DIAGNOSTIC MANUAL

2010 MaxxForce® 7 Engine

Navistar, Inc.

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Foreword

Navistar, Inc. is committed to continuous research and development to improve products and introduce technological advances. Procedures, specifications, and parts defined in published technical service literature may be altered.

NOTE: Photo illustrations identify specific parts or assemblies that support text and procedures; other areas in a photo illustration may not be exact.

This manual includes necessary information and specifications for technicians to maintain Navistar® diesel engines. See vehicle manuals and Technical Service Information (TSI) bulletins for additional information.

Technical Service Literature	
1172039R1	*MaxxForce® 7 Operation and Maintenance Manual*
0000002383	*MaxxForce® 7 (EPA 10) with HD-OBD Engine Service Manual*
0000001681R1	*MaxxForce® 7 (EPA 10) with HD-OBD Engine Diagnostic Manual*
0000003382	MaxxForce® 7 (EPA 10) with HD-OBD *Hard Start and No Start Diagnostics Form*
0000003381	*MaxxForce® 7 (EPA 10) with HD-OBD Performance Diagnostics Form*
0000003201	*MaxxForce® 7 (EPA 10) with HD-OBD Engine Wiring Schematic Form*

Technical Service Literature is revised periodically. If a technical publication is ordered, the latest revision will be supplied.

NOTE: To order technical service literature, contact your International dealer.

Service Diagnosis

Service diagnosis is an investigative procedure that must be followed to find and correct an engine application problem or an engine problem.

If the problem is engine application, see specific vehicle manuals for further diagnostic information.

If the problem is the engine, see specific *Engine Diagnostic Manual* for further diagnostic information.

Prerequisites for Effective Diagnosis

- Availability of gauges and diagnostic test equipment
- Availability of current information for engine application and engine systems
- Knowledge of the principles of operation for engine application and engine systems
- Knowledge to understand and do procedures in diagnostic and service publications

Technical Service Literature required for Effective Diagnosis

- *Engine Service Manual*
- *Engine Diagnostic Manual*
- Diagnostics Forms
- Engine Wiring Schematic
- Service Bulletins

Safety Information

This manual provides general and specific maintenance procedures essential for reliable engine operation and your safety. Since many variations in procedures, tools, and service parts are involved, advice for all possible safety conditions and hazards cannot be stated.

Read safety instructions before doing any service and test procedures for the engine or vehicle. See related application manuals for more information.

Disregard for Safety Instructions, Warnings, Cautions, and Notes in this manual can lead to injury, death or damage to the engine or vehicle.

Safety Terminology

Three terms are used to stress your safety and safe operation of the engine: Warning, Caution, and Note

Warning: A warning describes actions necessary to prevent or eliminate conditions, hazards, and unsafe practices that can cause personal injury or death.

Caution: A caution describes actions necessary to prevent or eliminate conditions that can cause damage to the engine or vehicle.

Note: A note describes actions necessary for correct, efficient engine operation.

Safety Instructions

Work Area

- Keep work area clean, dry, and organized.
- Keep tools and parts off the floor.
- Make sure the work area is ventilated and well lit.
- Make sure a First Aid Kit is available.

Safety Equipment

- Use correct lifting devices.
- Use safety blocks and stands.

Protective Measures

- Wear protective safety glasses and shoes.
- Wear correct hearing protection.
- Wear cotton work clothing.
- Wear sleeved heat protective gloves.
- Do not wear rings, watches or other jewelry.
- Restrain long hair.

Vehicle

- Make sure the vehicle is in neutral, the parking brake is set, and the wheels are blocked before servicing engine.

- Clear the area before starting the engine.

Engine

- The engine should be operated or serviced only by qualified individuals.
- Provide necessary ventilation when operating engine in a closed area.
- Keep combustible material away from engine exhaust system and exhaust manifolds.
- Install all shields, guards, and access covers before operating engine.
- Do not run engine with unprotected air inlets or exhaust openings. If unavoidable for service reasons, put protective screens over all openings before servicing engine.
- Shut engine off and relieve all pressure in the system before removing panels, housing covers, and caps.
- If an engine is not safe to operate, tag the engine and ignition key.

Fire Prevention

- Make sure charged fire extinguishers are in the work area.

NOTE: Check the classification of each fire extinguisher to ensure that the following fire types can be extinguished.

1. Type A — Wood, paper, textiles, and rubbish
2. Type B — Flammable liquids
3. Type C — Electrical equipment

Batteries

- Always disconnect the main negative battery cable first.
- Always connect the main negative battery cable last.
- Avoid leaning over batteries.
- Protect your eyes.
- Do not expose batteries to open flames or sparks.
- Do not smoke in workplace.

Compressed Air

- Use an OSHA approved blow gun rated at 207 kPa (30 psi).
- Limit shop air pressure to 207 kPa (30 psi).
- Wear safety glasses or goggles.
- Wear hearing protection.
- Use shielding to protect others in the work area.
- Do not direct compressed air at body or clothing.

Tools

- Make sure all tools are in good condition.
- Make sure all standard electrical tools are grounded.

- Check for frayed power cords before using power tools.

Fluids Under Pressure

- Use extreme caution when working on systems under pressure.
- Follow approved procedures only.

Fuel

- Do not over fill the fuel tank. Over fill creates a fire hazard.
- Do not smoke in the work area.
- Do not refuel the tank when the engine is running.

Removal of Tools, Parts, and Equipment

- Reinstall all safety guards, shields, and covers after servicing the engine.
- Make sure all tools, parts, and service equipment are removed from the engine and vehicle after all work is done.

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Engine Identification

Engine Serial Number

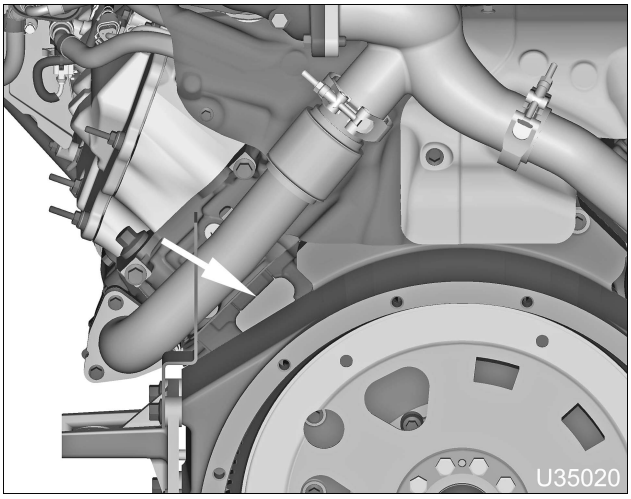

Figure 1 Engine serial number

The engine serial number is stamped on the crankcase pad, on the rear left side below the cylinder head.

Engine Serial Number Example

6.5HM2YXXXXXXX

6.5 – Engine displacement (liters)
H – Diesel, turbocharged, air-intercooled and electronically controlled
M2 – Motor truck
Y – United States, Huntsville
7 digit suffix – Sequence number

Emission Label

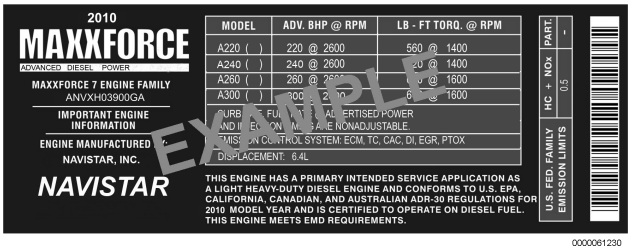

Figure 2 U.S. Environmental Protection Agency (EPA) Exhaust Emission Label (example)

The U.S. Environmental Protection Agency (EPA) exhaust emission label is on top of the EGR manifold mixer on the front of the engine. The label includes the following:

- Advertised brake horsepower ratings
- Engine model code

- Service applications
- Emission family and control systems
- Year the engine was certified to meet EPA emission standards

Engine Accessories

The following engine accessories may have manufacturers' labels or identification plates:

- Air compressor
- Air conditioning compressor
- Alternator
- Cooling fan clutch
- Power steering pump
- Starter motor

Labels or identification plates include information and specifications helpful to vehicle operators and technicians.

Engine Description

MaxxForce® 7 Features and Specifications

Engine configuration	4 stroke, V8 diesel
Displacement	6.4 liters (389 in^3)
Bore (sleeve diameter)	98.2 mm (3.87 in.)
Stroke	105 mm (4.134 in.)
Compression ratio	16.5:1
Aspiration	Dual Turbocharger and Charge Air Cooled (CAC)
Rated power @ rpm	See EPA exhaust emission label
Peak torque @ rpm	See EPA exhaust emission label
Engine rotation (facing flywheel)	Counterclockwise
Combustion system	Direct injection, turbocharged advanced EGR
Fuel system	Direct injection, common rail
Cooling system capacity (engine only)	10.23 liters (10.8 quarts US)
Lube system capacity (including filter)	18.9 liters (20 quarts US)
Lube system capacity (overhaul only, with filter)	19.9 liters (21 quarts US)
Firing order	1-2-7-3-4-5-6-8

Standard Features

The MaxxForce® 7 is a V8 engine with a displacement of 6.4 liters (389 cubic inches).

The electronic governor controls the engine rpm within a safe and stable operating range for ideal performance. A low-idle governor prevents the engine rpm from dropping below a stable speed to prevent stalling when various loads are demanded on the engine. A high-idle governor prevents the engine rpm from going above a safe speed that would cause internal damage to the engine.

The cylinder heads have four valves per cylinder. Each fuel injector is centrally located between the four valves and directs fuel over the piston bowl for improved performance and reduced emissions.

The camshaft is supported by five bushings pressed into the crankcase. The camshaft is crankshaft-driven and thrust is controlled by a plate mounted behind the rear bulkhead.

The overhead valve train includes hydraulic roller cam followers, push rods, rocker arms, and valve bridges to open the dual intake and exhaust valves.

The crankcase is composed of two major matching components. The upper crankcase houses the cylinders, main bearing saddles, and oil and coolant passages. Cast or machined. The lower crankcase consists of a structural plate with the main bearing caps machined into it for improved load retention and alignment.

The crankshaft is supported by five main bearings, with fore and aft thrust controlled at the upper half of the fourth main bearing. Two connecting rods are attached to each crankshaft rod journal and are offset to minimize vibration. Piston pins are free-floating, allowing the pins free, lateral movement within the connecting rod as well as the piston. Piston pins are held in place with retaining rings.

One-piece aluminum-alloy pistons are fitted with one keystone ring, one rectangular intermediate compression ring, and a two-piece oil control ring. The combustion bowl is located in the piston crown to reduce emissions. All pistons are mated to fractured cap joint connecting rods.

The Crankshaft Position (CKP) sensor and Camshaft Position (CMP) sensor are used by the Engine Control Module (ECM) to calculate rpm, fuel timing, fuel quantity, and duration of fuel injection.

The Exhaust Gas Recirculation (EGR) system includes an EGR valve, Intake Air Heater (IAH), and Engine Throttle Valve (ETV). The EGR valve assembly is mounted on the manifold mixer on the front top of the engine. The ETV is installed on the Intake Air Heater (IAH) mounted on the manifold mixer.

A gerotor lube oil pump, mounted on the front crankcase bulkhead, is driven by the crankshaft to supply pressurized oil to engine components. All MaxxForce® 7 engines use an engine oil cooler and spin-on oil filter. The oil filter is located at the lower driver-side corner of the engine where there is an integrated filter header to the cast-aluminum oil pan.

An open crankcase breather system draws crankcase vapors through a breather element. The breather element coalesces (separates) and oil migrates towards the low point in the housing which then gets returned back to crankcase. Clean blow-by gas (vapors) exit the breather cover and vents out to atmosphere.

The high-pressure fuel system includes a High-pressure Fuel Pump (HPFP), high-pressure common rails, and fuel injectors. The ECM electronically controls the injectors, which allows multiple injections and more precise fuel delivery to improve combustion, emissions, and cold-start performance.

The low-pressure fuel system uses an electric fuel lift pump to draw fuel from the fuel tank(s) to the engine. This eliminates the need for a hand primer. The pump is located in the primary and secondary fuel module mounted over the left valve cover. The primary fuel filter assembly includes a Water in Fuel (WIF) sensor and an optional fuel heater. Water and solids are separated from the fuel and the water is collected in the water separator bowl. The instrument panel WIF lamp illuminates and 'Water in Fuel' message is displayed when water needs to be drained. A manual drain valve is provided in the water separator bowl to drain water out. Fuel is discharged to

the secondary fuel filter. The secondary fuel filter assembly is pressure-regulated and incorporates an air bleed orifice to automatically purge air introduced into the system.

A two-stage turbocharger provides boost air pressure to the engine for various speed and load conditions. An electronically controlled solenoid modulates boost air to a wastegate actuator.

The EGR system circulates cooled exhaust into the intake air stream in the intake manifold. This cools the combustion process and reduces the formation of NO_X engine emissions.

Diamond Logic® engine control is a single electronic control unit that monitors and controls the engine and chassis components.

A relay-controlled grid heater is used to aid cold, ambient starting

A coolant heater raises the temperature of the coolant surrounding the cylinders for improved performance during cold weather startups.

Optional Features

An air compressor is available for applications that require air brakes or air suspension.

An optional fuel heater is available and installed in the primary fuel filter assembly. It warms the supply fuel to prevent waxing during cold conditions where the fuel filter module's internal fuel passages between the primary and secondary filter do not provide sufficient warming.

Chassis-mounted Features

A Charge Air Cooler (CAC) is an air-to-air heat exchanger which increases the density of the air charge.

The Aftertreatment System processes engine exhaust so that it meets emission requirements at the tailpipe.

- The oxidation catalyst removes oxygen and hydrocarbons in the exhaust stream.
- The Diesel Particulate Filter (DPF) captures and removes particulates in the exhaust stream.

Engine Components

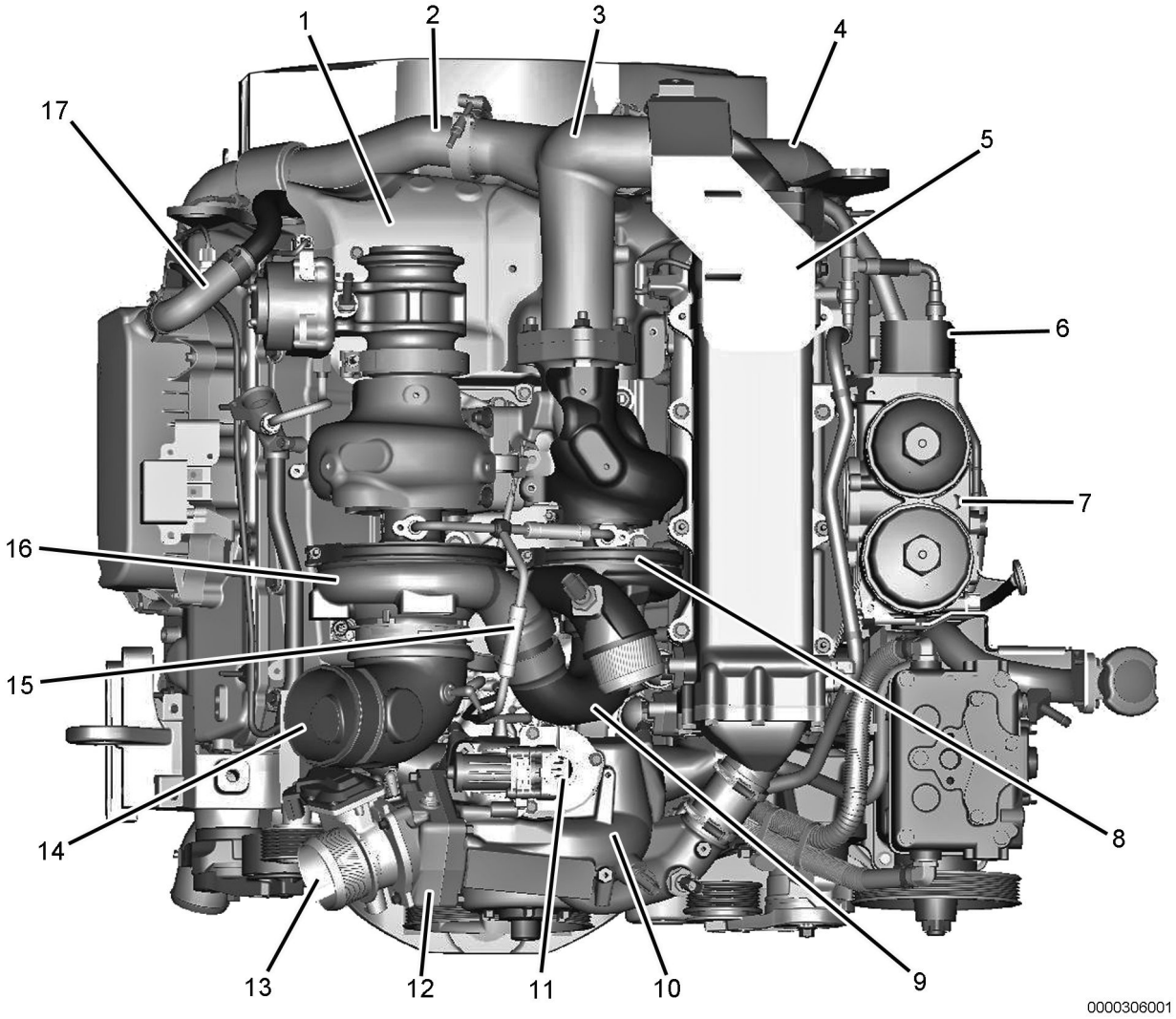

Figure 3 Top

1. Pump cover heat shield (right)
2. Right exhaust tube assembly
3. Exhaust turbocharger inlet manifold
4. Left exhaust tube assembly
5. EGR cooler
6. Fuel cooler
7. Fuel filter module housing
8. High-pressure turbocharger assembly
9. Crossover tube
10. Manifold mixer
11. EGR valve
12. Inlet Air Heater (IAH)
13. Engine Throttle Valve (ETV)
14. Turbocharger inlet duct assembly
15. Turbocharger oil supply tube
16. Low-pressure turbocharger assembly
17. Draft tube

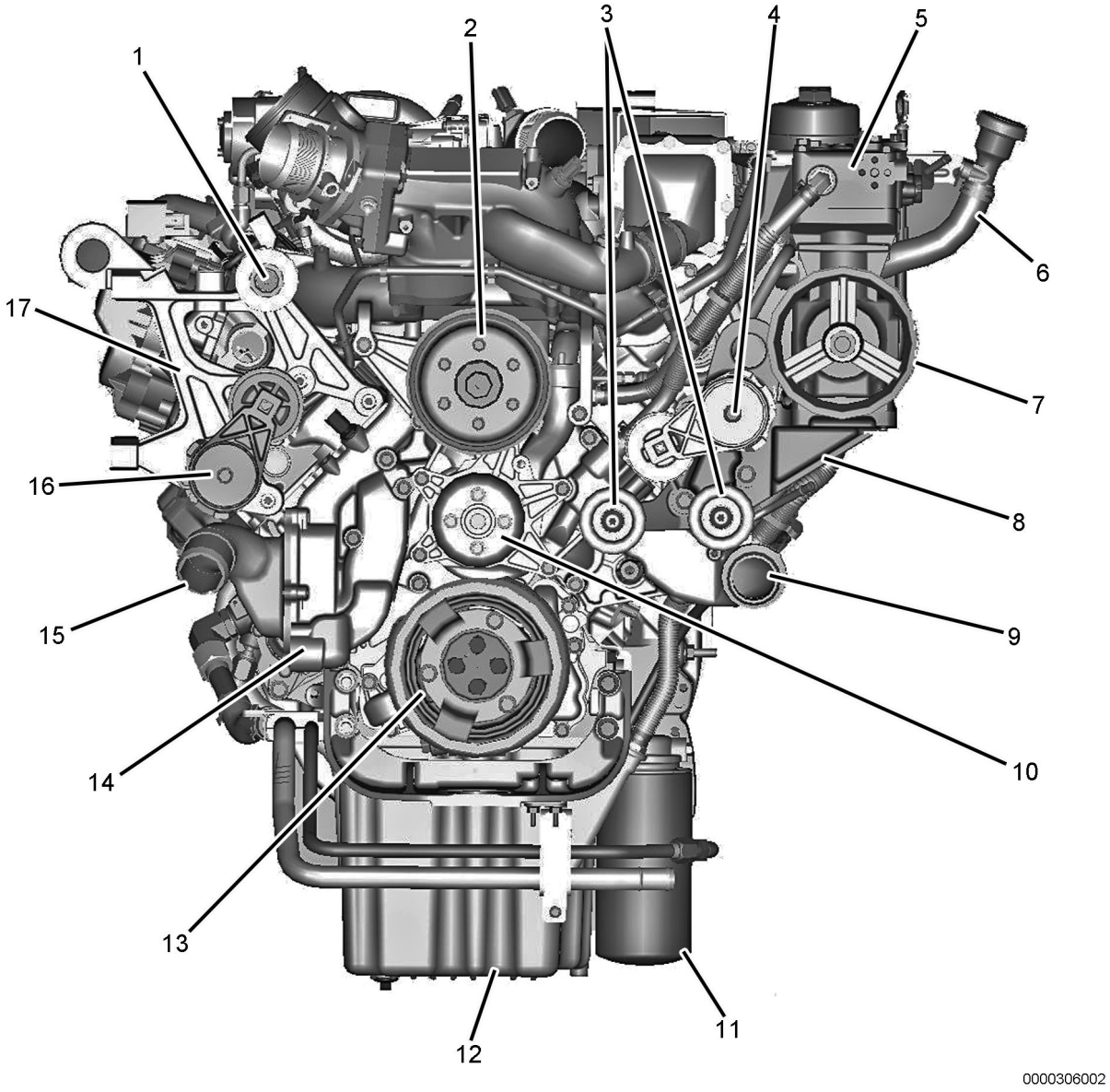

Figure 4 Front

1. Grooved idler pulley
2. Fan pulley
3. Flat idler pulley (2)
4. Belt tensioner (if equipped with air compressor)
5. Air compressor
6. Oil fill tube assembly
7. Air compressor pulley
8. Air compressor bracket
9. Coolant inlet
10. Water pump pulley
11. Oil filter assembly
12. Oil pan
13. PTO air compressor front pulley
14. Front crankcase cover (heater return)
15. Thermostat housing (coolant outlet)
16. Belt tensioner
17. Alternator bracket

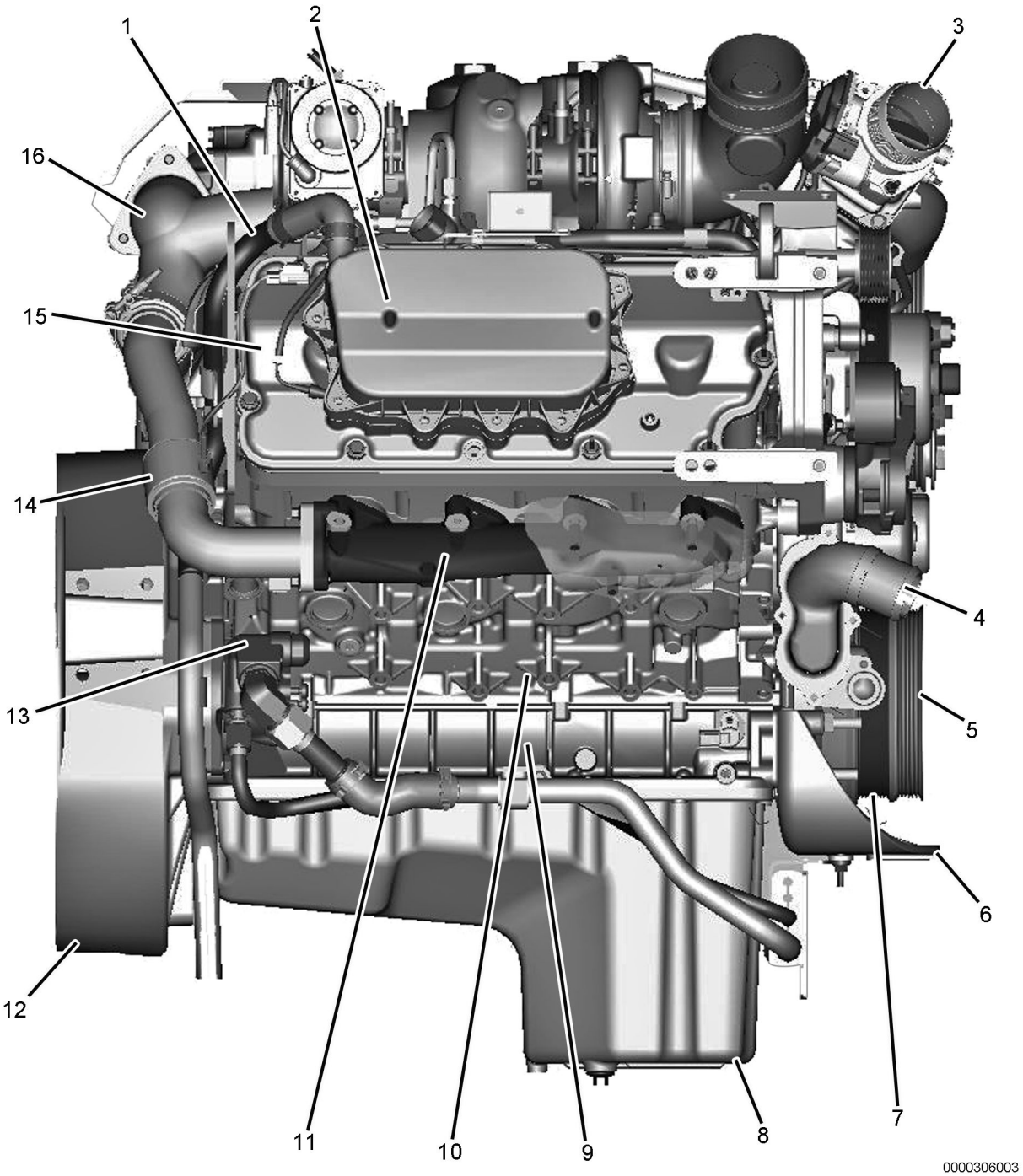

Figure 5 Right

1. Draft tube
2. Breather cover
3. ETV
4. Thermostat housing (coolant return)
5. PTO air compressor front pulley
6. Front engine mounting support
7. Vibration damper
8. Oil pan
9. Lower crankcase
10. Upper crankcase
11. Right exhaust manifold
12. Rear crankcase cover assembly (flywheel housing)
13. Power steering pump
14. Right exhaust tube assembly
15. Right valve cover
16. Exhaust turbocharger inlet manifold

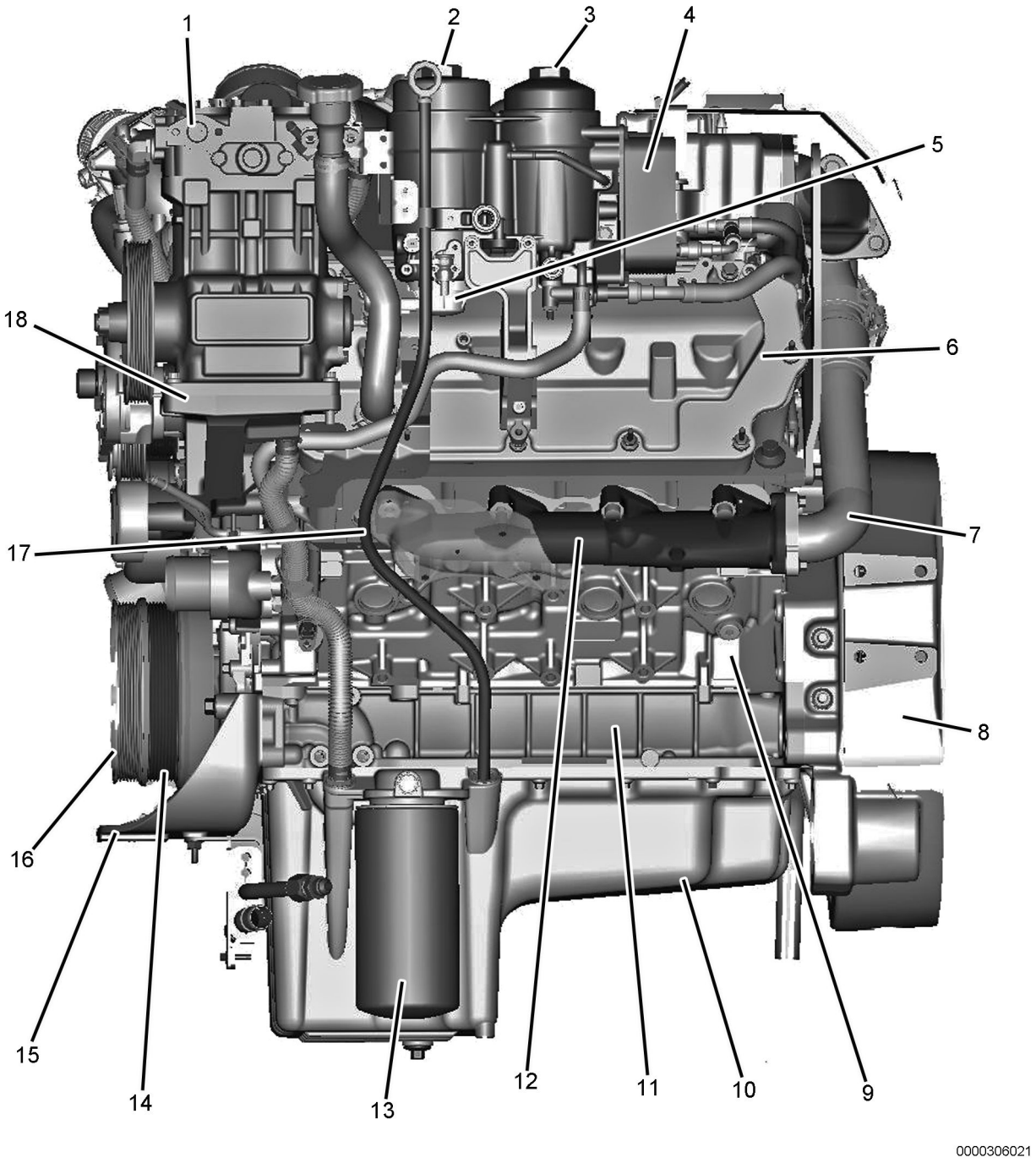

Figure 6 Left

1. Air compressor assembly
2. Filter cap (primary)
3. Filter cap (secondary)
4. Fuel cooler
5. Fuel pump
6. Left valve cover
7. Left exhaust tube assembly
8. Crankcase rear cover (flywheel housing)
9. Upper crankcase
10. Oil pan
11. Lower crankcase
12. Left exhaust manifold
13. Oil filter
14. Vibration damper
15. Front engine mounting support
16. PTO air compressor front pulley
17. Oil level gauge tube
18. Air compressor bracket

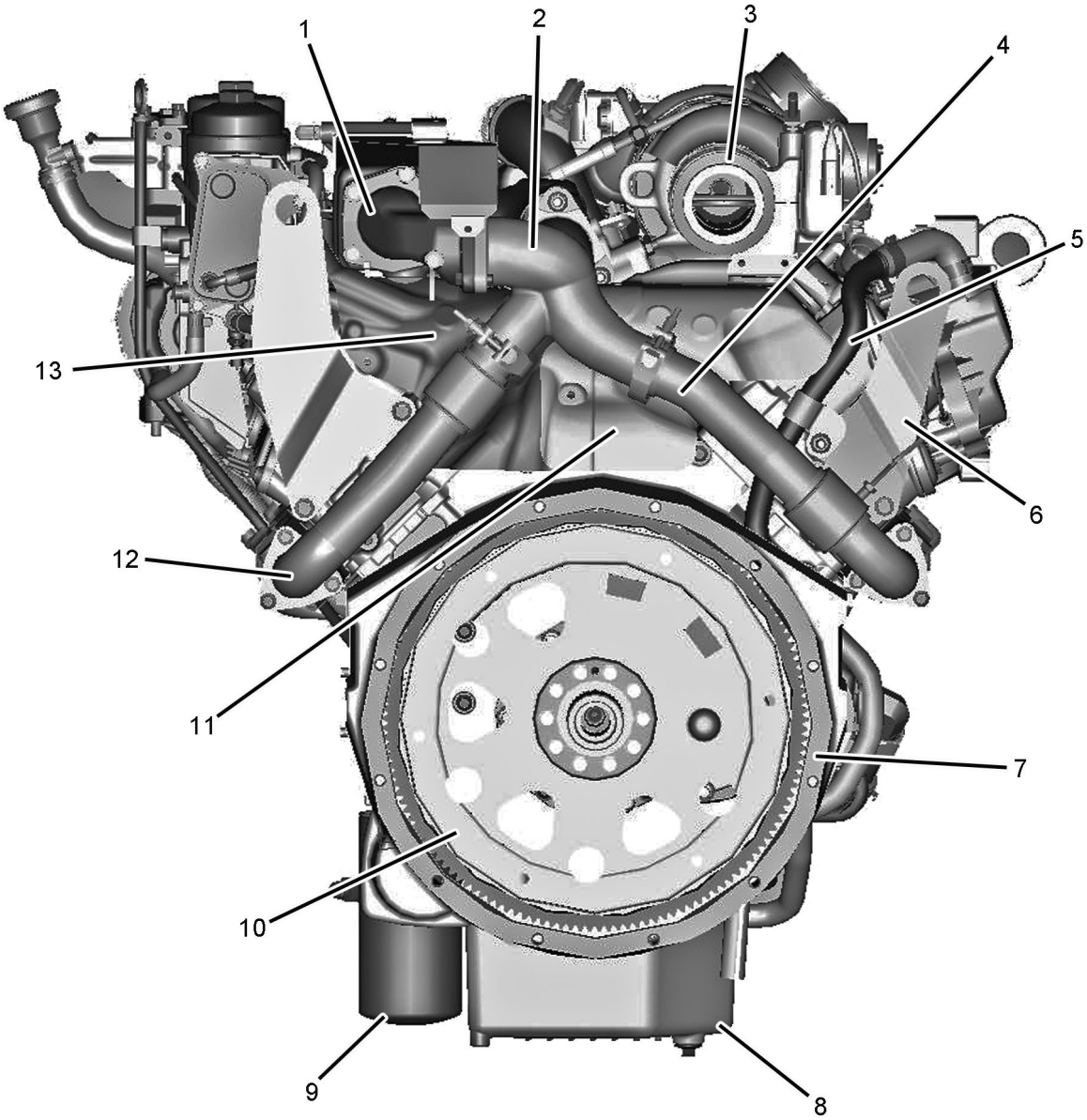

Figure 7 Rear

1. EGR cooler
2. Exhaust turbocharger inlet manifold
3. Low-pressure turbocharger assembly
4. Right exhaust tube assembly
5. Draft tube
6. Lifting eye
7. Crankcase rear cover (flywheel housing)
8. Oil pan
9. Oil filter
10. Flexplate
11. Pump cover heat shield (right)
12. Left exhaust tube assembly
13. Pump cover heat shield (left)

Air Management System

Air Management Components and Air Flow

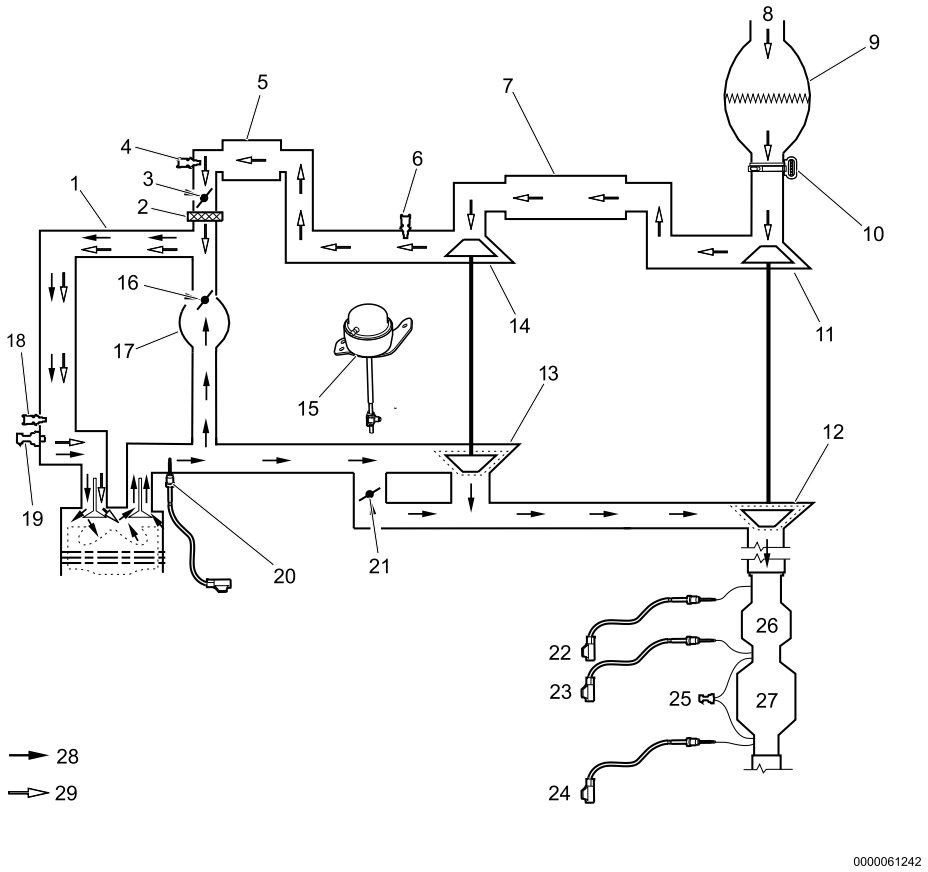

Figure 8 Air Management System (AMS)

1. Air intake manifold
2. Inlet Air Heater (IAH)
3. ETV and Engine Throttle Position (ETP) sensor
4. Charge Air Cooler Outlet Temperature (CACOT) sensor
5. Charge Air Cooler (CAC)
6. Turbocharger 1 Compressor Outlet Temperature (TC1COT) sensor
7. Air crossover tube assembly
8. Air inlet
9. Air filter
10. Mass Air Flow / Air Inlet Temperature (MAF / AIT) sensor
11. Low-pressure turbocharger compressor
12. Low-pressure turbocharger turbine
13. High-pressure turbocharger turbine
14. High-pressure turbocharger compressor
15. Turbocharger 2 Wastegate (TC2WG) actuator
16. EGR Control Valve and EGR Position sensor
17. EGR cooler
18. Intake Manifold Temperature (IMT) sensor
19. Intake Manifold Pressure (IMP) sensor
20. Exhaust Gas Temperature (EGT) sensor
21. Turbocharger wastegate valve
22. DOC Inlet Temperature (DOCIT) sensor
23. DPF Inlet Temperature (DPFIT) sensor
24. DPF Outlet Temperature (DPFOT) sensor
25. DPF Differential Pressure (DPFDP) sensor
26. Diesel Oxidation Catalyst (DOC)
27. Diesel Particulate Filter (DPF)
28. Exhaust gas
29. Intake air

Air Flow

Air flows through the air filter assembly and enters the low-pressure turbocharger. The compressor in the low-pressure turbocharger increases pressure, temperature, and density of the intake air before it enters the air crossover tube. From the air crossover tube assembly, air enters the high-pressure turbocharger. The high-pressure turbocharger compressor further increases the pressure, temperature, and density of the intake air. The high-pressure Turbocharger 2 Wastegate (TC2WG) solenoid and the TC2WG actuator control the output of the high-pressure turbocharger by adjusting the wastegate valve inside the turbocharger. From the high-pressure turbocharger, air enters the Charge Air Cooler (CAC). Cooled compressed air flows from the CAC through the ETV and Exhaust Gas Recirculation (EGR) mixer into the intake manifold.

If the EGR valve is open, some exhaust gas mixes with compressed intake air inside the EGR mixer and flows into the cylinders. If the EGR valve is closed, only compressed intake air flows into the cylinders.

After combustion, exhaust gas is forced through the exhaust manifolds to the EGR cooler and turbochargers. Some exhaust gas is cooled in the EGR cooler and flows through the EGR valve to the intake air stream. When exhaust gas mixes with air and fuel, it reduces the formation of Nitrogen Oxides (NO_X) engine emissions. The rest of the exhaust gas flows through the high-pressure turbocharger turbine and then through the low-pressure turbocharger turbine. The high-pressure turbine is on the same shaft as the high-pressure turbocharger compressor and compresses the mixture of filtered air. The low-pressure turbocharger turbine is on the same shaft as the low-pressure compressor.

The high-pressure TC2WG actuator is controlled by the Engine Control Module (ECM) and responds to engine loads. During heavy loads, increased exhaust flow turns the turbine wheel faster. This increased speed turns the compressor impeller faster and supplies greater boost pressure to the intake manifold. To prevent too much boost from building, the wastegate valve diverts exhaust away from the turbine wheel. Conversely, when engine load is light, the flow of exhaust decreases and less air is forced into the intake manifold. Therefore, the wastegate valve forces more exhaust towards the turbine wheel to compensate.

Charge Air Cooler (CAC)

Air from the dual stage turbocharger assembly passes through a network of heat exchanger tubes inside the CAC before entering the ETV. Outside air flows through the CAC and cools the charged air. Cooled intake air improves the fuel-to-air ratio during combustion. This results in improved emission control and power output.

Charge Air Cooler Outlet Temperature (CACOT) Sensor

The CACOT is a thermistor-style sensor that measures charged-air temperature entering the Engine Throttle Valve (ETV). As temperature increases, resistance drops, causing the voltage signal interpreted by the Engine Control Module (ECM) to vary. The ECM monitors this signal for Exhaust Gas Recirculation (EGR) system control and Charge Air Cooler (CAC) performance.

