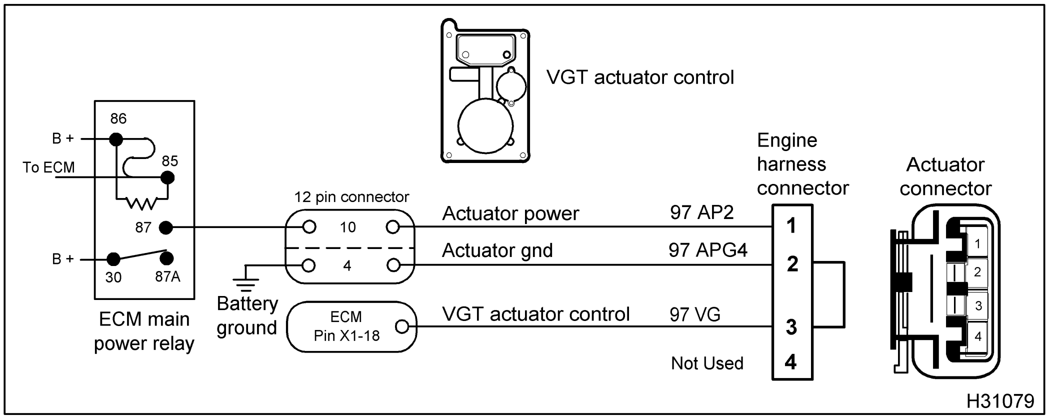



**Figure 502 VGT circuit diagram**

**NOTE:** Turn the ignition switch to OFF before disconnecting engine wiring harness connectors from components.

See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**Output State Test - Signal Check** (Actuator Control Voltage check has been completed. Pin 2 to ECM Chassis Ground is to specification. Connect Turbo Breakout Harness to engine harness and actuator harness. Run the Low and High Output State Tests. See "Diagnostic Software Operation" in Section 3 (page 68) for procedure to do the Low and High Output State Tests.)

| Test State/Point | Setting/Spec | Comment |
|---|---|---|
| Output State Test - Low | DMM set to V - DC | Listen and observe to verify if crank lever of VGT actuator moves. Toggling between the Low and High Output State Tests can be done during this test. |
| 3 to 2 | 0 V to 0.25 V | If > 0.25 V, disconnect actuator harness and connect 500 Ohm Resistor Harness between 3 and 2. Retest Output State Test - Low.<br>• If > 0.25 V the concern is with engine harness or ECM, check for a short to B+ or $V_{REF}$. Do the Actuator Control Voltage Check at ECM (page 558) and Harness Resistance Checks (page 561).<br>• If < 0.25 V, the concern is either high resistance in wiring or the VGT actuator. Do Harness Resistance Checks (page 561) to confirm integrity of wiring. See *Chassis Electrical Circuit Diagram Manual*.<br>If integrity of wiring is confirmed to be in good condition, replace VGT actuator. |
| Output State Test - High | DMM set to V - DC | Listen and observe to verify if crank lever of VGT actuator moves. Toggling between the Low and High Output State Tests can be done during this procedure. |
| 3 to 2 | B+ ± 0.5 V | If < B+, disconnect actuator harness and connect 500 Ohm Resistor Harness between 3 and 2. Retest Output State Test - High.<br>• If < B+, the concern is with engine harness or ECM, check for a short to ground or open VGT actuator control. Do the Actuator Control Voltage Check at ECM (page 558) and Harness Resistance Checks (page 561).<br>• If equal to B+, the concern is either high resistance in wiring or the VGT actuator. Do Harness Resistance Checks (page 561) to confirm integrity of wiring. See *Chassis Electrical Circuit Diagram Manual* needs to be referenced to check wiring from $BAT_{GND}$ to 12 - Pin Connector.<br>If integrity of wiring is confirmed to be in good condition, replace VGT actuator. |

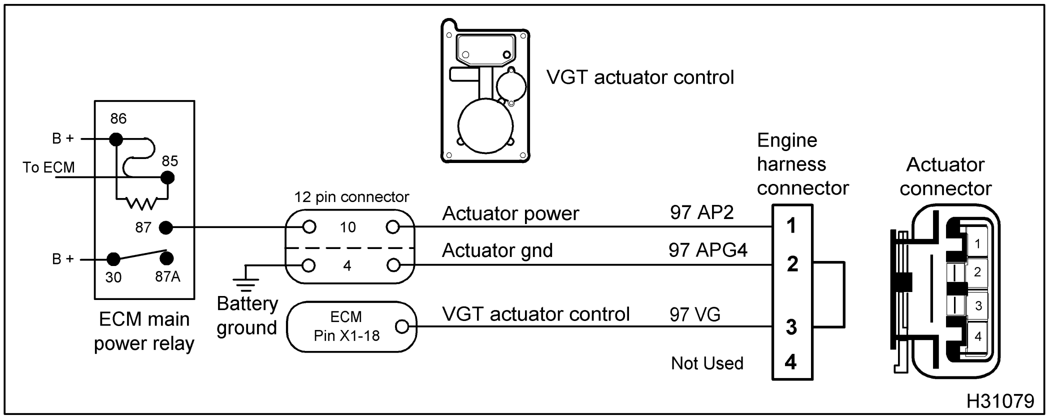



**Figure 503 VGT circuit diagram**

**NOTE:** If an Actuator Control Voltage Check was not to specification, continue with this check.

Turn the ignition switch to OFF when disconnecting engine wiring harness connectors from components.