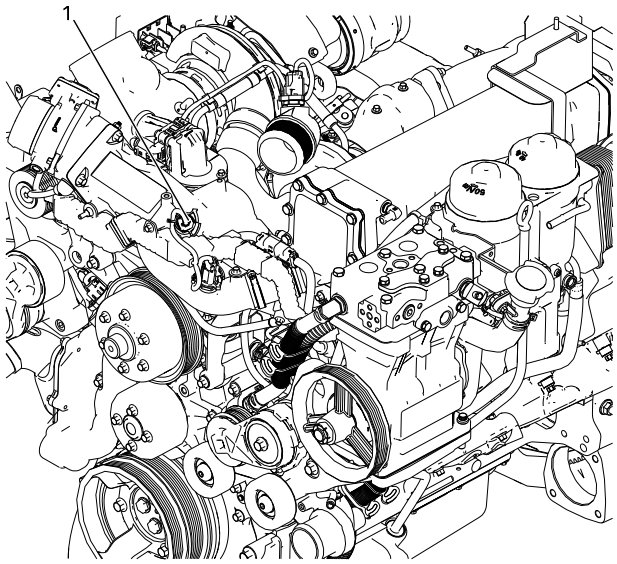

Figure 9 Charge Air Cooler Outlet Temperature (CACOT) Sensor

1. CACOT Sensor

Dual Turbocharger Assembly

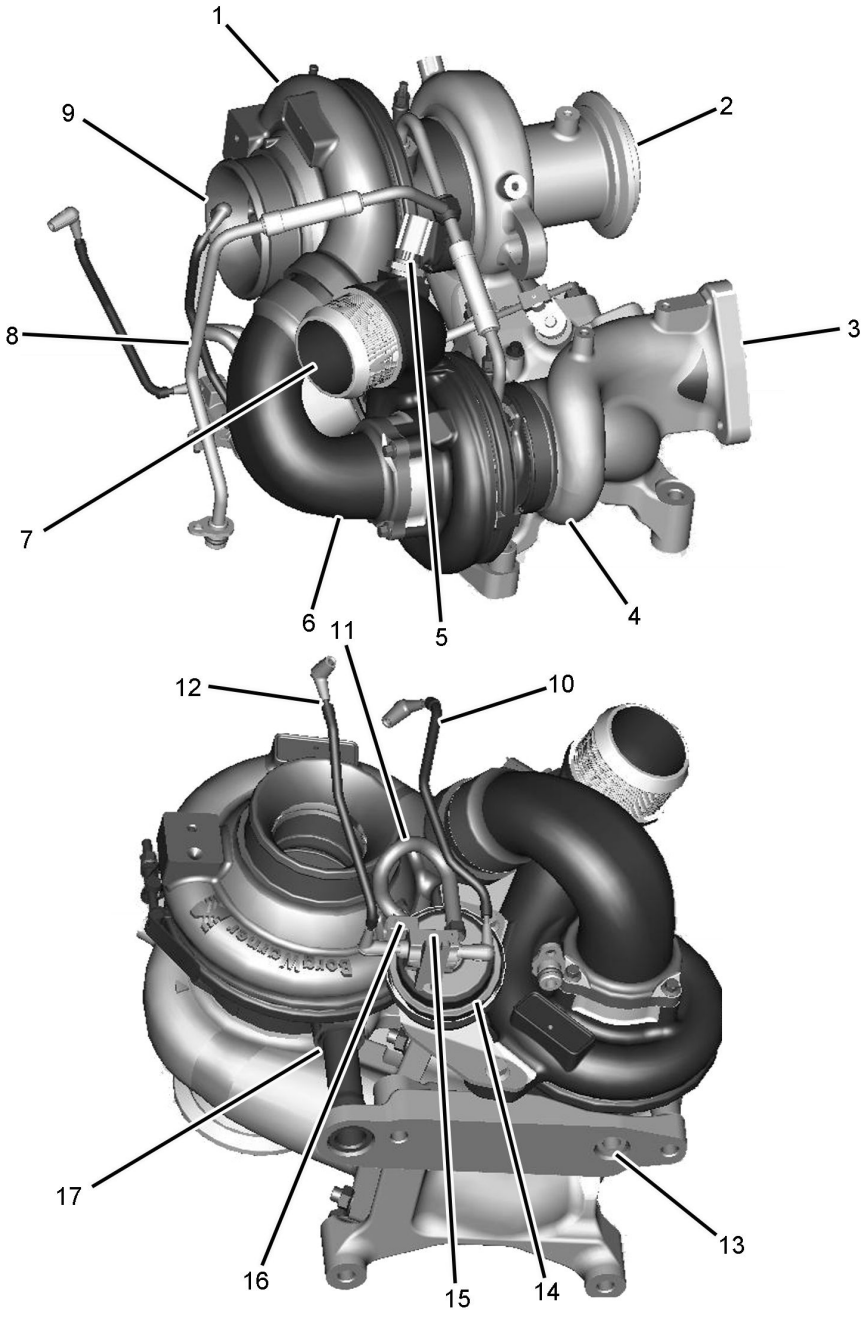

Figure 10 Dual Turbocharger Assembly

1. Low-pressure turbocharger
2. Low-pressure turbocharger turbine outlet
3. Exhaust inlet
4. High-pressure turbocharger
5. Turbocharger 1 Compressor Outlet Temperature (TC1COT) sensor
6. Crossover tube
7. High-pressure turbocharger compressor outlet
8. Turbocharger oil supply tube
9. Air inlet
10. Relief-to-duct tube assembly
11. Wastegate tube assembly
12. Boost solenoid tube assembly
13. High-pressure turbocharger drain port
14. TC2WG actuator
15. TC2WG solenoid
16. TC2WG solenoid electrical connector
17. Low-pressure turbocharger drain tube

MaxxForce® 7 engines are equipped with an electronically controlled dual turbocharging system. This system provides high levels of charge air pressure to improve engine performance and reduce emissions. The dual turbocharger assembly is connected to the turbocharger exhaust inlet manifold. Because of its ability to generate very high charge air pressure levels and to prevent Charge Air Cooler (CAC) overloading conditions, the system is fitted with a spring-loaded turbocharger wastegate valve.

The turbocharger wastegate valve is actuated by boost air pressure. Boost air pressure to the TC2WG actuator is controlled by an electronically controlled TC2WG solenoid, based on a Pulse Width Modulation (PWM) signal supplied by the Engine Control Module (ECM).

High-pressure Turbocharger

The high-pressure turbocharger assembly is equipped with a wastegate valve that regulates turbocharger boost by controlling the amount of exhaust gases that pass through the high-pressure turbine. When the boost demand is high, or when the boost demand reaches a predetermined value, the TC2WG actuator opens the wastegate valve. This allows part of the exhaust gas flow to bypass the high-pressure turbine. Compressed air from the low-pressure compressor housing enters the high-pressure turbine compressor through the air crossover tube. Where it is further compressed and sent to the charge air cooler.

Turbocharger 1 Compressor Outlet Temperature (TC1COT) Sensor

The TC1COT is a thermistor-style sensor that measures charged-air temperature leaving the turbocharger compressor before the Charge Air Cooler (CAC). As temperature increases, resistance drops, causing the voltage signal interpreted by the Engine Control Module (ECM) to vary. The ECM monitors this signal for engine protection.

Low-pressure Turbocharger

The low-pressure turbine is attached directly to the output of the high-pressure turbine. The exhaust gases enter the low-pressure turbine housing and exit through the low-pressure turbine outlet. Fresh air from the air filter enters the low-pressure compressor where it is compressed and air from the low-pressure compressor is piped directly to the high-pressure compressor inlet.

Turbocharger 2 Wastegate (TC2WG) Solenoid

The TC2WG solenoid controls the TC2WG actuator by regulating the boost control air supply based on a Pulse Width Modulation (PWM) signal received from the ECM.

With no PWM signal, the TC2WG solenoid is open and control air is supplied to the TC2WG actuator maintaining it in the open position. When an increase in the charge air pressure is required, the ECM supplies PWM voltage to close the TC2WG solenoid. When the TC2WG solenoid closes, it interrupts the control air supply to the TC2WG actuator and at the same time relieves the air pressure from the TC2WG actuator by allowing it to vent to the turbocharger inlet duct. The TC2WG actuator then closes, resulting in increased charge air pressure.

Exhaust Gas Recirculation (EGR) System

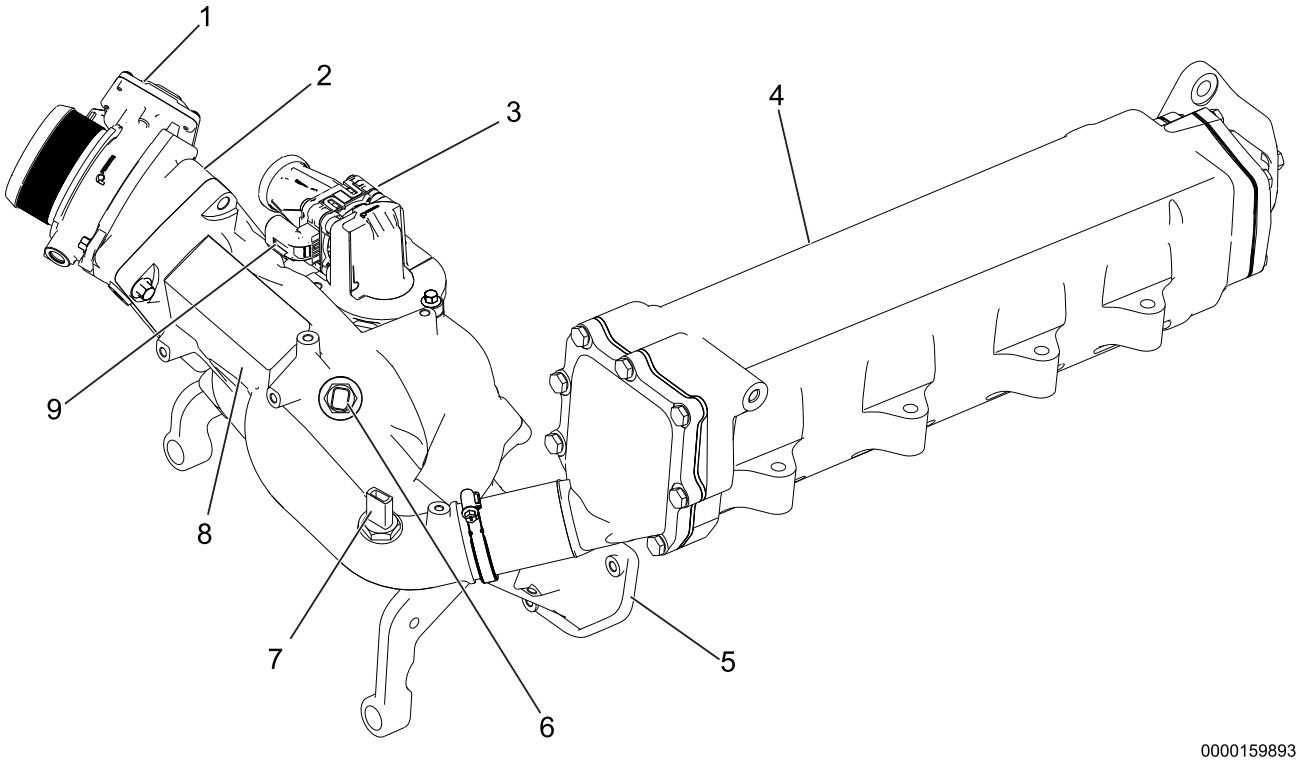

Figure 11 EGR system

1. Engine Throttle Valve (ETV)
2. Inlet Air Heater (IAH)
3. EGR valve
4. EGR cooler
5. Distribution duct
6. Charge Air Cooler Outlet Temperature (CACOT) sensor
7. EGRT Sensor
8. Manifold mixer
9. EGR Valve Connector

Exhaust Gas Recirculation (EGR) is an emission-control technology, which significantly reduces Nitrogen Oxide (NO_X) emissions. The EGR system is also used to adjust the fuel-to-air ratio for Diesel Particulate Filter (DPF) regeneration.

NO_X gas forms during a reaction between nitrogen and oxygen at the high temperatures of combustion. By mixing exhaust gases with the inlet air, peak combustion temperature is reduced thus reducing the formation of NO_X emissions.

EGR Flow

Some exhaust from the turbocharger inlet manifold flows into the EGR cooler. Exhaust from the EGR cooler flows into a manifold mixer, through the EGR valve, and then into the intake manifold.

When EGR is required, the EGR valve opens, allowing cooled exhaust gases to enter the intake manifold to be mixed with filtered intake air. The exhaust gases are then recycled through the combustion process.

EGR Control Valve and Position Sensor

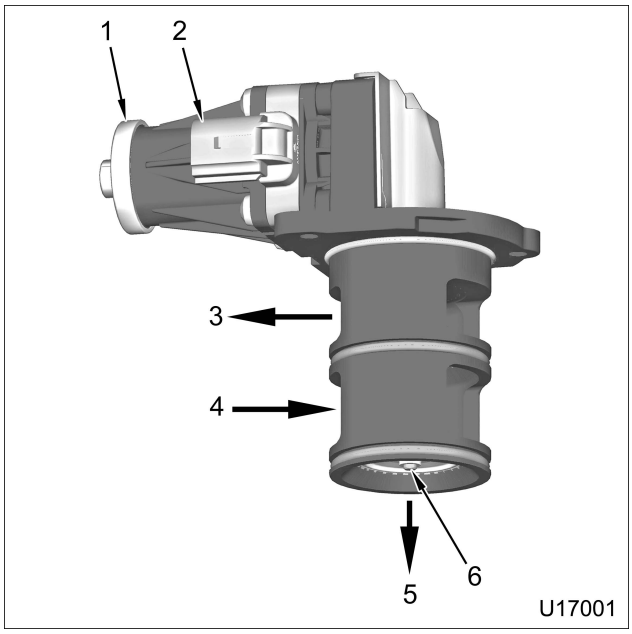

Figure 12 EGR valve

1. Direct Current (DC) motor
2. Electrical connector
3. Exhaust outlet
4. Exhaust inlet
5. Exhaust outlet
6. Poppet valve assembly

The EGR valve uses a DC motor to control the position of the poppet valve assembly. The motor drives the poppet valve assembly, while driving the position sensor. The poppet valve assembly has two valve heads (poppets) on a common shaft.

Exhaust flow enters the EGR valve elbow housing and enters the EGR valve. Exhaust flows through the two valve poppets into the manifold mixer, where it mixes with incoming air from the air inlet throttle valve. The mixed air goes into the intake manifold and cylinders.

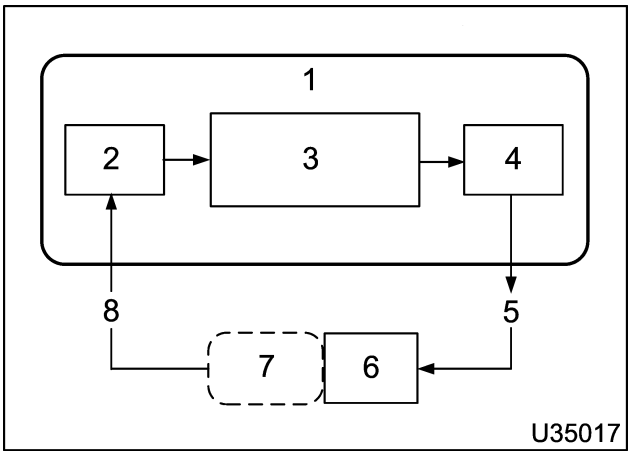

Figure 13 EGR closed loop operation

1. ECM
2. Measured position
3. Compare with desired position
4. Adjust duty cycle
5. Duty cycle
6. EGR valve
7. Position sensor
8. Voltage

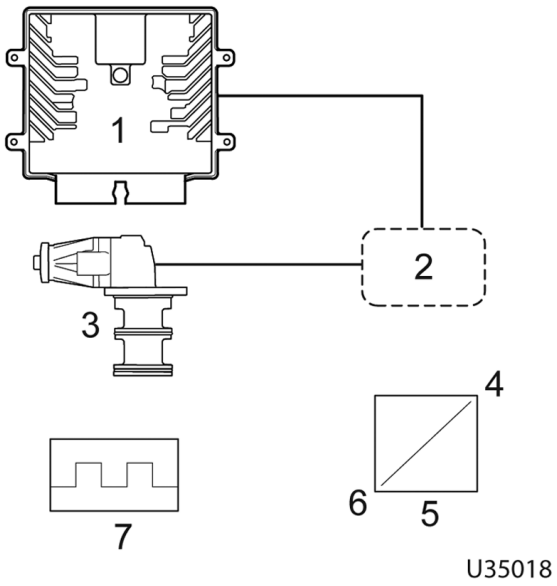

Figure 14 EGR control

1. ECM
2. Position sensor
3. EGR valve
4. 5 volts
5. Analog voltage
6. 0 volts
7. Output signal

The EGR valve consists of two major components: a valve body and an actuator motor. A Hall-effect position sensor monitors valve movement. The EGR valve assembly is mounted on the manifold mixer on the front top of the engine

The EGR motor receives the desired EGR position from the ECM to position the valve for exhaust gas recirculation. The EGR position sensor provides feedback to the ECM on the valve position.

Engine Throttle Valve (ETV) and Position Sensor

ETV regulates the amount of fresh air flow coming into the system. When the engine needs fresh air, the default state of the ETV is opened. When air flow needs to be restricted, the ETV is commanded to close by the ECM.

The ECM monitors the Aftertreatment System. The ECM controls the ETV during AFT regeneration and purge. The ETV is controlled to restrict intake air, which increases the exhaust temperature to clean the Diesel Particulate Filter (DPF). The ETV is also used to help drive more EGR during normal operation.

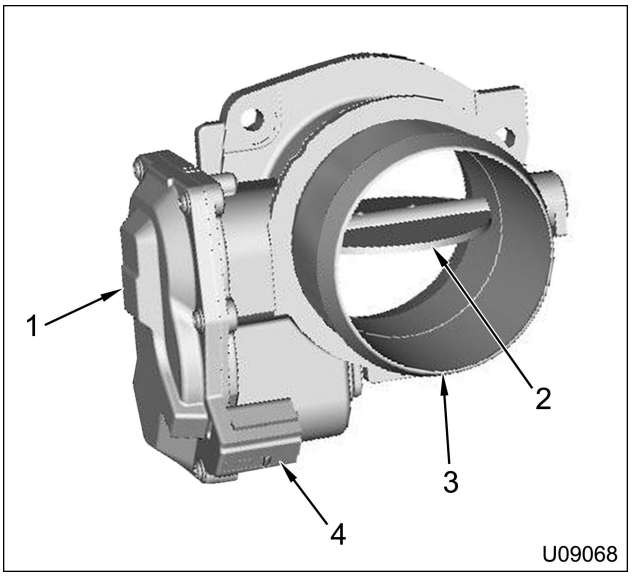

Figure 15 ETV

1. DC motor
2. Throttle blade
3. Inlet air intake
4. Electrical connector

The ETV uses a DC motor to control the position of the throttle blade. The motor drives the throttle blade, while at the same time the position sensor is being read. The ETV consists of two major components, the valve body and actuator motor. A Hall-effect position sensor monitors valve movement.

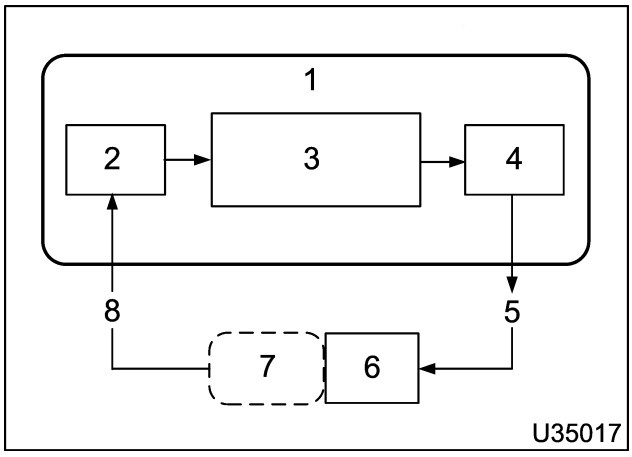

Figure 16 ETV closed loop operation

1. ECM
2. Measured position
3. Compare with desired position
4. Adjust duty cycle
5. Duty cycle
6. ETV
7. Position sensor
8. Voltage

The ETV motor receives the desired valve position from the ECM to position the valve for fresh air flow. The position sensor provides feedback to the ECM on valve position.

Aftertreatment (AFT) System

The AFT System, part of the larger exhaust system, processes engine exhaust to meet emissions requirements. The AFT system traps particulate matter (soot) and prevents it from leaving the tailpipe.

AFT Control System

The control system performs the following functions:

- Monitors exhaust gases and aftertreatment system, and controls engine operating parameters for emission processing and failure recognition
- Cancels regeneration in the event of catalyst or sensor failure
- Monitors the level of soot accumulation in the DPF and adapts engine operating characteristics to compensate for increased back pressure
- Controls engine operating parameters to make regeneration automatic
- Maintains vehicle and engine performance during regeneration

Sensors

Sensors produce a representative electronic signal based on temperature and pressure. It is used by the control system to regulate the aftertreatment function.

The sensors measure temperature and pressure in the exhaust flow.

Diesel Oxidation Catalyst (DOC)

The DOC does the following:

- Oxidizes hydrocarbons and carbon monoxide (CO) in exhaust stream
- Provides heat for exhaust system warm-up
- Aids in system temperature management for the DPF
- Oxidizes NO into NO_2 for passive DPF regeneration

Diesel Particulate Filter (DPF)

The DPF does the following:

- Captures and temporarily stores carbon-based particulates in a filter
- Allows for oxidation (regeneration) of stored particulates once loading gets to a particular level (pressure drop)
- Reduces exhaust back pressure for optimized engine performance by reducing the soot load through regeneration into ash
- Stores noncombustible ash

AFT Conditions and Responses

The operator is alerted audibly or with instrument panel indicators of system status. Automatic or manual regeneration is required when levels of soot exceed acceptable limits. For additional information see the applicable vehicle *Operator's Manual* and the vehicle visor placard.

Fuel System

Fuel System Components

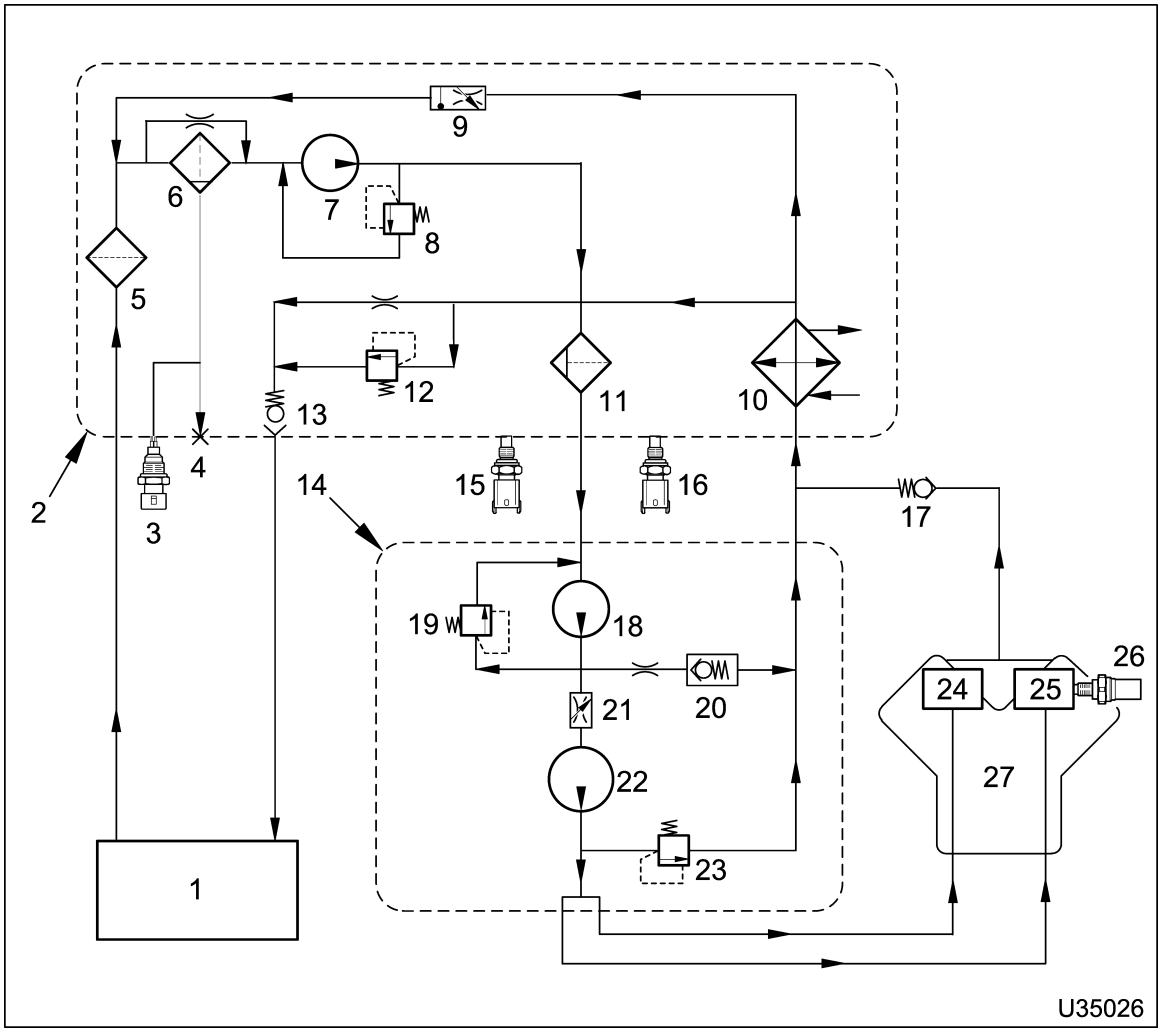

Figure 17 Fuel system schematic

1. Fuel tank
2. Fuel filter module housing
3. Water In Fuel (WIF) sensor
4. Manual water drain
5. Fuel heater (Optional)
6. Primary fuel filter
7. Fuel Pump
8. Pressure relief valve
9. Thermal recirculation valve
10. Liquid fuel cooler
11. Secondary fuel filter
12. Pressure regulator
13. Shutoff valve
14. Engine High Pressure Fuel Pump (HPFP)
15. Fuel Delivery Pressure (FDP) sensor (optional)
16. Engine Fuel Temperature (EFT) sensor
17. Injector Leak Off (ILO) check valve
18. Internal Transfer Pump (ITP)
19. ITP regulator
20. HPFP cooling and lubrication flow valve
21. Fuel Volume Control Valve (FVCV)
22. HPFP
23. Fuel Pressure Control Valve (FPCV)
24. High-pressure Common Rail (HPCR) (Left)
25. High-pressure Common Rail (HPCR) (Right)
26. Fuel Rail Pressure (FRP) sensor
27. Engine

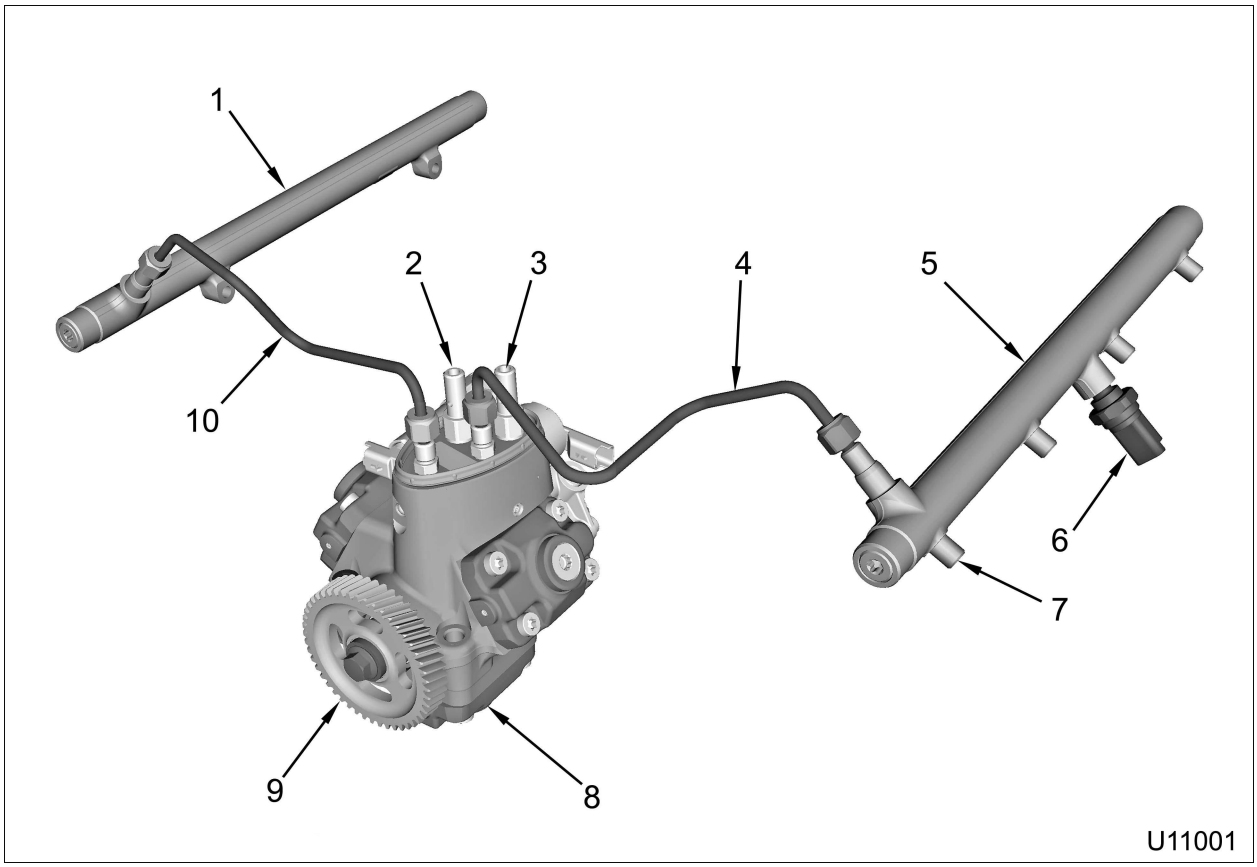

Figure 18 High-pressure fuel system

1. Left rail assembly
2. Pump return hose connection (pump-to-cooler)
3. Filter to pump hose connection (secondary fuel filter-to-pump)
4. Pump right tube assembly (pump-to-rail)
5. Right rail assembly
6. Fuel Rail Pressure (FRP) sensor
7. Fuel rail-to-injector fuel tube port (4 for each rail)
8. HPFP
9. HPFP gear
10. Pump left tube assembly (pump-to-rail)

High-pressure Fuel System

High-pressure Fuel Pump (HPFP) Assembly

The HPFP is a three-piston volumetric pump that supplies fuel at high pressure to both fuel rails. The HPFP is mounted in the rear valley on top of the engine and is driven by the camshaft.

Internal Transfer Pump (ITP)

The ITP is part of the HPFP assembly and driven off the same shaft as the HPFP assembly. The ITP supplies fuel at a slightly higher pressure and flow to the HPFP through the Fuel Volume Control Valve (FVCV). The ITP also provides fuel for cooling and lubrication of the HPFP. Fuel is rerouted as pump return flow through the HPFP cooling and lubrication valve. Pressure is maintained at the inlet of the HPFP piston pump by an ITP regulator.

Fuel Pressure Control Valve (FPCV)

The FPCV controls the fuel pressure to the fuel rails. The FPCV is located in the HPFP assembly and is controlled by the ECM. FPCV control depends on fuel pressure and fuel temperature.

Fuel Volume Control Valve (FVCV)

The FVCV regulates the volume of flow sent to the HPFP. The FVCV is located in the HPFP assembly and is controlled by fuel rail pressure, via the ECM. The FVCV allows just sufficient quantity of fuel to be delivered to the HPFP depending on engine load, speed, injector quantity, fuel temperature, and number of injections per cycle.

Fuel Rail Pressure (FRP) Sensor

The FRP sensor monitors fuel pressure in the fuel rails and sends a signal to the ECM. The FRP sensor is installed in the right fuel rail. The FRP sensor harness is routed through the right Under Valve Cover (UVC) harness along with the fuel injector connections.

High-pressure Piezo Common Rail (HPCR) System

The HPFP pumps fuel through separate tubes to each fuel rail. Each fuel rail has four fuel tubes, one for each injector, that maintain constant pressure from the high-pressure pump to each injector.

The injectors are capable of five injections; two pre-injection, a main-injection, a post-injection, and a late post-injection. Pre-injection and post-injection reduce combustion noise, mechanical load, and exhaust emissions. The main-injection cycle injects and atomizes fuel in the combustion chambers for combustion. The late post-injection cycle adds fuel to the exhaust to regenerate the aftertreatment system.

Each injector has an actuator that opens or closes the injector nozzle holes. Charging the actuator opens the nozzle holes; discharging the actuator closes the nozzle holes. The ECM charges and discharges each actuator by energizing the appropriate high-side or low-side output. The low-side output supplies a return circuit for each actuator.

Return Fuel System

The return fuel system moves unused fuel from the fuel injectors to the fuel cooler. Excess fuel out of the FVCV and the FPCV mix with fuel from the fuel injectors on the way to the fuel cooler.

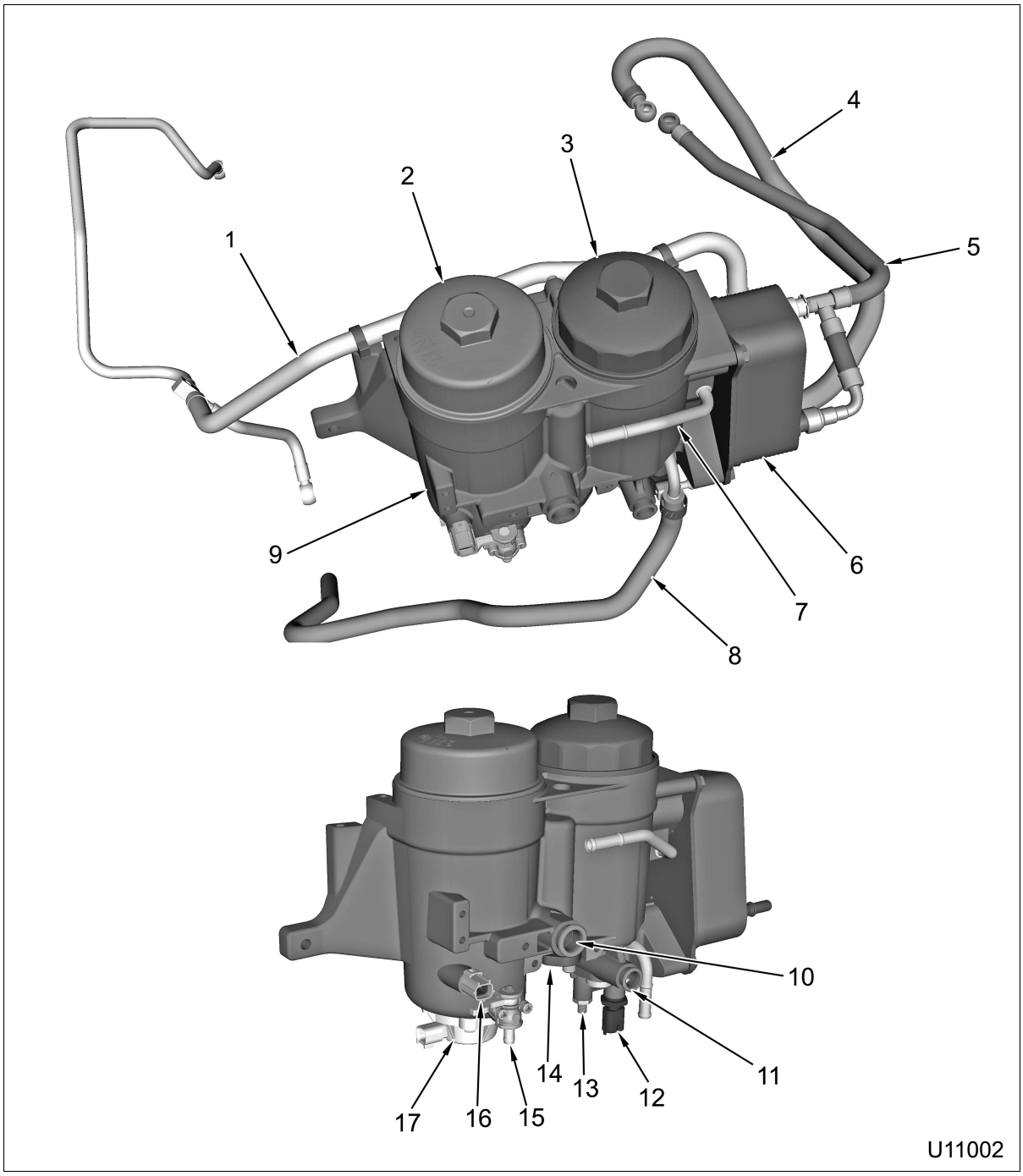

Figure 19 Low-pressure fuel system

1. Injector return hose assembly
2. Filter cap (primary)
3. Filter cap (secondary)
4. Filter-to-pump hose assembly
5. Pump-to-cooler hose assembly
6. Fuel cooler
7. Coolant supply hose
8. Coolant return hose
9. Fuel filter module housing
10. Fuel inlet from tank
11. Fuel return to tank
12. Engine Fuel Temperature (EFT) sensor
13. Diagnostic valve (standard)
14. Fuel heater block-off plate or fuel heater (optional)
15. Water drain valve
16. Water In Fuel (WIF) sensor
17. Fuel Pump

Low-pressure Fuel System

Fuel Pump

A constant-flow electric pump draws fuel from the fuel tank(s) through the primary fuel filter and supplies fuel to the secondary fuel filter. The fuel pump is mounted at the bottom center of the primary fuel filter.

Primary Fuel Filter

A 10–micron primary filter removes water and filters fuel from the fuel tank(s). The primary filter is above the low-pressure fuel pump.

Secondary Fuel Filter

A 3–5 micron secondary fuel filter assembly also removes water and filters fuel from the low-pressure fuel pump. The filter has an internal drilled air bleed orifice to automatically remove air from the fuel. The filtered fuel from the primary fuel filter is mixed with the cooled fuel from the fuel cooler and is directed to a secondary fuel filter. System pressure is maintained by an internal pressure regulator.

Fuel from the pressure regulator and air bleed orifice returns to the fuel tank(s).

The fuel module has a temperature sensor mounted in the supply line to the HPFP. A fuel temperature sensitive recirculation fuel valve allows some warmer recirculated fuel from the fuel cooler to flow to the primary filter when tank fuel is colder. This helps prevent filter waxing. When fuel temperatures are warm to hot, the valve closes and all recirculated fuel goes into the secondary housing where it mixes with fuel from the primary filter, electric pump, and tank.

Fuel Cooler

The combined fuel from the fuel injectors and the HPFP is cooled by the fuel cooler using engine coolant. Cooled fuel is then directed to the inlet of the secondary fuel filter.

Fault Detection / Management

The ECM can detect if the output is shorted to ground / battery, the output is open, or if an injector is shorted.

Engine Lubrication System

Lubrication System Components and Oil Flow

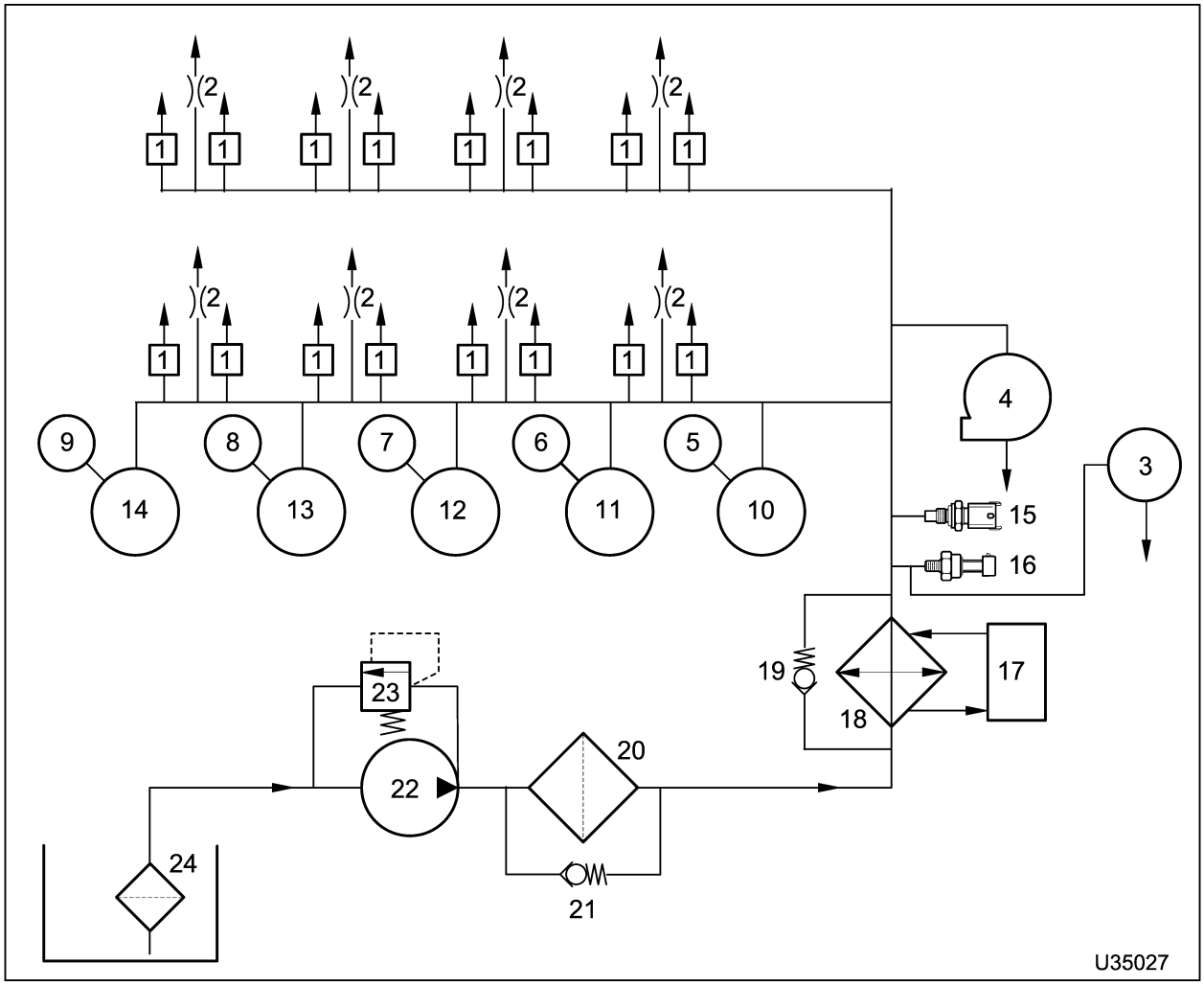

Figure 20 Lubrication system

1. Camshaft follower
2. Piston cooling tube
3. Air compressor (optional)
4. Dual turbocharger assembly
5. Cam bearing 1
6. Cam bearing 2
7. Cam bearing 3
8. Cam bearing 4
9. Cam bearing 5
10. Main bearing 1 and crank pins
11. Main bearing 2 and crank pins
12. Main bearing 3 and crank pins
13. Main bearing 4 and crank pins
14. Main bearing 5 and crank pins
15. Engine Oil Temperature (EOT) sensor
16. Engine Oil Pressure (EOP) sensor
17. Engine coolant
18. Oil cooler
19. Bypass valve
20. Oil filter
21. Bypass valve
22. Oil Pump
23. Pressure regulator
24. Oil pickup and screen

The lubrication system is pressure-regulated, full-flow cooled, and full-flow filtered.

A gerotor oil pump includes an oil pump housing, cover plate, gerotor assembly (inner and outer gears), and pressure-regulating valve assembly. The inner rotor gear of the gerotor pump is driven by the crankshaft.

The gerotor oil pump draws and pressurizes oil from the oil pan through an oil pickup tube and screen. Pressurized oil in the pump flows through passages in the oil pump housing, enters a passage in the lower crankcase dirty side, flows through a passage in the oil pan dirty side to the dirty side of the oil filter. Oil is filtered in the oil filter (outside to inside) and flows from the center of the oil filter into a passage in the clean side of the oil pan and lower crankcase before returning to the passage in the clean side of the oil pump.

If the oil cooler is restricted, a bypass valve in the oil cooler cover opens; oil bypasses the oil cooler and flows directly to the various systems in the engine. If the oil filter element is restricted, a bypass valve in the oil filter housing opens; oil bypasses the filter element and flows through passages in the (clean side) of the oil pan-lower crankcase-upper crankcase, before going to the oil cooler.

Oil pressure is governed by the pressure-regulating valve assembly. The pressure-regulating valve in the discharge oil flow relieves excess oil pressure by allowing excess flow back to the suction side of the gerotor oil pump.

Oil flows from the oil pump into the upper crankcase, to a passage in the oil cooler cover, and through the oil cooler plates; cooled oil flows back to the cooler cover and is distributed to various systems in the engine.

Each bypass valve ensures full flow of oil to the engine, if the filter or cooler is restricted, including high oil viscosity cold start conditions.

The oil cooler passage directs cooled, filtered oil to the optional air compressor, oil supply tube to lubricate the turbocharger bearings, and oil to the main oil galleries. Lubrication oil from the turbocharger drains back to the oil pan through slotted passages in the cooler cover plate and upper crankcase. The cooler cover has ports for EOP and EOT sensors.

Cooling System

Cooling System Components and Flow

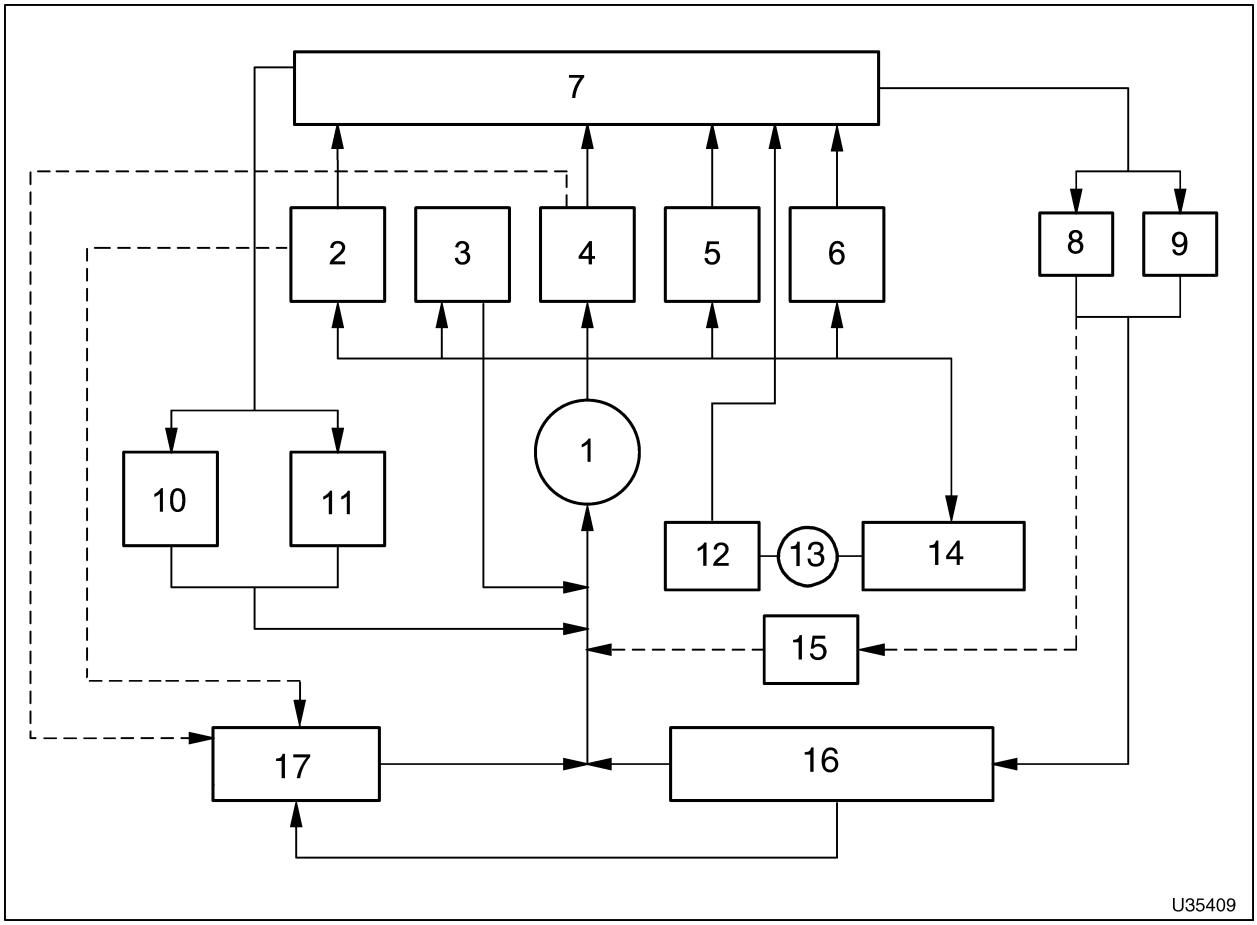

Figure 21 Cooling system schematic

1. Water pump
2. EGR cooler
3. Oil cooler
4. Air compressor (optional)
5. Left cylinder head / crankcase
6. Right cylinder head / crankcase
7. Cross-over
8. Thermostat 1
9. Thermostat 2
10. Heater core
11. Heater core (optional)
12. Fuel cooler
13. Fuel Coolant Valve (FCV)
14. Secondary radiator
15. Bypass
16. Radiator
17. Deaeration tank

The cooling system keeps the engine within a designated temperature range.

Water Pump

The centrifugal water pump is mounted in the front crankcase cover. The water pump has a built-in reservoir to catch small amounts of coolant that may seep past the seal. Water pump rotation is counterclockwise when viewed from the front of the engine.

If the dual thermostats are shut, coolant is circulated through an internal bypass in one of the thermostats.

The vehicle mounted deaeration tank keeps the system full with a line to the suction of the water pump.

Front Crankcase Cover Flow

Pressurized coolant from the water pump flows through the coolant supply housing in the front cover. Flow is directed through passages in the crankcase and ports in the front cover to support cooling system requirements.

- Two passages (left and right) direct coolant through the crankcase front to rear to cool the cylinder walls and then directed up to the cylinder head through ports in the top deck.
- A passage directs coolant from the front cover and through the crankcase to the oil cooler to cool the lubricating oil.
- A port in the front cover directs coolant through tubing to the EGR cooler to cool the exhaust gases.
- A port in the front cover directs coolant through tubing to the air compressor.
- A port in the front cover directs coolant through a secondary radiator to the fuel cooler, to cool unused fuel.

Hot coolant return flow is directed through passages in the crankcase and ports in the front cover to the coolant return cross-over housing.

- Two passages (left and right) through the crankcase return coolant from the cylinder heads.
- A port in the coolant return cross-over housing returns coolant through tubing from the air compressor.
- A port in the coolant return cross-over housing returns coolant through tubing from the EGR cooler.
- A port in the coolant return cross-over housing returns coolant through tubing from the fuel cooler.

The coolant return housing has one temperature sensor point.

The coolant return cross-over supplies coolant to the vehicle heater core for cab heating.

The coolant return cross-over housing directs coolant to the dual thermostat housing.

A passage through the crankcase returns coolant from the oil cooler directly to the water pump eye.

Thermostats

Two thermostats are located in the thermostat housing. If the coolant temperature is above the thermostat opening temperature, coolant flows to the vehicle mounted radiator to be cooled. If the coolant temperature is below the opening temperature for both thermostats, both thermostats are closed. Coolant returns back to the water pump through a bypass on one of the thermostats. As the coolant temperature increases, the first thermostat starts to open and allows flow through the radiator. As coolant temperature continues to increase, the first thermostat will fully open. The second thermostat will then start to open, increasing flow to the radiator until both thermostats are fully open.

Deaeration Tank

The radiator and the coolant system are kept full and pressurized by the deaeration tank. As coolant in the radiator heats up and expands, the level in the deaeration tank goes up and pressure increases. The deaeration tank also removes air from the cooling system.

Radiator Shutters (220 Horsepower only)

Closing the radiator shutters keeps the engine warm during cold weather operation. This provides faster warm-up of the passenger cab and faster windshield defrosting.

Fuel Coolant Valve (FCV)

The FCV is used to redirect coolant through the fuel cooler. The ECM uses the Engine Fuel Temperature (EFT) sensor to monitor fuel temperature and controls the FCV to maintain the desired fuel temperature. The valve opens automatically allowing coolant to pass through the cooler. The ECM controls this valve in cold weather to warm the fuel and also prevents the temperature from getting too hot.

Engine Speed Position System

The Engine Speed Position System provides a summary of camshaft and crankshaft synchronization status information to the system. It sets the operating modes of camshaft and crankshaft acquisition depending on synchronization status, availability, and detected failures. The signal source for engine position is selected on the activated operating mode.

Camshaft and crankshaft signal acquisition is set passive for a calibrated delay after key-off has been detected at low engine speed and for another calibrated delay after a loss of synchronization at low engine speed. This avoids wrong injection, ignition and diagnosis with backward rotation after rapid key-off / on or stalling.

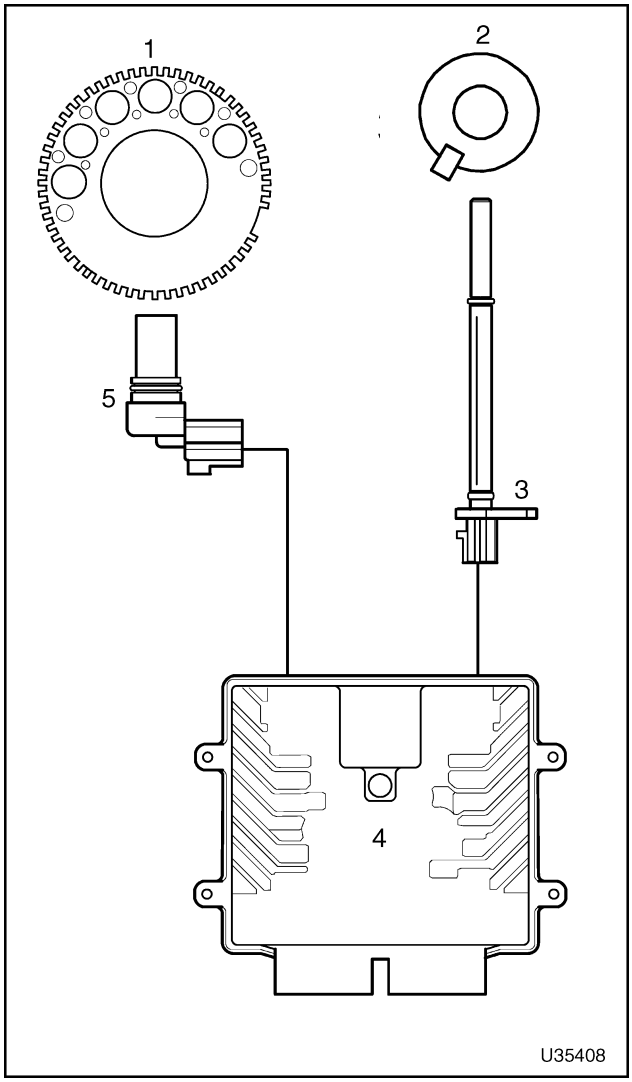

Figure 22 Engine Speed Position System

1. Crankshaft target wheel
2. Camshaft target wheel
3. Camshaft Position (CMP) sensor
4. ECM
5. Crankshaft Position (CKP) sensor

Electronic Control System

Electronic Control System Components

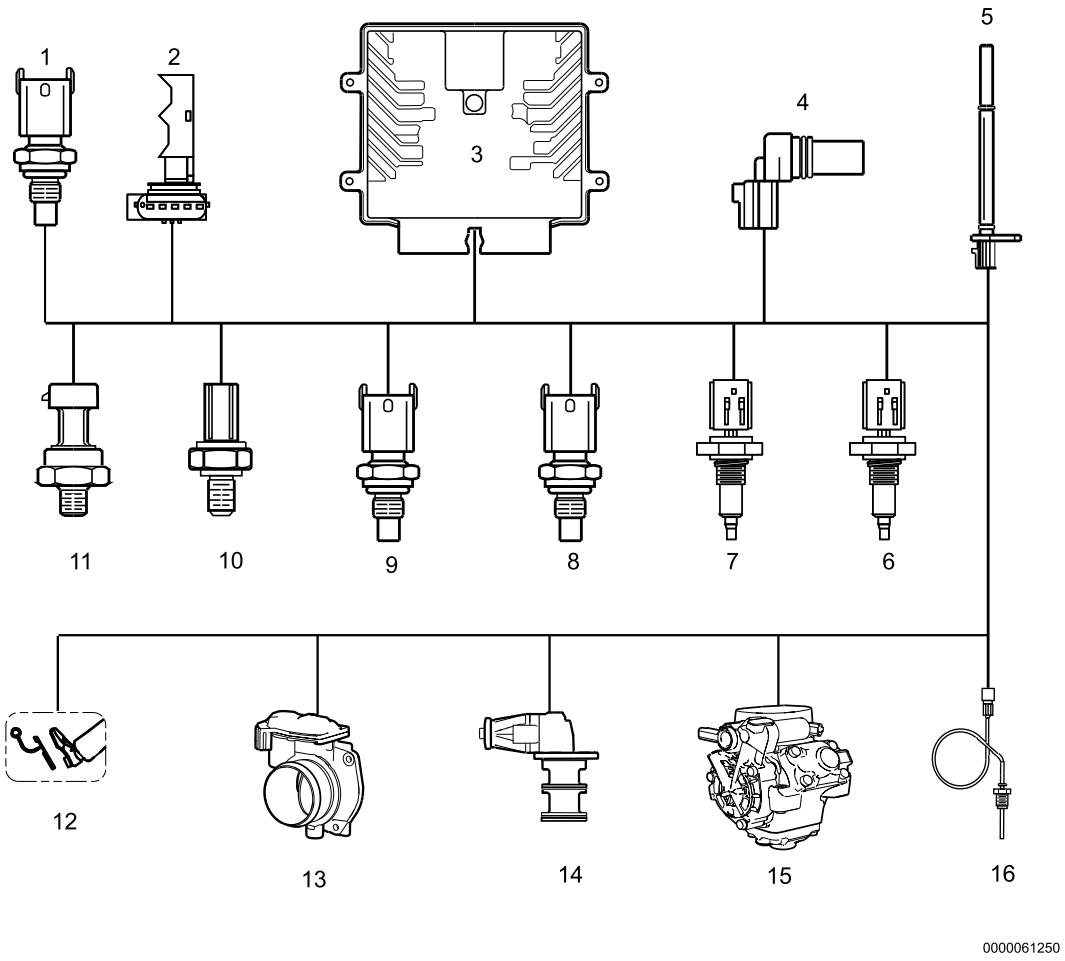

Figure 23 Electronic Control System

1. Engine Coolant Temperature (ECT) sensor
2. Mass Air Flow / Air Inlet Temperature (MAF / AIT) sensor
3. Engine Control Module (ECM)
4. Crankshaft position (CKP) sensor
5. Camshaft position (CMP) sensor
6. Charge Air Cooler Outlet Temperature (CACOT) sensor
7. Turbocharger 1 Compressor Outlet Temperature (TC1COT) sensor
8. Engine Fuel Temperature sensor
9. Engine Oil Temperature 1 (EOT) sensor
10. Engine Oil Pressure (EOP) sensor
11. Intake Manifold Pressure (IMP) sensor
12. Accelerator Pedal Position (APP) sensor
13. Engine Throttle Valve (ETV) and position sensor
14. EGR Control Valve and position sensor
15. High Pressure Fuel Pump (HPFP)
16. Exhaust Gas Temperature (EGT) sensor

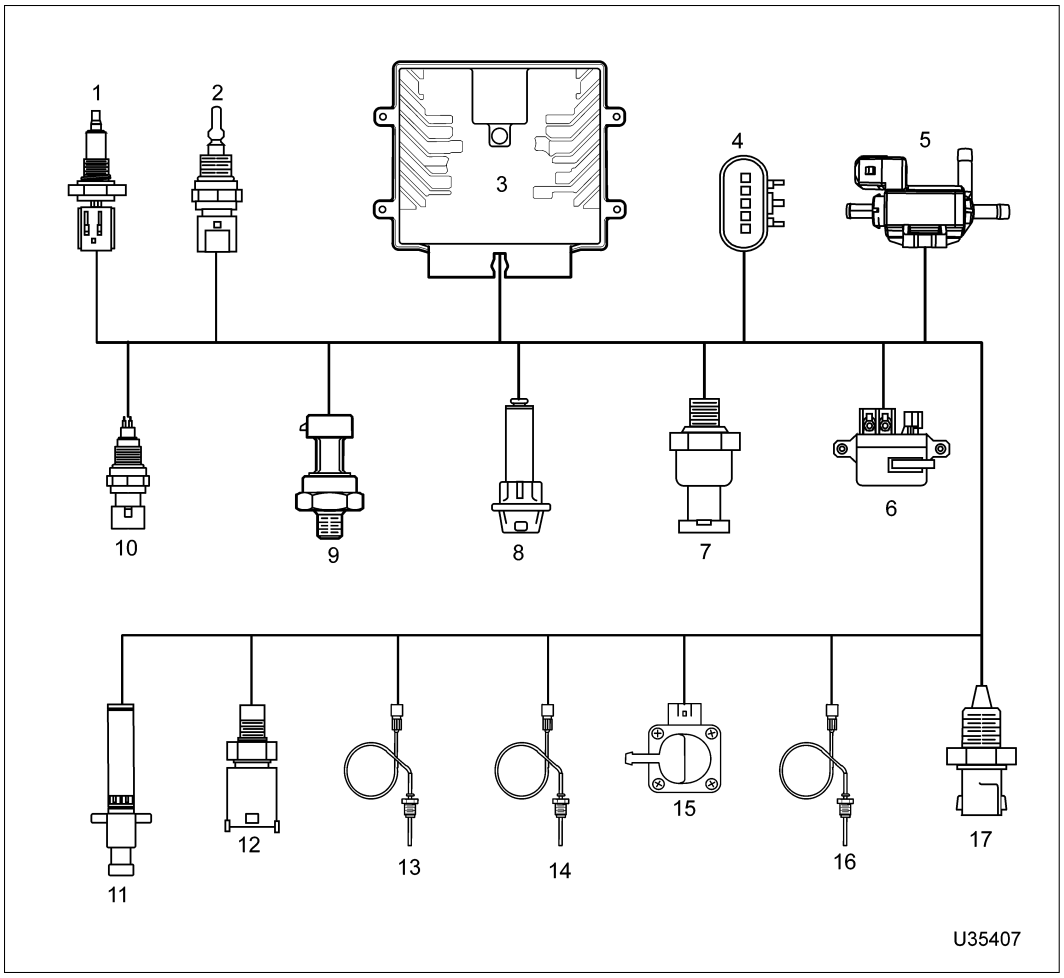

Figure 24 Electronic Control System

1. Exhaust Gas Recirculation Temperature (EGRT) sensor
2. Intake Manifold Temperature (IMT) sensor
3. Engine Control Module (ECM)
4. Engine Fan Control (EFC) (optional)
5. Turbocharger 2 Wastegate (TC2WG) solenoid
6. Inlet Air Heater (IAH) relay
7. Fuel Rail Pressure (FRP) sensor
8. Fuel Pump
9. Fuel Delivery Pressure (FDP) sensor (optional)
10. Water In Fuel (WIF) sensor
11. Fuel Heater (optional)
12. Transmission Outlet Temperature (manual)
13. DOC Inlet Temperature (DOCIT) sensor
14. DPF Inlet Temperature (DPFIT) sensor
15. DPF Differential Pressure (DPFDP) sensor
16. DPF Outlet Temperature (DPFOT) sensor
17. Engine Coolant Level (ECL) sensor

Operation and Function

The Engine Control Module (ECM) monitors and controls the engine to ensure maximum performance and adherence to emissions standards. The ECM has four primary functions:

- Provides reference voltage (VREF)
- Conditions input signals
- Processes and stores control strategies
- Controls actuators

Reference Voltage (VREF)

The ECM supplies a 5–volt VREF signal to input sensors in the electronic control system. By comparing the 5–volt VREF signal sent to the sensors with their respective returned signals, the ECM determines pressures, positions, and other variables important to engine and vehicle functions.

The ECM supplies three independent circuits for VREF:

- VREF supplies 5 volts to engine sensors
- VREF supplies 5 volts to vehicle aftertreatment
- VREF supplies 5 volts to fuel injector control

Signal Conditioner

The signal conditioner in the internal microprocessor converts analog signals to digital signals, squares up sine wave signals, or amplifies low-intensity signals to a level the ECM microprocessor can process.

Microprocessor

The ECM microprocessor stores operating instructions (control strategies) and value tables (calibration parameters). The ECM compares stored instructions and values with conditioned input values to determine the correct operating strategy for all engine operations.

Continuous calculations in the ECM occur at two different levels or speeds: Foreground and Background.

- Foreground calculations are faster than background calculations and are normally more critical for engine operation. Engine speed control is an example.
- Background calculations are normally variables that change at slower rates. Engine temperature is an example.

Suspect Parameter Numbers (SPN) and Fault Mode Indicators (FMI) are set by the microprocessor if inputs or conditions do not comply with expected values.

Diagnostic strategies are also programmed into the ECM. Some strategies monitor inputs continuously and command the necessary outputs for correct performance of the engine.

Microprocessor Memory

The ECM microprocessor includes Flash Memory and Random Access Memory (RAM).

Flash Memory

Flash memory is a nonvolatile form of memory that is electrically erasable and re-programmable. ROM (Read Only Memory) was used when the program (control strategy and calibration) was built into the physical silicon or was burnt in with a one time programming. In ROM, the program is fixed, and to change it you physically have to change the hardware. With Flash memory, you can keep reprogramming it. Flash memory is used to update vehicles in the field (over public CAN) with new calibrations, software bug fixes, or new features.

Flash memory includes the following:

- Vehicle configuration, modes of operation, and options
- Engine Family Rating Code (EFRC)
- Engine warning and protection modes

RAM

RAM stores temporary information for current engine conditions. Temporary information in RAM is lost when the ignition switch is turned to OFF or when ECM power is interrupted. RAM information includes the following:

- Engine temperature
- Engine rpm
- Accelerator pedal position

Engine Fan Control (EFC)

The purpose of the engine fan is to prevent engines in trucks with smaller cooling systems from overheating and to act as a vehicle retarding device.

The electrically controlled viscous fan drive consists of a fluid port that controls the amount of fluid flow which in turn leads to rotation of the fan. The opening and closing of the valve is activated with a pulse-width modulated output (PWM) from the ECM.

The valve is wired to Vehicle Power (VPWR) on one side and is connected to a switching low side driver in the ECM.

Inlet Air Heater (IAH)

The IAH is primarily used to assist the engine in starting under cold weather conditions. In addition, it helps to reduce white smoke emissions by heating the incoming air.

The ECM controls a relay through a 12V digital high side driver. When the relay coil is charged with 12 volts, the high current contacts inside are drawn together. This completes an electric circuit between the IAH and the vehicle's battery.

The ECM disables the relay by outputting zero volts. With no voltage across the relay coil, the contacts separate and the connection to the battery is broken, shutting down the IAH.

Actuator Control

The ECM controls the actuators by applying a low-level signal (low-side driver) or a high-level signal (high-side driver). When switched on, both drivers complete a ground or power circuit to an actuator.

Actuators are controlled in three ways, determined by the kind of actuator.

- A duty cycle (percent time on / off)
- A controlled pulse width
- Switched on or off

Actuators

The ECM controls engine operation with the following:

- EGR Valve and Position Sensor
- ETV and Position Sensor
- TC2WG Actuator
- Engine Fan Control (EFC)
- Exhaust Throttle
- Inlet Air Heater (IAH)
- Exhaust Back Pressure Valve (EBPV)

H-Bridge Circuit

The EGR valve and ETV actuator motors are operated by an H-Bridge (bipolar) circuit in each valve assembly.

An H-Bridge circuit operates like putting a power source on one side of a motor and connecting the other side of the motor to a ground. This turns the motor. By shifting the leads on the motor it will turn in the opposite direction.

To control the motor in both forward and reverse with a processor, you need an H-Bridge. Relays configured in this fashion make an H-Bridge. The high side drivers are the relays that control the positive voltage to the motor. This is called sourcing current. The low side drivers are the relays that control the negative voltage to sink current to the motor. Sinking current is the term for connecting the circuit to the negative side of the power supply, which is usually ground.

Exhaust Gas Recirculating (EGR) Valve and Control

The EGR valve controls the flow of exhaust gases to the intake manifold. The EGR valve is integrated with an EGR Position (EGRP) sensor.

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

The ECM controls motor speed using PWM. The EGR is closed by driving the EGR High (EGRH) circuit high. When driving the EGRH high, this causes EGR Low (EGRL) circuit to go low.

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

ETV and Engine Throttle Position Sensor

The ETV is used to control air / fuel mixture during a regeneration process of the aftertreatment system. The ETV is also used to ensure a smooth engine shut down by restricting air flow to the engine at shut down.

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

The ECM controls motor speed using PWM. The Engine Throttle Valve is close by driving the ETV circuit high. When driving the ETV high, this causes ETV circuit to go low.

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

Engine and Vehicle Sensors

Thermistor Sensors

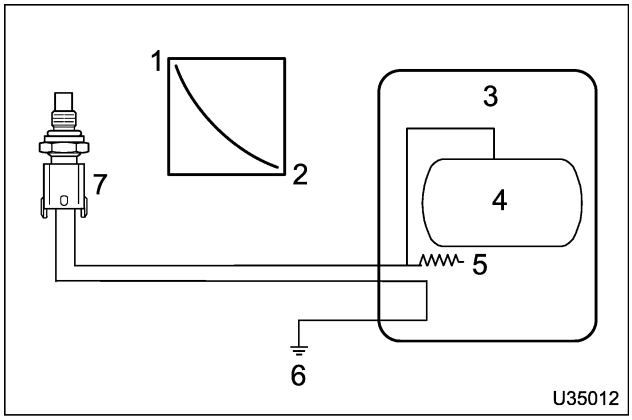

Figure 25 Thermistor sensors

1. 5 Volts
2. 0 Volts
3. ECM
4. Microprocessor
5. VREF
6. Ground
7. Temperature sensor

A thermistor sensor changes electrical resistance with changes in temperature. Resistance in the thermistor decreases as temperature increases, and increases as temperature decreases. Thermistors work with a resistor that limits current in the ECM to form a voltage signal matched with a temperature value.

The top half of the voltage divider limits current inside the ECM. A thermistor sensor has two electrical connectors, signal return and ground. The output of a thermistor sensor is a nonlinear analog signal.

Thermistor type sensors include the following:

- Charge Air Cooler Outlet Temperature (CACOT) sensor
- DOC Inlet Temperature (DOCIT) sensor
- DPF Inlet Temperature (DPFIT) sensor
- DPF Outlet Temperature (DPFOT) sensor
- Engine Coolant Temperature 1 (ECT) sensor

- Engine Oil Temperature (EOT) sensor
- Engine Fuel Temperature (EFT) sensor
- Exhaust Gas Temperature (EGT) sensor
- Exhaust Gas Recirculation Temperature (EGRT) sensor
- Intake Manifold Temperature (IMT) sensor
- Mass Air Flow / Air Inlet Temperature (MAF / AIT) sensor
- Transmission Outlet Temperature (manual) sensor
- Turbocharger 1 Compressor Outlet Temperature (TC1COT) sensor

Variable Capacitance Sensors

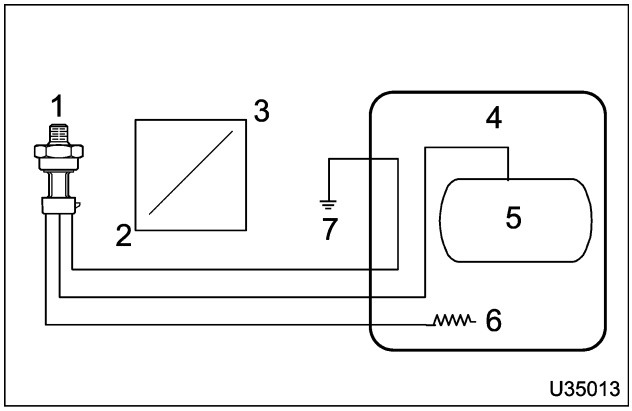

Figure 26 Variable capacitance sensors

1. Sensor
2. 0 Volts
3. 5 Volts
4. ECM
5. Microprocessor
6. VREF
7. Ground

Variable-capacitance sensors measure pressure. The pressure measured is applied to a ceramic material. The pressure forces the ceramic material closer to a thin metal disk. This action changes the capacitance of the sensor.

The sensor is connected to the ECM by three wires:

- VREF
- Signal
- Signal return (ground) (SIG GND)

The sensor receives the VREF and returns an analog signal voltage to the ECM. The ECM compares the voltage with pre-programmed values to determine pressure.

The operational range of a variable capacitance sensor is linked to the thickness of the ceramic disk. The thicker the ceramic disk, the more pressure the sensor can measure.

Variable Capacitance type sensors include the following:

- Intake Manifold Pressure (IMP) sensor
- Engine Oil Pressure (EOP) sensor
- Fuel Delivery Pressure (FDP) sensor
- Fuel Rail Pressure (FRP) sensor

Micro Strain Gauge (MSG) Sensor

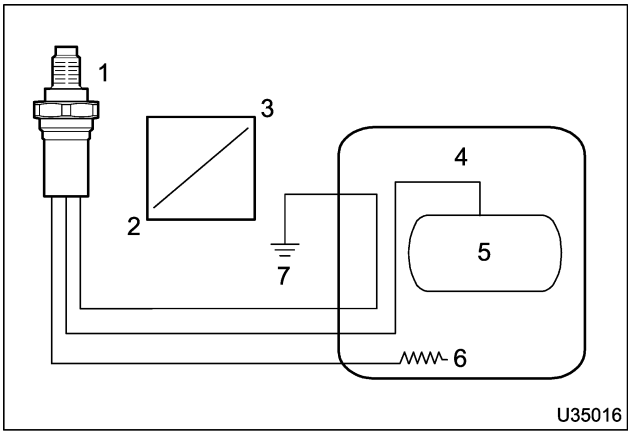

Figure 27 MSG sensor

1. Pressure Sensor
2. 0 Volts
3. 5 Volts
4. ECM
5. Microprocessor
6. VREF
7. Ground

A Micro-Strain Gauge (MSG) sensor measures pressure. Pressure to be measured exerts force on a pressure vessel that stretches and compresses to change resistance of strain gauges bonded to the surface of the pressure vessel. Internal sensor electronics convert the changes in resistance to a ratiometric voltage output.

The sensor is connected to the ECM by three wires:

- VREF
- Signal
- Signal return (ground) (SIG GND)

The sensor is powered by VREF received from the ECM and is grounded through the ECM to a common sensor ground.

MSG Sensors

- Fuel Rail Pressure (FRP) sensor

Magnetic Pickup Sensors

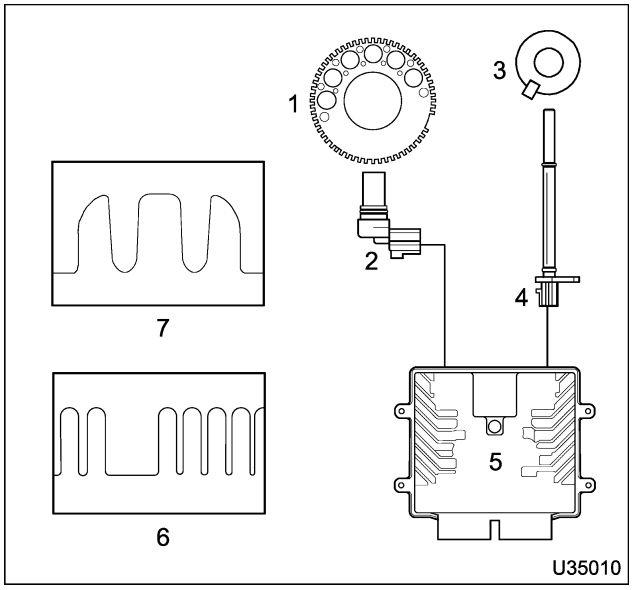

Figure 28 Magnetic pickup sensors (typical)

1. Crankshaft Timing Disk
2. CKP Sensor
3. Camshaft with Peg
4. CMP Sensor
5. ECM
6. CKP signal
7. CMP signal

A magnetic pickup sensor generates an alternating frequency that indicates speed. Magnetic pickups have a two-wire connection for signal and ground. This sensor has a permanent magnetic core surrounded by a wire coil. The signal frequency is generated by the rotation of gear teeth that disturb the magnetic field.

Magnetic Pickup Sensors

- Crankshaft Position (CKP) sensor
- Camshaft Position (CMP) sensor

Potentiometer

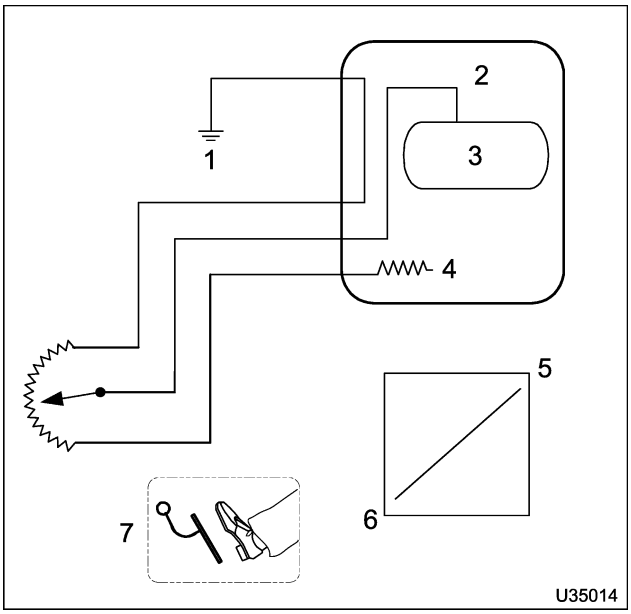

Figure 29 Potentiometer

1. Ground
2. ECM
3. Microprocessor
4. VREF
5. 5 Volts
6. 0 Volts
7. Accelerator pedal

A potentiometer is a variable-voltage divider that senses the position of a mechanical component. A reference voltage is applied to one end of the potentiometer. Mechanical, rotary, or linear motion moves the wiper along the resistance material, changing voltage at each point. Voltage is proportional to the amount of mechanical movement.

Potentiometer

- Accelerator Pedal Position (APP) sensor

Switches

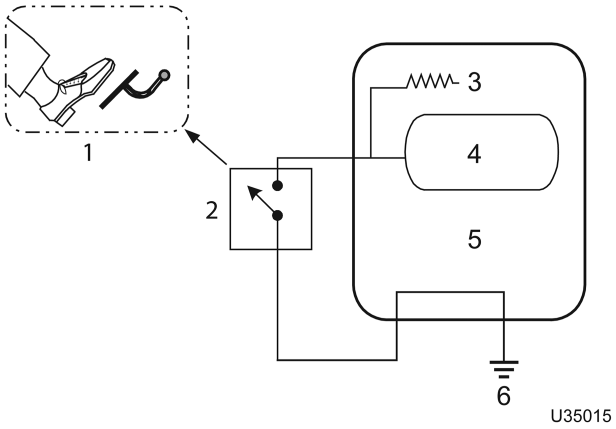

Figure 30 Switch

1. Accelerator pedal
2. Accelerator Pedal Position (APP)
3. VREF
4. Microprocessor
5. ECM
6. Ground

Switches indicate position or condition. They operate open or closed, regulating the flow of current. A switch can be a voltage input switch or a grounding switch. A voltage input switch supplies the ECM with a voltage when it is closed. A grounding switch grounds the circuit when closed, causing a zero voltage signal. Grounding switches are usually installed in series with a current limiting resistor.

Switches

- Engine Coolant Level (ECL) switch
- Water In Fuel (WIF) sensor

Inlet Air Heater (IAH) System

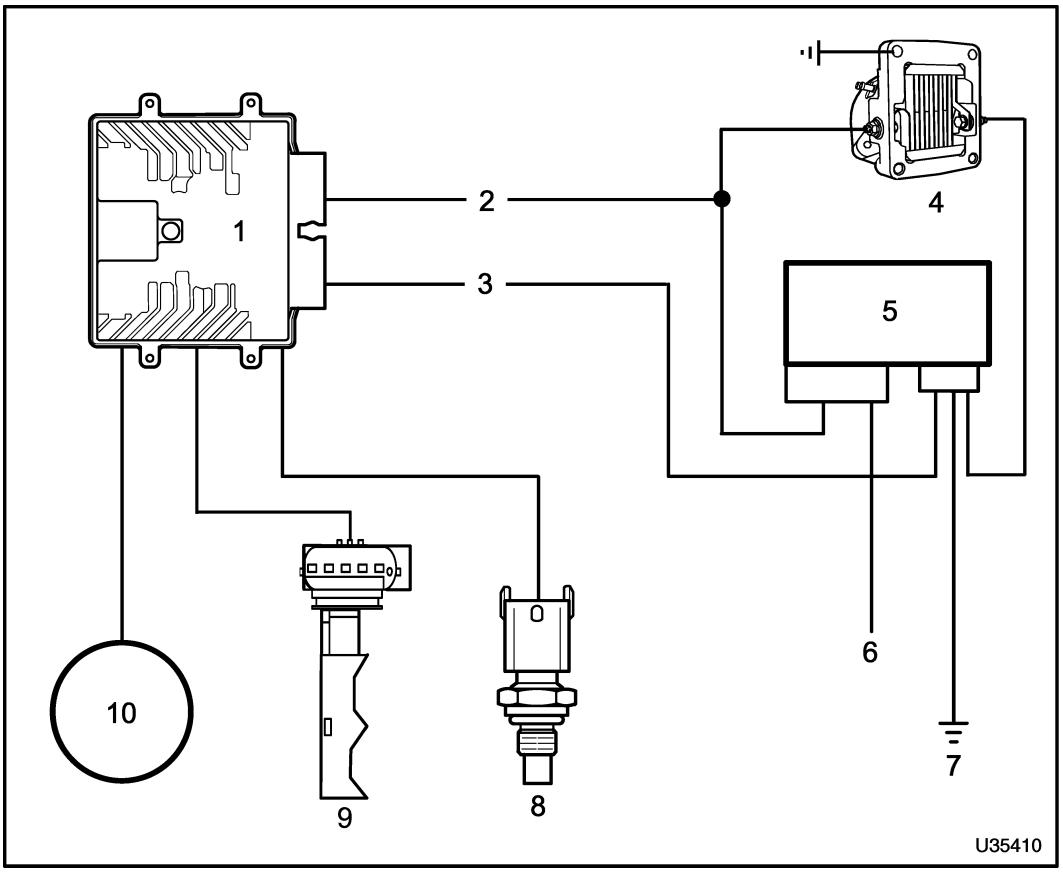

Figure 31 IAH system

1. ECM
2. IAHD – Inlet Air Heater Diagnostics
3. IAHC – Inlet Air Heater Control
4. Inlet Air Heater (IAH)
5. IAH relay
6. B+ at alternator motor post
7. Ground
8. ECT sensor
9. Mass Air Flow / Air Inlet Temperature (MAF / AIT) sensor
10. WAIT TO START lamp

The IAH system warms the incoming air to aid cold engine starting and reduce exhaust emissions during warm-up.

The ECM activates the IAH by energizing the IAH relay while monitoring programmed conditions for engine coolant temperature, air inlet temperature, and atmospheric pressure.

The ECM controls the WAIT TO START lamp and IAH relay separately.

The engine is ready to start when the WAIT TO START lamp is turned off by the ECM. The ECM turns the IAH on for a predetermined amount of time, based on ECT, AIT, and BAP. The IAH can remain on while the engine is running to reduce exhaust emissions and white smoke during engine warm-up.

If the ECT is above 50 °C (122 °F), the IAH will not reactivate when restarting the engine unless the AIT is 10 °C (50 °F) or colder.

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Standard Features

Electronic Governor Control

The governor controls engine rpm within a safe and stable operating range. The low idle governor prevents engine rpm from dropping below a stable speed to prevent stalling when various loads are demanded on the engine. The high idle governor prevents engine rpm from going above a safe speed that would cause engine damage.

SAE J1939 Data Link - also known as CAN (public)

The vehicle is equipped with an SAE standard J1939 CAN datalink:

- The J1939 datalink is used for diagnostics and calibration communications for the Engine Control Module (ECM).
- The J1939 datalink is used for communications between the ECM, Electric Gauge Cluster (EGC), and Body Controller (BC).

The J1939 datalink is accessed through the cab diagnostic connector. The datalink provides communication between the ECM and the Electronic Service Tool (EST).

The SAE J1939 data link supports:

- Transmission of engine parameter data
- Transmission and clearing of Diagnostic Trouble Codes (DTCs)
- Diagnostics and troubleshooting
- Programming performance parameter values
- Programming engine and vehicle features
- Programming calibrations and strategies in the ECM
- Inter-module communications between the:
    - Engine Control Module (ECM)
    - Body Controller (BC)
    - Electronic Gauge Cluster (EGC)
    - Automatic transmission controller
    - Electronic Service Tool (EST)

For additional information, see J1939 data link (page 310) in “Electronic Control Systems Diagnostics” section in this manual.

SAE J1587 Data Link - also known as the American Trucking Association (ATA) data link.

The SAE J1587 data link communicates limited information between the engine, the Electronic Gauge Cluster (EGC), Body Controller (BC), Transmission Control Module (TCM), Anti-lock Brake System (ABS) Module, and Telematics modules.

Service Diagnostics

NOTE: 2010 and newer model year vehicles no longer utilize DTC identification by number. DTCs are now identified, using the Suspect Parameter Number (SPN) and Failure Mode Indicator (FMI) identifiers.

The EST provides diagnostic information, using the SAE J1939 data link. The recommended EST is the EZ-Tech® with ServiceMaxx™ diagnostic software provided by Navistar.

Faults from sensors, actuators, electronic components, and engine systems are detected by the ECM and sent to the EST as DTCs. Effective engine diagnostics require and rely on DTCs.