See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**12-pin Actuator Power Voltage Check** (Actuator Control Voltage Check has been completed and Turbocharger is not connected. Connect 12-pin Breakout Harness to engine and chassis wiring harness. Turn the ignition switch to ON.)

| Test State/Point | Setting/Spec | Comment |
|---|---|---|
| 10 to 4 | B+ ± 0.5 V | If equal to B+, concern is within engine wiring harness. Do Harness Resistance Check – VGT Actuator to 12-Pin Connector (page 561).<br>If < B+, continue with next test point, 10 to chassis ground. |
| 10 to chassis gnd | B+ ± 0.5 V | If equal to B+, but 10 to 4 did not, the concern is between 12-pin connector and chassis ground. Check for high resistance or open in ground circuit. See truck *Chassis Electrical Circuit Diagram Manual*.<br>If < B+, disconnect engine wiring harness from 12-pin Breakout Harness and retest.<br>• If equal to B+, diagnose engine wiring harness to turbo. Do Harness Resistance Check – VGT Actuator to 12-Pin Connector (page 561).<br>• If < B+, the concern is between 12-Pin Connector and ECM Main Power Relay. See truck *Chassis Electrical Circuit Diagram Manual*. |
| 4 to chassis gnd | 0 V to 0.25 V | If > 0.25 V disconnect engine wiring harness from 12 - Pin Breakout Harness and retest.<br>• If < 0.25 V, diagnose engine wiring harness, do Harness Resistance Check – VGT Actuator to 12-Pin Connector (page 561).<br>• If > 0.25 V, the concern is between 12-Pin Connector and battery ground terminal. See truck *Chassis Electrical Circuit Diagram Manual*. |

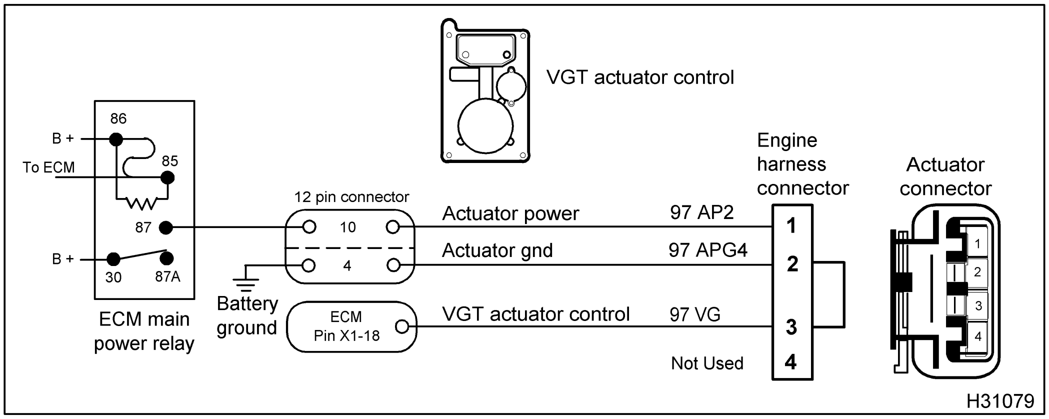



**Figure 504 VGT circuit diagram**

**NOTE:** If an Actuator Control Voltage Check was not to specification, continue with this check.

Turn the ignition switch to OFF when disconnecting engine wiring harness connectors from components.

See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**Actuator Control Voltage Check at ECM** (Connect breakout box X-1 only to ECM and engine harness. Engine harness is not connected to actuator harness. Connect 500 Ohm Resistor Harness between X1-18 and X1-6. Turn the ignition switch to ON. See “Diagnostic Software Operation” in Section 3 (page 68) for procedure to do the Low and High Output State Tests.)

| Test State/Point | Setting/Spec | Comment |
|---|---|---|
| KOEO | DMM set to V - DC | |
| X1–18 to X1– 6 | DMM set to V - DC[1]<br>DMM set to duty cycle[2] | If in specification, run the Low and High Output State Tests.<br>If not in specification, disconnect engine harness from breakout box harness and retest.<br>• If not in specification, run the Low and High Output State Tests.<br>• If in specification, diagnose engine wiring harness. Do Harness Resistance Check – VGT Actuator to ECM (page 562). |
| Output State Test - Low | DMM set to V - DC | Listen and observe to verify if crank lever of VGT actuator moves. Toggling between the Low and High Output State Tests can be done during this test. |
| X1–18 to X1–6 | 0 V to 0.25 V | If > 0.25 V, disconnect engine harness from breakout box harness and retest.<br>• If < 0.25 V, diagnose engine wiring harness. Do Harness Resistance Check – VGT Actuator to ECM (page 562).<br>• If > 0.25 V, with breakout box only connected to ECM, replace ECM. |

| | | |
|---|---|---|
| Output State Test - High | DMM set to V - DC | Listen and observe to verify if crank lever of VGT actuator moves. Toggling between the Low and High Output State Tests can be done during this test. |
| X1–18 to X1–6 | B+ ± 0.5 V | If value is not in specification, disconnect engine harness from breakout box harness and retest.<br>• If equal to B+, diagnose engine wiring harness. Do Harness Resistance Check – VGT Actuator to ECM (page 562).<br>• If < B+ with breakout box only connected to ECM, replace ECM. |

1 Values are calibration dependent. See “DT 466 Performance Specifications” – Appendix A (page 619) or “DT 570 and HT 570 Performance Specifications – Appendix B (page 643).

2 Use the EST with MasterDiagnostics® software to view VGT duty cycle with key-on engine-off. When using the Fluke 88 DMM, measurement is typically within 2% of what MasterDiagnostics® reads.

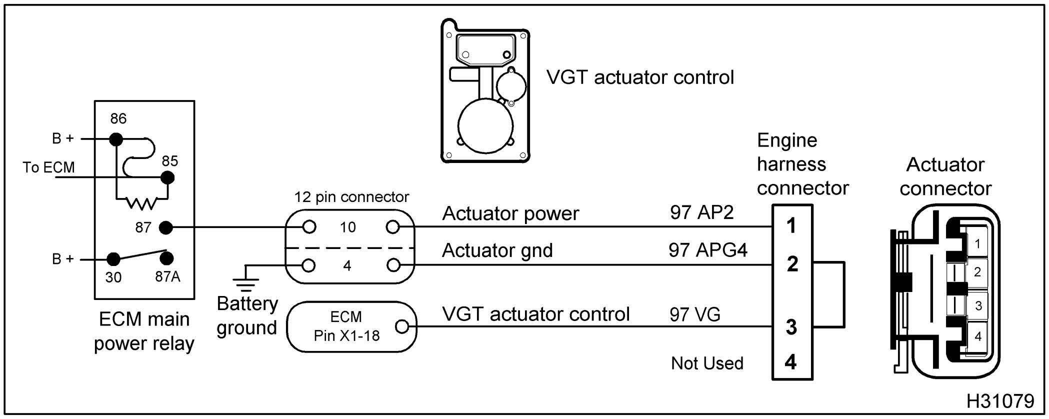



**Figure 505 VGT circuit diagram**

**NOTE:** Turn the ignition switch to OFF when disconnecting engine wiring harness connectors from components.

See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**Harness Resistance Checks – ECM to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Connect Turbo Breakout Harness to engine wiring harness only.

| Test Point | Spec | Comment |
|---|---|---|
| 1 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground on actuator power within wiring harness. |
| 2 to Pin A (9260) | < 5 Ω | If > 5 Ω, check for an open circuit. |
| 3 to Pin A (9260) | >1 kΩ | If < 1 kΩ, check for short to ground on VGT actuator control within wiring harness. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Harness Resistance Checks – ECM to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect engine harness from actuator. Use disconnected negative battery cable for ground test point.

| Test Point | Spec | Comment |
|---|---|---|
| 1 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground on actuator power. |
| 2 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| 3 to gnd cable | >1 kΩ | If < 1 kΩ, check for short to ground on VGT actuator control. |

**Harness Resistance Checks – VGT Actuator to 12-pin Connector** (Turn the ignition switch to OFF. Connect Turbo Breakout Harness to engine wiring harness only. Connect 12-pin Breakout Harness to engine wiring harness only. Checks are from VGT actuator to 12-pin connector.)

| | | |
|---|---|---|
| 1 to 10 | < 5 Ω | If > 5 Ω, check for open in actuator power. |
| 2 to 4 | < 5 Ω | If > 5 Ω, check for open in actuator ground. |

**Harness Resistance Checks – 12-pin Connector to ECM Chassis Ground** (Turn the ignition switch to OFF. Connect 12-pin Breakout Harness to chassis wiring harness only. Disconnect chassis connector 9260[1].)

| | | |
|---|---|---|
| 10 to Pin A (9260) | > 1 kΩ | If < 1 kΩ, check for short to ground on chassis wiring harness ground circuit. |
| 4 to Pin A (9260) | < 5 Ω | If > 5 Ω, check for open circuit in chassis wiring harness ground circuit. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

| | | |
|---|---|---|
| **Harness Resistance Checks – 12-Pin Connector to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect 12-pin connector and use chassis side for test point. Use disconnected negative battery cable for ground test point.) | | |
| 10 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| 4 to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |
| **Harness Resistance Checks – VGT Actuator to ECM** (Connect Turbo Breakout Harness to engine wiring harness only. Connect breakout box X1 to engine wiring harness only.) | | |
| 3 to X1-18 | < 5 Ω | If > 5 Ω, check for open in VGT actuator control. |

1 Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. Refer to truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

**$V_{REF}$ (Reference Voltage)**

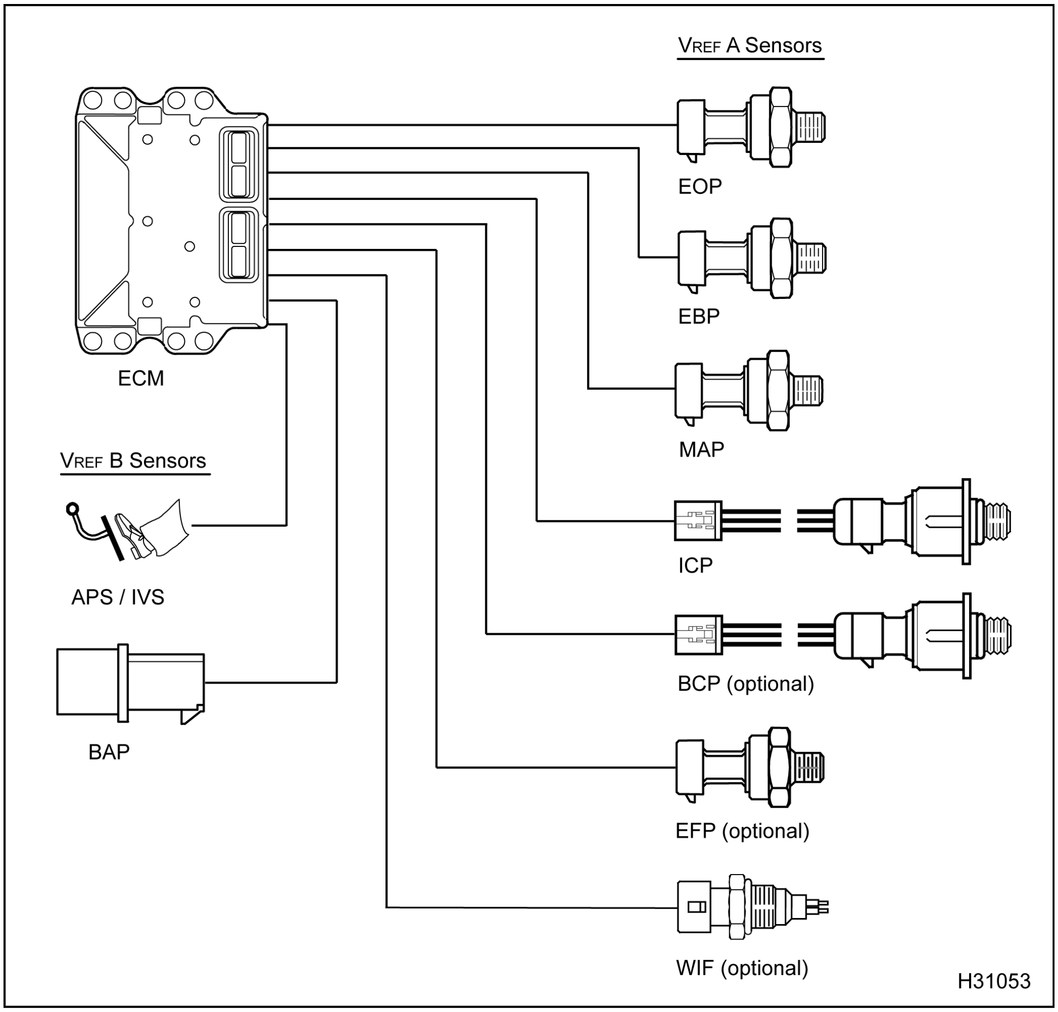



**Figure 506 Function diagram for the $V_{REF}$**

The function diagram for the $V_{REF}$ includes the following:

- Engine Oil Pressure (EOP) sensor
- Exhaust Back Pressure (EBP) sensor
- Manifold Absolute Pressure (MAP) sensor
- Injection Control Pressure (ICP) sensor
- Brake Control Pressure (BCP) sensor (optional)
- Engine Fuel Pressure (EFP) sensor (optional)
- Water in Fuel (WIF) sensor (optional)
- Accelerator Position Sensor (APS)
- Barometric Absolute Pressure (BAP) sensor
- Electronic Control Module (ECM)

**Function**

The ECM contains a regulated 5 V DC voltage reference source to power engine and vehicle sensors. The sensor signals are compared to the $V_{REF}$ to determine actual sensor output signal values. These values are processed by the ECM for engine operation.