DTC identification is accomplished using two fault code identifiers. These two identifiers, known as the Suspect Parameter Number (SPN) and the Failure Mode Indicator (FMI) are displayed in the DTC window.

- **Suspect Parameter Number (SPN)** The SPN identifies the individual component causing the fault.
- **Failure Mode Indicator (FMI)** The FMI identifies the fault or condition effecting the individual component.

Event Logging System

The event logging system records engine operation above maximum rpm (over speed), low engine coolant level, high engine coolant temperature, or low engine oil pressure. The readings for the odometer and hourmeter are stored in the ECM memory at the time of an event and can be retrieved, using the EST.

Electronic Speedometer and Tachometer

The engine control system calibrates vehicle speed from 0 to 157,157 pulses per mile. Any new speed calibration information must be programmed with an EST.

The tachometer signal is generated by the ECM by computing signals for the Camshaft position (CMP) sensor and Crankshaft Position (CKP) sensor. The calculated engine speed is then sent to the instrument cluster through the J1939 CAN Data link.

Aftertreatment (AFT) System

One of the most important reasons for aftertreatment is to catalyze carbon monoxide (CO), Oxides of Nitrogen (NOx), and Hydrocarbons (HC) (Normal operation). The engine and vehicle exhaust piping includes an Aftertreatment System to capture soot and other particulates before they exit the exhaust pipe. The soot is captured by the Diesel Particulate Filter (DPF) and is periodically converted to carbon dioxide (CO2) by a Regeneration (Regen) process.

For additional information, see AFT System (page 207) in “Electronic Control Systems Diagnostics” section of this manual.

Fuel Delivery Pressure (FDP) Monitor

The FDP monitors the fuel pressure and indicates when the fuel filter needs to be serviced by displaying the Fuel Filter warning message on the instrument panel.

For additional information, see FDP Sensor in “Electronic Control Systems Diagnostics” section of this manual.

Inlet Air Heater (IAH)

The Inlet Air Heater (IAH) system warms the incoming air supply to aid cold engine starting and reduce white smoke during engine warmup. The ECM controls the intake air heater and monitors the engine temperature. When the engine is ready for cranking, the ECM sends a message to shut off the WAIT TO START lamp.

For additional information, see IAH System (page 591) in “Electronic Control Systems Diagnostics” section of this manual.

Fast Idle Advance

Fast idle advance increases engine idle speed up to 900 rpm for faster warmup to operating temperature. This occurs when the ECM monitors Engine Coolant Temperature (ECT) sensor input and adjusts fuel injector.

Low idle speed is increased proportionally when below 104°F (40°C) at 700 rpm to below -22°F (-30°C) at 900 rpm maximum.

Cold Ambient Protection (CAP)

CAP safeguards the engine from damage caused by prolonged idle at no load during cold weather.

CAP maintains engine coolant temperature by increasing engine rpm to a programmed value. CAP also improves cab warmup.

CAP is standard on all trucks without an idle shutdown timer, with a clutch switch (manual transmissions) or a neutral safety switch (automatic transmission).

For additional information, see CAP in “Engine Operation” section of the *Engine Operation and Maintenance Manual*.

Coolant Temperature Compensation (CTC)

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

Before standard engine warning or optional warning / protection systems engage, the ECM begins reducing fuel delivery when engine coolant temperature reaches approximately 107 °C (225 °F). A rapid reduction of 20 percent is commanded when engine coolant temperature reaches approximately 110 °C (230 °F).

NOTE: Coolant temperature compensation is disabled in emergency vehicles and school buses that require 100 percent power on demand.

Engine Crank Inhibit (ECI)

ECI will not allow the starting motor to crank when the engine is running or the automatic transmission is in gear.

For additional information, see SMC Circuit (page 687) in “Electronic Control Systems Diagnostics” section of this manual.

Optional Features

Change Oil Service Interval

The change oil service interval feature is designed to provide a visual reminder to the operator that the oil change interval has expired and that routine maintenance procedures should be performed.

The term “interval” in this case is used to describe the distance, time, or fuel used between the last maintenance performed on the vehicle and the next maintenance which is due.

It is essential that operators are trained to know the maintenance schedules and instructions regarding the operation and reset functionality of the service interval for the feature to be effective.

The change engine oil interval message can be programmed with the EST for mileage, hours, or amount of fuel used. The change oil message timer can be reset using the CRUISE ON and RESUME / ACCEL switches or EST.

Road Speed Limiting (RSL)

Vehicle road speed can be limited to a maximum speed as programmed by the customer. An EST is required for programming.

RSL is a feature designed to regulate the maximum vehicle speed as controlled by the accelerator pedal.

Customer programmable parameters within the ECM provide vehicle speed governor-related options that can be adjusted to suit the customer’s needs.

Additional programming flexibility is included to allow a trade-off to be made between performance and fuel economy.

Cruise Control

Cruise Control is a well known feature that offers driving comfort by providing a method for an operator to set and maintain a constant vehicle speed without using the accelerator pedal. It is especially useful when the operator is required to drive on highways at a constant speed for many miles. Customer programmable parameters within the engine control module (ECM) provide maximum and minimum allowable cruise control speeds.

To operate cruise control, see appropriate truck model Operator's Manual.

Traction Control

Traction control is a system that identifies when a wheel is going faster than the other wheels during acceleration.

When a traction control condition occurs, a data link message is sent to the ECM to limit fuel for the purpose of reducing engine torque.

Vehicles must have both a transmission and an Antilock Braking System (ABS) that supports traction control.

Exhaust Back Pressure Valve (EBPV)

The EBPV increases exhaust back-pressure to aid in the deceleration rate of the vehicle. This option is placed in the exhaust piping after the turbochargers.

Engine Warning Protection System (EWPS)

The EWPS safeguards the engine from undesirable operating conditions to prevent engine damage and to prolong engine life. The ECM will illuminate the red ENGINE lamp and sound the warning buzzer when the ECM detects:

- High engine oil temperature.
- Low engine oil pressure.
- High engine coolant temperature.
- Low engine coolant level (if equipped).

When the protection feature is enabled and a critical engine condition occurs, the on-board electronics will shut the engine down. An event logging feature will record the event in engine hours and odometer readings. After the engine has shutdown, and the critical condition remains, the engine can be started for a 30-second run time.

For complete EWPS description and additional information, see EWPS (page 518) in “Electronic Control Systems Diagnostics” section of this manual.

Idle Shutdown Timer (IST)

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

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

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

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

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

IST for California ESS Compliant Engines

Beginning in 2008 MY, all International® MaxxForce® engines certified for sale in the state of California will conform to mandatory California Air Resources Board (CARB) ESS regulations.

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

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

The duration of CARB mandated values can be reduced by programming the customer IST programmable parameter to a value lower than 15 minutes.

Engine Idle Shutdown Timer (IST for Federal–Optional)

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

For additional information, see IST System (page 653) in “Electronic Control Systems Diagnostics” section of this manual.

Electronic Fan (EFAN)

Engine electronics allow for the operation of an electronic fan or an air fan solenoid. The engine fan control commands higher airflow through the radiator when the Air Conditioner (A / C) is on or when the engine coolant or inlet air temperature goes above a set temperature. For additional information, see EFC (page 444) in “Electronic Control Systems Diagnostics” section of this manual.

Radiator Shutter Enable (RSE)

The RSE feature provides a signal to open or close the radiator shutters. Closing the shutters will keep the engine warm during cold weather operation. This provides faster warmup of the passenger cab and enables faster windshield defrosting.

For additional information, see RSE (page 681) in “Electronic Control Systems Diagnostics” section of this manual.

In Cab Power Take-Off (PTO) Control

The engine speed control feature, commonly referred to as Power Take-off (PTO), provides a method for an operator to set and maintain a constant engine speed without using the accelerator pedal. It is commonly used for powering auxiliary devices.

Customer programmable parameters within the ECM provide in-cab engine speed control related options that can be adjusted to suit the customer’s needs. Choosing whether the operator is allowed to increase the engine speed using the accelerator pedal without disengaging the PTO is an example.

Remote Accelerator Pedal Position (RAPP)

This engine speed control feature, provides a method for an operator to set and maintain engine speed without using the accelerator pedal. It is commonly used for powering auxiliary devices.

When control over engine speed is required from outside the vehicle’s cab, remote mounted switches must be used to turn on PTO engine speed control and select the desired engine speed. This functionality is referred to as Remote Engine Speed Control (RESC).

Engine speed can be ramped up and down with RESC similar to the way the in-cab PTO feature works; however, the RESC feature includes two additional switches (remote preset and remote variable), which allow the operator to choose the mode of engine speed control operation.

Customer programmable parameters within the ECM provide RESC related options that can be adjusted to suit the customer’s needs. Choosing whether a remote throttle pedal is used for PTO operation is an example.

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Connecting EST with ServiceMaxx™ Software to Engine

To connect the Electronic Service Tool (EST) with ServiceMaxx™ software to the engine, the NAVCoM or NAVLink Interface cable must be connected between the EST and Diagnostic Connector. The Diagnostic Connector is located inside the vehicle cab, above the clutch pedal.

Viewing Diagnostic Trouble Codes

Diagnostic Trouble Codes (DTCs)

2013 model year vehicles no longer utilize DTC identification by number. DTCs are now identified using the Suspect Parameter Number (SPN) and Failure Mode Indicator (FMI) identifiers only. These two identifiers are displayed in the DTC Window.

Suspect Parameter Number (SPN)

The SPN identifies the individual component causing the fault.

Failure Mode Indicator (FMI)

The FMI identifies the fault or condition affecting the individual component.

Active and Previously Active DTCs

Active DTCs are codes that are currently present.

Previously active DTCs are historical codes that may be set by intermittent conditions, or by an operating condition, which is not currently present.

All active and previously active DTCs will be indicated in the DTC Type column.

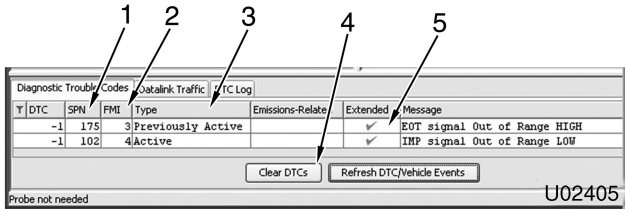


Figure 32 DTC window

1. SPN column
2. FMI column
3. DTC Type column
4. Clear DTCs button
5. Extended (Freeze Frame)

Service Bay Tests

Key On, Engine Off (KOEO) Tests

KOEO tests are available using the Tests menu option.

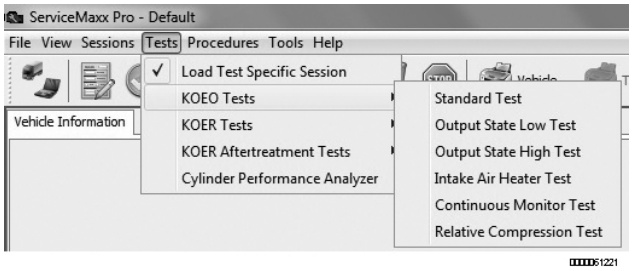


Figure 33 ServiceMaxx™ Test Menu – Engine Off Tests

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)

KOEO Standard Test

The KOEO Standard Test is done to ensure proper functioning of the Engine Control Module (ECM) memory areas. The KOEO Standard Test is used to conduct the CPU and RAM, SPI- Bus, Flash Memory, and the ROM tests. It is also known as the ECM Self-Test.

Once the KOEO Standard Test is started, ServiceMaxx™ software automatically loads the KOEO Standard Test Session for viewing during the test and does the ECM Self-Test.

The KOEO Standard Test runs for about 20 seconds. Once the test is complete, ServiceMaxx™ software exits the test and displays the Test Completed, Successful message.

KOEO Output State Low and High

The KOEO Output State Test is used to verify proper functionality of components, their related circuits, the harness, and the ECM.

The KOEO Output State Test is comprised of KOEO Output State Low and KOEO Output State High. During the KOEO Output State Low Test, the ECM commands the output circuits to their low voltage state (0V). The Exhaust Gas Recirculation (EGR) valve and Engine Throttle Valve (ETV) are DC motors that are commanded to 0% position during the test. The fuel pump is a two-pin actuator, where Fuel Pump Control-High (FPC-H) is commanded to low voltage (0V).

During the KOEO Output State High Test, the ECM commands the output circuits to their high voltage state (12V). EGR and ETV are commanded to 100% position during the test. FPC-H is commanded to high voltage (12V).

The KOEO Output State Low and High tests are designed to be aborted anytime by requesting Stop Tests in ServiceMaxx™ software. ServiceMaxx™ software will display the User Requested Cancellation message and abort the test. However, both tests automatically time out after about 30 minutes.

KOEO Intake Air Heater

The KOEO Output State Intake Air Heater test is used to check for proper functionality of the Intake Air Heater (IAH) relay circuit, harness, and ECM by energizing the IAH.

During the KOEO Output State Intake Air Heater test, the ECM commands the IAH to its High Voltage State (12V).

The KOEO Intake Air Heater test will run for about 45 seconds. Once the test is complete, ServiceMaxx™ software automatically exits the test and displays the Test Completed, Successful message. The KOEO Intake Air Heater test can be requested twice per key ON cycle.

KOEO Continuous Monitor Test

The KOEO Continuous Monitor test is used to detect intermittent circuit faults by disabling fault filtering.

During the test, signals are continuously monitored and faults are immediately logged. It provides a graphical view of all the signals, and allows the technician to easily detect intermittent spiking or momentary loss of signal. It is to be performed during manipulation of the connectors, wiring, and harnesses of the suspected faulty component.

Once the KOEO Continuous Monitor Test is requested, monitor the sensor voltage while wiggling the connectors, wiring, and harness of the component. If the circuit of the sensor is interrupted, the signal will spike.

The KOEO Continuous Monitor Test is designed to be aborted anytime by selecting Stop Tests in ServiceMaxx™ software. ServiceMaxx™ software will display the User Requested Cancellation message and abort the test. The test automatically times out after about 16 minutes.

Relative Compression Test

The Relative Compression Test is used to determine if any cylinder has abnormally low compression and is operating below peak efficiency.

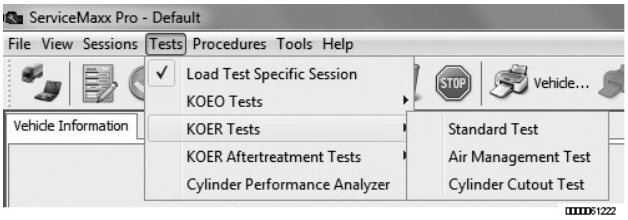
The Relative Compression Test measures differences in crankshaft speed from the point of peak compression to the point of minimum compression for each cylinder. This test is only run during engine cranking and no fuel condition.

Once the test is requested, engine speed at peak compression of each cylinder is captured while engine is cranked for about 15 seconds with no fuel. The results of the test are transmitted in ServiceMaxx™ software once the cranking is completed.

The duration of the test is about 20 seconds. Once the test is completed, ServiceMaxx™ software will display the Test Completed, Successful message and display the test results.

Key On, Engine Running (KOER) Tests

KOER tests are available using the Tests menu option.



KOER Standard Test

The KOER Standard Test is used to perform a sequence of tests related to the fuel pressure and the exhaust back-pressure subsystems.

The KOER Standard Test elevates the engine speed and cycles the Fuel Rail Pressure (FRP) system pressure through its minimum and maximum value to ensure proper system functionality.

The KOER Standard test starts by elevating the engine speed to 1200 RPM, disabling Diesel Particulate Filter (DPF) regeneration, and fixing set-points for the Exhaust Gas Recirculation (EGR) valve, Engine Throttle Valve (ETV), and Turbocharger 2 Wastegate (TC2WG) control valve. Once these are maintained, the FRP system is commanded to its lowest operating pressure. If the pressure falls below the low threshold limit, the corresponding fault will be set as active in ServiceMaxx™ software. If the low pressure test passes, the system is commanded to its maximum pressure. If the pressure does not meet the minimum threshold for maximum pressure, the corresponding fault will be set as active in ServiceMaxx™ software. The duration of the KOER Standard Test is approximately 70 seconds. Once the test is complete, ServiceMaxx™ software displays the Test Completed, Successful message and aborts the test.

KOER Air Management Test

The KOER Air Management Test is used to perform a sequence of tests related to the Exhaust Gas Recirculation (EGR) System.

The KOER Air Management Test elevates the engine speed and cycles the EGR, Engine Throttle Valve (ETV), and Turbocharger 2 Wastegate (TC2WG) control valves through their open and closed states. If there is a discrepancy between position desired and actual set-point, then a fault is set.

The KOER Air Management Test starts by elevating the engine speed to approximately 1200 RPM, disabling Diesel Particulate Filter (DPF) regeneration, and fixing set-points for the Fuel Pressure Control Valve (FPCV), Fuel Volume Control Valve (FVCV), ETV, and TC1WC. Once these are maintained, the EGR is cycled between open and closed by providing the desired Mass Air Flow (MAF) set-point to the EGR close-loop control. If the desired flow is not achieved, the subsystem is diagnosed. This is followed by cycling the ETV between open and close. The engine speed is then elevated to 2200 RPM to cycle the TC1WC by providing the desired boost set-point to the TC1WC close-loop control. If the desired boost is not achieved, the subsystem is diagnosed.

The duration of the KOER Air Management Test is approximately 105 seconds. Once the test is complete, ServiceMaxx™ software displays the Test Completed, Successful message.

KOER Cylinder Cutout Test

The KOER Cylinder Cutout Test disables injectors during any set idle engine speed to assist the technician in diagnosing injector failures.

The KOER Cylinder Cutout Test allows the technician to shut off / disable individual injectors for the duration of the test in order to identify an injector problem or to audibly diagnose an injector problem.

Once the KOER Cylinder Cutout Test is initiated, each injector can be enabled or disabled individually in any order. The results of the disabling tests are displayed in ServiceMaxx™ software.

The test is designed to be aborted anytime by the user. Every time an injector is returned to its normal state after disabling, a Test Complete message associated with that injector is displayed in ServiceMaxx™ software.

Key On, Engine Running (KOER) Aftertreatment Tests

KOER Aftertreatment Tests are available using the Tests menu option.

Onboard Filter Cleanliness Test

The Onboard Filter Cleanliness Test (OBFCT) increases engine speed to measure pressure differential across the Diesel Particulate Filter (DPF). This includes running a complete Parked Regen.

ServiceMaxx™ Procedures

Fuel Pressure Adaptation Reset

The ECM maintains the reliability of the Fuel Rail Pressure system as parts age by storing Fuel Pressure Adaptation values. When any Fuel Injection parts (High Pressure Pump, High Pressure Rail, Injectors, or ECM) are replaced, these values need to be reset.

KOER MAF Sensor Calibration

The KOER MAF Sensor Calibration is used to learn the Mass Air Flow (MAF) signal dynamically, based on the engine parameters, the MAF sensor signal itself, and by comparing it to appropriate MAF.

During the KOER MAF Sensor Calibration, the MAF signal is measured and its equivalent mass airflows are calculated at various engine speeds (6-16 set points) using the speed density equation.

Once the KOER MAF Sensor Calibration is initiated, the engine speed is commanded to different set points, the Turbocharger 2 Wastegate (TC2WG) is adjusted accordingly, and the MAF signal values and the corresponding airflows are stored. These values are used to calculate the speed density coefficients, which help determine actual MAF readings.

The duration of the procedure is about two minutes and twenty seconds. Once the test is complete, ServiceMaxx™ software displays the result of the test and whether a MAF trim was successful. ServiceMaxx™ software displays the Test Completed, Successful message.

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Coolant System

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

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

WARNING: To prevent personal injury or death, allow engine to cool before working with components.

Air Compressor Leak Test

Tools

ZTSE2384 – Radiator Pressure Test Kit

1. Drain coolant from the system as described in the *Engine Service Manual*.

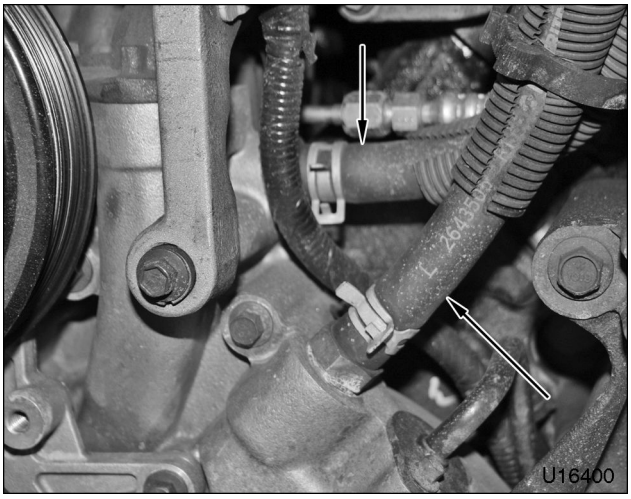

Figure 35 Air compressor coolant hoses

2. Remove two hose clamps and disconnect the coolant supply and return hoses for the air compressor from the crankcase.
3. Fill air compressor coolant passage and hoses with coolant.

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

4. Adapt air pressure fitting and regulator to one of the coolant hoses and block opposite hose.
5. Pressurize air compressor coolant hoses to 103 kPa (15 psi) using the Radiator Pressure Test Kit ZTSE2384.
   - If a leak is noticed, repair or replace the air compressor.
   - If coolant is not leaking, see Front Cover Inspection (page 88) in this section.
6. Test the cooling system again after any repair to validate the repair.

Combustion Leaks to Coolant

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

Symptom

Combustion leaks can be identified by coolant overflowing from deaeration tank or air bubbles in the coolant.

Possible Causes

- Improper service
- Failed injector sleeve
- Failed air compressor (if equipped)
- Failed head gasket
- Failed Exhaust Gas Recirculation (EGR) cooler
- Porous cylinder wall

The likely cause of combustion gas leakage to the cooling system is an EGR cooler failure. However, this should not be considered unless there is evidence of engine overheating or high engine mileage without proper coolant conditioning.

Tools

- ZTSE2384 – Radiator Pressure Test Kit
- ZTSE4535 – Cylinder Head Test Plate
- Straight edge
- Feeler gauge

Combustion Leak Test

1. If the engine is equipped with an air compressor, verify that the excess coolant comes from a combustion leak and not the air compressor.
2. Plug in the cylinder block heater, if available, to warm coolant.
   - If the engine is equipped with an air compressor, go to the next step.
   - If the engine is not equipped with an air compressor, go to step 4.
3. Remove coolant discharge line from air compressor housing. Run the engine to test the coolant system for combustion leakage.
   - If coolant continues overflowing from the deaeration tank, go to the next step.
   - If coolant stops overflowing from deaeration tank, repair or replace the air compressor, see Air Compressor Leak Test (page 79) in this section.

WARNING: To prevent personal injury or death, make sure the engine has cooled before removing components.

4. Remove exhaust tubes from the rear of the exhaust manifolds.

WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:

- Allow the engine to cool for 15 minutes.
- Wrap a thick cloth around the radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn to vent pressure.
- Pause for a moment to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.

5. Install Radiator Pressure Test Kit ZTSE2384 with appropriate adapter on the deaeration tank.
6. Pressurize the cooling system to 103 kPa (15 psi).

WARNING: To prevent personal injury or death, be aware that crankshaft may rotate suddenly when a cylinder is pressurized.

NOTE: Inspect for evidence of coolant in the exhaust manifold.

7. Bar engine over by hand and inspect for evidence of coolant in the exhaust manifold.

   NOTE: This might have to be repeated several times.

   - If leak is slight, pressure may have to be left on overnight and inspect cooling system for leakage in morning. If installed, leave cylinder block heater plugged in.
   - If leak is found, determine which cylinder head is leaking and go to the next step.

8. Remove leaking cylinder head from engine as described in the *Engine Service Manual*. Perform all inspections and pressure test cylinder head to verify leak path. Inspect cylinder head gasket for coolant leaks and verify crankcase and cylinder head surface flatness using a straight edge and feeler gauge.

   NOTE: It is recommended to replace the injector sleeves for a cylinder that shows combustion leakage.

9. If the injector sleeves were replaced, retest the cylinder head with Cylinder Head Test Plate to verify repair.
10. Reinstall cylinder head on the engine as described in the *Engine Service Manual*.
11. Fill the deaeration tank, with coolant, to the FULL mark.

Coolant Leak to Exhaust / Intake

Symptoms

- Coolant residue at exhaust manifold flanges
- Engine overheating
- Coolant smell in exhaust
- Coolant leaking from exhaust
- Severe case - engine hydraulic lock

Possible Causes

- Failed EGR cooler
- Injector cup and gasket leak

- Porosity in cylinder head castings
- Blown or leaking cylinder head gasket

Tools

- ZTSE2384 – Radiator Pressure Test Kit
- KL 20040 NAV – EGR Cooler Leak Detection Kit

EGR Cooler Inspection

WARNING: To prevent personal injury or death, make sure the engine has cooled before removing components.

WARNING: To prevent personal injury or death, carefully remove turbocharger exhaust tubing. Coolant in tubing could splash out and create slippery conditions.

NOTE: Do not remove EGR cooler end caps prior to inspection. Removing end caps will result in rejection of warranty claim.

1. Remove the Exhaust Gas Recirculation Temperature (EGRT) sensor on the outlet side of the EGR cooler and inspect cavity for presence of coolant.

- If coolant is present, go directly to step 6.
- If no coolant is present, go to next step.

2. Remove the exhaust manifold turbo inlet crossover pipe between the EGR cooler exhaust inlet, exhaust tubes and turbocharger exhaust inlet following the procedures in the *Engine Service Manual*.
3. Remove both exhaust tubes.

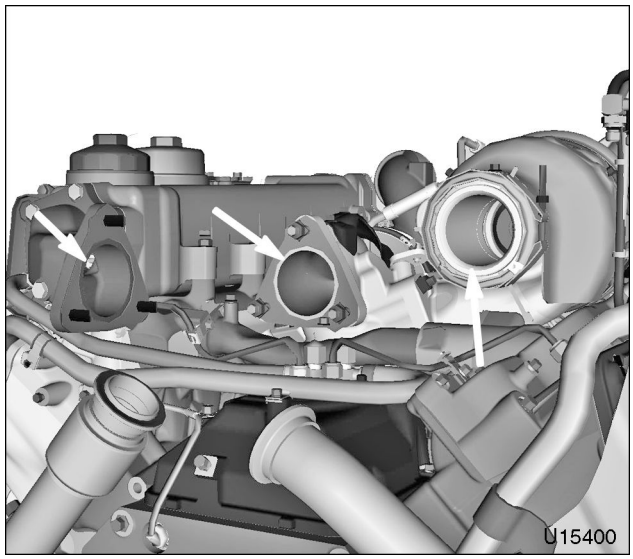

Figure 36 Exhaust ports

4. Check for presence of coolant in exhaust tubes, exhaust manifolds, and EGR cooler exhaust inlet.
5. Plug in the cylinder block heater, if available, to warm coolant.

WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:

- Allow the engine to cool for 15 minutes.
- Wrap a thick cloth around the radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn to vent pressure.
- Pause for a moment to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

6. Install Radiator Pressure Test Kit ZTSE2384 with the appropriate adapter on the deaeration tank.
7. Pressurize cooling system to 103 kPa (15 psi).
8. Bar engine over by hand and check for evidence of coolant flowing out of the exhaust manifolds.
   - If coolant is found, go to Cylinder Head Leak Test (page 88) in this section.
   - If no coolant is found, continue with the next step.
9. Check EGR cooler exhaust inlet for coolant.
   - If coolant is present, replace EGR cooler following the procedures in the *Engine Service Manual*.
   - If no leak is found but pressure is dropping rapidly, go to Combustion Leak Test (page 81) in this section.
   - If no leak is found, continue with the next step.
10. Drain coolant from the system as described in the *Engine Service Manual*.
11. Remove and pressure test the EGR cooler following the procedure in the *Engine Service Manual*.
    - If a leak is noticed, replace the EGR cooler.
    - If a leak is not noticed, install the EGR cooler following the procedure in the *Engine Service Manual* and go to Cylinder Head Leak Test (page 88) in this section.

Coolant in Lube Oil

Symptom

Crankcase lube oil contaminated with coolant will generally cause the oil to thicken and turn gray. The crankcase may also be overfilled.

Possible Causes

- Accessory leak (water cooled air compressor)
- Injector sleeve leak
- Cylinder head cup plug failure
- Cylinder head gasket leak
- Oil cooler failure
- Front cover gasket damage

- Front cover, cylinder head, or crankcase porosity
- EGR cooler failure
- Cracked intake manifold coolant passage

Tools

- ZTSE2384 – Radiator Pressure Test Kit
- ZTSE4409 – Pressure Test Kit
- ZTSE6029 – Oil Cooler Block Off
- Straight edge
- Feeler gauge

Lube Oil Contamination

1. Check coolant level and oil level dipsticks to verify oil contamination complaint.
   - If the crankcase lube oil is contaminated with coolant, the oil will have a light gray sludgy appearance.
   - If coolant in the oil cannot be verified, an oil sample can be taken for analysis.
2. Plug in cylinder block heater, if available, to warm coolant.
3. If engine is equipped with an air compressor, isolate compressor from the engine and test for coolant leak. See Air Compressor Leak Test (page 79) in this section.
4. Drain engine oil and remove oil filter following procedures in the *Engine Service Manual*. Leave oil drain plug out of pan and oil filter off.

WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:

- Allow the engine to cool for 15 minutes.
- Wrap a thick cloth around the radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn to vent pressure.
- Pause for a moment to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

5. Install Radiator Pressure Test Kit ZTSE2384 with appropriate adapter on the deaeration tank.
6. Pressurize cooling system to 103 kPa (15 psi).
7. Leave pressure on system for 15 minutes and verify 103 kPa (15 psi) pressure is maintained on Radiator Pressure Test Kit ZTSE2384.
8. Check for coolant leaking out of the oil pan drain hole.
   - If coolant system pressure is dropping and no coolant is leaking from oil pan drain hole, go to step 9.
   - If coolant is leaking into oil pan, remove valve covers following the procedure in the *Engine Service Manual* and inspect the following:

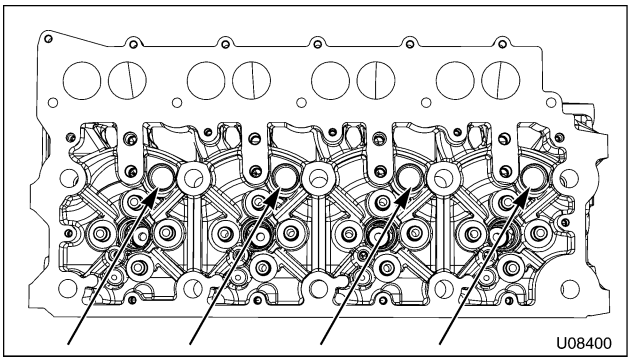

Figure 37 Cylinder head cup plugs

- Inspect entire cylinder head area for leaks at the cup plugs.
- If no leaks are found in above areas, go to step 10, and inspect for crankcase leakage.

9. Remove the oil pan and filter following the procedures in the *Engine Service Manual*.

WARNING: To prevent personal injury or death, be aware that crankshaft may rotate suddenly when a cylinder is pressurized.

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

10. Inspect for leakage in crankcase.
    - Verify 103 kPa (15 psi) pressure is maintained on Radiator Pressure Test Kit ZTSE2384.
    - If no leakage is found, do the next step.
    - If leak is found, verify leak path and make repair following the procedures in the *Engine Service Manual*.

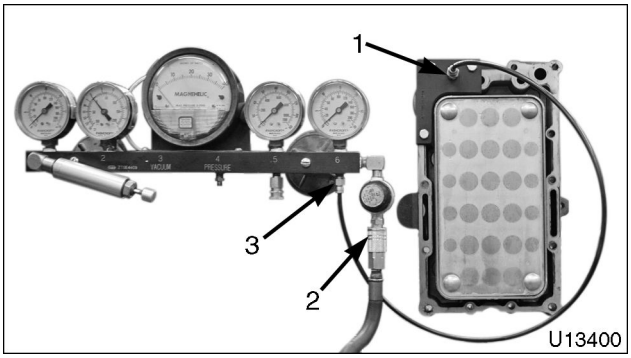

Figure 38 Oil cooler cover assembly pressure test

1. Oil Cooler Block Off
2. Regulated air supply
3. Pressure Test Kit

11. Remove and test the oil cooler following the procedures in the *Engine Service Manual*.
    - If a leak is found, replace oil cooler assembly.

- If no leak is found, see Front Cover Inspection (page 88) in this section.

Front Cover Inspection

1. Remove front cover and inspect gaskets and sealing surfaces following the procedure in the *Engine Service Manual*.
2. Reinstall front cover following the procedure in the *Engine Service Manual*.
3. Pressure test the cooling system after any repair, to validate.

Cylinder Head Leak Test

1. Remove valve covers following the procedure in the *Engine Service Manual*.
2. Plug in block heater, if available, to warm coolant.

WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:

- Allow the engine to cool for 15 minutes.
- Wrap a thick cloth around the radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn to vent pressure.
- Pause for a moment to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

3. Install Radiator Pressure Test Kit ZTSE2384 with appropriate adapter on the deaeration tank.
4. Pressurize cooling system to 103 kPa (15 psi).

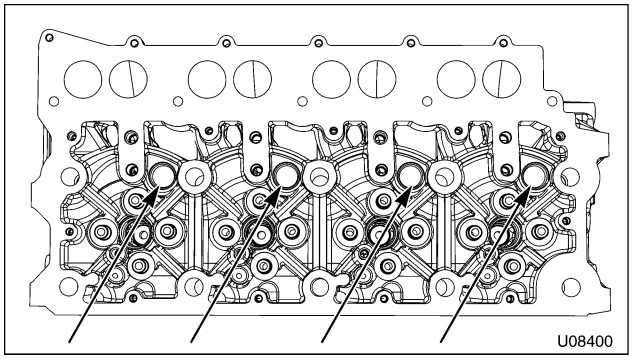

Figure 39 Cylinder head cup plugs

5. Inspect both cylinder heads for cracks or leaks at the cup plugs.
   - If leaking, repair or replace cracked or leaking component.
   - If no leak is found, do the next step.
6. Drain coolant from the system as described in the *Engine Service Manual*.

7. Remove one cylinder head from engine following the procedures in the *Engine Service Manual*.
8. Inspect and pressure test cylinder head following procedures in the *Engine Service Manual*.
    - Inspect cylinder head gasket for damage at sealing points. Verify crankcase and cylinder head surfaces flatness using a straight edge and feeler gauge. Replace cylinder head gasket and head bolts. Repair or replace cylinder head if necessary.
    - Inspect cylinder head for cracks in the coolant passages. Repair or replace.
9. Inspect crankcase coolant passages and cylinders for cracks following procedures in the *Engine Service Manual*.
10. If no leak is found, repeat steps 7 and 8 for the second cylinder head.
11. Pressure test cooling system to confirm repair.
12. Fill cooling system.

Coolant Over-Temperature

Symptom

When the coolant temperature is above 107 °C (224 °F), a Diagnostic Trouble Code (DTC) will set and the Engine Control Module (ECM) will command less fueling. A torque loss will occur.

When the coolant temperature is above 109 °C (228 °F), the red ENGINE lamp will be illuminated and a DTC will set.

When the coolant temperature is above 112 °C (234 °F), the red ENGINE lamp will flash, an audible alarm will sound, and a DTC will set. If the vehicle has the warning protection feature enabled, the engine will shut down after 30 seconds.

Possible Causes

- Low engine coolant level
- Coolant leaks
- Internal or external radiator blockage or wrong radiator
- Water pump failure
- One or both coolant thermostats missing or stuck (closed)
- Slipping cooling fan drive clutch
- Cooling fan blade assembly wrong or damaged
- Broken / worn accessory drive belt
- Accessory belt tensioner failure
- Instrument panel gauge error
- Engine Coolant Temperature 1 (ECT1) sensor biased
- Chassis effects, transmission, or aftermarket equipment

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- ZTSE4799 – Digital Infrared Thermometer
- ZTSE2384 – Radiator Pressure Test Kit

Coolant Over-Temperature Diagnostics and Repair

1. Check coolant deaeration tank is filled to the FULL mark.

   If coolant level is low, look for external leaks at radiator, engine, and all coolant tubes and hoses.

2. Inspect the condition of the following items: cooling fan, shroud, accessory drive belt, accessory drive belt tensioner, cooling fan drive clutch, and radiator.

   - If vehicle is new or recently repaired, verify the correct part number for any component related to the cooling system.
   - Verify that the cooling fan, cooling fan drive clutch, and radiator are clean of debris and dirt build-up. Clean areas as required.

   CAUTION: To prevent radiator damage, when using high-pressure washer, be careful not to get the wand too close to radiator fins.

3. Connect EST and check for active and previously active DTCs related to engine coolant over-temp conditions. Compare Engine Coolant Temperature 1 (ECT1), Engine Oil Temperature (EOT), and Intake Manifold Temperature (IMT) with key ON, engine OFF. After a cold soak of at least eight hours, all temperature sensors should read within 2° C (3.6° F) of each other.
4. Run engine up to an operating temperature of at least 70° C (158° F). Monitor ECT1 using the EST.
5. Attempt to duplicate the operator's concern of coolant over-temperature.

   - If concern cannot be duplicated, clean radiator fins (if not done previously). Flush the radiator fins with water on the cooling fan side of the radiator. Do not continue further with diagnostics.
   - If coolant over-temperature is duplicated, continue with the next step.

WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:

- Allow the engine to cool for 15 minutes.
- Wrap a thick cloth around the radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn to vent pressure.
- Pause for a moment to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.

6. Install the Radiator Pressure Test Kit ZTSE2384 with appropriate adapter on the deaeration tank and run engine at elevated idle. Monitor system pressure using the Radiator Pressure Test Kit ZTSE2384 gauge.

   - If pressure is higher than the pressure rating of the cooling system cap, continue with Combustion Leaks to Coolant (page 81) in this section.
   - If pressure gauge reading is below pressure rating of system, continue with step 7.

7. Remove and inspect thermostats following the procedure in the *Engine Service Manual*. Check for correct opening temperature on both thermostats.

   - Replace as needed. Retest for condition after repair.
   - If both thermostats pass test, continue to next step.

8. If over-temperature condition remains, remove radiator and have it flow tested and cleaned or replaced. Retest engine for over-temperature condition with repaired or new radiator.

Temperature Sensor Validation Test

1. Connect EST and check for active and previously active DTCs related to engine coolant over-temp conditions.
   - Repair problems relating to coolant over-temp DTCs before continuing.
   - If no DTCs exist, do next step.
2. Using the EST, compare ECT1, EOT, and IMT with ignition key ON, engine OFF. After a cold soak of at least 8 hours, all temperature sensors should read within 2° C (3.6° F) of each other.
3. Use the Digital Infrared Thermometer ZTSE4799 at the EGR cooler inlet port, operate the engine, and use the EST to monitor ECT1.
4. Run engine up to an operating temperature of at least 70 °C (158 °F). Monitor ECT1 using the EST, instrument panel coolant temperature gauge and the Digital Infrared Thermometer ZTSE4799. Attempt to duplicate the operator's concern of coolant over-temperature.
   - If instrument panel coolant temperature gauge reads a different temperature than the EST and thermometer, refer to the *Electrical System Troubleshooting Guide* for the appropriate model and year of vehicle.
   - If thermometer and EST read values with a difference greater than ± 3° C (± 5.4° F), see ECT1 Sensor (page 421) in the “Electronic Control Systems Diagnostics” section of this manual.
   - If the gauge is reading correctly and the engine is running over-temperature, go to Cooling System Operating Pressure Test (page 92) in this section.

Cooling System Operating Pressure Test

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:

- Allow the engine to cool for 15 minutes.
- Wrap a thick cloth around the radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn to vent pressure.
- Pause for a moment to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.

1. Install the Radiator Pressure Test Kit ZTSE2384 on the deaeration tank and run engine at elevated idle.
2. Monitor system pressure using the Radiator Pressure Test Kit ZTSE2384 gauge.
   - If pressure is higher than the pressure rating of the cooling system cap, go to Combustion Leaks to Coolant (page 81) in this section.
   - If pressure gauge reading is below pressure rating of system, replace the thermostats.

Engine Inspection

Symptom

Excessive low power on takeoff or intermittent low power from drive cycle to drive cycle

Possible Causes

Low Power

- Electrical power or ground issue
- Inoperative turbocharger assembly or failed turbocharger actuator
- Aerated fuel
- ECM or electronic control system faults
- Poor fuel quality
- Low supply pressure fuel pressure below specification
- High-pressure fuel pressure below specification
- Fuel injectors not working properly
- Inoperative Engine Throttle Valve (ETV)
- Power cylinders problem
- Valve train problems
- Failed Charge Air Cooler(s) (CAC)
- Aftertreatment (AFT) system issues
- Plugged Diesel Particulate Filter (DPF)
- Plugged Diesel Oxidation Catalyst (DOC)

Rough Idle

- Poor fuel quality
- Low supply fuel pressure below specification
- High-pressure fuel pressure below specification
- Aerated fuel
- Electronic control system faults
- Plugged DPF
- Plugged Diesel Oxidation Catalyst (DOC)
- Fuel injectors not working properly
- Exhaust Gas Recirculation (EGR) valve stuck open
- Power cylinder problems
- Valve train problems
- Engine or flywheel balance problems
- Exhaust system to cab / chassis contact
- Loose or worn engine mounts

Tools

- Digital Multimeter (DMM)
- EST with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

Low Power (Turbocharger Assembly and Actuator)

For low power issues, perform the tests in the “Performance Diagnostics” (page 160) section of this manual.

Rough Idle

1. Confirm conditions when rough idle complaint is present. When does rough idle occur?
    - Hot - operating temperature
    - Cold
    - After high speed operation
    - Over entire engine speed range
    - Combination of the above conditions
    - Is chassis vibration or any other condition or observation present when engine idles rough.
2. Inspect exhaust system for contact with frame or body of vehicle. Exhaust pipe contact with cab or frame may transmit engine vibrations and noise to cab.
3. Complete the following performance diagnostic tests in the “Performance Diagnostics” section of this manual.

- Visual Inspections

- Fuel. Verify quantity and quality. Check for aeration and correct pressure.
- KOEO Standard Test
- Check for DTCs
- KOER Standard Test
- KOER Air Management Test
- Crankcase Pressure Test
- Fuel Rail Pressure

Engine and Flexplate Balance Inspection

Inspect engine and drivetrain balance. Rough idle that gets worse with no-load acceleration may be caused by an out-of-balance engine, flexplate, or torque converter. Remove the accessory drive belt to isolate accessories during balance testing.

Inspect vibration damper for cracks and misalignment.

Inspect flexplate for cracks, damage and verify proper orientation. When removing or installing the flexplate, ensure the locating dowel is in the right place and the flexplate is located properly on the dowel.

Inspect the primary balancer shaft to ensure it is properly installed.