The system has two $V_{REF}$ circuits:

- $V_{REF}$ A for engine sensors
- $V_{REF}$ B for chassis sensors

**NOTE:** See truck *Chassis Electrical Circuit Diagram Manual* for APS and BAP sensor circuit diagrams.

### $V_{REF}$ Circuit Operation

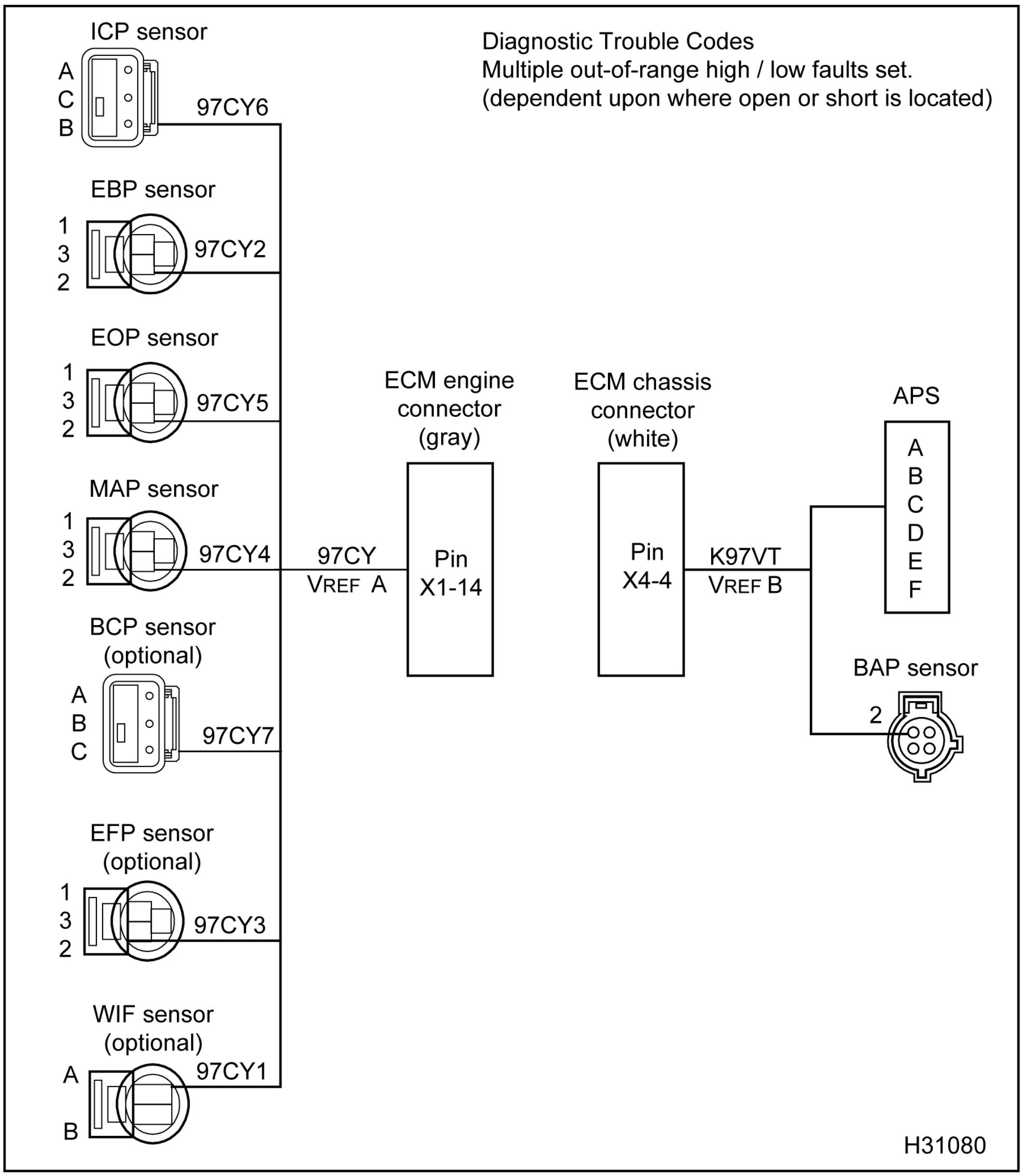



**Figure 507 $V_{REF}$ circuit diagram**

The ECM supplies $V_{REF}$ at Pin X1–14 (engine connector) and at X4–4 (chassis connector) when the ignition switch is on.

**Fault Detection / Management**

There are no DTCs for $V_{REF}$. When a $V_{REF}$ circuit fault occurs in a sensor, the ECM may set an out of range high or low code. Multiple high or low codes are indicators of a $V_{REF}$ or signal ground fault condition. When a $V_{REF}$ signal is shorted to ground, shorted to ground occurs, the ECM will reset and cause a stumble.

When the ECM sets multiple sensor DTCs, the $V_{REF}$ circuit is open or shorted, or the signal ground circuit is open. To determine if the $V_{REF}$ circuits are the cause, complete the pin-point diagnostics check.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Breakout Harness
- Breakout Box
- Terminal Test Adapter Kit

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

### $V_{REF}$ Pin-Point Diagnostics

**Voltage Reference Connector Checks** (If multiple DTCs are set, remove harness connections and measure $V_{REF}$ at suspected sensor circuits.)

| Sensor | Test Point | Spec | Comment |
|---|---|---|---|
| EBP | 2 to gnd | 5 V ±0.5 V | Check $V_{REF}$ at each sensor. To isolate area of short or open circuit, identify sensors without $V_{REF}$ and sensors that share a common $V_{REF}$. If disconnecting a sensor causes $V_{REF}$ to be present in the circuit that had no previous $V_{REF}$, it is likely that the disconnected sensor had shorted $V_{REF}$ to ground. |
| MAP | 2 to gnd | 5 V ±0.5 V | |
| ICP | B to gnd[1] | 5 V ±0.5 V | |
| APS | C to gnd | 5 V ±0.5 V | |
| BAP | 2 to gnd | 5 V ±0.5 V | |
| EOP | 2 to gnd | 5 V ±0.5 V | |
| BCP (optional) | B to gnd[1] | 5 V ±0.5 V | |
| EFP (optional) | 2 to gnd | 5 V ±0.5 V | |
| WIF (optional) | B to gnd | 5 V ±0.5 V | |

[1] Test point Pin B is at vavle cover pass through connector. If additional testing is needed, test point Pin 2 should be used at under valve cover connector.

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Connector Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect sensors and negative battery cable.)

| Sensor | Test Point | Spec | Comment |
|---|---|---|---|
| EBP | 2 to gnd | >500 Ω | If resistance is < spec, check for short to ground. If a short to ground condition exists, remove all sensor connectors that are connected to $V_{REF}$ and ECM. Inspect to determine if short is in sensor, ECM, or wiring harness. Spec is >1 kΩ with all common sensors disconnected from harness. |
| MAP | 2 to gnd | >500 Ω | |
| ICP | B to gnd[1] | >500 Ω | |
| APS | C to gnd | >1 kΩ | |
| BAP | 2 to gnd | >1 kΩ | |
| EOP | 2 to gnd | >500 Ω | |
| BCP (optional) | B to gnd[1] | >500 Ω | |
| EFP (optional) | 2 to gnd | >500 Ω | |
| WIF (optional) | B to gnd | >500 Ω | |

**Harness Resistance Checks** (Turn the ignition switch to OFF. Ensure that all accessories are turned off. Disconnect sensors and connect breakout box to engine harness only.)

| Sensor | Test Point | Spec | Comment |
|---|---|---|---|
| EBP | 2 to X1–14 | < 5 Ω | Measure resistance with DMM from sensor connector to breakout box pins. If resistance is > 5 Ω, check for high resistance or an open in the $V_{REF}$ supply circuit. |
| MAP | 2 to X1–14 | < 5 Ω | |
| ICP | B to X1–14[1] | < 5 Ω | |
| APS | C to X4–4 | < 5 Ω | |
| BAP | 2 to X4–4 | < 5 Ω | |
| EOP | 2 to X1–14 | < 5 Ω | |
| BCP (optional) | B to X1–14[1] | < 5 Ω | |
| EFP (optional) | 2 to X1–14 | < 5 Ω | |
| WIF (optional) | B to X1–14 | < 5 Ω | |

**VSS (Vehicle Speed Sensor)**

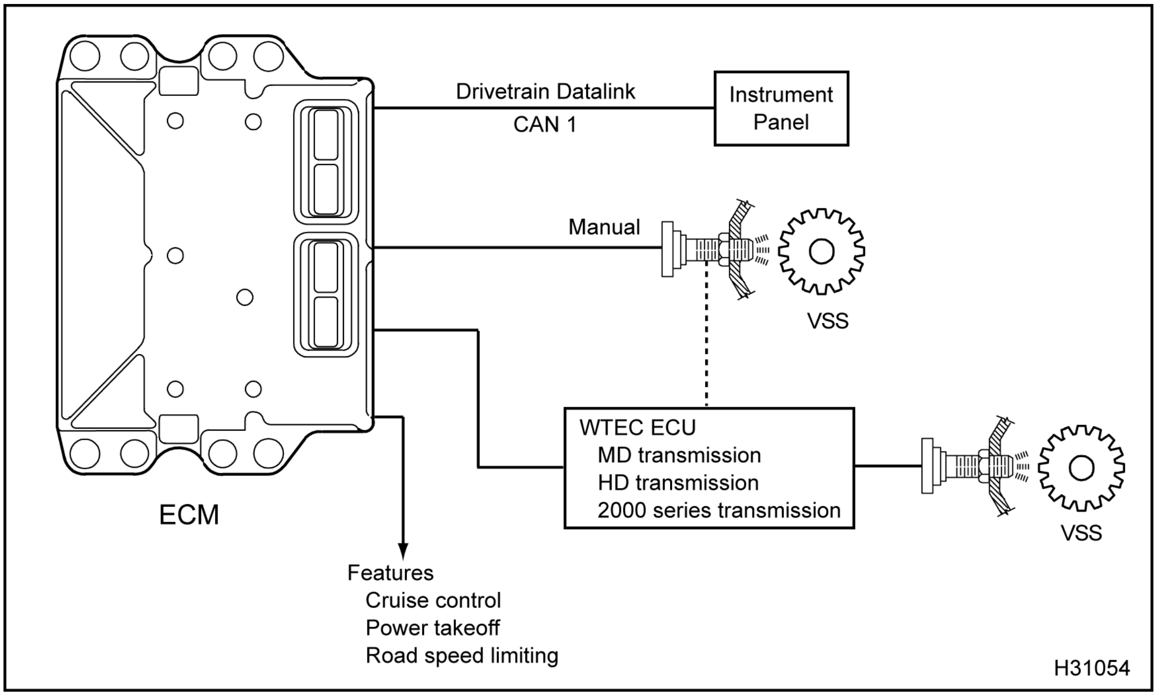



**Figure 508 Function diagram for the VSS**

The function diagram for the VSS includes the following:

- VSS
- Electronic Control Module (ECM)
- World Transmission Electronic Control (WTEC) ECM
- Cruise Control
- Power Takeoff
- Road Speed Limit

**Function**

The VSS is on the left side of the transmission. The VSS reads the rotation of a 16 toothed gear and produces a sine wave signal. The ECM processes the sine wave signal to calculate vehicle speed. The Drivetrain Datalink (CAN 1) transmits the calculated speed to the speedometer. The calculated speed also assists in control strategies that include Cruise Control, Power Takeoff, and Road Speed Limiting.

Allison WTEC MD, HD, and 2000 series transmissions use an internal VSS that sends a signal to the transmission module. The transmission module processes the signal and sends a square wave signal to the engine ECM.