Isolate the engine from transmission by removing the transmission and torque converter. Start the engine and evaluate imbalance. If the engine runs smoothly, diagnose the torque converter and transmission. See applicable vehicle *Service Manual*.

Manual Compression Test

Tools

- ZTSE6073 – Manual Compression Tool (Qty:1)
- ZTSE4861 – High-Pressure Fuel System Block-Off Caps (Qty: 8)
- ZTSE2482A – Cylinder Compression Gauge

Test Procedure

1. Make sure vehicle is parked and / or in neutral on a flat surface.
2. Remove valve covers.
3. Disconnect crank sensor harness from crank sensor and disconnect 16-pin Engine Control Module (ECM) connector.
4. Remove all high-pressure fuel lines.
5. Remove all injector and store in a clean area.
6. Crank engine over to clear fuel from cylinders.
7. Install Manual Compression Test Tool ZTSE6073 in desired cylinder (tighten to 28 lb-ft [38 N•m]).
8. Install Cylinder Compression Gauge ZTSE2482A onto Manual Compression Test Tool.
9. Crank engine over, only allowing four revolutions.
10. Record pressure reading from compression gauge.
11. Repeat for each cylinder.
12. Reassemble engine.

Electrical System

ECM Reset (Intermittent Engine Stumble)

Symptom

An Engine Control Module (ECM) reset occurs when the ECM momentarily reboots or is turned OFF and ON while the engine is operating. Symptoms of this include the following:

- Wait to Start lamp cycles on while engine running
- Engine stumbles and may die
- Loss of accelerator pedal authority
- Miles driven are not logged if ECM reset occurs during current key cycle

If a reset occurs, the engine will momentarily stumble, and the ECM will go through a normal KEY ON cycle. This includes the following:

- Illuminate the Wait to Start lamp
- Validate the accelerator pedal position

If the pedal is not at idle position when the reset occurs, a DTC is set and engine speed goes to low idle. The ECM will not allow accelerator pedal authority until the Accelerator Pedal Position (APP) sensor is released.

Possible Causes

Momentary loss of power to the ECM may be caused by:

- Poor (intermittent OPEN or high resistance) ground connection
- Poor battery power feed harness connection
- Poor fuse connection
- Intermittent open at connectors
- Poor power relay connection
- Poor module connection, corrosion, or water

Diagnostics for Engine Stumble

1. Go to Fuel System (page 98) in this section.

See ECM PWR Relay (page 408), and ECM Self Diagnostics (page 415) in the “Electronic Control Systems Diagnostics” section of this manual or the application specific truck *Circuit Diagram Manual* and *Service Manual* when performing the following steps.

2. Check all ECM related fuses.
3. Check all Battery, VIGN and ground connections for the ECM.
4. Monitor ECM powers and grounds with breakout box under operator complaint conditions.
5. Monitor injector powers and grounds with breakout harness under operator complaint conditions.
6. If root cause has not been identified in previous steps, continue diagnosis by doing the remaining tests in “Performance Diagnostics” section of this manual.

Fuel System

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

WARNING: To prevent personal injury or death, store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

NOTE: If symptom is related to high pressure fuel supply, see “Hard Start and No Start Diagnostics” (page 122) section of this manual

Excessive Fuel Consumption

Symptom

Engine is using more fuel than previously required to perform the same task.

Possible Causes

Operator effects

- Inaccurate recordkeeping or tank filling
- Winter blend or No. 1 fuel
- Unrealistic expectations

Application effects

- Heavy loading Gross Vehicle Weight (GVW)
- Low rear axle ratio
- Large frontal area
- Accessory usage such as Power Takeoff
- Additional equipment drawing fuel from vehicle fuel tanks
- Extended idle applications
- Tire size, tire condition, or air pressure

Chassis effects

- Brake drag
- Cooling fan clutch locked ON
- Transmission slippage / shifting
- Fuel tank plumbing or venting

- Intake or exhaust restriction

Engine effects

- Oil aeration
- Incorrect or inoperative thermostat(s)
- Failed turbocharger control system
- Fuel system performance loss
- Fuel system leaks
- Base engine performance loss

Verifying Excessive Fuel Consumption Complaints

1. Review operator and fueling records.
2. Loss of fuel economy is normal if winter blend fuel, kerosene or No. 1 diesel fuel is being used.
3. Review vehicle specifications to determine if fuel consumption is normal for type of application and use of vehicle. Compare consumption with similar vehicles in the same application and Truck Computer Analysis of Performance and Economy (TCAPE) report.
4. Do all tests on Performance Diagnostic form or in “Performance Diagnostics” section of this manual.

   These tests will verify the operating condition of the following engine and chassis systems:

   - Intake system
   - Exhaust system
   - Fuel delivery and filtration
   - High-pressure fuel system
   - Injector operation
   - Turbocharger operation
   - Base engine condition
   - Electronic control system condition

   If all tests are passed, the engine is operating normally.

Fuel in Coolant

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

Symptom

Coolant contaminated with diesel fuel will have a diesel fuel odor.

Possible Causes

- Leaking or cracked injector sleeve with injector O-ring failure
- Cracked or porous cylinder head casting in fuel return area
- Broken fuel cooler

Tools

- ZTSE2384 – Radiator Pressure Test Kit
- Fitting attached to clear line to container (obtain locally)
- Diesel fuel container
- ZTSE4535 – Cylinder Head Test Plate
- ZTSE4607 – Fuel Line Test Adapter

Fuel in Coolant Leakage Test (Low-pressure)

1. Remove fuel line at the fuel cooler. Plug fuel line and place suitable diesel fuel container under the fuel cooler to catch draining fuel.

WARNING: To prevent personal injury or death, store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:

- Allow the engine to cool for 15 minutes.
- Wrap a thick cloth around the radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn to vent pressure.
- Pause for a moment to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.

2. Verify coolant contamination.
    - Check for diesel fuel odor in coolant.
    - Coolant may be discolored if diesel fuel is present.
3. Fill deaeration tank with coolant to the FULL mark.
4. Plug in the cylinder block heater, if available, to warm coolant.

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

5. Install Radiator Pressure Test Kit ZTSE2384 with appropriate adapter on the deaeration tank.
6. Pressurize cooling system to 103 kPa (15 psi).
7. Inspect the fuel cooler for any coolant coming from the fuel side. If the cooler is leaking, replace the cooler and retest.
8. If the fuel cooler is not leaking, remove fuel injector return line banjo fittings following the procedures in the *Engine Service Manual*.
9. Inspect the fuel injector return line bores at cylinder heads for coolant leaks.
    - If leak is found, remove valve cover and fuel injectors from the suspect cylinder head, following procedures in the *Engine Service Manual*. Observe injector sleeves for leakage. Repair cylinder head, as necessary. After repair, pressurize cooling system to confirm repair.
    - If no leak is found, remove each cylinder head one at a time following the procedures as described in the *Engine Service Manual*. Perform all inspections and pressure test cylinder head to check for leak paths.

Fuel in Coolant Leakage Test (High-pressure)

WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:

- Allow the engine to cool for 15 minutes.
- Wrap a thick cloth around the radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn to vent pressure.
- Pause for a moment to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.

1. Verify coolant contamination.
   - Check for diesel fuel odor in coolant.
   - Coolant may be discolored if diesel fuel is present.
2. Fill deaeration tank with coolant to the FULL mark.
3. Plug in the cylinder block heater, if available, to warm coolant.

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

NOTE: When removing the cylinder head injector return line banjo bolts, fuel may leak out. Put in a suitable container to collect this leakage. Collect and dispose of this fuel according to local regulations.

WARNING: To prevent personal injury or death, store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

4. Remove the left and right cylinder head injector return line banjo bolts, following the procedures in the *Engine Service Manual*.

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

5. Individually pressurize both fuel injector return lines from the cylinder heads to 550 to 690 kPa (80 to 100 psi) using the Fuel Line Test Adapter ZTSE4607. Observe deaeration tank for air bubbles or loss of pressure at gauge.
   - If leak is found, do all inspections and test cylinder heads to verify leak path. Repair cylinder head, as necessary.
   - If no leak is found, continue with Fuel in Coolant Leakage Test (Low-pressure) (page 101) in this section.

Fuel In Lube Oil

Symptom

Oil contaminated with diesel fuel will have diesel fuel odor and the oil level in engine will consistently increase.

Possible Causes

Leaking fuel under the valve cover

- Fuel Rail Pressure (FRP) sensor
- Fuel rail to fuel injector supply lines
- Fuel injector(s)
- A leaking injector sleeve or injector tip could cause contaminated engine oil, but would most likely be identified as a performance problem.

Porous cylinder head

- Most likely on low mileage vehicles

Tools

- One gallon of clean diesel fuel
- ZTSE4618 – UV Leak Detection Kit (black light)

Verifying Fuel Dilution from Oil System

Over time the engine oil will naturally dilute with fuel over the recommended service interval due to post injection during active and passive regenerations. Mild dilution is acceptable, if this is the case then there is no concern and warranty will not cover any diagnostic procedures performed on the unit. Dilution issues are evident when the engine is making excessive amounts of oil that is noticeable in a short time frame of oil life. Before performing any diagnostics make sure the ECM calibration is current and any open AFCs have been performed. In severe dilution cases the enclosed high pressure fuel system could potentially have developed a leak over time putting fuel into the oil. Check with the customer and his oil service habits, if they are not in line with the recommended service as outlined below have the oil changed and release the unit for the customer to monitor the level.

Symptoms

- Low oil pressure
- Increasing oil level
- Black smoke
- Excessive oil carry over into intake
- High crankcase pressure
- Engine vibration

Fuel Dilution Diagnostics

1. Update ECM calibration if needed and note which calibration is in the ECM before and after the update
2. Check the oil level and note the level
3. Confirm oil is diluted with fuel

a. Perform Paper Drop Test: Sample the oil and drip some onto a piece of paper. If a clear ring forms around the oil this is the diesel fuel separating from the oil.

   1. Diesel is Present: Sample the oil and send it out for testing (Keep results and if a case file is needed scan them, and attach to the case file) and proceed.

   2. Diesel is not Present: Proceed to steps 4 and 5, review service records drain the oil to a proper level and release the unit back to the customer to monitor the level.

4. Check for active and inactive DTCs.

5. Request the latest service record from the customer and note how many hours and miles are on the current oil change (Ensure Proper Maintenance Habits).

6. For 2007-2009 MaxxForce 7: Inspect breather type and take note of which type it is.

   a. Non-Bus Application: Install Open Breather Kit 1889886C91 if needed.

7. Inspect the inlet of the Charge Air Cooler (CAC) with a flash light and mirror for plugging and oil contamination.

   a. CAC plugged / dirty: Attempt to Flush CAC (Replace if needed) then proceed.

   b. CAC not plugged: Proceed to next step.

8. Inspect the Turbocharger for oil / fin damage / shaft play.

   a. Turbocharger Damaged or Pushing Oil: Perform all necessary steps in diagnosing / replacing the turbocharger(s), cleaning the engine, and inspecting the aftertreatment. Diagnose turbocharger following IK1200535 for oil leaks inspect exhaust side for oil. If all seems okay then clean the turbocharger (Cleaning Kit 1891576C91).

   b. For 2007-2009 MaxxForce 7: Perform Diesel Oxidation Catalyst (DOC) Cleaning Procedure: Reference IK1200478, it will automatically create a snapshot of the procedure (attach to case file later if needed). If DTC 1213 Remote Throttle Signal Out of Range Low is active after running the cleaning, see IK0800323 to clear the code

9. Ensure the oil is at proper level and mark dipstick. Road test for 30 miles and if needed, perform a stationary regeneration. Let engine cool down. Check oil level to see if it has risen.

NOTE: Oil expands when hot.

10. In cases of extreme dilution if oil level did not rise, request customer approval for an oil service. If the oil is new and heavily diluted, contact CSE and request a good will warranty coverage on oil service.

11. For 2010-2013 MaxxForce 7: If oil level is still rising, get Crankcase Pressure and Blow-by readings at Idle and Wide Open Throttle (WOT). If readings recorded are out of specification, proceed with a manual compression test. If Crankcase Pressure on the 2010-2013 MaxxForce 7 is out of specification and Blow-By is in specification, then crankcase breather is most likely plugged.

NOTE: Use the specification defined in these articles. The Blow-By test is only for 2010-2013 MaxxForce 7 and is similar to the Crankcase Pressure test on 2007-2009 MaxxForce 7. The crankcase pressure test on 2010-2013 MaxxForce 7 is different, and is meant to test crankcase breather for plugging. There is always CCP and Blow-By, and they are always greater at WOT).

12. For 2007-2009 MaxxForce 7: See IK1200881.

13. For 2010-Current MaxxForce 7: Reference the diagnostic manual EGES485 under Performance Diagnostics >> Special Test Procedures >> Blow-by Test & Crankcase Pressure Test.

14. If within specification, remove the valve covers then reassemble needed components to run engine. Connect separate, clean-fuel source and add CUMMINS dye to fuel. Allow engine to idle to operating temperature and watch for leaking injectors with black light.
15. If leaks are found, replace component and check for leaks. If no leaks are present, reassemble and check for dilution.
16. If leak is not found, run the Standard Test in ServiceMaxx™. This will increase FRP which increases the chance of a leak. Inspect all high-pressure fuel system connections and fittings including the FRP sensor, injector bodies, both jumper tube ends, and the high-pressure rails. If no leaks are present, proceed to next step.
17. Brake stall the engine and watch for leaks. Shut down truck and feel around all the high-pressure fittings and check your finger for dye. If no leaks are found, pull the High-Pressure Fuel Pump cover. clean off any fuel present from removing the lines and perform the same tests while looking for leaks at the pump.
18. If no leaks are found and unit is gaining oil, open a case file including all information obtained in previous steps.

Fuel to Exhaust

Symptom

Fuel leaking into the exhaust results in a wet exhaust system and possible damage to the Diesel Particulate Filter (DPF).

Possible Causes

- Fuel injector leaking
- Internal engine damage

Do High-pressure Fuel System Leak Test, (page 155) in the “Hard Start and No Start Diagnostics” section of this manual.

Air or Combustion Leaks to Fuel

Possible Causes

- Compression leak past compression gasket to fuel return
- Loose fuel injector hold down
- Missing or damaged stainless steel injector gasket
- Combustion leaks to fuel will exhibit one or more of these characteristics:
    - Engine stall during operation
    - Rough running engine
    - Extended engine crank time (hard start)
    - Fuel Rail Pressure (FRP) slow to build while cranking
    - Excessive fuel pressure in the low-pressure fuel system while cranking
    - Pulsating fuel pressure (low-pressure fuel system) during crank or engine running at idle
    - No start

Air or Combustion Leak to Fuel Test

Inspect cylinder head for combustion leaks using a test adapter to validate cylinder head is leaking to the fuel system.

1. Verify operator complaint.

⚠ WARNING: To prevent personal injury or death, do not smoke or park vehicle near open flames or sparks when draining fuel. Store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

2. Place a suitable container under the secondary fuel filter housing to catch draining fuel.
3. Disconnect the injector return lines from each cylinder head following the procedure in the *Engine Service Manual*.
4. Install Fuel Line Test Adapter ZTSE4607 with clear plastic hose at the fuel return line fitting in the engine cylinder head.

⚠ WARNING: To prevent personal injury or death, wear safety glasses with side shields.

CAUTION: To prevent engine damage, if engine fails to start within 20 seconds, release ignition switch and wait 2 to 3 minutes to allow starter motor to cool.

5. Submerge the test line in a container filled with water.
6. Turn ignition switch to ON and start or crank engine for 20 seconds. Inspect for air or combustion leaks in the fuel. Inspect for the following.
   - Combustion gasses or smoke coming from sample line or bubbles in water.
   - Audible sound of air / compression from sample line
7. If no leak is noticed testing one head, remove line and repeat steps 2 through 6 on the opposite head.
8. If leak is noticed, continue to step 9.
9. Remove one injector following the procedure in the *Engine Service Manual* and test for combustion leak.

   NOTE: If failed cylinder is not diagnosed removing the first injector, reinstall injector following the procedure in the *Engine Service Manual* and continue one for the remaining injectors.
   - If the leak stops, replace injector and cup plug.
   - If leakage continues, confirm an air or combustion leak to the fuel supply, identify the failed cylinder head and remove, following the procedure in the *Engine Service Manual.*
10. After air or combustion leaks to fuel have been repaired and retested, remove both return line banjo fittings, re-install the return line banjo fittings with new copper gasket, following the procedures in the *Engine Service Manual*.

Low Fuel Pressure and Aeration

Symptom

Fuel aeration will exhibit one or more of the following characteristics:

- Engine stall during operation
- Rough running engine

- Extended engine crank time (hard start)
- Fuel pressure slow to build while cranking
- Excessive fuel pressure while cranking
- Pulsating fuel pressure during crank or engine running at idle
- Difficulty priming fuel system

Possible Causes

- Leaks in fuel supply to fuel pump
- Loose fuel injector holddown
- Missing / damaged stainless steel injector gasket
- Suction side leak or cracked line

Water In Fuel (WIF) Check

Possible Causes

- Water or ice in fuel supply system or damaged connection
- Corrosion on connector, sensor, or cover plate assembly
- Failed ECM
- Failed WIF sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Clean flat drain pan, with a wide opening

Drain Water from Primary Fuel Filter

1. Connect Electronic Service Tool (EST) with ServiceMaxx™ software to vehicle's Diagnostic Connector.
2. Check for active and previously active DTCs.
3. Correct any sensor DTCs before proceeding. See WIF sensor (page 727) in the "Electronic Control Systems Diagnostics" section of this manual.
4. If the WIF DTC SPN 4192/FMI 31 is active or fuel system contamination is suspected, continue with next step.
5. Put a clean flat drain pan under the primary filter.

WARNING: To prevent personal injury or death, do not smoke or park vehicle near open flames or sparks when draining fuel. Store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

6. Drain the water separator following the procedures in the *Engine Service Manual*.

7. Check fuel in drain pan for contamination. Dispose of the contents in the drain pan properly, in accordance with local requirements.
   - Excessive water or contaminants may indicate that the tank and fuel system need to be flushed and cleaned.
   - The fuel should be clear, not cloudy. Cloudy fuel indicates that the fuel is not a suitable grade for cold temperatures.
   - The fuel should not be dyed red or blue, these colors indicate off-highway fuel.
   - Fuel should not be waxing or gelling. Waxing or gelling in cold weather can clog the fuel filters and the fuel pump and cause restrictions in the fuel or low fuel pressure.
8. Turn ignition switch to ON, determine if SPN 4192/FMI 31 is active.
   - If SPN 4192/FMI 31 is not active, the procedure is complete, do not continue.
   - If SPN 4192/FMI 31 is active, continue with the next step.

NOTE: If SPN 4192/FMI 31 is active after the water has been drained, the WIF sensor or the WIF sensor connector may be corroded, the condition should be corrected and retested.

9. Check the WIF sensor connector. See WIF sensor (page 727) in the “Electronic Control Systems Diagnostics” section of this manual.
10. Turn ignition switch to ON, determine if SPN 4192/FMI 31 is active.
    - If SPN 4192/FMI 31 is not active, the procedure is complete, do not continue.
    - If SPN 4192/FMI 31 is active, replace the primary fuel filter.
    - If SPN 4192/FMI 31 is active, check fuel lines and tank(s) water or other contaminates. Drain and clean fuel lines as needed.

Over-Temperature

Symptom

When the engine fuel temperature is above 70°C (158°F), a fault code will set and the ECM illuminates the Amber Warning Lamp (AWL). When temperature drops below 70°C (158°F), the fault becomes inactive. When the engine fuel temperature is above 80°C (176°F), an additional fault code will set and the ECM illuminates the red stop lamp. When temperature drops below 80°C (176°F), the fault becomes inactive.

Possible Causes

- Fuel cooler failure
- Faulty Fuel Cooler Control Valve (FCCV)
- Biased Engine Fuel Temperature (EFT) sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708

Fuel Over-Temperature Diagnosis and Repair

1. Remove oil cooler and inspect for signs of leakage or restriction

2. Connect EST and check for active and previously active DTCs related to engine fuel over-temperature conditions
   - Repair problems relating to fuel over-temp DTCs before continuing.
   - If no DTCs exist, do next step.
3. Using EST, compare Engine Coolant Temperature 1 (ECT1), Engine Fuel Temperature (EFT), and Intake Manifold Temperature (IMT) with ignition key ON, engine OFF. After a cold soak of at least 8 hours, all temperature sensors should read within 3.6°F (2°C) of each other.

Lubrication System

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

WARNING: To prevent personal injury or death, when routing test line, do not crimp line, run line too close to moving parts, or let line touch hot engine. Secure the gauge and test line to not obstruct vehicle operation.

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

Turbocharger Oil Discharge

Symptoms

- Oil discharge at compressor and turbine outlet
- Oil in Charge Air Cooler (CAC) plumbing and hoses
- Oil coking at the compressor discharge or in the air induction system

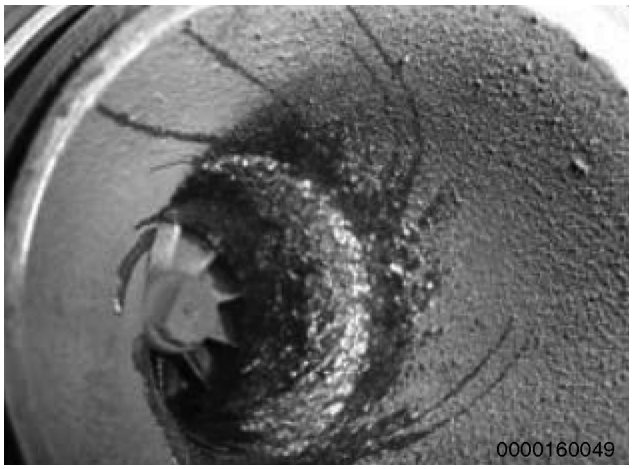

Figure 40 Oil Discharge at Turbine Outlet

Figure 41 Oil Discharge at Compressor Outlet 1

Figure 42 Oil Discharge at Compressor Outlet 2

Possible Causes

- Exhaust engine brake
- Plugged air filter
- Excessive engine idling
- A worn or defective air brake compressor
- Excessive crankcase pressure
- Plugged turbo oil drain
- Excessive exhaust back-pressure
- Excessive turbine shaft radial and axial bearing clearance (wheel contacting the housing)

Figure 43 Restricted Oil Drain

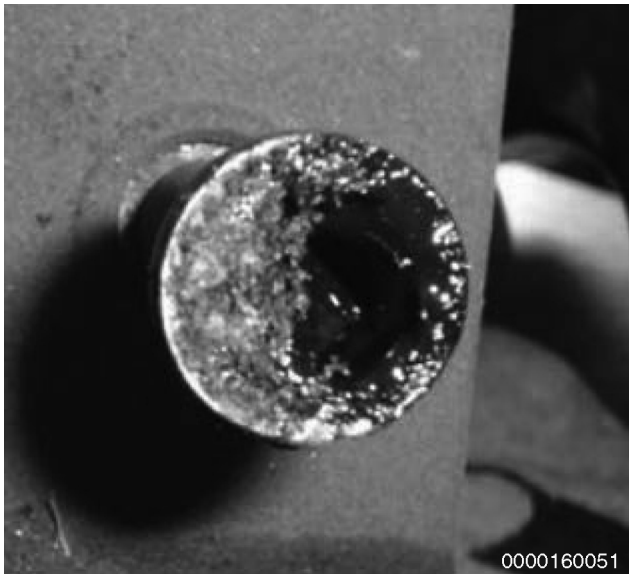

Figure 44 Highly Restricted Oil Drain

Diagnosing Turbocharger Oil Discharge from Turbine Outlet

Step	Action	Decision
1	Perform the following turbine shaft checks: • Radial clearance • Axial clearance • Compressor wheel contact with the housing Does the compressor wheel contact the housing?	Yes: Clean turbocharger oil supply screen in oil cooler housing. Replace turbocharger assembly. No: Go to Step 2.

Step	Action	Decision
2	Inspect for plugged turbocharger oil drain. A plugged turbocharger oil drain will cause excessive oil pressure in bearing housing which results in oil migrating to compressor housing. Is turbocharger oil drain plugged?	Yes: Clean turbocharger oil drain and advise a more strict maintenance schedule. No: Go to Step 3.

Step	Action	Decision
3	Inquire about engine idling times. Excessive engine idling creates unfavorable conditions in compressor housing where pressures are low, promoting oil migration from the bearing housing. Is excessive engine idling a factor?	Yes: Recommend reduced engine idle operation or enable Idle Shutdown Timer (IST). No: Go to Step 4.

Step	Action	Decision
4	Test for excessive crankcase pressure. Excessive crankcase pressure affects pressure balance between bearing and compressor housings. Probable causes of excessive crankcase pressure are as follows: • Plugged Breather • Worn or defective air brake compressor • Worn valve guides • Worn or damaged power cylinders Are any of the listed possible causes present?	Yes: Repair cause of excessive crankcase pressure. No: After performing all diagnostic steps, verify each step was completed correctly, the proper decision was made, and return vehicle to service. If oil discharge continues, notify supervisor for further action..

Diagnosing Turbocharger Oil Discharge from Compressor Outlet

Step	Action	Decision
1	Perform the following turbine shaft checks: • Radial clearance • Axial clearance • Compressor wheel contact with the housing Does the compressor wheel contact the housing?	Yes: Clean turbocharger oil supply screen in oil cooler housing. Replace turbocharger assembly. No: Go to Step 2.

Step	Action	Decision
2	Inquire about engine brake usage. Is the engine brake used on a regular basis?	Yes: Use of engine brake may result in engine oil in air induction system. Under these conditions, engine oil in the air induction system should be considered normal operation. No: Go to Step 3.

Step	Action	Decision
3	Inspect for plugged air filter. A plugged air filter will cause high inlet air restriction affecting pressure balance between bearing and compressor housing. Is air filter plugged?	Yes: Change air filter. No: Go to Step 4.

Step	Action	Decision
4	Inspect for plugged turbocharger oil drain. A plugged turbocharger oil drain will cause excessive oil pressure in bearing housing which results in oil migrating to compressor housing. Is turbocharger oil drain plugged?	Yes: Clean turbocharger oil drain and advise a more strict maintenance schedule. No: Go to Step 5.

Step	Action	Decision
5	Inquire about engine idling times. Excessive engine idling creates unfavorable conditions in compressor housing where pressures are low, promoting oil migration from the bearing housing. Is excessive engine idling a factor?	Yes: Recommend reduced engine idle operation or enable Idle Shutdown Timer (IST). No: Go to Step 6.

Step	Action	Decision
6	Inspect Charge Air Cooler (CAC) hose. Running engine with CAC hose disconnected from compressor outlet affects pressure balance between bearing and compressor housings. Is CAC hose disconnected or damaged?	Yes: Re-install or replace CAC hose. Advise that engine should never be run with CAC hose disconnected. No: Go to Step 7.

Step	Action	Decision
7	Inspect exhaust system (including Diesel Oxidation Catalyst [DOC] and Diesel Particulate Filter [DPF]) for restrictions. Excessive back-pressure affects pressure balance between bearing and compressor housings creating an unfavorable, negative-pressure in compressor housing. Is exhaust system restricted?	Yes: Repair restriction in exhaust. No: Go to Step 8.

Step	Action	Decision
8	Test for excessive crankcase pressure. Excessive crankcase pressure affects pressure balance between bearing and compressor housings. Probable causes of excessive crankcase pressure are as follows: • Plugged Breather • Worn or defective air brake compressor • Worn valve guides • Worn or damaged power cylinders Are any of the listed possible causes present?	Yes: Repair cause of excessive crankcase pressure. No: After performing all diagnostic steps, verify each step was completed correctly, the proper decision was made, and return vehicle to service. If oil discharge continues, notify supervisor for further action..

Low Oil Pressure

Possible Causes

- Low oil level: oil leak, oil consumption or incorrect servicing
- High oil level: incorrect servicing, fuel in oil, or coolant in oil
- Stuck oil pressure regulator
- Scored or damaged oil pump
- Engine Oil Pressure (EOP) sensor biased
- Missing oil gallery cup plugs (front or rear)
- Broken, missing, or loose piston cooling tube(s)
- Missing, damaged, or worn bearing inserts or camshaft bushings
- Lifter missing (will also have performance problems)
- Aeration (cracked pickup tube, missing O-ring)
- Debris in lifter(s)

Tools

ZTSE4409 – Pressure Test Kit

Low Oil Pressure Diagnostics

1. Verify oil level in engine using oil level gauge while vehicle is parked on level ground. Check to see if oil is contaminated with fuel or coolant.
   - Engine oil level will vary depending on temperature of engine.
   - If oil is contaminated, go to Fuel in Lube Oil (page 103) or Coolant in Lube Oil (page 84) in this section.
2. Connect Pressure Test Kit ZTSE4409 air gauge to diagnostic port on the oil pan, using adapter (obtain locally).
3. Start the engine and measure oil pressure at both low and high idle, under no load conditions. Engine must be at normal operating temperature.
   - If oil pressure reads within specification listed in “Appendix A: Performance Specifications” (page 813) and the instrument panel indicator indicated low pressure, perform EOP Sensor (page 492) in the “Electronic Control Systems Diagnostics” section of this manual. Repair or replace the oil pressure indicator as required.
   - If oil pressure does not read within the specification, continue with the next step.
4. Remove and inspect oil pressure regulator as described in the *Engine Service Manual*.
   - The oil pressure regulator piston should move freely in its bore in the front cover.
   - If oil pressure regulator is functional and passes visual inspection, reinstall regulator following the procedures in the *Engine Service Manual*. Redo this procedure starting with step 3. If oil pressure remains low, continue with the next step.
5. Remove and inspect the lube oil pump following the procedure in the *Engine Service Manual*.
   - Inspect the lube oil pump housing and cover for gouging or deep scratches.
   - Inspect the gerotor gears for excessive wear or damage.
   - If no excessive damage is found, continue with the next step.

6. Drain oil from engine using a clean drain pan. Inspect oil drain plug magnet, drained oil and oil filter for foreign debris.

   An oil sample should be taken to determine level of engine wear metals and contaminants in the oil.

7. Remove oil pan following the procedure in the *Engine Service Manual*. Inspect for missing, loose, or damaged oil pickup tube, O-ring, piston cooling tubes, bearing inserts, and cam bushings.

8. To prevent damage to the engine, verify the oil filter is intact. Running the engine with a failed oil filter could cause rapid deterioration of the engine due to dirty oil.

9. Reinstall the oil pump and oil pump cover.

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

10. Connect regulated shop air line to the oil filter diagnostic coupling assembly.

11. Slowly apply air pressure in 34.5 kPa (5 psi) increments to 345 kPa (50 psi).

12. Inspect for gross leaks internally.

    - If a major leak is observed from the front cover area, continue with the next step.
    - If a major leak is observed from the rear cover area, continue with step 15.
    - If a major leak is not observed, remove engine from vehicle. Disassemble engine and perform full inspection of all components following procedures in the *Engine Service Manual*.

13. Remove the front cover from the engine following procedures in the *Engine Service Manual* and complete inspection of the lube oil pump.

14. With front cover removed from the engine, verify that the front main oil gallery cup plugs are in position and not damaged.

WARNING: To prevent personal injury or death, support engine (if in chassis) before removing rear cover or flywheel.

15. Remove the rear cover from the engine as described in the *Engine Service Manual*. Verify the rear main oil gallery cup plugs are in position and not damaged.

Over-Temperature

Symptom

When the engine oil temperature rises above 123°C (254°F) while the engine is running, a fault code will set and the ECM illuminates the Amber Warning Lamp (AWL). When temperature drops below 123°C (254°F), the fault becomes inactive. When the engine oil temperature rises above 140°C (284°F) while the engine is running, an additional fault code will set and the ECM illuminates the red stop lamp. When temperature drops below 140°C (284°F) the fault becomes inactive.

Possible Causes

- Low oil level
- Diluted engine oil
- Excessive engine load
- Oil cooler failure

- Biased Engine Oil Temperature (EOT) sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708

Oil Over-Temperature Diagnosis and Repair

NOTE: Overloading engine can cause and engine oil over-temperature condition

1. Check engine oil level. If oil level is low, check for oil leaks or other causes of low oil level. If oil level is okay, continue to next step.
2. Check for diluted engine oil. If oil is contaminated, go to Fuel in Lube Oil (page 103), or Coolant in Lube Oil (page 84) in this section.
3. Remove oil cooler and inspect for signs of leakage or restriction.

Sensor Validation Test

1. Connect EST and check for active and previously active DTCs related to engine oil over-temperature conditions.
   - Repair problems relating to oil over-temperature DTCs before continuing.
   - If no DTC exists, do next step.
2. Using the EST, compare Engine Coolant Temperature 1 (ECT1), Engine Oil Temperature (EOT), and Intake Manifold Temperature (IMT) with ignition key ON, engine OFF. After a cold soak of at least 8 hours, all temperature sensors should read within 2° C (3.6° F) of each other.

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Diagnostics Form

Required Test Procedures

Do required test procedures in sequence. Doing a required test out of sequence can cause incorrect results.

1. Initial Key On Check

☐ Check Integral Digital Display for WATER IN FUEL indicator.

Does WATER IN FUEL indicator stay on?	☐ Yes	☐ No

● If WATER IN FUEL stays on, go to Fuel Quality Check.

2. Visual Inspection

☐ Check all fluid levels.
☐ Inspect electrical connectors.
☐ Inspect air filter minder.
Note: If filter minder indicates a restriction, go to Intake Restriction Test in Performance Diagnostics.
☐ Inspect CAC.
☐ Inspect for visible exhaust damage.

Are all fluid levels within specifications?	☐ Yes	☐ No
Are power and ground connections okay?	☐ Yes	☐ No
Is air filter okay?	☐ Yes	☐ No
Is exhaust system okay?	☐ Yes	☐ No
Comments:		

●If intake system repair is made or intake system is disturbed, go to MAF Sensor Test in Performance Diagnostics.

2.1 Fuel Level Check

☐ Check instrument panel gauge and look into fuel tank to verify fuel level.

Is there fuel in the fuel tank?	☐ Yes	☐ No
Comments:		

● If fuel gauge reads above empty, but tank is empty, diagnose gauge.
● If fuel tank is empty, add fuel and turn ignition key ON. With ignition key ON and engine OFF, fuel system should self-prime within 30 seconds.

2.2 Fuel Quality Check

☐ Route clear hose from fuel drain valve on fuel filter housing to approved container. Open drain valve and fill approved container.
☐ Check for water, waxing, icing, sediment, gasoline, or kerosene.

Is fuel contaminated?	☐ Yes	☐ No
Comments:		

U02415

Figure 45 Diagnostics 0000003382 (Hard Start and No Start)

The Hard Start and No Start Diagnostics Form directs technicians to systematically troubleshoot a hard start or no start condition and avoid unnecessary repairs.

This Diagnostic Manual section shows detailed instructions of the tests on the form. The manual should be used along with the form and referenced for supplemental test information. Use the form as a worksheet to record test results.

Do Test Procedures in sequence. Doing a test out of sequence can cause incorrect results. If the customer complaint is found and corrected, it is not necessary to complete the remaining tests.

See appropriate section of this manual for Diagnostic Trouble Codes (DTCs) and engine specifications.

Diagnostics Form 0000003382 is available in 50-sheet pads. To order technical service literature, contact your International dealer.

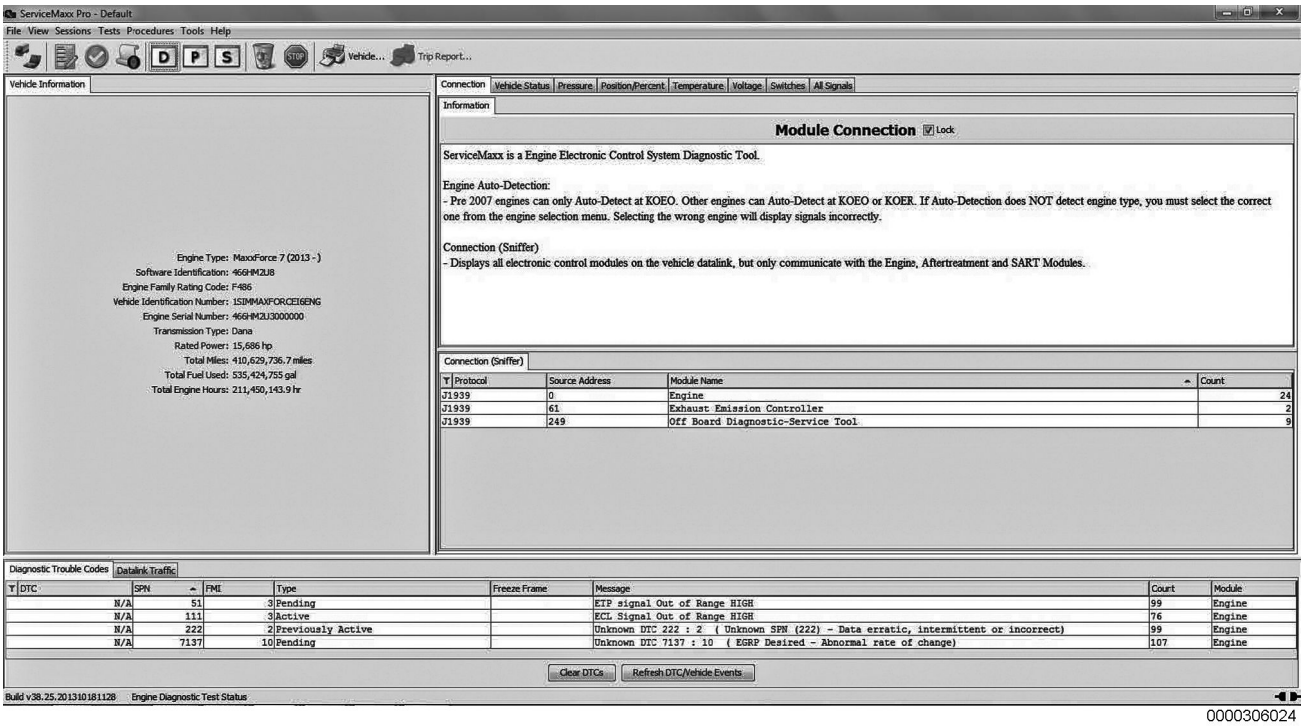
Diagnostics Form Header Information

Note: This form must be completed before calling for technical assistance.		
Technician:	Date:	Unit Number:
ECM Calibration:	Miles:	Hours:
Engine Serial Number:	Horsepower Rating:	Torque:
Transmission (select one): ☐ Manual ☐ Automatic		
VIN:		
Complaint:		

U02413

Enter Diagnostics Form Header Information

1. Technician
2. Date
3. Unit No. (dealer's quick reference number)
4. Customer complaint (interview driver)
5. Connect Electronic Service Tool (EST) with ServiceMaxx™ software to Diagnostic Connector.
6. Using the EST with ServiceMaxx™ software, log all vehicle information needed on the form header.



0000306024

Figure 47 ServiceMaxx™ opening screen (example)

7. Verify the following vehicle information matches the ServiceMaxx™ displayed information:
   - Vehicle Identification Number (VIN)
   - Electronic Control Module (ECM) calibration
   - Rated Horsepower (HP)
   - Engine Family Rating Code (EFRC)
   - Transmission
   - Engine Serial Number (SN)

     NOTE: The engine serial number is located on the right side of the crankcase, below the cylinder head. It is also on the engine emission label on the valve cover.
8. Enter the following information on the Diagnostics Form:
   - Odometer (miles)
   - Engine hours
   - Intake air temperature
   - Coolant temperature

Test Procedures

NOTE: If this is a cold start problem, do the Inlet Air Heater Test (page 139) first.

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

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

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

WARNING: To prevent personal injury or death, provide proper ventilation when operating an engine in a closed area. Inhalation of exhaust gas can be fatal.

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

1. Initial Key On Check

Purpose

Determine the following:

- Is the Engine Control Module (ECM) powered up?
- Is the WATER IN FUEL lamp on?

Tools

None

Procedure

1. Turn ignition switch to ON. Do not start engine. Check for the following:
   - Amber Warning Lamp (AWL) is on
2. If the AWL stays on and a text message is displaying Water in Fuel, take a fuel sample and evaluate quality. If water is present, drain and flush fuel tank and replace both primary and secondary fuel filters.

Possible Causes

WAIT TO START lamp does not illuminate

- No key power (VIGN)

- Failed ECM ground circuit
- No power from main power relay to ECM
- ECM failure
- Amber WAIT TO START lamp is out (will not cause hard start or no start).
- CAN link to instrument panel not working (will not cause hard start or no start).

NOTE: Instrument panel AWL should cycle ON, then OFF, if there is no water in the system. Lamp will stay ON if water is detected.

WARN ENGINE lamp stays illuminated

- Water in fuel
- Electrical circuit failure

2. Visual Inspection

Purpose

Check all fluid levels and inspect engine systems for problems such as leaks, open connections, harness chaffing.

Tools

None

Engine Oil

1. Park vehicle on level ground and check oil level.

   NOTE: Turn ignition switch to OFF and shut down engine. Wait 15 minutes for oil level to stabilize.

2. Use oil level gauge (dipstick) to verify engine oil level.
3. Record results on Diagnostics Form.
   - If level is below specification, inspect for leaks, oil consumption, or improper servicing. If engine oil level is low, fill to specification.
   - If level is above specification, inspect for fuel dilution, coolant contamination, or improper servicing. If engine oil level is above specification, drain to specification.

CAUTION: If oil is contaminated, oil and filter must be replaced.

NOTE: If change engine oil indicator is illuminated, check maintenance history. See *Engine Operation and Maintenance Manual* for information on resetting service intervals.

Engine Coolant Level

1. Park vehicle on level ground.

NOTE: Turn ignition switch to OFF, shut down engine, and allow to cool. Ensure coolant temperature has stabilized to a safe temperature and pressure.

2. Check coolant level as indicated on deaeration tank level window.
3. Record results on Diagnostics Form.
   - If level is above or below deaeration tank fill level, inspect for leaks, coolant in the oil, or coolant in the intake or exhaust. See Coolant Over-Temperature Diagnostics and Repair (page 91), Fuel in Coolant (page 100), and Combustion Leaks to Coolant (page 81) in the “Engine Symptoms Diagnostics” section of this manual.
   - If level is at deaeration tank fill level, and no tank contamination is evident, no repair is required.

NOTE: If coolant is contaminated, replace coolant.

CAUTION: Coolant in the exhaust could damage the Diesel Particulate Filter (DPF) and Diesel Oxidation Catalyst (DOC). Inspect DPF and DOC for damage. See AFT System (page 207) in the “Electronic Control Systems Diagnostics” section of this manual for inspection of the DPF and DOC.

Electrical System

Inspect batteries and electrical system (engine and vehicle) for poor or loose connections, corroded terminals, or broken and damaged wires. Repair electrical system as required.