**VSS Circuit Operation (Manual and Allison Transmissions)**

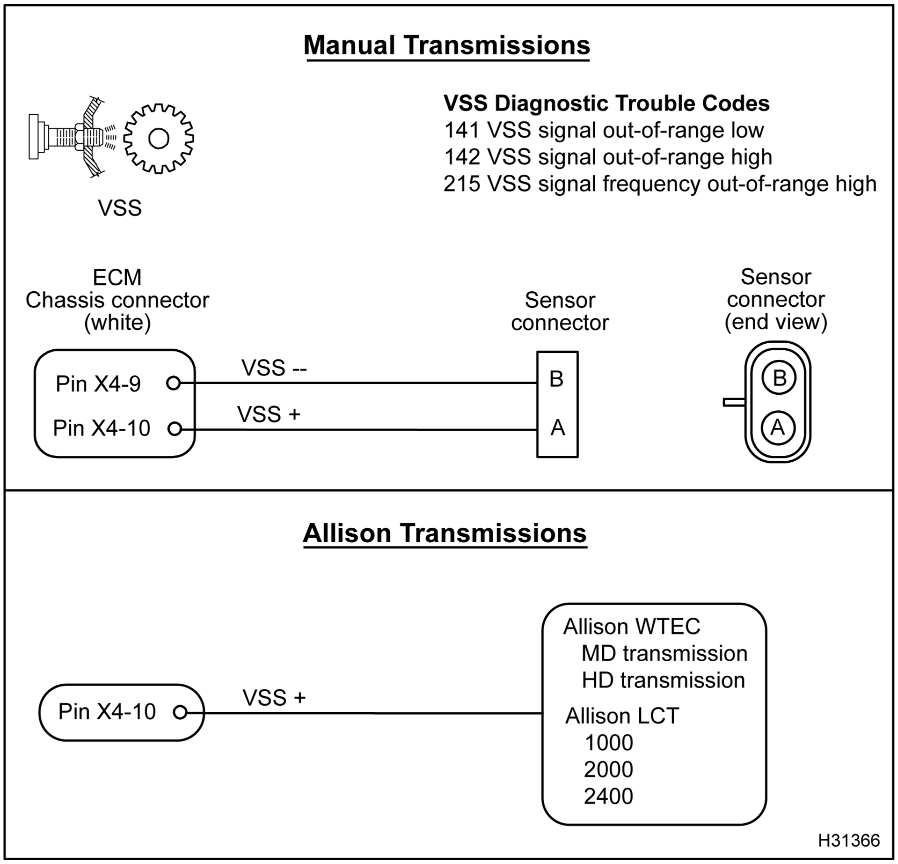



**Figure 509 VSS circuit diagram (manual and Allison transmissions)**

**Fault Detection / Management**

The ECM performs diagnostic checks on the VSS circuit when the engine is operating at 0 mph. The ECM transmits a voltage signal on the VSS circuit and determines if the return voltage is out of range high or low. When a fault condition is detected, the ECM disables the cruise control and power takeoff. If the road speed limiting option is enabled, the ECM will limit engine rpm for all gears.

The ECM will not set DTCs for VSS circuit failure for vehicles equipped with Allison transmissions.

**NOTE:** See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations. To diagnose Allison transmission VSS sensor problems, see truck *Electrical System Troubleshooting Guide* and Allison maintenance and diagnostic manuals.

**VSS Diagnostic Trouble Codes (DTCs)**

DTCs are read using the EST or by counting the flashes from the amber and red ENGINE lamp.

**DTC 141**
**VSS signal out-of-range low**

- DTC 141 is set by the ECM when an out of range low condition is detected in the VSS circuit.
- When DTC 141 is active the amber ENGINE lamp is not illuminated.

**DTC 142**
**VSS signal out-of-range high**

- DTC 142 is set by the ECM when an out of range high condition is detected in the VSS circuit.

- When DTC 142 is active the amber ENGINE lamp is not illuminated.

**DTC 215**
**VSS signal frequency out-of-range high**

- DTC 215 is set by the ECM when the ECM detects a VSS signal greater than 4365 Hz.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- *Electrical System Troubleshooting Guide* (truck manual)
- Electrical Circuit Diagrams (truck manual)

## VSS Pin-Point Diagnostics (Manual Transmissions)

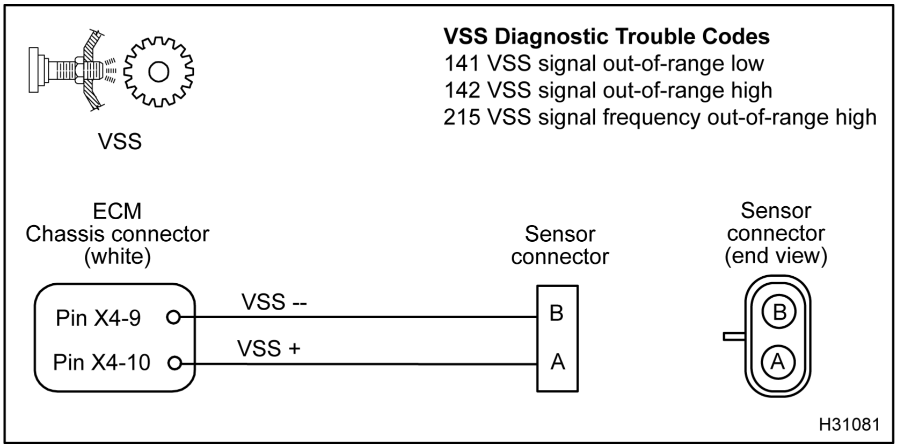



**Figure 510 VSS circuit diagram (manual transmissions)**

The VSS circuit requires the use of vehicle circuit diagrams. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**Connector Voltage Checks** (Disconnect harness from sensor. Inspect for bent pins or corrosion. Turn the ignition switch to ON.)

| Test Point | Spec | Comment |
|---|---|---|
| B to gnd | 2 V to 3 V | ECM pull up voltage when sensor disconnected. If no voltage present, check for open or short to ground. |
| A to gnd | 2 V to 3 V | |
| **Sensor Resistance Checks** (Check with sensor disconnected and ignition switch OFF.) | | |
| B to A | 600 Ω to 800 Ω | Manual transmission (measure resistance through sensor) |
| **Sensor and Circuit Resistance Checks** (Check with breakout box connected [X4 only] to engine harness only with VSS connected. Inspect for bent pins or corrosion.) | | |
| X4–10 to X4–9 | 600 Ω to 800 Ω | Manual transmission (measure resistance through sensor) |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.)