Exhaust System

Inspect exhaust system (engine and vehicle) for damaged or plugged tailpipe. Repair exhaust system as required.

Intake Air System and Charge Air Cooler (CAC)

1. Inspect CAC system, including intercooler and all intake piping and ducts, for leaks and damage.

   Inspect the following parts for restriction, damage, or incorrect installation:

   - Air inlet hoses and ducts
   - Air filter housing, filter element, and gaskets
   - CAC and piping
   - Air filter inlet and duct - look inside duct and remove any restrictions.

Figure 48 Air filter restriction gauge

2. Check the air filter restriction gauge.
3. Inspect all CAC and intake air connections and clamps.
4. If a CAC or intake air system problem is found, repair as required.

NOTE: If air intake system repair is made, or air intake system is disturbed, go to KOER MAF Sensor Calibrate Procedure in Diagnostic Software Operation (page 76) section in this manual for specific EST software procedures to perform this procedure.

2.1 Fuel Level Check

⚠ WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

1. Park vehicle on level ground.
2. Check instrument panel fuel gauge and look into fuel tank to verify fuel level.
   - If fuel gauge reads above empty, but fuel tank is empty, diagnose fuel gauge, see *Electrical System Troubleshooting Guide* for the appropriate model and year of vehicle.
   - If fuel tank is empty, add fuel and turn ignition switch to ON. With ignition key ON, engine OFF, fuel system should self-prime within 30 seconds.
   - Always verify fuel level before diagnosing a fuel pressure problem.

2.2 Fuel Quality Check

Purpose

Check for poor fuel quality or contaminants.

Tools

- Clear diesel fuel container (approximately 1 liter or 1 quart)
- Clear plastic hose

Possible Causes

- Debris, waxing, water, or ice in the fuel system
- Oil, gasoline, or kerosene present in fuel tank
- Fuel grade incorrect for cold temperature

Procedure

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

WARNING: To prevent personal injury or death, store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

1. Place approved diesel fuel container under fuel drain valve and open.
2. Turn ignition switch to ON, engine OFF.

NOTE: Instrument panel Amber Warning Lamp (AWL) should cycle on, then off, if there is no water in the system. Lamp will stay on if water is detected.

3. Turn ignition switch to OFF.

   NOTE: To prevent aeration of the fuel, wait 30 to 60 seconds after turning ignition switch to OFF before opening fuel drain valve.

   NOTE: If fuel sample does not flow, see Fuel Pump Check (page 142) in this section.

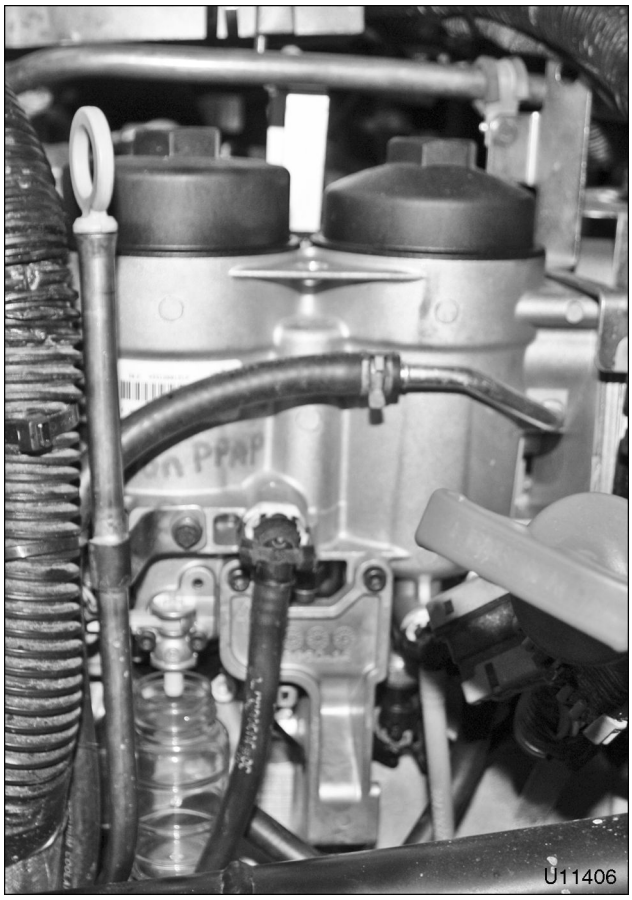


Figure 49 Fuel Sample

4. Drain enough fuel into container to effectively check for contamination.
5. Check for water, waxing, icing, sediment, gasoline, or kerosene by shaking fuel sample container and letting contents settle.
   - Sediments will fall to the bottom of the fuel sample container.
   - Gasoline and kerosene will separate from the diesel fuel.
   - Waxing or icing will prevent diesel fuel from flowing out of the fuel drain valve.
   - If the fuel quality is questionable, correct the problem. Take another sample to verify fuel quality is satisfactory.
   - If the fuel quality is satisfactory, continue to next test.

3. EST Connection and Data Recording

NOTE: See the “Diagnostic Software Operation” (page 67) section in this manual for specific EST software procedures to do this test.

NOTE: Ideally, allow the engine to cold soak for at least 2 hours before recording results.

Purpose

Determine if engine sensor readings are within specification for engine starting.

Monitoring Engine Systems using an EST

Tools

- EST with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

Procedure

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

1. Turn ignition switch to ON, engine OFF.
2. Using the EST, start the ServiceMaxx™ software.

   NOTE: See “Diagnostic Software Operation” (page 67) section in this manual for ECM and EST communication problems.
3. Record the following sensor readings on Diagnostics Form:
   - Barometric Pressure (BARO)
   - Air Inlet Temperature (AIT)
   - Engine Coolant Temperature 1 (ECT1)
   - Engine Oil Temperature (EOT)
   - Intake Manifold Temperature (IMT)
   - Fuel Delivery Pressure (FDP)
   - Fuel Rail Pressure (FRP)
   - DPF Differential Pressure (DPFDP)
4. If sensor is out of specification, go to suspect sensor diagnostic in “Electronic Control Systems Diagnostics” (page 191) section of this manual.
5. Use ServiceMaxx™ software to run KOEO Output State Test High and Low.
6. Record voltage signals for the following on the Diagnostics Form:
   - Exhaust Gas Recirculation Position (EGRP)
   - Engine Throttle Position (ETP)
7. If signal is out of specification, go to suspect actuator diagnostic in “Electronic Control Systems Diagnostics” (page 191) section of this manual.
8. Monitor DPF status signal value and record on Diagnostics Form.
   - If DPF status is Regen needed-critical level, disconnect exhaust system upstream of the Pre-Diesel Oxidation Catalyst (PDOC) and attempt to start engine.

4. Check for DTCs

NOTE: 2010 model year or newer vehicles no longer utilize DTC identification by number. DTCs are now identified using the SPN and FMI identifiers only. These two identifiers, known as the Suspect Parameter Number (SPN) and the Failure Mode Indicator (FMI), are displayed in the DTC Window.

- Suspect Parameter Number (SPN) – The SPN identifies the individual component causing the DTC.
- Failure Mode Indicator (FMI) – The FMI identifies the fault or condition affecting the individual component.
- Active DTCs are codes that are active now.
- Previously active DTCs are historical faults that may be caused by intermittent signals or an operating condition that is not currently present.

Purpose

Identify DTCs.

Tools

- EST with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Start the ServiceMaxx™ software.

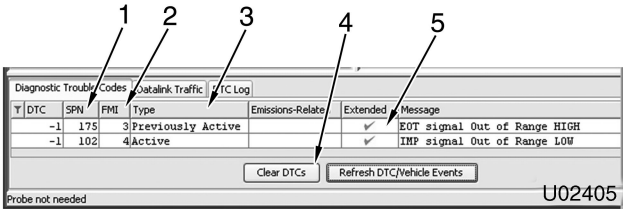


Figure 50 DTC window

1. Suspect Parameter Number (SPN) column
2. Failure Mode Indicator (FMI) column
3. DTC type column
4. Clear DTCs button
5. Extended (Freeze Frame)

NOTE: Click the extended button to receive a Freeze Frame data of when the code was set.

3. Record DTCs on the Diagnostics Form.
   - Correct any active DTCs. See the “Diagnostic Trouble Code Index” in this manual.
   - Investigate any previously active DTCs for possible intermittent operating conditions during which the DTC was set.

5. Engine Cranking

NOTE: See the “Diagnostic Software Operation” (page 67) section in this manual for specific EST software procedures to do this test.

Purpose

Determine if engine systems meet operating specifications to start engine.

Monitoring Engine Systems using an EST

Tools

- EST with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)

Procedure

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

1. Turn ignition switch to ON, engine OFF.
2. Using the EST, start the ServiceMaxx™ software.

   NOTE: See “Diagnostic Software Operation” (page 67) section in this manual for ECM and EST communication problems.
3. Click on Sessions from the menu bar and select the Hard Start – No Start session.

WARNING: To prevent personal injury or death, provide proper ventilation when operating an engine in a closed area. Inhalation of exhaust gas can be fatal.

4. Crank the engine for a maximum of 20 seconds while monitoring Key On, Engine Running (KOER) signals.
5. Monitor the following KOER signals:

   NOTE: If engine is not equipped with a Fuel Delivery Pressure (FDP) sensor, use a mechanical gauge.

   - Switched Battery volts (B+)
   - Engine Speed (RPM)
   - Fuel Delivery Pressure (FDP)
   - Fuel Rail Pressure (FRP)
6. Visually inspect Charge Air Cooler (CAC) between CAC and Engine Throttle Valve (ETV).
   - If CAC hose collapses while cranking engine, inspect for CAC plugging and if low-pressure turbocharger spins freely.
7. Record KOER signals on the Diagnostics Form.
   - If Switched Battery voltage drops below specification, check cranking voltage at batteries using a DMM. If cranking voltage is below specification, check batteries and charging system, connect battery charger, and retest.
   - If no Engine Speed signal is present, see CKP Sensor (page 319) and CMP Sensor (page 322) in Electronic Control Systems Diagnostics section of this manual.
   - If cranking rpm is below specification, check batteries and starting system.
   - If FDP is below specification, go to Low Pressure Fuel System (page 141) in this section and begin fuel system tests. If not equipped with FDP sensor, go to Fuel Pump Check (page 142) in this section and continue with the remainder of the fuel system check.
   - If FRP does not increase, go to Low Pressure Fuel System (page 141) in this section.
   - If AIT is below specification, see Inlet Air Heater Test (page 139) in this section.
   -

Possible Causes

Low battery voltage

- Failed batteries

- High-resistance at battery cable connections or in wiring to the ECM
- Failed ECM main power relay

Low cranking rpm

- Electrical system malfunctions, low batteries, starter failure, or incorrect oil
- Mechanical engine damage
- No rpm indication on the EST while cranking the engine
  - — Failed Crankshaft Position (CKP) sensor
  - — Failed Camshaft Position (CMP) sensor
  - — Failed circuit to ECM

Low Fuel Rail Pressure

- Failed FRP sensor
- Failed High Pressure Fuel Pump (HPFP)
- Low FDP
- Aerated fuel

Monitoring FRP using a Breakout Harness

NOTE: This is an alternate procedure to be used if an EST is not available.

Tools

- Digital Multimeter (DMM)
- Breakout Harness ZTSE6038

Procedure

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

1. See “Appendix A: Performance Specifications” (page 813) in this manual for specifications and record on Diagnostics Form.

Figure 51 12-pin injector connector disconnected

2. Disconnect the engine harness from the right-side 12-pin injector connector.
3. Connect Breakout Harness ZTSE6038 to the 12-pin injector connector and engine harness.
4. Use DMM to measure FRP sensor voltage by connecting POS to Pin E-10 and NEG to Pin E-6.
5. Start or crank engine for no more than 20 seconds.
6. Measure signal voltage and cranking rpm. Compare measurements to specifications.
   - If in specification, continue to next test.
   - If not in specification, see LP.2 – Fuel Pressure Test (page 142) in this section.

Possible Causes

- Failed FRP sensor
- Failed high-pressure pump
- Low Fuel Delivery Pressure (FDP)
- High-pressure leaks
- Aerated fuel

Special Test Procedures

NOTE: Any special test procedure can be performed if directed from one of the previous required test procedures.

Inlet Air Heater (IAH) Test

Purpose

Inspect IAH system for malfunctions.

Tools

- EST with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- EXP-1000 HD by Midtronics - Current Clamp

Possible Causes

- Failed wiring harness or connection
- Failed IAH relay
- Failed IAH element
- Failed ECM

Amperage Draw

Procedure

NOTE: Inspect for damaged, loose, or corroded terminals. Repair if necessary.

NOTE: KOEO Standard Test must be run before running other KOEO tests.

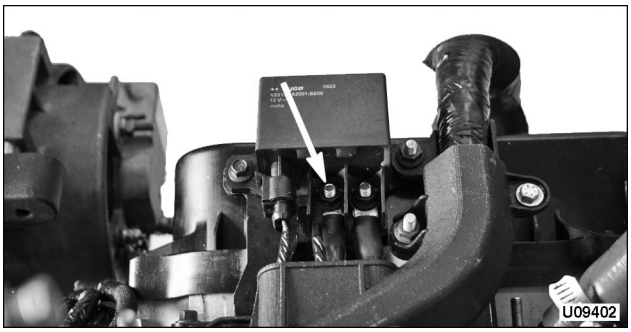


Figure 52 IAH Relay B+ feed circuit

1. See “Appendix A: Performance Specifications” (page 813) in this manual for specifications.
2. Install EXP-1000 HD by Midtronics with amp clamp around the IAH relay B+ feed circuit.
3. Turn ignition switch to ON, engine OFF.
4. Using the EST with ServiceMaxx™ software, run the KOEO Intake Air Heater test.

5. Use a DMM and EXP-1000 HD by Midtronics amp clamp to measure amperage draw going to the IAH element.
6. Record results on the Diagnostics Form.
   - If amperage draw does not meet specification, see IAH (page 591) in the Electronic Control Systems Diagnostics section of this manual.
   - If amperage draw meets specifications, the IAH system is working properly.

Low-pressure Fuel System

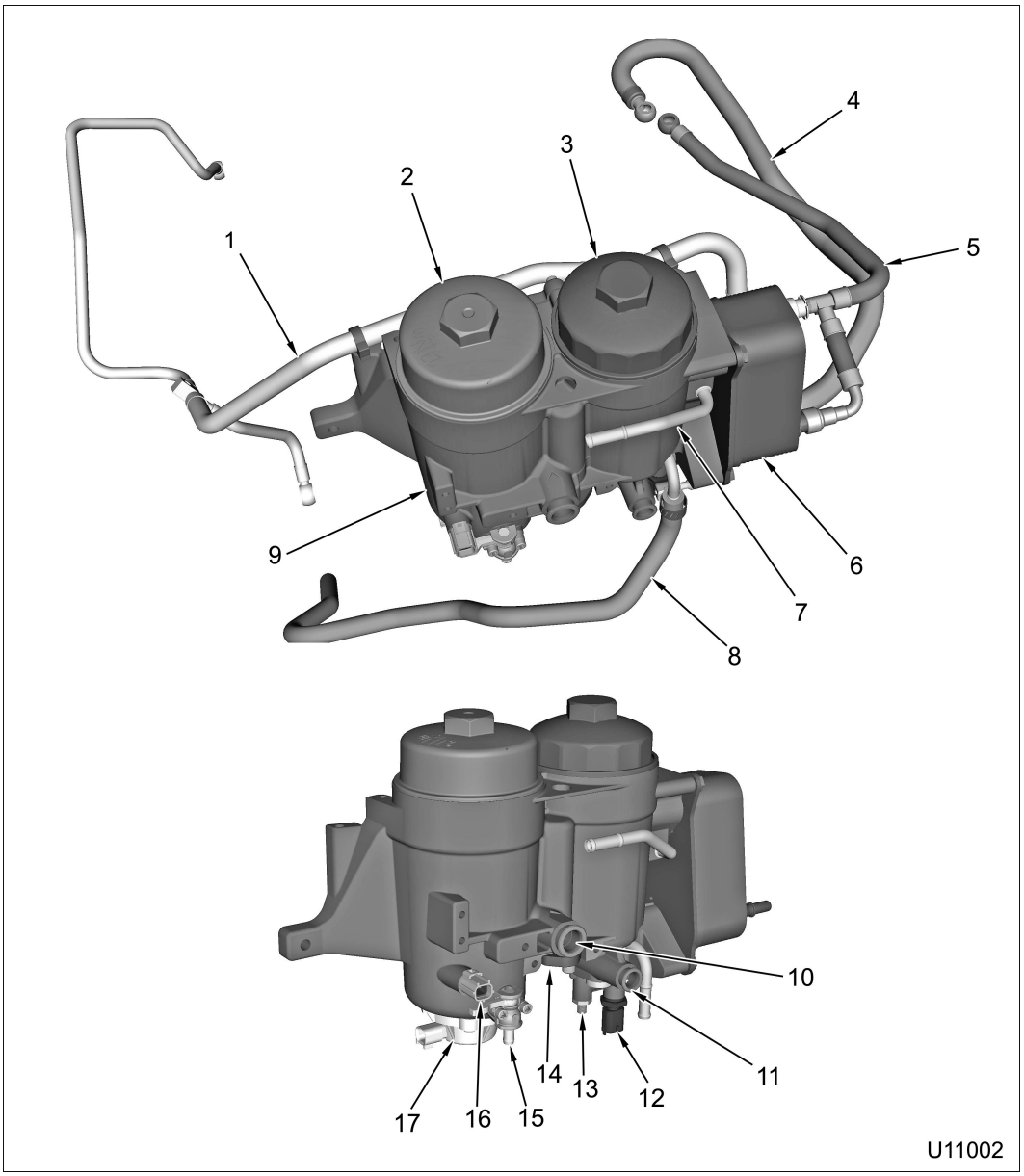


Figure 53 Low-pressure fuel system

1. Injector return hose assembly
2. Filter cap (primary)
3. Filter cap (secondary)
4. Filter-to-pump hose assembly
5. Pump-to-cooler hose assembly
6. Fuel cooler
7. Coolant supply hose
8. Coolant return hose
9. Fuel filter module housing
10. Fuel inlet from tank
11. Fuel return to tank
12. Engine Fuel Temperature (EFT) sensor
13. Diagnostic valve (standard) or Fuel Delivery Pressure (FDP) sensor (optional)
14. Fuel heater block-off plate or fuel heater (optional)
15. Water drain valve
16. Water In Fuel (WIF) sensor
17. Fuel Pump

WARNING: To prevent personal injury or death, store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

LP.1 - Electrical Fuel Pump Check

Purpose

Check for fuel pump operation.

Tools

None

Procedure

NOTE: The ECM will command the fuel pump to run for 5 seconds after the ignition switch is turned to the OFF position.

1. Turn ignition switch to ON, engine OFF.
2. Listen for the fuel pump (shop noise can drown out the fuel pump sound).
   - The ECM will command the FPC to run for 5 seconds without the engine running. If FPC does not run for 5 seconds, see Fuel Pump (page 548) in the “Electronic Control Systems Diagnostics” section of this manual.
   - If fuel pump is not heard, verify ECM power by going to Fuel Pump (page 548) in the “Electronic Control Systems Diagnostics” section of this manual.
   - If fuel pump is heard and runs for 5 seconds with the engine off, continue to LP.2 - Fuel Pressure Test (page 142) in this section.

LP.2 - Fuel Pressure Test

Purpose

Check for low Fuel Delivery Pressure (FDP).

Tools

- Graduated cylinder (0 -700 mL)
- EST with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- ZTSE4681 – Fuel Pressure Gauge with 30 psi gauge

Check Fuel Delivery Pressure Using the EST

NOTE: This procedure is only valid on engines equipped with an FDP sensor.

1. See Appendix A: Performance Specifications (page 813) in this manual for FDP specifications.
2. Turn ignition switch to ON, engine OFF.
3. Using the EST, start the ServiceMaxx™ software.
4. Monitor FDP and record results on Diagnostics Form.
   - If pressure is below specification, go to LP.3 - Fuel Aeration Check (page 144) in this section.
   - If within specification, go to LP.7 - Return Fuel Flow Test (page 148) in this section.
   - If fuel gauge pressure is above specification, go to LP.8 - Fuel Return Restriction Test (page 148) in this section.

Check Fuel Delivery Pressure Manually

NOTE: This procedure is only valid on engines equipped with a fuel filter module housing diagnostic valve.

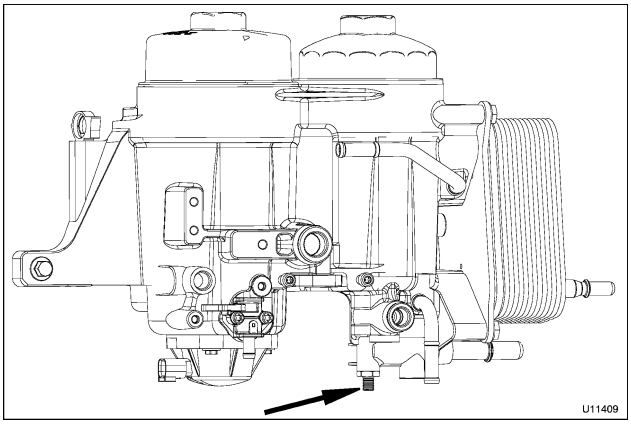


Figure 54 Fuel filter module housing diagnostic valve

1. Connect 30 psi Fuel Pressure Gauge ZTSE4681 with shutoff valve and clear drain hose to the diagnostic valve on the fuel filter assembly.
2. Route clear drain hose into an approved diesel fuel container.
3. Turn ignition switch to ON, engine OFF.
4. Close shutoff valve on Fuel Pressure Gauge ZTSE4681.
5. Measure fuel pressure at the fuel filter module housing diagnostic valve using the Fuel Pressure Gauge ZTSE4681.
   - If pressure is below specification, go to LP.3 - Fuel Aeration Check (page 144) in this section.
   - If within specification, go to LP.7 - Return Fuel Flow Test (page 148) in this section.
   - If fuel gauge pressure is above specification, go to LP.8 - Fuel Return Restriction Test (page 148) in this section.

LP.3 - Fuel Aeration Check

Purpose

Check for aerated fuel.

Tools

- Graduated cylinder (0 -700 mL)
- ZTSE4681 – Fuel Pressure Gauge with 30 psi gauge

Possible Causes

- Cracks or leaks in fuel supply line
- Leaks at the Fuel Filter assembly

Procedure

⚠ WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

⚠ WARNING: To prevent personal injury or death, store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

1. Retain fuel pressure gauge to fuel filter assembly diagnostic valve setup from LP.2 - Fuel Pressure Test (page 145).
2. Place approved diesel fuel container under fuel drain valve and open valve.
3. Turn ignition switch to ON, engine OFF and open fuel shutoff valve on Fuel Pressure Gauge ZTSE4681.

NOTE: Instrument panel Amber Warning Lamp (AWL) should cycle on, then off, if there is no water in the system. Lamp will stay on if water is detected.

4. Monitor fuel flow from clear line on Fuel Pressure Gauge ZTSE4681 and check for aeration (bubbles).

   NOTE: To prevent aeration of the fuel, wait 30 to 60 seconds after turning ignition switch to OFF before opening fuel drain valve.

   NOTE: If fuel sample does not flow, see Electrical Fuel Pump Check (page 142) in this section.

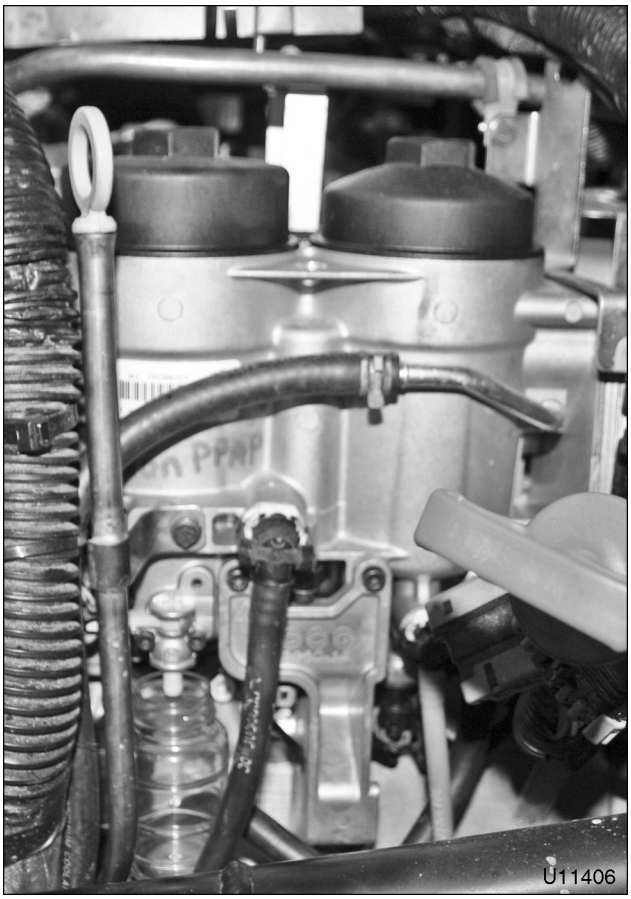


Figure 55 Fuel Sample

5. Drain enough fuel into container to effectively check for aeration. Mark results on Diagnostics Form.
   - If fuel does not flow from pressure gauge, go to LP.4 - Fuel Thermal Valve Check (page 146) in this section.
   - If fuel is aerated, repair fuel supply line between tank and fuel filter assembly.
   - If fuel is not aerated, go to LP.5 - Low-pressure Fuel Pump Dead Head Test (page 146) in this section.

LP.4 - Fuel Thermal Valve Check

Purpose

Check the fuel thermal valve.

Tools

- Diesel fuel container

WARNING: To prevent personal injury or death, store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

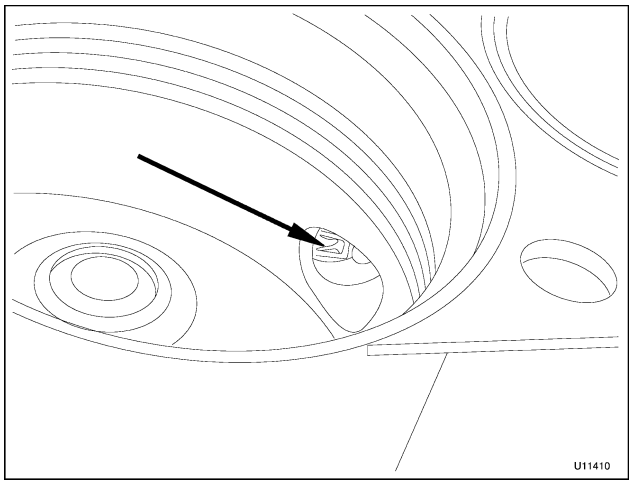


Figure 56 Fuel thermal valve (inside fuel filter assembly)

NOTE: Check for related recalls, iKnow letters, and service bulletins using Service Portal network regarding Fuel Thermal Bypass Valve.

1. Remove primary fuel filter cap.
2. Inspect and ensure fuel thermal bypass valve end cap, brass motor, and snap ring are in place and undamaged.
3. Record result on Diagnostics Form.
   - If thermal valve is damaged or is missing parts, replace fuel thermal valve.
   - If fuel thermal valve is not damaged, go to LP.5 - Fuel Pump Dead Head Test (page 146) in this section.

LP.5 - Fuel Pump Dead Head Test

Purpose

Check for fuel supply system restriction and fuel pressure regulator valve function.

Tools

- Diesel fuel container
- ZTSE4681 – Fuel Pressure Gauge with 30 psi gauge

Procedure

1. Retain fuel pressure gauge to fuel filter assembly diagnostic valve setup from LP.2 - Fuel Pressure Test (page 145).

WARNING: To prevent personal injury or death, store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

2. Disconnect fuel return line from fuel filter assembly and capture excess fuel into approved diesel fuel container.
3. Turn ignition switch to ON, engine OFF.
4. Close shutoff valve on Fuel Pressure Gauge ZTSE4681 and measure pressure.
5. Record results on the Diagnostics Form.
   - If fuel gauge pressure is below specification, go to LP.6 - Alternative Fuel Supply Test (page 147) in this section.
   - If fuel gauge pressure is within specification, replace fuel pressure regulator valve assembly.

LP.6 - Alternative Fuel Supply Test

Purpose

Check for fuel supply system restriction and low-pressure fuel pump.

Possible Causes (High and Low Restriction)

- Dirt or jelled fuel in the fuel filter
- Kinked or bent fuel supply line or a blocked fuel pickup tube
- Loose fuel line on the suction side of the fuel system
- Failed fuel regulator valve (located in secondary fuel filter housing)
- Failed fuel pump

Tools

- Diesel fuel container
- 15-637-01 – Clean Fuel Source Tool
- ZTSE4681 – Fuel Pressure Gauge

Procedure

1. Retain fuel pressure gauge to fuel filter assembly diagnostic valve setup from LP.2 - Fuel Pressure Test (page 142).

WARNING: To prevent personal injury or death, store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

2. Remove fuel supply line from fuel filter assembly and connect Clean Fuel Source Tool 15-637-01. Use diesel fuel container to collect fuel when line is disconnected.
3. Turn ignition switch to ON, engine OFF.
4. Close shutoff valve on Fuel Pressure Gauge ZTSE4681 and measure pressure.

5. Record results on the Diagnostics Form.
   - If fuel gauge pressure is below specification, replace low-pressure fuel pump according to *Engine Service Manual*.
   - If fuel gauge pressure is within specification, repair open or restriction in fuel supply line to fuel filter assembly.

LP.7 - Return Fuel Flow Test

Purpose

Check for fuel pump or fuel filter housing damage.

Tools

- Fuel Return Test Line
- Graduated cylinder (0 - 700 mL)

Procedure

1. Connect Fuel Return Test Line to fuel filter assembly.

WARNING: To prevent personal injury or death, store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

2. Route Fuel Return Test Line to an approved diesel fuel container with measuring marks.

   NOTE: Fuel Pump will run for 5 seconds after ignition switch is turned to OFF. Accurately measuring fuel volume requires starting a timer as soon as ignition switch is turned to ON and turning ignition switch to OFF after 10 seconds.

3. Turn ignition switch to ON, engine OFF. Measure 15 seconds of fuel flow.
4. Record results on the Diagnostics Form.
   - If fuel flow volume is below specification, replace fuel filters and retest.
   - If fuel flow volume is within specification, go to LP.8 - Fuel Return Restriction Test (page 148) in this section.

LP.8 - Fuel Return Restriction Test

Purpose

Check for fuel line, fuel pump, or fuel filter housing damage.

Tools

- Fuel Return Test Line
- Graduated cylinder (0 - 700 mL)

Procedure

1. Reconnect fuel return line to fuel filter assembly.

WARNING: To prevent personal injury or death, store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

2. Disconnect fuel return line from fuel tank.
3. Route fuel return line to an approved diesel fuel container with measuring marks.
4. Turn ignition switch to ON, engine OFF. Measure 15 seconds of fuel flow.

   NOTE: Fuel Pump will run for 5 seconds after ignition switch is turned to OFF. Accurately measuring fuel volume requires starting a timer as soon as ignition switch is turned to ON and turning ignition switch to OFF after 10 seconds.
5. Measure 15 seconds of fuel flow.
6. Record results on the Diagnostics Form.
   - If fuel flow volume is below specification, repair restriction in fuel return line.
   - If fuel flow volume is within specification, go to HP.4 – High Pressure Fuel Pump Dead Head Test (page 154) in this section.

High-pressure Fuel System Tests

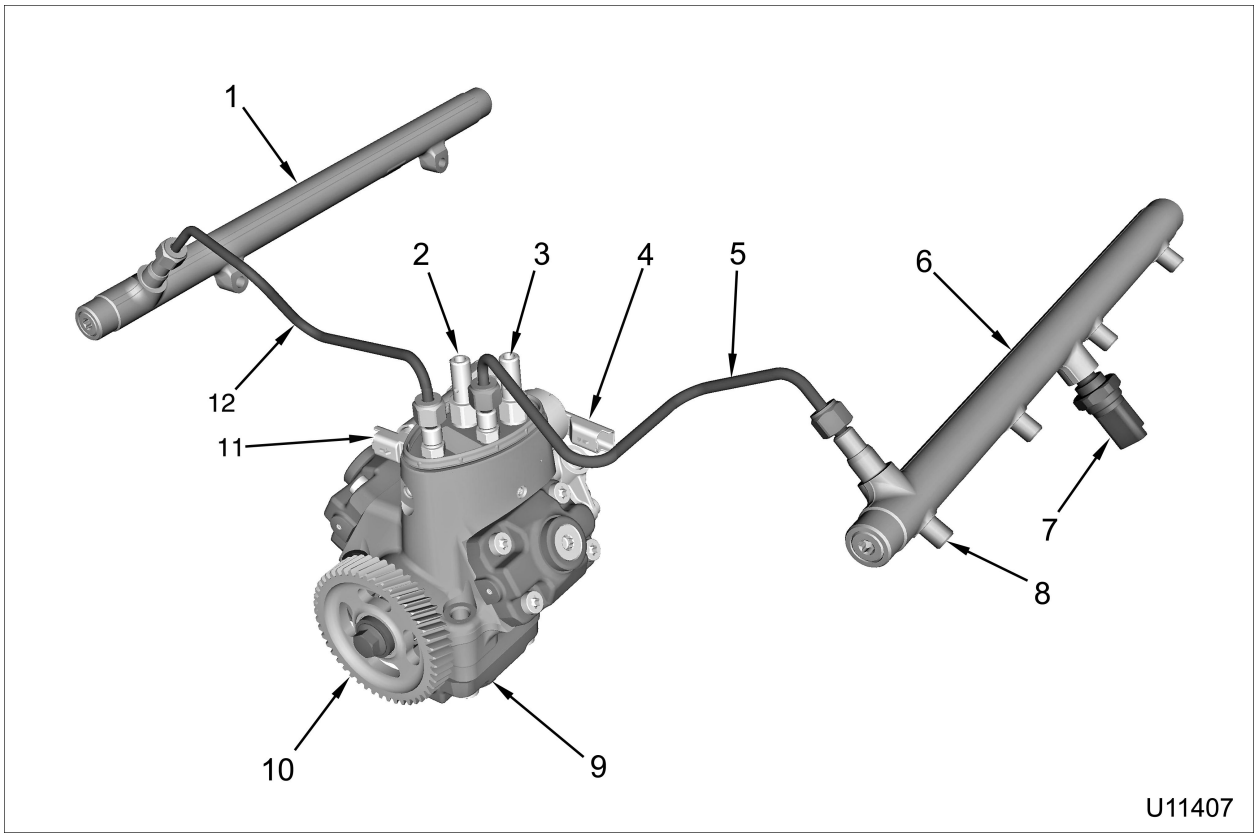


Figure 57 High-pressure fuel system

1. Left rail assembly
2. Pump return hose connection (pump-to-cooler)
3. Filter to pump hose connection (secondary fuel filter-to-pump)
4. Fuel Pressure Control Valve (FPCV)
5. Pump right tube assembly (pump-to-rail)
6. Right rail assembly
7. Fuel Rail Pressure (FRP) sensor
8. Fuel rail-to-injector fuel tube port (4 for each rail)
9. HPFP
10. HPFP gear
11. Fuel Volume Control Valve (FVCV)
12. Pump left tube assembly (pump-to-rail)

WARNING: To prevent personal injury or death, store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

HP.1 - Fuel Pressure Control Valve (FPCV) and Fuel Volume Control Valve (FVCV) Check

Purpose

Check for FPCV and FVCV function.

Possible Causes

- Fuel Rail Pressure (FRP) sensor or circuit
- Missing Fuel Pressure Control Valve (FPCV)
- Fuel Volume Control Valve (FVCV) or circuit
- Engine Control Module (ECM)
- High-pressure fuel line leaks (internal or external fuel lines)
- Failed HPFP
- Fuel injectors
- Insufficient low-pressure fuel pressure
- Plugged fuel filter
- Aerated fuel
- Cracked or leaking fuel lines

Tools

- EST with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 00-01464-00 – 98-Pin Engine Cable
- 00–00956–08 – 180-Pin Breakout Box
- ZTSE4674 – Breakout Harness

Procedure

NOTE: KOEO Standard Test must be run before any other ServiceMaxx™ tests are performed.

1. Connect 180-Pin Breakout Box 00–00956–08 between ECM and engine harness using 98-Pin Engine Cable 00-01464-00.
2. Turn ignition switch to ON, engine OFF.
3. Start ServiceMaxx™ software.
4. Measure voltage from FPCV (E-18) to GND and record results on Diagnostics Form.
5. Measure voltage from FVCV (E-16) to GND and record results on Diagnostics Form.
6. Click on the Tests drop-down menu and select Engine Off Tests.
7. From the Engine Off Tests drop-down menu, select KOEO Output State Test High and Low.

8. Monitor the FPCV and FVCV voltage. Record results on Diagnostics Form.
    - If not in specification, see FPCV (page 543) or FVCV (page 587) in the Electronic Control Systems Diagnostics section of this manual.
    - If in specification, continue to HP.2 - FPCV and FVCV Resistance Check (page 152) in this section.

HP.2 - FPCV and FVCV Resistance Check

Purpose

Check for FPCV and FVCV function.

Possible Causes

- Fuel Rail Pressure (FRP) sensor or circuit
- Fuel Volume Control Valve (FVCV) or circuit
- Engine Control Module (ECM)
- Fuel Volume Control Valve (FPCV) or circuit
- Failed HPFP
- Insufficient low-pressure fuel pressure
- Plugged fuel filter
- Aerated fuel
- Cracked or leaking fuel lines

Tools

- Digital Multimeter (DMM)
- 00-01464-00 – 98-Pin Engine Cable
- 00–00956–08 – 180-Pin Breakout Box
- ZTSE4674 – Breakout Harness

Procedure

1. Turn ignition key OFF.
2. Connect 180-Pin Breakout Box 00–00956–08 and 98-pin E-cable 00-01464-00 between ECM and Engine Harness, leave ECM disconnected.
3. Disconnect ECM relay and connect Breakout Harness ZTSE4674. Leave ECM relay disconnected.
4. Measure resistance between FVCV (E-18) and ECM relay pin 87.
5. Measure resistance between FVCV (E-16) and ECM relay pin 87.
6. Record results on Diagnostics Form.
    - If resistance is out of specification, go to “Electronic Control Systems Diagnostics” (page 191) for valve in question.
    - If resistance is within specification, go to HP.3 - Fuel Rail Leak Check.

HP.3 - Fuel Rail Leak Check

Purpose

Check for Fuel Rail leaks.

Possible Causes

- Fuel rail system leakage such as fuel lines
- Failed HPFP
- Failed injector
- Biased sensors
- Low or no low-side fuel pressure

Tools

- EST with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- ZTSE4861 - Fuel Rail Block Off Plug

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

Procedure

CAUTION: To prevent engine damage, when high-pressure fuel line connections are broken, the fuel line must be replaced.

NOTE: When removing the pump tube assemblies, fuel may leak out. Put in a suitable catch or container to collect this leakage. Collect and dispose of this fuel according to local regulations.

1. Remove Breakout Harnesses from the previous test. Restore Electrical connections.

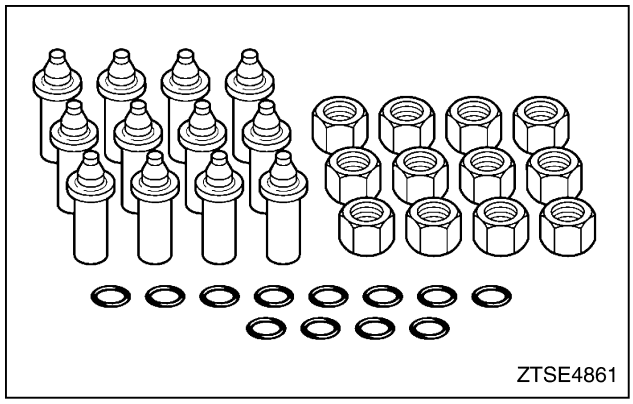


Figure 58 Fuel Rail Block Off Plugs

2. Disconnect the left head high-pressure fuel tube assembly and cap off the HPFP output port using the Fuel Rail Block Off Plug ZTSE4861.

   NOTE: Replace any high-pressure fuel line that was disconnected during testing, after testing is completed.

3. Using the EST, start the ServiceMaxx™ software and monitor Fuel Rail Pressure (FRP).
4. Turn ignition switch to ON; crank the engine for 15 to 20 seconds, record the results on the Diagnostics Form.
   - If the FRP is not within specification, go to HP.4 High Pressure Pump (HPFP) Dead Head Test.
   - If the Fuel Rail Pressure is within specification, go to HP.5 Injector Leak Isolation Check (Left Bank) (page 155).

HP.4 - High-pressure Fuel Pump (HPFP) Dead Head Test

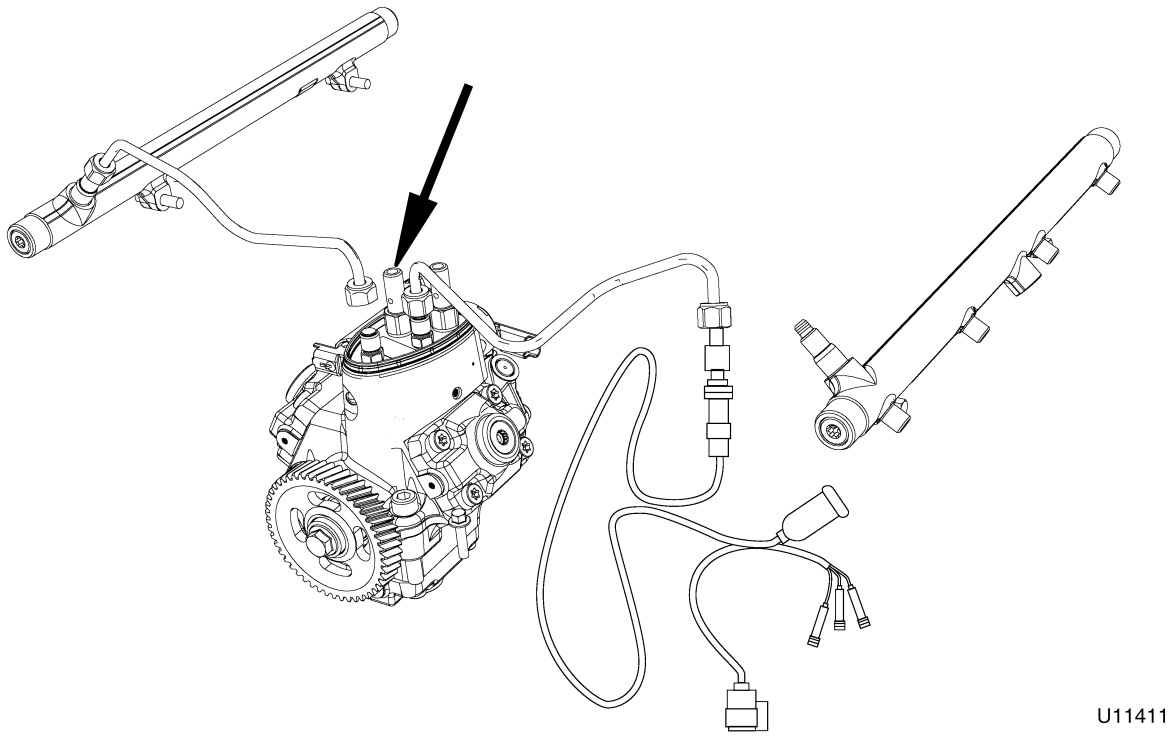


Figure 59 HPFP output port

Possible Causes

- Fuel Rail Pressure (FRP) sensor or circuit
- Missing Fuel Pressure Control Valve (FPCV)
- Fuel Volume Control Valve (FVCV) or circuit
- Engine Control Module (ECM)
- High-pressure fuel line leaks (internal or external fuel lines)
- Failed HPFP

- Fuel injectors
- Insufficient low-pressure fuel pressure
- Plugged fuel filter
- Aerated fuel
- Cracked or leaking fuel lines

Tools

- EST with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- Spare FRP sensor (obtain locally)
- 00–00956–08 – 180-Pin Breakout Box
- ZTSE4837 – High-Pressure Pump Test Fitting
- ZTSE4861 – Fuel Rail Block Off Plugs
- ZTSE6038 – Breakout Harness

Procedure

1. Retain test setup from previous test.
2. Disconnect right high-pressure tube assembly from cylinder head.
3. Use High-pressure Pump Test Fitting to connect Fuel Rail Pressure (FRP) sensor to right high-pressure tube assembly.
4. Connect Breakout Harness ZTSE6038 to right UVC harness. Leave disconnected from right head.
5. Connect other end of Breakout Harness ZTSE6038 to FRP sensor in right HPFP tube.
6. Use ServiceMaxx™ software to monitor FRP.
7. Crank engine for 15 to 20 seconds while monitoring FRP; record results on Diagnostics Form.
   - If FRP is within specification, go to HP.6 - Injector Leak Isolation Check (Right Bank) (page 156).
   - If FRP is not within specification, remove HPFP cover and verify gear is not loose or damaged. If gear is okay, replace HPFP.

HP.5 - Injector Leak Isolation Check (Left Bank)

Purpose

Check for and isolate leaking injector.

Possible Causes

- High-pressure fuel line leaks (internal or external fuel lines)
- Fuel injectors

- Cracked or leaking fuel lines

Tools

- ZTSE4861 – Fuel Rail Block-off Plugs
- ZTSE6038 – Breakout Harness

Procedure

1. Restore HPFP left tube assembly to cylinder head.
2. Disconnect HPFP right tube assembly; install FRP sensor and test fitting to HPFP right tube.
3. Connect ZTSE6038 breakout harness to right bank 12-pin injector engine harness; leave disconnected from right head.
4. Remove left cylinder head valve cover.
5. Isolate leaking injector by removing one injector tube at a time; capping off HPFP rail feed using ZTSE4861 Fuel Rail Block-off Plugs.
6. Crank engine for 15 to 20 seconds while monitoring Fuel Rail Pressure; record results on Diagnostics Form.
    - Isolate the injector causing the problem; replace that injector and all the injector tubes that were removed during the test procedure.

HP.6 - Injector Leak Isolation Check (Right Bank)

Purpose

Check for and isolate leaking injector.

Possible Causes

- High-pressure fuel line leaks (internal or external fuel lines)
- Fuel injectors
- Cracked or leaking fuel lines

Tools

- ZTSE4861 – Fuel Rail Block-off Plugs

Procedure

1. Restore 12-pin injector connection to right cylinder head.
2. Restore HPFP right tube assembly to cylinder head.
3. Remove right cylinder head valve cover.
4. Isolate leaking injector by removing one injector tube at a time; capping off HPFP rail feed using Fuel Rail Block-off Plugs ZTSE4861.
5. Crank engine for 15 to 20 seconds while monitoring Fuel Rail Pressure; record results on Diagnostics Form.
    - Isolate the injector causing the problem; replace that injector and all the injector tubes that were removed during the test procedure.

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Diagnostic Form

Required Test Procedures

Do required test procedures in sequence. Doing a required test out of sequence can cause incorrect results.

1. Initial Key On Check

☐ Check Integral Digital Display for WATER IN FUEL indicator.

Does WATER IN FUEL indicator stay on?	☐ Yes	☐ No

● If WATER IN FUEL stays on, go to Fuel Quality Check.

2. Visual Inspection

☐ Check all fluid levels.
☐ Inspect electrical connectors.
☐ Inspect for visible exhaust damage.
☐ Inspect air filter minder.
Note: If filter minder indicates a restriction, go to Intake Restriction Test in Performance Diagnostics.

Are all fluid levels within specifications?	☐ Yes	☐ No
Are power and ground connections okay?	☐ Yes	☐ No
Is air filter okay?	☐ Yes	☐ No
Is exhaust system okay?	☐ Yes	☐ No

Comments:

●If intake system repair is made or intake system is disturbed, go to MAF Sensor Test in Section 6 of the EGES-485.

3 EST Connection and Data Recording

☐ Use ServiceMaxx™ software to record KOEO pressure and temperature values.
NOTE: Ideally, allow the engine to cold soak for at least 2 hours before recording results.

Signals	Specification	Actual
Barometric pressure	-	
Air Inlet Temperature	-	
Engine Coolant Temperature	-	
Engine Oil Temperature	-	
Intake Manifold Temperature	-	
Fuel Delivery Pressure	5 psi	
Fuel Rail Pressure	0 psi	
DPF Differential Pressure	0 psi	

● If sensor is out of specification, go to suspect sensor in Electronic Control Systems Diagnostics.

U02414

Figure 60 Diagnostics Form 0000003381 (Performance Diagnostics)

The Performance Diagnostics Form directs technicians to systematically troubleshoot a performance condition and avoid unnecessary repairs.

This Diagnostic Manual section shows detailed instructions of the tests on the form. The manual should be used along with the form and referenced for supplemental test information. Use the form as a worksheet to record test results.

Do Test Procedures in sequence. Doing a test out of sequence can cause incorrect results. If the customer complaint is found and corrected, it is not necessary to complete the remaining tests.

See appropriate section of this manual for Diagnostic Trouble Codes (DTCs) and engine specifications.

Diagnostics Form 0000003381 is available in 50-sheet pads. To order technical service literature, contact your International dealer.

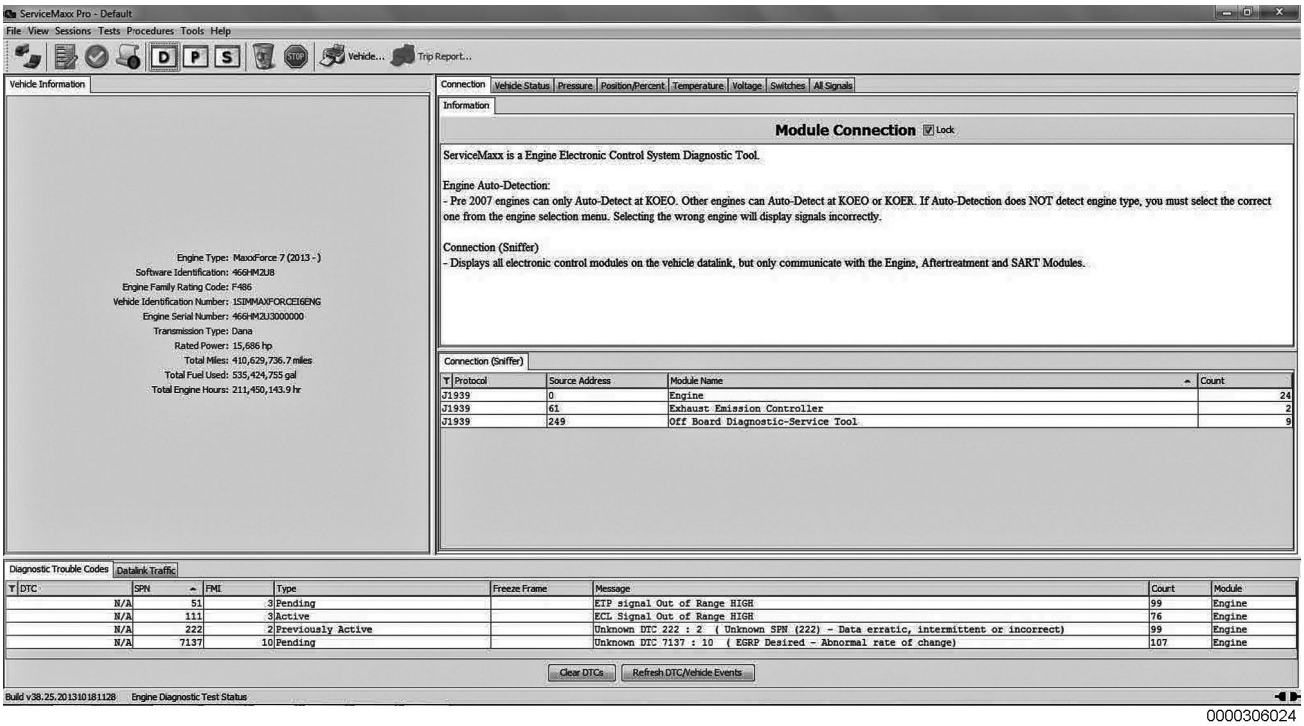
Diagnostics Form Header Information

Note: This form must be completed before calling for technical assistance.		
Technician:	Date:	Unit Number:
ECM Calibration:	Miles:	Hours:
Engine Serial Number:	Horsepower Rating:	Torque:
Transmission (select one):	☐ Manual	☐ Automatic
VIN:		
Complaint:		

U02413

Enter Diagnostics Form Header Information

1. Technician
2. Date
3. Unit No. (dealer's quick reference number)
4. Customer complaint (interview driver)
5. Connect Electronic Service Tool (EST) with ServiceMaxx™ software to Diagnostic Connector.
6. Using the EST with ServiceMaxx™ software, log all vehicle information needed on the form header.



0000306024

Figure 62 ServiceMaxx™ opening screen (example)

7. Verify the following vehicle information matches the ServiceMaxx™ displayed information:
   - Vehicle Identification Number (VIN)
   - Electronic Control Module (ECM) calibration
   - Rated Horsepower (HP)
   - Engine Family Rating Code (EFRC)
   - Transmission
   - Engine Serial Number (SN)

     Note: The engine serial number is located on the right side of the crankcase, below the cylinder head. It is also on the engine emission label on the valve cover.
8. Enter the following information on the Diagnostics Form:
   - Odometer (miles)
   - Engine hours
   - Intake air temperature
   - Coolant temperature

Test Procedures

1. Initial Key On Check

Purpose

Determine the following:

- Is the Engine Control Module (ECM) powered up?
- Is the WATER IN FUEL lamp on?

Tools

None

Procedure

1. Turn ignition switch to ON. Do not start engine. Check for the following:
   - Amber Warning Lamp (AWL)
2. If the AWL stays on and a text message is displaying Water in Fuel, go to Fuel Quality Check (page 170).

Possible Causes

WAIT TO START lamp does not illuminate

- No key power (VIGN)
- Failed ECM ground circuit
- No power from main power relay to ECM
- ECM failure
- Amber WAIT TO START lamp is burned out (will not cause hard start or no start).
- CAN link to instrument panel not working (will not cause hard start or no start).

NOTE: Instrument panel AWL should cycle ON, then OFF, if there is no water in the system. Lamp will stay ON if water is detected.

AMBER WARNING lamp stays illuminated

- Water in fuel
- Electrical circuit failure

2. Visual Inspection

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

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

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

WARNING: To prevent personal injury or death, provide proper ventilation when operating an engine in a closed area. Inhalation of exhaust gas can be fatal.

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

Purpose

Check all fluid levels and inspect engine systems for problems such as leaks, open connections, harness chaffing.

Tools

None

Engine Oil

NOTE: Check engine oil level prior to starting performance diagnostics.

1. Park vehicle on level ground and check oil level.

   NOTE: Turn ignition switch to OFF and shut down engine. Wait 15 minutes for oil level to stabilize.

2. Use oil level gauge (dipstick) to verify engine oil level.
3. Record results on Diagnostics Form.
   - If level is below specification, inspect for leaks, oil consumption, or improper servicing. If engine oil level is low, fill to specification.
   - If level is above specification, inspect for fuel dilution, coolant contamination, or improper servicing. If engine oil level is above specification, drain to specification.
   - If level is to specification, no oil level adjustment is required.

CAUTION: If oil is contaminated, oil and filter must be replaced.

NOTE: If change engine oil indicator is illuminated, check maintenance history. See *Engine Operation and Maintenance Manual* for information on resetting service intervals.

Fuel Level

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

1. Park vehicle on level ground.

2. Check instrument panel gauge and look into fuel tank to verify fuel level.
   - If gauge reads above empty, but tank is empty, diagnose dash gauge. Verify sufficient fuel level before diagnosing a pressure problem.
   - If fuel tank is empty, add fuel, and prime fuel system following procedures in the *Engine Operation and Maintenance Manual*.
   - If no problems are found, no action is required.

Engine Coolant Level

1. Park vehicle on level ground.

WARNING: Turn ignition switch to OFF, shut down engine, and allow to cool. Ensure coolant temperature has stabilized to a safe temperature and pressure.

2. Check coolant level as indicated on deaeration tank level window.
3. Record results on Diagnostics Form.
    - If level is above or below deaeration tank fill level, inspect for leaks, coolant in the oil, or coolant in the intake or exhaust. See Coolant Over-Temperature Diagnostics and Repair (page 91), Fuel in Coolant (page 100), and Combustion Leaks to Coolant (page 81) in the “Engine Symptoms Diagnostics” section of this manual.
    - If level is at deaeration tank fill level, and no tank contamination is evident, no repair is required.

NOTE: If coolant is contaminated, replace coolant.

CAUTION: Coolant in the Exhaust could damage the Diesel Particulate Filter (DPF) and Diesel Oxidation Catalyst (DOC). Inspect DPF and DOC for damage. See AFT System (page 207) in the “Electronic Control Systems Diagnostics” section of this manual for inspection of the DPF and DOC.

Electrical System

Inspect batteries and electrical system (engine and vehicle) for poor or loose connections, corroded terminals, or broken and damaged wires.

- If electrical system problem is found, make repairs as required.
- If no problems are found, no repair is required.

Exhaust System

Inspect exhaust system (engine and vehicle) for damaged or plugged tailpipe.

- If exhaust system problem is found, make repairs as required.
- If no problems are found, no repair is required.

Intake Air System and Charge Air Cooler (CAC)

1. Inspect CAC system, including intercooler and all intake piping and ducts, for leaks, and damage.

    Inspect the following parts for restriction, damage, or incorrect installation:

    - Air inlet hoses and ducts
    - Air filter housing and filter element
    - CAC and piping
    - Air filter inlet and duct - look inside duct and remove any restrictions.

Figure 63 Air filter restriction gauge

2. Check the air filter restriction gauge.
3. Inspect all CAC and intake air connections and clamps.
4. If a CAC or intake air system problem is found, repair as required.

   NOTE: If repair is made and intake system is disturbed, run the KOER MAF Sensor Calibrate Procedure (page 76).

3. EST Connection and Data Recording

NOTE: See the “Diagnostic Software Operation” (page 67) section in this manual for specific EST software procedures to do this test.

NOTE: Ideally, allow the engine to cold soak for at least 2 hours before recording results.

Purpose

Determine if engine sensor readings are within specification for engine starting.

Monitoring Engine Systems using an EST

Tools

- EST with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

Procedure

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

1. Turn ignition switch to ON, engine OFF.
2. Using the EST, start the ServiceMaxx™ software.

   NOTE: See “Diagnostic Software Operation” (page 67) section in this manual for ECM and EST communication problems.
3. Record the following sensor readings on Diagnostics Form:
   - Barometric Pressure

- Air Inlet Temperature
- Engine Coolant Temperature
- Engine Oil Temperature
- Intake Manifold Temperature
- Fuel Delivery Pressure
- Fuel Rail Pressure
- DPF Differential Pressure

4. If sensor is out of specification, go to suspect sensor diagnostic in “Electronic Control Systems Diagnostics” (page 191) section of this manual.
5. Open Output State Test High and Low in the ServiceMaxx™ software.
6. Record voltage signals for the following on the Diagnostics Form:
   - Exhaust Gas Recirculation Position (EGRP)
   - Engine Throttle Position (ETP)
7. If signal is out of specification, go to suspect actuator diagnostic in “Electronic Control Systems Diagnostics” (page 191) section of this manual.
8. Monitor DPF status signal value and record on Diagnostics Form:
   - If DPF status is Regen needed-critical level, run Onboard Filter Cleanliness Test

4. Check for DTCs

NOTE: 2010 model year vehicles no longer utilize DTC identification by number. DTCs are now identified using the SPN and FMI identifiers only. These two identifiers, known as the Suspect Parameter Number (SPN) and the Failure Mode Indicator (FMI), are displayed in the DTC Window.

- Suspect Parameter Number (SPN) – The SPN identifies the individual component causing the DTC.
- Failure Mode Indicator (FMI) – The FMI identifies the fault or condition affecting the individual component.
- Active DTCs are codes that are active now.
- Previously active DTCs are historical faults that may be caused by intermittent signals or an operating condition that is not currently present.

Purpose

Identify DTCs.

Tools

- EST with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Start the ServiceMaxx™ software.

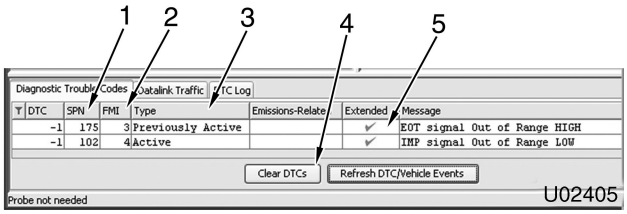


Figure 64 DTC window

1. Suspect Parameter Number (SPN) column
2. Failure Mode Indicator (FMI) column
3. DTC type column
4. Clear DTCs button
5. Extended (Freeze Frame)

NOTE: Click the extended button to receive a Freeze Frame data of when the code was set.

3. Record DTCs on the Diagnostics Form:
   - Correct any active DTCs. See the “Diagnostic Trouble Code Index” in this manual.
   - Investigate any previously active DTCs for possible intermittent operating conditions during which the DTC was set.

5. Fuel Quality Check

Purpose

Check for poor fuel quality or contaminants.

Tools

- Clear diesel fuel container (approximately 1 liter or 1 quart)
- Clear plastic hose

Possible Causes

- Debris, water, or ice in the fuel system
- Oil, gasoline, or kerosene present in fuel tank
- Fuel grade incorrect for cold temperature

Procedure

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

WARNING: To prevent personal injury or death, store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

1. Connect clear hose from fuel drain on filter housing to approved diesel fuel container.
2. Turn ignition switch to ON, engine OFF.

NOTE: Instrument panel Amber Warning Lamp (AWL) should cycle ON, then OFF, if there is no water in the system. Lamp will stay ON if water is detected.

3. Turn ignition switch to OFF.

   NOTE: To prevent aeration of the fuel, wait 30 to 60 seconds after turning ignition switch OFF before opening fuel drain valve.

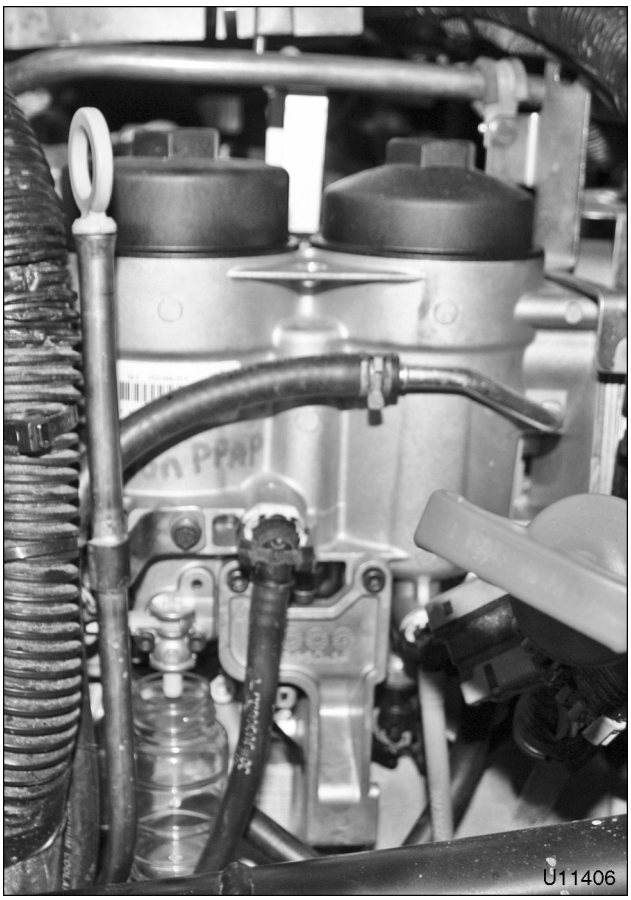


Figure 65 Fuel Sample

4. Drain enough fuel into container to effectively check for contamination.
5. Check for water, waxing, icing, sediment, gasoline, or kerosene by shaking fuel sample container and letting contents settle.
   - Sediments will fall to the bottom of the fuel sample container.
   - Gasoline and kerosene will separate from the diesel fuel.
   - Waxing or icing will prevent diesel fuel from flowing out of the fuel drain valve.
   - If the fuel quality is questionable, correct the problem. Take another sample to verify fuel quality is satisfactory.
   - If the fuel quality is satisfactory, continue to next test.

6. Fuel Pressure and Aeration Check

Purpose

Check for low Fuel Delivery Pressure (FDP) and aeration (bubbles in fuel).

Tools

- EST with ServiceMaxx™ software
- ZTSE4681 – Fuel Pressure Gauge
- Graduated cylinder (0 - 700 mL)

Check Fuel Delivery Pressure Using the EST

NOTE: This procedure is only valid on engines equipped with an FDP sensor and will not test for aeration.

1. See “Appendix A: Performance Specifications” (page 813) in this manual for FDP specifications.
2. Turn ignition switch to ON, engine OFF.
3. Using the EST, start the ServiceMaxx™ software.
4. Monitor FDP and record results on Diagnostics Form.
    - If FDP is below specification, replace fuel filters, prime low-pressure fuel system and retest. See KOEO Fuel Pump Prime (page 75).
    - If still below specification after fuel filter replacement and priming procedure, continue to the next test.
    - If FDP is in specification, continue to next test.
    - If FDP is above specification, see FDP Sensor (page 538) in “Electronic Control Systems Diagnostics” section of this manual.

Check Fuel Delivery Pressure Manually

NOTE: This procedure is only valid on engines equipped with a fuel filter housing diagnostic valve.

NOTE: Verify water drain lever is closed properly. If any leaks are noticed, see the *Engine Service Manual* for o-ring replacement procedure.

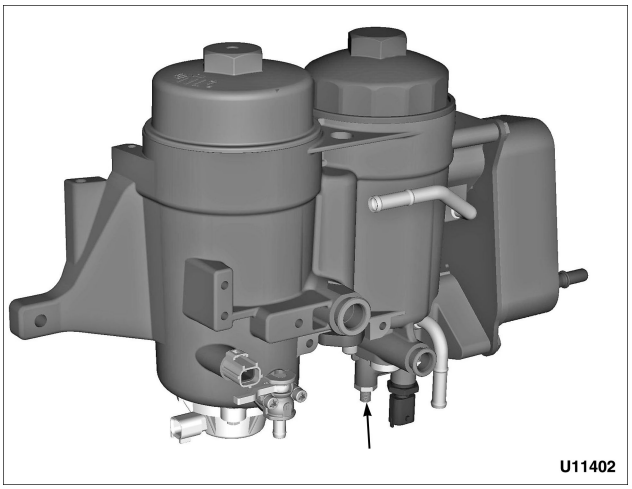


Figure 66 Fuel filter housing diagnostic valve

1. Connect Fuel Pressure Gauge ZTSE4681, with shutoff valve and clear drain hose, to the fuel test port located on the Fuel Filter module.
2. Route clear drain hose into an approved diesel fuel container.
3. Turn ignition switch to ON, engine OFF.
4. Open shutoff valve; check for aeration (bubbles flowing through clear line).
5. Close shut off valve and measure fuel pressure at the fuel filter housing diagnostic valve using the Fuel Pressure Gauge ZTSE4681.
6. Record results on Diagnostics Form.
    - If pressure is below specification, or aerated, go to Low-pressure Fuel System in Hard Start and No Start Diagnostics section (page 141).

NOTE: Analog or digital pressure gauge is required for measuring low-pressure side, if engine is not equipped with an FDP sensor.

7. Engine Low Idle to High Idle

NOTE: See “Diagnostic Software Operation” (page 67) section in this manual for specific EST software procedures to do this test.

Purpose

Determine Accelerator Pedal Position (APP) function, CAC function, and Fuel Pressure performance.

Tools

- EST with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- ZTSE4681 – Fuel Pressure Gauge with 30 psi gauge

Procedure

1. Retain fuel pressure gauge setup from previous test.

2. Turn ignition switch to ON, engine OFF.
3. Start the ServiceMaxx™ software.
4. Open the Performance Session.
5. Monitor APP sensor signal and depress accelerator pedal to the floor.
6. Record results on Diagnostics Form.
    - If APP signal does not go from 0% to 99.6%, or response time is slow, see APP (page 272) in “Electronic Control Systems Diagnostics” section of this manual.
7. Start engine and press the record button.
8. Inspect CAC hose for collapsing while running test.
9. Allow engine to idle for 20 seconds.
10. Depress accelerator pedal to the floor and hold for 20 seconds.
11. Return to low idle and stop recording; record CAC observation on Diagnostics Form.
    - If CAC collapses during test, inspect CAC for plugging and check if the Low-pressure Turbocharger spins freely.
12. Play back logging and record results on Diagnostics Form.
    - If Fuel Pressure drops below specification, go to “Low-pressure Fuel System” in the Hard Start, No Start (page 122) section of this manual.
    - If Fuel Rail Pressure is below specification, verify Low-pressure Fuel System is working correctly, before diagnosing High-pressure Fuel System.
    - If engine does not accelerate smoothly or feels unbalanced, run the Relative Compression Test (page 184) and Cylinder Cutout Test (page 184).
    - If Intake Manifold Pressure is below specification, go to Turbocharger Checks (Under Boost) (page 177).
    - If all readings are within specification, go to Road Test.

8. Road Test (0–60 mph, Full Throttle)

NOTE: See “Diagnostic Software Operation” (page 67) section in this manual for specific EST software procedures to do this test.

Purpose

Check for unacceptable engine performance at 0–60 mph, full throttle by means of maximum boost and minimum fuel pressure.

Tools

- EST with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

Unacceptable Boost Possible Causes

- Boost leaks
- Restricted intake or exhaust
- Control system faults
- Biased IMP sensor
- Power cylinder condition
- Exhaust leaks
- Biased MAF sensor
- Low fuel pressure
- Failed EGR valve
- Failed turbochargers
- Failed fuel injectors
- Plugged DPF
- Plugged DOC

Unacceptable Fuel Rail Pressure Possible Causes

- FRP circuit fault
- Failed electric fuel pump
- Failed high-pressure fuel pump
- Failed fuel injectors
- High-pressure fuel line leaks
- Biased FRP sensor

Unacceptable Fuel Pressure Possible Causes

- Fuel filter blockage
- Incorrect fuel grade for cold climate
- Debris, water, or ice in fuel system
- Oil, gasoline, or kerosene present in fuel system
- Excessive leak on high-pressure fuel side
- Fuel supply line leak, damage, or blockage
- Air leak in suction side fuel line or filter assembly
- Failed fuel regulator valve (located in fuel filter housing)
- Failed fuel pump
- Failed fuel thermal valve

WARNING: To prevent personal injury or death, read all safety instructions in the “Safety Information” section of this manual.

Procedure

1. Retain Fuel Gauge setup from previous test.
2. Turn ignition switch to ON, engine OFF.
3. Start the ServiceMaxx™ software and ensure full functionality.

NOTE: See “Diagnostic Software Operation” (page 67) in this manual for Engine Control Module (ECM) and EST communication problems.

4. Open the Performance session.
5. Start engine and run until minimum engine coolant temperature of 158°F (70°C) is reached.
6. Set the Performance snapshot to record at 0.2 second interval for the following Parameter Identifiers (PIDs):
   - Engine Speed (ERPM)
   - Engine load (EL %)
   - Fuel Rail Pressure (FRP)
   - Intake Manifold Pressure (IMP)
   - Vehicle speed
7. Find an open stretch of road. Start snapshot recording. When driving conditions are safe, select a suitable gear and accelerate from 0 to 60 mph at uninterrupted full throttle.
8. When road test is complete, stop snapshot recording.
9. Save snapshot for review and future reference.
10. Replay recording using the Open Engine File feature. Review results for EL %, ERPM, IMP, FRP, and vehicle speed.
    - Pay close attention to rated HP and peak TQ rpm.
    - EL % should be near 100 percent.
11. Record results on Diagnostics Form.
    - If results are in specification, no repair is required.
    - If results are out of specification, correct problems. Test again to validate repairs.
    - If Fuel Pressure drops below specification, go to Special Test Procedures, Low Fuel Pressure in the Hard Start, No Start (page 122) section of this manual.
    - If Fuel Rail Pressure is below specification, verify Low-pressure Fuel System is working correctly, before trying to diagnose High-pressure System.
    - If engine does not accelerate smoothly or feels unbalanced, run the Relative Compression Test (page 184) and Cylinder Cutout Test (page 184).
    - If Intake Manifold Pressure is below specification, go to Turbocharger Checks (Under Boost) (page 177).
    - If Intake Manifold Pressure is above specification, go to Waste-gate checks (Over Boost) (page 177).

Special Test Procedures

Use any Special Test Procedure when directed from the above Required Procedures.

Turbocharger Checks (Under Boost)

Purpose

Check for Low-pressure Turbocharger malfunctions.

Possible Causes

- Failed turbocharger, wastegate actuator, or actuator solenoid

Procedure

1. Recall presence of any concerning noise during road test. Record results on Diagnostics Form.
2. If a concerning audible noise can be heard, cease operation and attempt to further isolate the issue.
3. Visibly inspect AMS system for leaks or broken clamps. Record results on Diagnostics Form.
4. Visibly inspect CAC and exhaust system for oil carry-over. Record results on Diagnostics Form.
5. If the CAC is filled with oil, drain oil from cooler, perform Blow-by Test and Crankcase Pressure Test. If within specification replace turbocharger(s) clean out all components with oil contamination as necessary.
6. Remove turbocharger compressor inlet tube and verify turbo vanes are not damaged and spin freely. Record results on Diagnostic Form.
7. If Turbocharger vanes are damaged or do not spin freely, replace Turbocharger according to the *0000002383 Engine Service Manual*.

Wastegate Checks (Over Boost)

Purpose

Check Turbocharger Wastegate operation.

Tools

- EST with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- ZTSE4409 – Pressure Test Kit

Procedure

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

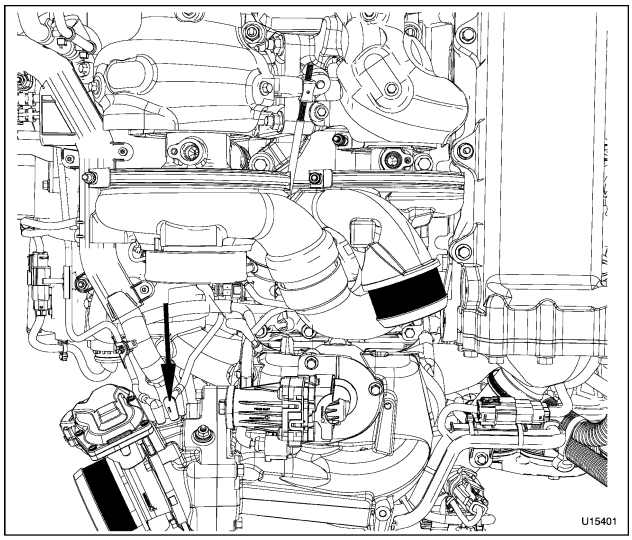


Figure 67 Location of Wastegate Hose Next to ETV

NOTE: If TC2 Wastegate is stuck at 100% during engine operation, cycle the key allowing the ECM to shut down, then key back on and recheck operation. (This condition may occur after a MAF recalibration has been performed.)

1. Use Pressure Test Kit ZTSE4409 with regulated compressed air.
2. Remove Wastegate hose next to Engine Throttle Valve.
3. Connect to regulated air.
4. Apply 186 kPa (27 psi) to supply hose.
5. Turn ignition switch to ON, engine OFF.
6. Using the EST, start ServiceMaxx™ software.
7. Run KOEO Output State Tests High and Low while visually monitoring wastegate movement.

NOTE: Vented air is directed to the turbo inlet elbow.

8. Record results on the Diagnostics Form.

- If Wastegate actuator cycles open and closed during the Output State Tests High and Low, turbo control is working correctly.
- If wastegate does not open, check wastegate actuator diaphragm for leakage by placing your hand near actuator linkage rod at actuator housing. If there are no signs of leakage, check for frozen wastegate lever. If wastegate actuator is leaking, replace wastegate actuator following procedures in 0000002383 MaxxForce® 7 Engine Service Manual. If diaphragm and lever are okay, continue to next step.

9. Remove Pressure Test Kit from wastegate hose and restore to pretest condition.
10. Connect regulated air directly to the pneumatic actuator.
11. Apply 186 kPa (27 psi) of regulated air to actuator.
12. Visually monitor Wastegate movement.

13. Record results on Diagnostics Form.
    - If Wastegate actuator does not move, see TC2WG Solenoid (page 698) in “Electronic Control Systems Diagnostics” section of this manual.
    - If Wastegate does not open, replace Turbocharger following procedures in the *Engine Service Manual*.

Charge Air Cooler (CAC) Checks

Purpose

Inspect for clogged or leaking CAC.

Possible Causes

- Loose hose clamps
- Collapsing CAC hoses
- Engine oil in CAC

Procedure

1. Inspect CAC hoses for damage or leaks.
2. Verify all CAC hose clamps are tight.
3. Remove turocharger-side CAC hose.
4. Inspect hose and CAC for engine oil.
5. Record results on Diagnostics Form.
    - If CAC or hose is filled with oil, drain oil from cooler, replace breather filter, and inspect breather supply hose for restriction or leaks.
    - If breather was replaced and supply hose is good, but oil is still entering the CAC, go to Blow-by Test and Crankcase Pressure Test (page 181).

Blow-by Test

Purpose

Measure the condition of the power cylinders.

Tools

- Standard plug (obtain locally)
- ZTSE4146A – Orifice
- ZTSE4284 – Crankcase Pressure Test Adaptor
- ZTSE4409 – Pressure Test Kit

Possible Causes

- Dirt in air induction system
- Badly worn or broken rings
- Cylinder bores badly worn or scored

- Leaking valve seals or worn valve guides
- Failed turbocharger seals
- Damaged turbo boost feed lines

Procedure

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To prevent personal injury or death, make sure the parking brake is set, the transmission is in neutral or park, and the wheels are blocked when running the engine in the service bay.

NOTE: Engine Coolant Temperature must be above 158°F (70°C) before testing.

1. Ensure the engine oil level is not above full mark and the oil level gauge is secured.
2. Inspect air induction for dirt ingestion.
   - If dirt has been ingested into air induction, go to Crankcase Pressure Test (page 181) in this section of the manual.
   - If no dirt has been ingested into air induction, continue to next step.

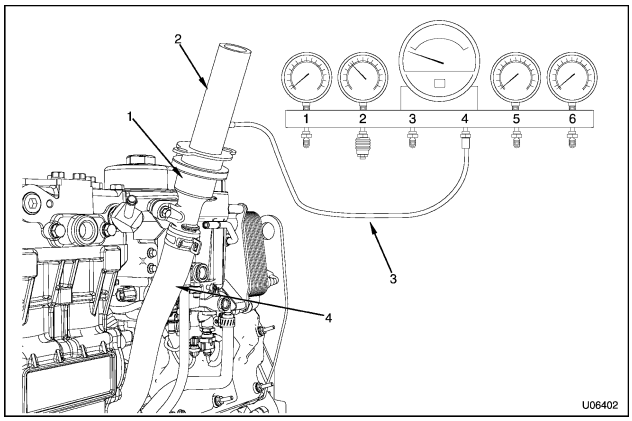


Figure 68 Blow-by Test Tool Setup

1. Crankcase Pressure Test Adaptor
2. Orifice
3. Line to Magnahelic Gauge
4. Oil Fill Tube

3. With engine OFF, remove oil fill cap.
4. Install Crankcase Pressure Test Adaptor ZTSE4284 to oil fill tube.
5. Connect Orifice ZTSE4146A to Crankcase Pressure Test Adaptor ZTSE4284.
6. Connect a line from the Orifice ZTSE4146A to the magnahelic gauge on the Pressure Test Kit ZTSE4409.
7. Using a standard plug, block off road draft tube, located on the bottom right side of the engine.

8. Start engine and run at low idle rpm. Monitor magnahelic gauge and record low idle blow-by pressure on Diagnostics Form.
9. Run engine at high idle (no load) rpm. Monitor magnahelic gauge and record high idle blow-by pressure on Diagnostics Form.

   NOTE: Allow the magnahelic gauge reading to stabilize before recording pressure reading.

   - If pressure is below specification, go to Crankcase Pressure Test (page 181).
   - If pressure is above specification, go to Relative Compression Test (page 184).

Crankcase Pressure Test

Purpose

Measure the amount of pressure in the crankcase.

Tools

- Adaptor (locally obtained)
- ZTSE4409 – Pressure Test Kit

Possible Causes

- Dirt in air induction system
- Badly worn or broken rings
- Cylinder bores badly worn or scored
- Leaking valve seals or worn valve guides
- Failed turbocharger seals
- Breather system restriction

Procedure

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To prevent personal injury or death, make sure the parking brake is set, the transmission is in neutral or park, and the wheels are blocked when running the engine in the service bay.

NOTE: Ensure engine is above operating temperature of 158°F (70°C) before starting test.

1. Ensure the engine oil level is not above full mark and the oil level gauge is secured.

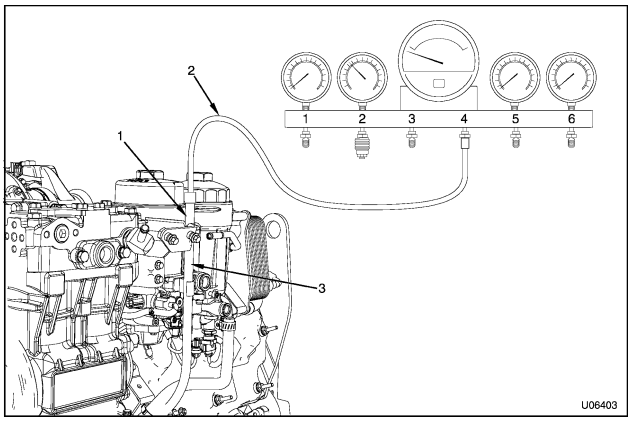


Figure 69 Crankcase Pressure Test Tool Setup

1. Adaptor (locally obtained)
2. Line to Magnahelic Gauge
3. Dipstick tube

2. Remove the dipstick from the dipstick tube. Attach 11/16-in hose with clamps and 1/4-in pipe adaptor to magnahelic gauge on Pressure Test Kit ZTSE4409.
3. Start engine and run at high idle (no load) rpm. Allow reading to stabilize, before recording crankcase pressure reading.
4. Record crankcase pressure on Diagnostics Form.
   - If pressure is within specification, no repair is needed.
   - If pressure is above specification, continue to next step.
5. Turn engine OFF. Replace the breather filter and recheck crankcase pressure. See *Engine Operation and Maintenance Manual* for breather filter replacement procedure.
   - If pressure is within specification, no repair is needed.
   - If pressure is above specification, continue to the Relative Compression (page 184) test in this section.

Intake Air Restriction Test

Purpose

Check for restrictions causing performance problems.

Tools

- Engine or dash-mounted air restriction indicator

Possible Causes

- Restricted air filter inlet and ducts
- Restricted, dirty, or collapsed air filter element
- Leaking or damaged Charge Air Cooler (CAC) couplings
- Restricted or collapsed inlet piping or hoses
- Exhaust system damage
- Restricted or full Diesel Particulate Filter (DPF)

Figure 70 Air cleaner restriction indicators

1. Mounted on air cleaner
2. Mounted on instrument panel

Procedure

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

NOTE: Intake Air Restriction should be less than 172-inH2O at 100 percent engine load, 2600 rpm.

1. Locate air restriction indicator. Run engine at high idle, no load.
2. Record intake restriction on Diagnostics Form.
   - If any restriction is detected, repair as required. If air filter is plugged, replace air filter. Reset restriction indicator and test again to validate repair.
   - If restriction is not apparent, no repair is required.

Relative Compression Test

NOTE: See the “Diagnostic Software Operation” (page 67) section in this manual for specific EST software procedures to do this test.

Purpose

Check for low cylinder compression

NOTE: Use a battery charger when performing this test. It is important that cranking rpm remains consistent throughout test.

Tools

- EST with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

Possible Causes

- Loose fuel injector
- Valve train damage
- Power cylinder damage

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Start ServiceMaxx™ software.
3. Select Diagnostics from the menu bar and V8 Relative Compression Tests from the drop-down menu.
4. Follow the on-screen instructions.
5. Record results on Diagnostics Form.
    - If the rpm difference for one cylinder is significantly less than the other cylinders, that cylinder is suspect for compression loss.

Cylinder Cutout Test

NOTE: See the “Diagnostic Software Operation” (page 67) section in this manual for specific EST software procedures to do this test.

Purpose

Determine the cause of rough engine idle.

NOTE: Before running this test, you must first verify there are no problems with the fuel system, then run the Relative Compression Test to verify compression is evenly balanced.

Tools

- EST with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

Possible Causes

- Open or shorted injector wiring

- Failed injector
- Failed ECM
- Power cylinder problem

Procedure

1. Start the engine.
2. Start ServiceMaxx™ software.
3. Select Tests from menu bar.
4. Select Cylinder Cutout Test from drop-down menu.
5. Select cylinder number and select Run (injector selected will be disabled and engine noise should change).
6. Record results on Diagnostics Form.
7. Select Normal Operation. Injector will be enabled and engine noise should return to previous state of operation.
8. Repeat steps 5 through 7 for the remaining cylinders.
    - Listen for tone changes from cylinder to cylinder.
    - If test identifies a suspect cylinder, replace that injector.