| | | |
|---|---|---|
| A to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |
| B to gnd cable | > 500 Ω | If < 500 Ω, check for short to ground. |

| | | |
|---|---|---|
| **Harness Resistance Checks** (Check with breakout box connected to chassis harness only. Check from ECM to sensor harness connector.) | | |
| X4–10 to A | < 5 Ω | If > 5 Ω, check for open circuit. |
| X4–9 to B | < 5 Ω | If > 5 Ω, check for open circuit. |
| **Operation Checks for VSS** (Check with breakout box connected to ECM and chassis harness. Turn the ignition switch to ON.) | | |
| X4–10 to X4–9 | > 2 V AC | If < 2 V AC, check sensor adjustment or replace failed sensor. |
| **Note:** If circuit checks are within specification and condition remains, see transmission manual for sensor inspection and adjustment. | | |
| **VSS Diagnostic Trouble Codes** | | |
| DTC 141 = ECM detected low voltage across VSS circuit for > 0.5 seconds | | |
| DTC 142 = ECM detected high voltage across VSS circuit for > 0.5 seconds | | |
| DTC 215 = ECM detected VSS frequency signal > 4365 Hz | | |

[1] Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. Refer to truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.

### VSS Pin-Point Diagnostics (Allison Transmissions)

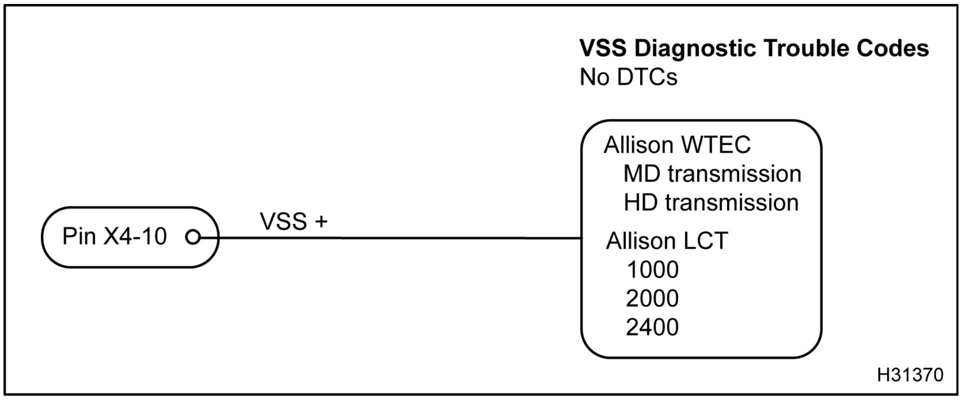



**Figure 511 VSS circuit diagram (Allison transmissions)**

The VSS circuit requires the use of vehicle circuit diagrams. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

**Connector Voltage Checks** (Disconnect harness from sensor. Inspect for bent pins or corrosion. Turn the ignition switch to ON.)

| Test Point | Spec | Comment |
|---|---|---|
| ECU transmission Pin to gnd | 2 V to 3 V | ECM pull up voltage when sensor disconnected. If no voltage present, check for open or short to ground. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

**Resistance Checks to Chassis Ground with Breakout Box** (Turn the ignition switch to OFF. Connect breakout box X4 only to chassis harness. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Use disconnected negative battery cable for ground test point.)

| | | |
|---|---|---|
| X4–10 to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to ground. |

**Harness Resistance Checks** (Check with breakout box connected to engine harness only. Check from ECM to sensor harness connector.)

| | | |
|---|---|---|
| X4–10 to ECU transmission Pin | < 5 Ω | If > 5 Ω, check for open circuit. |

**Note:** If circuit checks are within specification and condition remains, see transmission manual for sensor inspection and adjustment.

**WIF Sensor (Water in Fuel)**

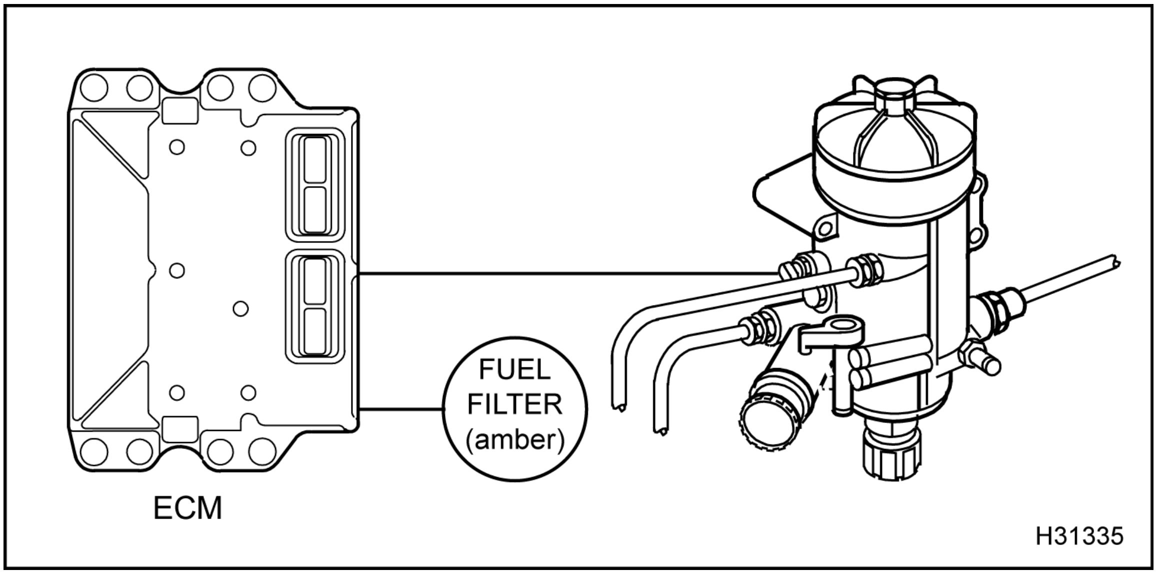



**Figure 512 Function diagram for the WIF system**

The function diagram for the WIF system includes the following:

- Electronic Control Module (ECM)
- Fuel filter assembly
- FUEL FILTER lamp (amber)

The Electronic Control Module (ECM) monitors the fuel filter header and alerts the operator when water is present in the fuel supply. When water is detected, the ECM will set a Diagnostic Trouble Code (DTC) and the amber FUEL FILTER lamp will illuminate.

The WIF system includes the ECM and the fuel filter assembly with a WIF sensor. The WIF sensor is used in the fuel filter assembly.

**WIF Circuit Operation**

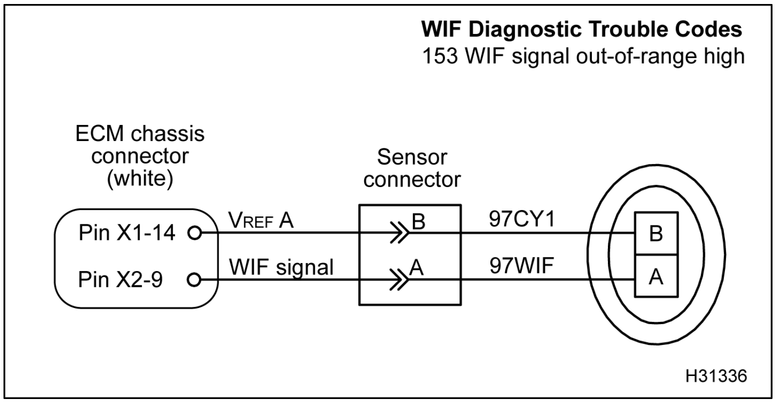



**Figure 513 WIF circuit diagram**

The WIF sensor uses two electrical contacts exposed to the fuel supply. When water is present in the fuel supply, the circuit between the contacts is closed. This allows a 5 V signal at ECM Pin X2–9. When water is not present, the circuit is open and ECM Pin X2–9 will be 0 V.

**Fault Detection / Management**

The ECM continuously monitors the WIF circuit for in-range faults. The ECM does not detect open or short circuits in the WIF circuit. When the ECM detects an in-range fault, DTC 153 will be set.

**WIF Diagnostic Trouble Codes (DTCs)**

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

**DTC 153**
**WIF signal out-of-range high**

- DTC 153 is set when the ECM detects an in-range voltage at or above 4.5 V at ECM Pin X2–9.
- DTC 153 is set when the WIF signal circuit is shorted to $V_{REF}$ or $V_{BAT}$.
- When DTC 153 is active, the FUEL FILTER lamp is not illuminated.

**Tools**

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Breakout Box

### WIF Pin-Point Diagnostics

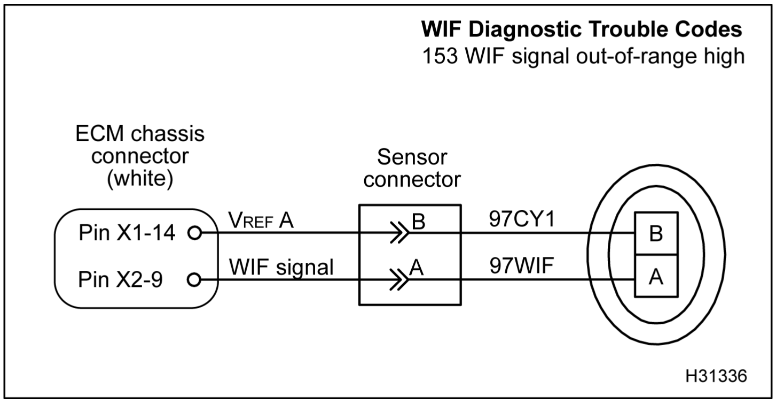



**Figure 514 WIF system circuit diagram**

The WIF circuit may require the use of vehicle circuit diagrams. See truck *Chassis Electrical Circuit Diagram Manual* for circuit numbers, connector and fuse locations.

| | | |
|---|---|---|
| **Voltage Checks at WIF Sensor Connector** (Disconnect harness from sensor and turn the ignition switch to ON.) **Note:** After removing connector, inspect for damaged pins, corrosion, or loose pins. Repair as required. | | |
| **Test Point** | **Spec** | **Comment** |
| A to gnd | 5 V ±0.5 V | If voltage < 5 V, check for open $V_{REF}$ circuit or failed ECM. |
| B to gnd | 0 V | If voltage > 0 V, check for signal circuit shorted to another circuit |
| **Sensor Resistance Check** (Disconnect connector from sensor and measure across sensor.) | | |
| A to B | > 1 kΩ | If < 1 kΩ, check for water in fuel, failed sensor, or shorted sensor harness. |
| **Connector Resistance Checks to ECM Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect harness from sensor.) | | |
| A to Pin B (9260) | > 1 kΩ | If < 1 kΩ, check for short to signal ground. |
| B to Pin B (9260) | > 1 kΩ | If < 1 kΩ, check for short to signal ground. |

**WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

| | | |
|---|---|---|
| **Connector Resistance Checks to Chassis Ground** (Turn the ignition switch to OFF. Disconnect chassis connector 9260[1]. Disconnect negative battery cable. Disconnect harness from sensor. Use disconnected negative battery cable for ground test point.) | | |
| A to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to chassis ground. |
| B to gnd cable | > 1 kΩ | If < 1 kΩ, check for short to chassis ground. |

| | | |
|---|---|---|
| **Harness Resistance Check – WIF Connector to ECM** (Turn the ignition switch to OFF. Connect breakout box to chassis harness only. Disconnect sensor.) | | |
| X1–14 to B | < 5 Ω | If > 5 Ω, check for open $V_{REF}$ circuit. |
| X2–9 to A | < 5 Ω | If > 5 Ω, check for open signal wire. |
| **Operational Voltage Checks for WIF Sensor** (Check with breakout box connected to ECM and engine harness and WIF sensor connected. Turn the ignition switch to ON.) | | |
| X2–9 to gnd | 0 V to 2.5 V | Voltage is 2.5 V with water in fuel. Voltage 0 V without water in fuel (use breakout box). |
| **WIF Diagnostic Trouble Codes** | | |
| DTC 153 = Signal voltage was > 4.5 V | | |

[1] Connector 9260 is a 2-wire connector usually located in the battery box. Pin A is the chassis ground connection for the ECM and IDM. Refer to truck Chassis Electrical Circuit Diagram Manual for complete chassis side ECM and IDM ground circuit information.