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Description

Section Information

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

- Suspect Parameter Number (SPN) and Failure Mode Indicator (FMI) with possible cause
- Circuit diagram
- Component function
- Circuit operation
- Component location
- Electronic Service Tool (EST) list
- Sensor End Diagnostics (with ServiceMaxx™ software)
- Pin-point Diagnostics (without ServiceMaxx™ software)
- Harness resistance check
- Operational voltage check (most components)

Electronic Control System Diagnostics Form

0000003201 Diagnostic Form

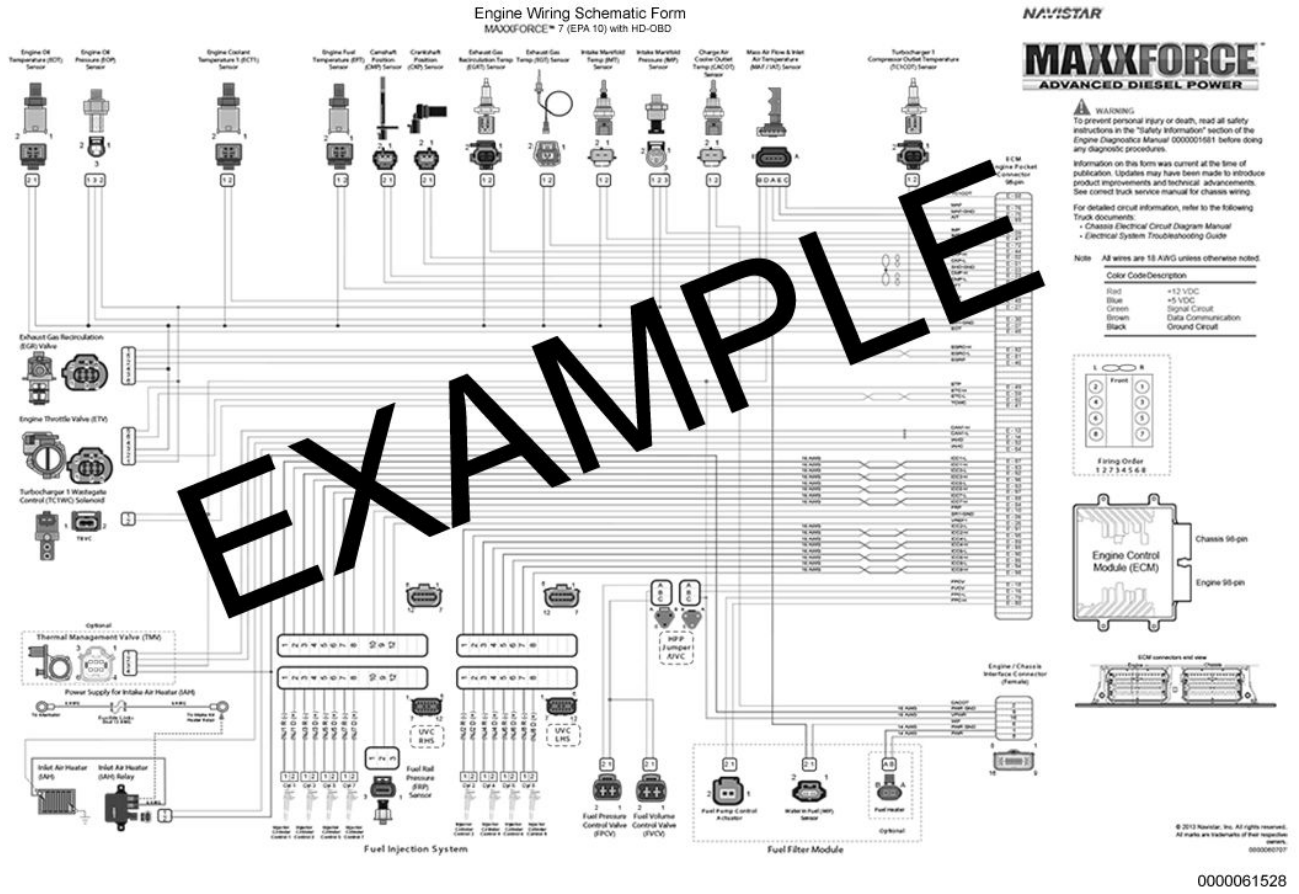


Figure 71 0000003201 (Front Side)

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

The Electronic Control System Diagnostics form consists of a circuit diagram for electrical components mounted on the engine and chassis side. For a detailed description of chassis circuits, circuit numbers, or connector and fuse locations, see truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*. See “Appendix B: Signal Values” (page 819) for signal values.

Diagnostic Form 0000003201 is available in 50-sheet pads. To order technical service literature, contact your International dealer.

Sensor and Actuator Locations

Engine Mounted Components

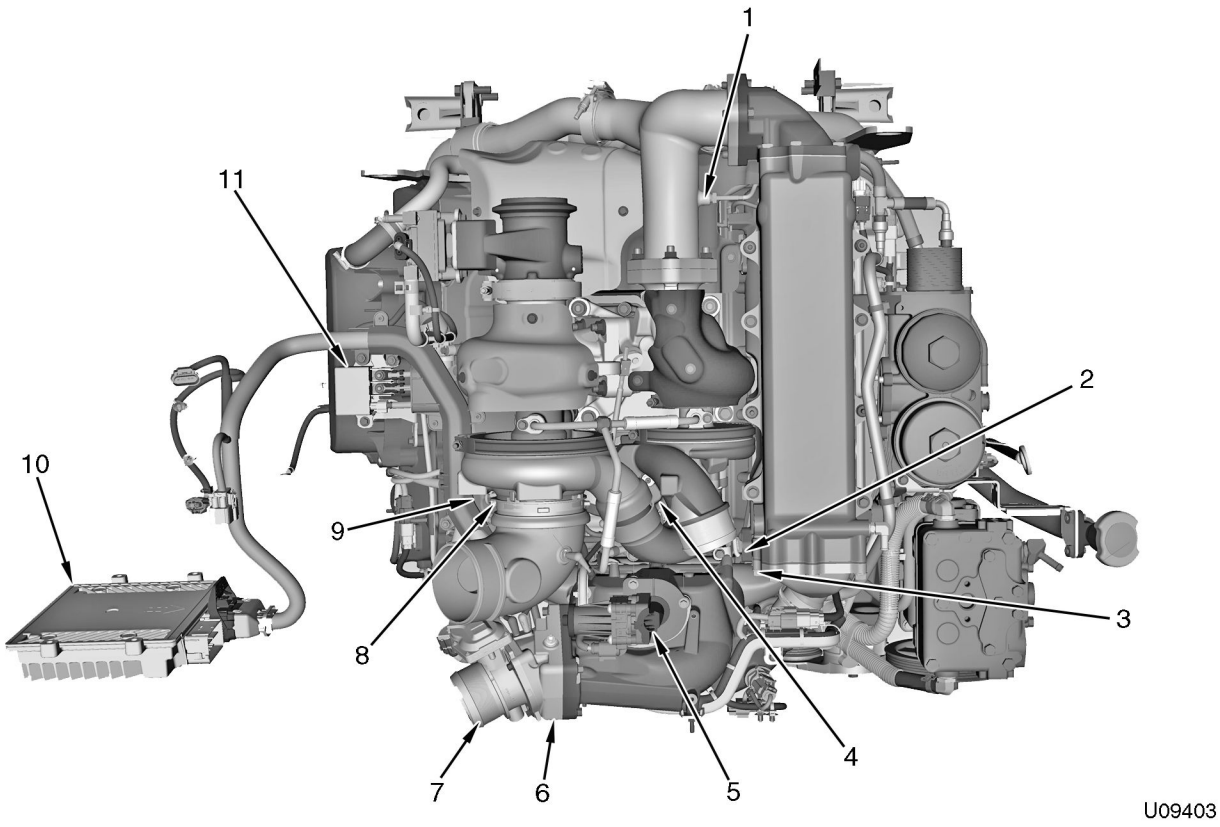


Figure 72 Engine View – Top

1. Exhaust Gas Temperature (EGT) sensor
2. Engine Oil Temperature (EOT) sensor
3. Engine Oil Pressure (EOP) sensor
4. Turbocharger 2 Wastegate (TC2WG)
5. Exhaust Gas Recirculation (EGR) valve
6. Inlet Air Heater (IAH)
7. Engine Throttle Valve (ETV)
8. Intake Manifold Pressure (IMP) sensor
9. Intake Manifold Temperature (IMT) sensor
10. Engine Control Module (ECM)
11. Inlet Air Heater (IAH) relay

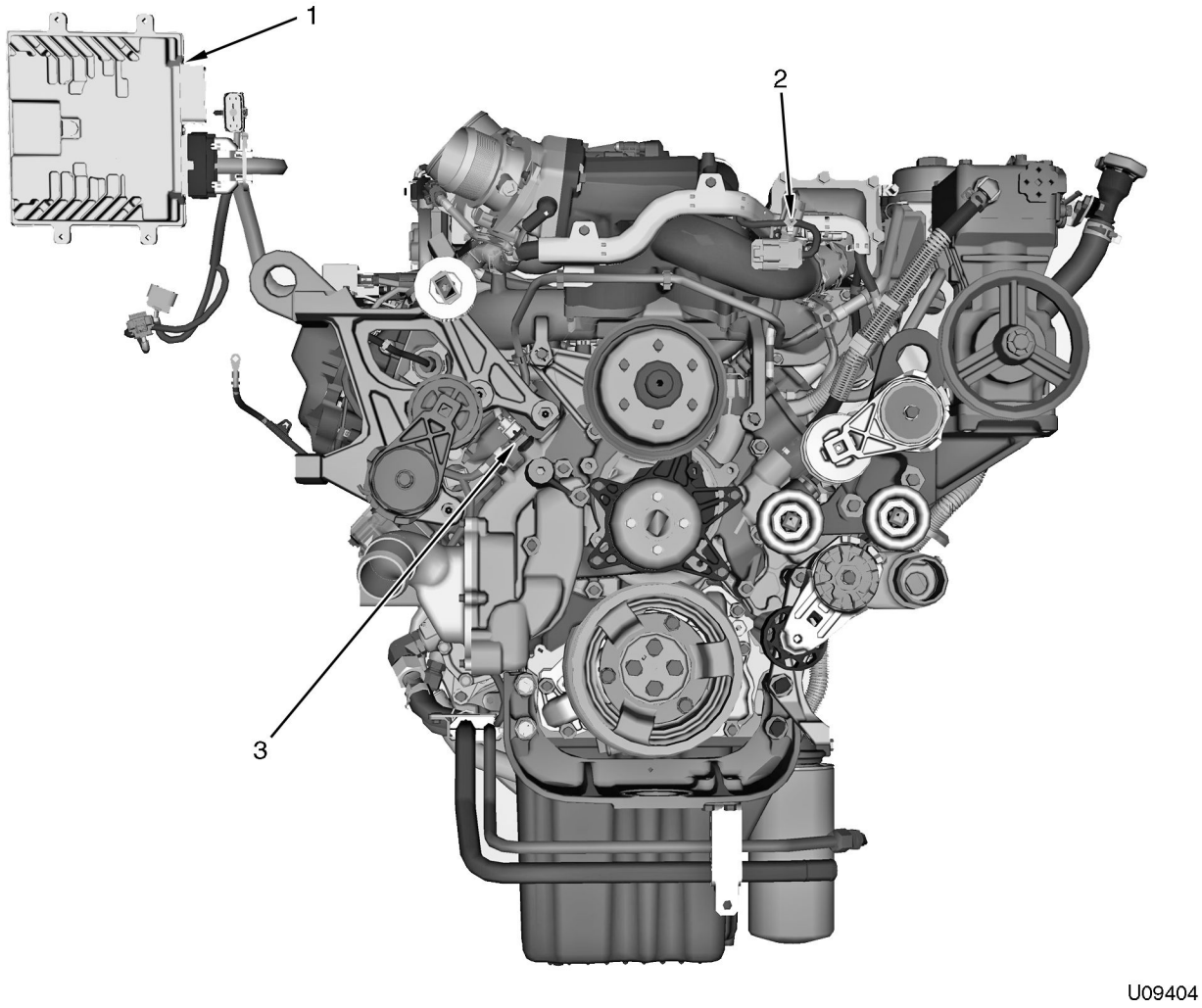


Figure 73 Engine View – Front

1. Engine Control Module (ECM)
2. Exhaust Gas Recirculation Temperature (EGRT) sensor
3. Engine Coolant Temperature 1 (ECT1) sensor

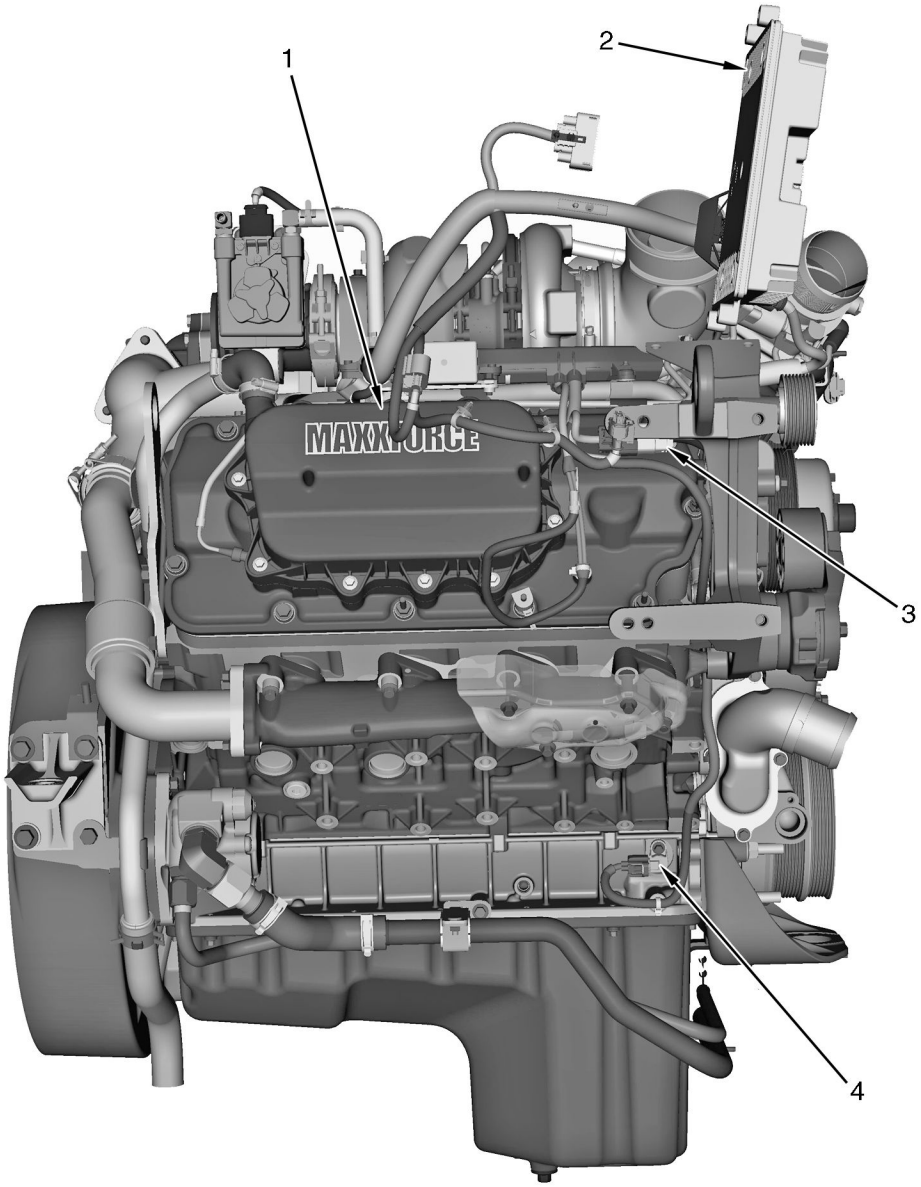


Figure 74 Engine View – Right

1. Fuel Rail Pressure (FRP) sensor (under valve cover)
2. Engine Control Module (ECM)
3. 12-Pin UVC connector
4. Crankshaft Position (CKP) sensor

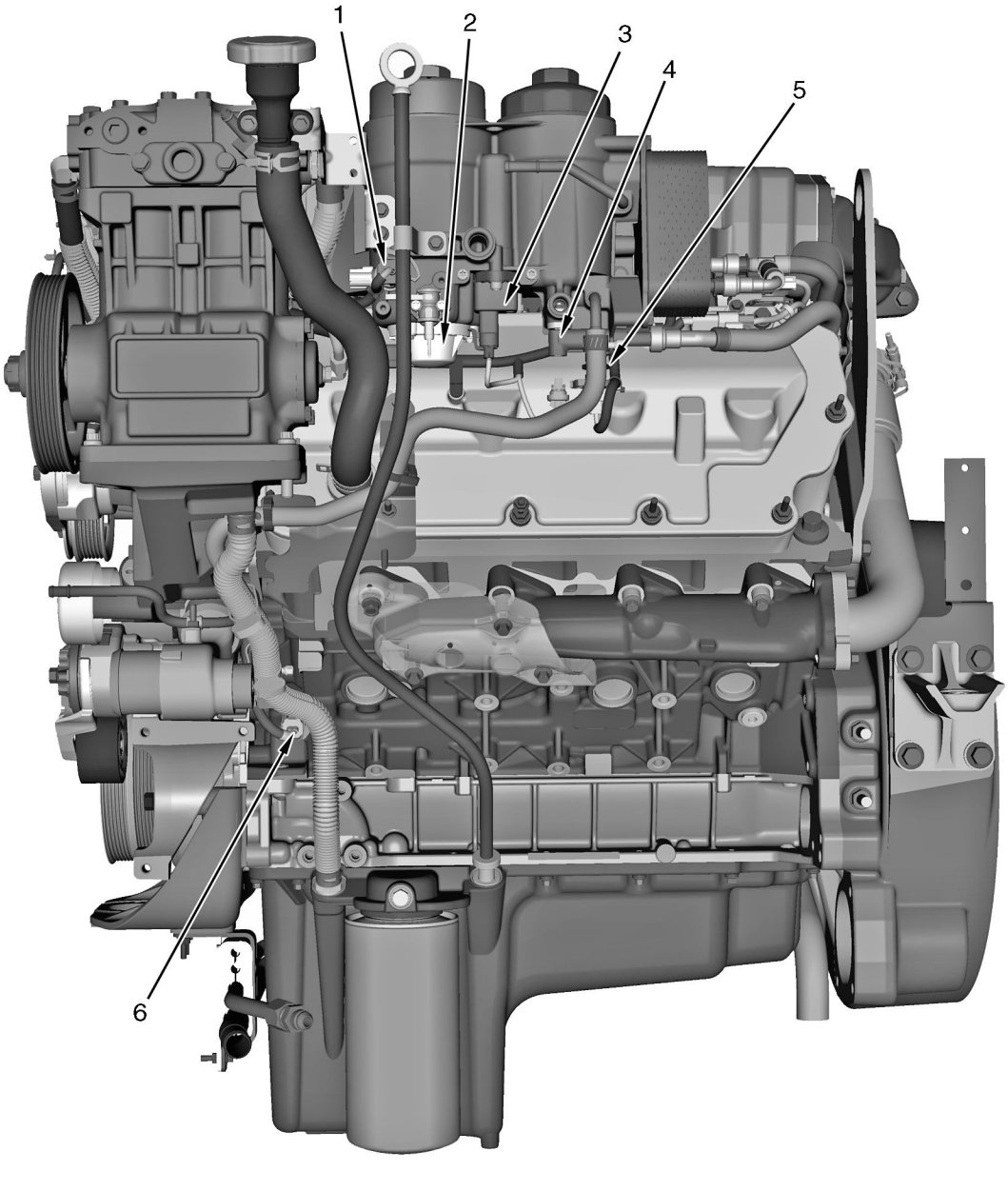
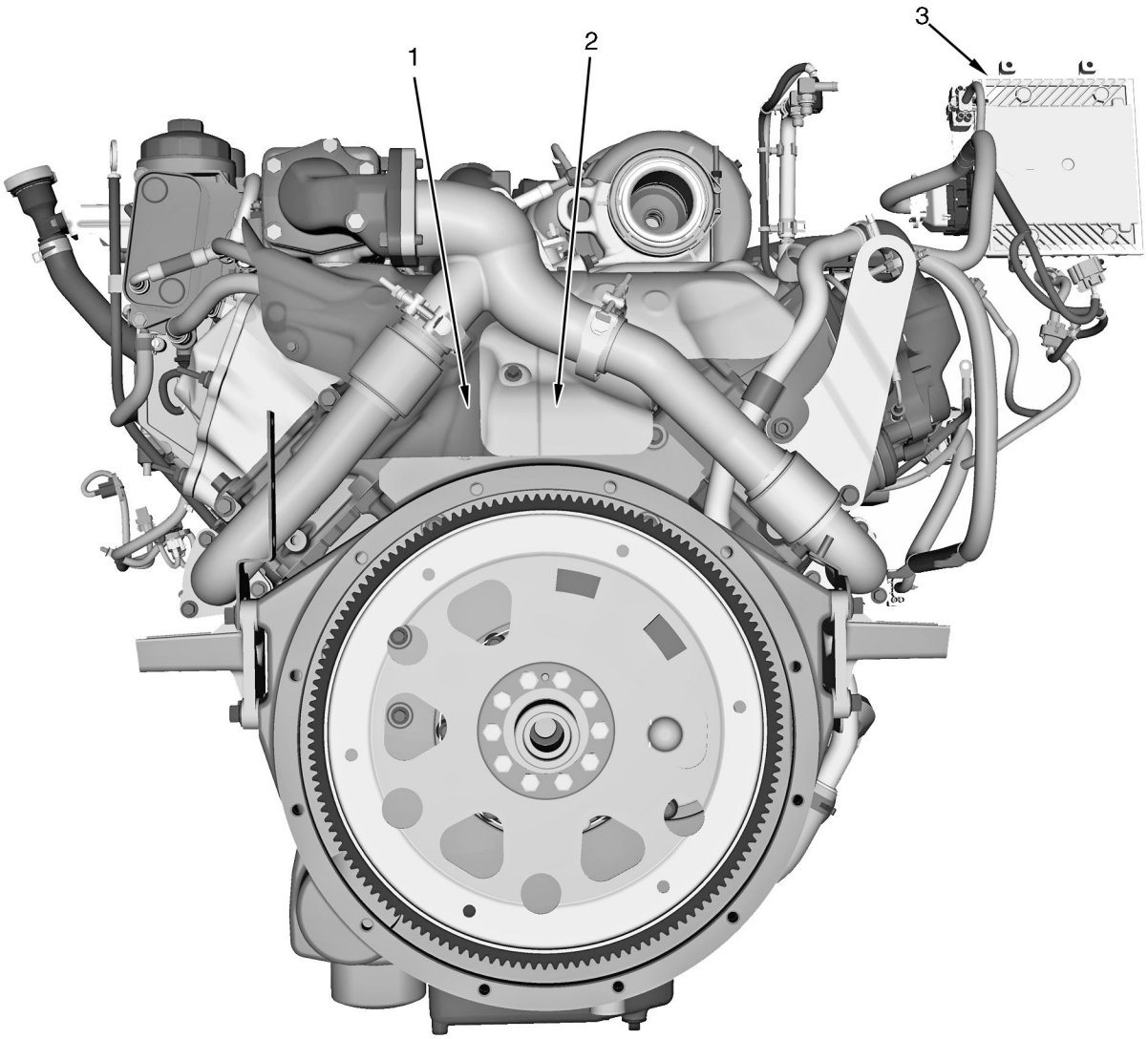


Figure 75 Engine View – Left

1. Water In Fuel (WIF) sensor
2. Fuel pump
3. Fuel Heater (if equipped)
4. Fuel Delivery Pressure (FDP) sensor (if equipped)
5. Engine Fuel Temperature (EFT) sensor
6. Camshaft Position (CMP) sensor



U09401

Figure 76 Engine View – Rear

1. Fuel Pressure Control Valve (FPCV) sensor (under heat shield)
2. Fuel Volume Control Valve (FVCV) sensor (under heat shield)
3. Engine Control Module (ECM)

Diagnostic Procedure Process

Description

The test procedures in this section are based on the assumption there is a DTC or problem with the component being tested.

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

Pin-grip Inspection

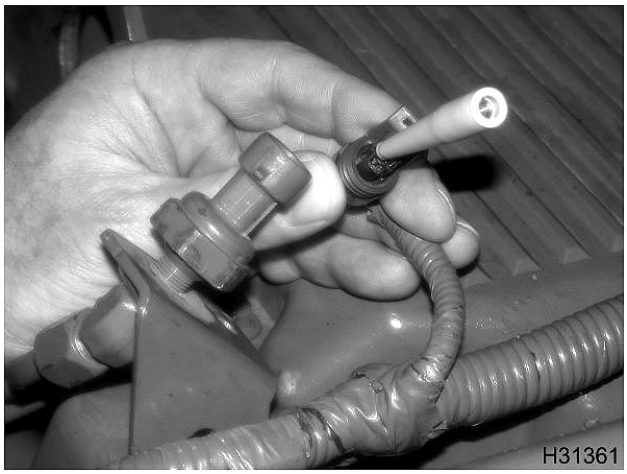


Figure 77 Pin grip check

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 Kit.

Diagnostics with EST

Sensors can be diagnosed quickly using an Electronic Service Tool (EST) with ServiceMaxx™ software. The tool monitors sensor signals back to the Engine Control Module (ECM) while testing the sensor's harness connection. Start this procedure with Sensor End Diagnostics.

Actuators can be diagnosed using ServiceMaxx™ software to command Output State test (high or low) while measuring voltage at the actuator's harness connection.

Diagnostics without EST

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

Sensor End Diagnostics (with ServiceMaxx™ software)

Sensor End Diagnostics (2-Wire)

1. Connect the EST to the Diagnostic Connector.
2. Turn ignition switch to ON, engine OFF.
3. Start ServiceMaxx™ software.
4. Open the Continuous Monitor session. This session lists all engine sensors.

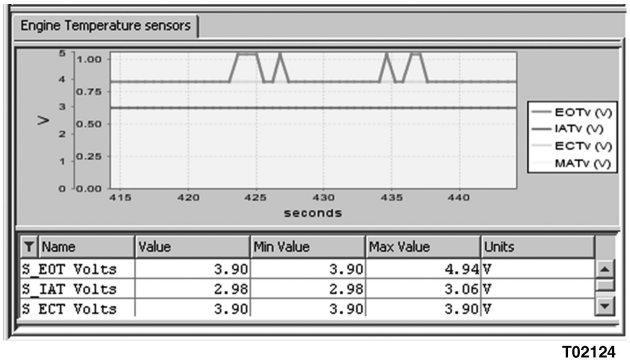


Figure 78 Sensor voltage

5. Monitor the sensor voltage and verify an active DTC is present.

   NOTE: If sensor signal circuit is shorted or open, the signal value will read NA or Error.

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

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

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

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

Example

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

Test Point	Spec	Comment
EST – Check DTC	SPN 175 FMI 3	If SPN 175 FMI 4 is active, check EOT signal for short to GND. Do Harness Resistance Check.

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

7. Short 3-Banana Plug Harness ZTSE4498 across the sensor signal circuit and engine GND.
8. The specified DTC should go active, unless the sensor signal circuit is open.

Example

Test Point	Spec	Comment
EST – Check DTC Short 3-Banana Plug Harness across 2 and GND	SPN 175 FMI 4	If SPN 175 FMI 3 is active, check EOT signal circuit for OPEN. Do Harness Resistance Checks.

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

9. Short 3-Banana Plug Harness ZTSE4498 across the sensor signal circuit and Signal Ground (SIG GND) circuit.
10. The specified DTC should go active, unless the SIG GND circuit is open.

Example

Test Point	Spec	Comment
EST – Check DTC Short 3-Banana Plug Harness ZTSE4498 across 1 and 2	SPN 175 FMI 3	If DTC is not active, check SIG GND for OPEN. Do Harness Resistance Checks.

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

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

Example

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

Sensor End Diagnostics (3-Wire)

1. Connect the EST to the Diagnostic Connector.
2. Turn ignition switch to ON, engine OFF.
3. Start ServiceMaxx™ software.
4. Run Continuous Monitor session. (This session lists all engine sensors.)

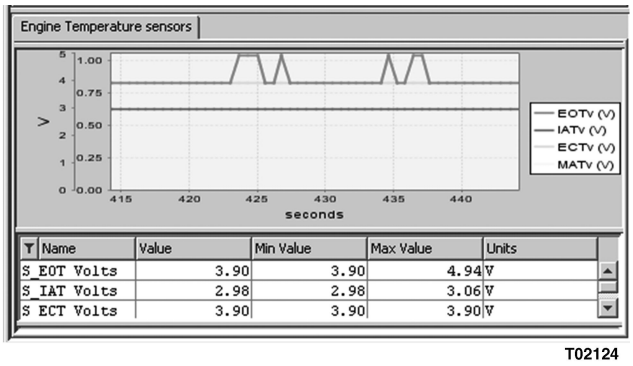


Figure 79 Sensor voltage

5. Monitor the sensor voltage and verify that an active DTC is present.

   NOTE: If sensor signal circuit is shorted or open, the signal value will read NA or Error.

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

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

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

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

Example

Test Point	Spec	Comment
EST – Check DTC	SPN 102 FMI 4	If SPN 102 FMI 3 is active, check IMP signal for short to Power (PWR)

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

7. Use a DMM to measure voltage on the Reference Voltage (VREF) circuit. Voltage should read 5 volts, unless VREF is open or shorted to GND, or a voltage is greater than VREF.

Example

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

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

8. Short 3-Banana Plug Harness ZTSE4498 across VREF and the sensor signal circuit.
9. The specified DTC should go active, unless the sensor signal circuit is open.

Example

Test Point	Spec	Comment
EST – Check DTC Short breakout harness across 2 and 3	SPN 102 FMI 3	If SPN 102 FMI 4 is active, check IMP signal for OPEN or short to GND. Do Harness Resistance Checks.

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

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

Example

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

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

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

Example

If checks are within specification, connect sensor and clear DTC's. If active code remains, replace sensor.

Pin-point Diagnostics (without ServiceMaxx™ software)

1. Connect breakout harness to the engine harness. Leave sensor disconnected.
2. Turn ignition switch to ON, engine OFF.
3. Use a DMM to measure voltage on each circuit to engine ground.

Example

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

- If the circuit is not within specification, the comment area will list possible cause or direct the technician to the next test point. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If the circuit is within specification, continue to the next test point.

Actuator Operational Voltage Check – Output State Test

This test will allow the technician to take voltage measurements on actuators commanded high or low.

1. Disconnect actuator. Inspect connector for damaged pins. Repair as necessary.
2. Connect breakout harness between engine harness and actuator.
3. Connect the EST to the Diagnostic Connector.
4. Turn ignition switch to ON, engine OFF.
5. Start ServiceMaxx™software.
6. Open the Output State session. This session allows the technician to monitor the state of all engine actuators.
7. Run the Output State test (high or low) or Glow Plug / IAH test.
8. Use a DMM to measure voltage on each circuit to engine ground.

Example

Test Point	Test	Spec	Comment
A to GND	Key On-Engine Off (KOEO)	B+	If < B+, check for OPEN circuit
B to GND	KOEO	B+	If < B+, check actuator coil for OPEN.
B to GND	Output State HIGH	B+	If < B+, check actuator control circuit for short to GND.
B to GND	Output State LOW	7.5 V	If > 7.5 V, check actuator control circuit for OPEN or short to PWR or failed across coil.

- If any circuit is not within specification, the comment area will list possible cause or direct the technician to the next test point.
- If all circuits are within specification, the actuator may not be operating mechanically.

Harness Resistance Check

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

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

1. Turn ignition switch to OFF or disconnect batteries.

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

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

Example

Test Point	Spec	Comment
E-66 to 2	< 5 Ω	If > 5 Ω, check EOT control circuit for OPEN.
E-66 to GND	> 1 kΩ	If < 1 kΩ, check EOT control circuit for short to GND.

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

Operational Voltage Check

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

1. Connect breakout box or breakout harness between Engine Control Module (ECM) and the component being tested.
2. Turn ignition switch to ON.
3. Open Continuous Monitor session or Output State test session (dependent upon what is being tested) using the ServiceMaxx™ software.
4. Run the Continuous Monitor test.
5. Verify actual sensor or actuator readings are within specification.

Example

Test Point	Condition	DMM	Signal Value
APP	Foot off pedal	0.64 V ± 0.5 V	0%
A to GND or C-48 to GND	Pedal to floor	3.85 V ± 0.5 V	102%
APP2	Foot off pedal	0 V	0 V
D to GND or C-33 to GND	Pedal to floor	B+	B+

Circuit Diagnostics

AFT (Aftertreatment) System

AFT System Diagnostics

SPN	FMI	Condition	Possible Causes	Actions
3251	0	DPFDP excessively high (Plugged filter)	• Biased Diesel Particulate Filter Differential Pressure (DPFDP) sensor • Diesel Oxidation Catalyst (DOC) or Diesel Particulate Filter (DPF) face plugged • High DPF soot load	Pin-Point Diagnostics (page 217)
3251	21	DPFDP excessively LOW (sensor / circuit fault or DPF missing)	• Biased DPFDP sensor • Leaks in DPFDP sensor hose • Reversed pressure lines on DPFDP sensor • Exhaust leak before DPF • Damaged DPF	Pin-Point Diagnostics (page 217)
3719	0	DPF Soot Load – Highest (Level 3/3)	• DPF needs to regenerate	Pin-Point Diagnostics (page 217)
3719	15	DPF Soot Load – Lowest (Level 1/3)	• DPF needs to regenerate	Pin-Point Diagnostics (page 217)
3719	16	DPF Soot Load – Moderate (Level 2/3)	• DPF needs to regenerate	Pin-Point Diagnostics (page 217)
3720	0	DPF Ash load at maximum limit (Remove DPF for cleaning)	• Replace DPF and reset the DPF replacement counter	Pin-Point Diagnostics (page 217)
3936	0	DPF soot load – Severe De-rate (regen disabled)	• Replace DPF and reset the DPF replacement counter	Pin-Point Diagnostics (page 217)

3936	2	DPF System Feedback Control Fault	•	Engine Throttle Valve (ETV) stuck open	Step-Based Diagnostics (page 220)
			•	DOC face plugged	
			•	Missing or melted DOC	
			•	Leaky exhaust system	
			•	DOC efficiency	
3936	8	DPF Regenerations are Occurring too Frequently	•	Low turbocharger boost levels	Step-Based Diagnostics (page 222)
			•	Exhaust system leaks	
			•	Diesel Particulate Filter Differential Pressure (DPFDP) reading high	
			•	EGR high flow	
			•	Ash or other contaminants in DPF	
3936	16	DPF Overtemp Monitor	•	High hydro-carbon slip	Pin-Point Diagnostics (page 217)
			•	Reduced DOC efficiency	
			•	Fuel injector leakage	
			•	High DPF soot load	
3936	20	DPF Feedback - Feedback Max Authority	•	DOC face plugged	Step-Based Diagnostics (page 227)
			•	Missing or Melted DOC	
			•	Exhaust system leaks	
			•	DOC Platinum Group Metals (PGM) depleted	

4766	10	Catalyst System Efficiency Below Threshold	• Exhaust system leaks • DOC face plugged • Missing or Melted DOC • DOC PGM depleted • MAF stuck HIGH	Step-Based Diagnostics (page 229)
5298	2	Reduced DOC efficiency - Engine De-rate	• Loss of washcoat • Cracked DOC • Removed / Tempered DOC • DOC face plugged • Aged DOC	Pin-Point Diagnostics (page 217)
5319	17	DPF Incomplete Regeneration	• High DPFDP after DPF regen • High ash level in DPF • DOC face plugged or missing DOC	Step-Based Diagnostics (page 232)
5319	31	DPF incomplete Regeneration	• High DPFDP after DPF regen • High ash level in DPF • Biased DPFDP sensor or circuit	Step-Based Diagnostics (page 235)

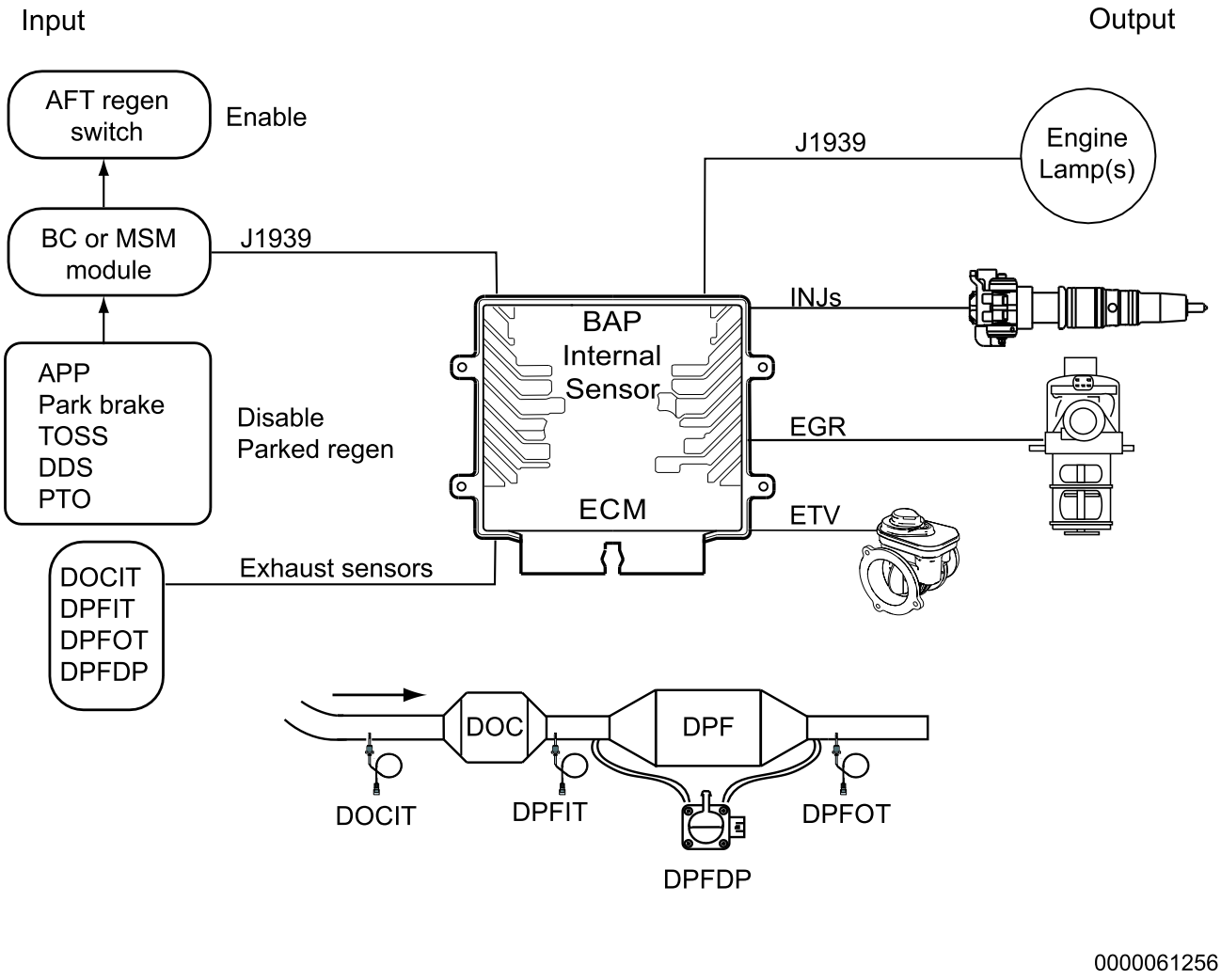


Figure 80 AFT System Diagram

Overview

The AFT system is designed to decrease harmful exhaust emissions. The DPF captures particulate matter (soot) and ash from the exhaust. Soot builds up in the DPF and must occasionally be heated and turned into ash, this is the DPF regeneration process. Ash buildup is periodically removed from the DPF by a special cleaning machine.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

AFT System Operation

When driving at high speeds or with heavy loads, the exhaust is hot enough to convert the soot to ash. When driving at lower speeds or lighter loads, the exhaust is typically not hot enough to convert the soot to ash. In these situations, the engine control system increases the exhaust temperature and the particulate matter can be converted to ash. Automatic regeneration occurs when driving. The operator is not required to do anything to start regeneration. An automatic regeneration is not possible during frequent stops or low operating speeds. If a regeneration is required in these conditions, do a manual parked regeneration.

Active Rolling Regeneration

When the ECM determines the DPF needs to be regenerated, the AFT lamp illuminates. The ECM controls the engine operation to increase exhaust temperature. This enables the DPF to convert accumulated particulate matter to ash.

The following entry conditions are required for active rolling regeneration:

- No disabling DTC (SPN 3936 / FMI 0, SPN 3936 / FMI 16, SPN 3251 / FMI 0)
- Engine Coolant Temperature (ECT) above 65°C (149°F)
- No engine warning, protection DTC active

Manual Parked Regeneration

WARNING: To prevent personal injury or death, keep clear of exhaust system components while running the Diesel Oxidation Catalyst (DOC) Cleaning Procedure. The temperature of some of the exhaust system components may rise to 816 °C (1,500 °F) while running the procedure. You should take extreme caution while working on or around exhaust system components after testing has been completed.

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

The following entry conditions are required for manual parked regeneration:

- DPF lamp ON, signaling need to regenerate
- No disabling DTC (SPN 3251 / FMI 0, SPN 3936 / FMI 0, SPN 3936 / FMI 16)
- ECT above 65°C (149°F)
- Engine running
- Vehicle speed below 1 mph
- Parking brake must be set
- Brake pedal not pressed
- Accelerator pedal not pressed
- PTO not active
- Driveline disengaged or vehicle in park or neutral position
- Turn inhibit regeneration switch to OFF and parked regeneration switch in ON position

Manual Parked Regeneration Procedure

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

It is necessary to do a manual parked regeneration when the exhaust filter indication (level 1) is on or the engine will lose power and shut down.

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

1. Park the vehicle safely off the road and away from flammable materials and vapors.
2. Before starting regeneration (using PARKED REGEN switch), the following conditions must be in place:
   - Parking brake must be set
   - Transmission must be in neutral or park
   - Coolant temperature must be minimum 65°C (149°F)
   - Accelerator, foot brake, or clutch pedal (if equipped) must not be pressed
   - Inhibit regeneration switch (if equipped), must be turned off
3. Press the ON position of the PARKED REGEN switch to initiate the regeneration cycle.

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

   The regeneration cycle lasts approximately 30 minutes.
4. When the regeneration cycle is complete, the indicator switch turns off. The engine rpm returns to normal idle and all exhaust filter indicators turn off. The vehicle is now ready for normal driving operation.

Diesel Oxidation Catalyst (DOC)

The DOC converts fuel to heat for DPF regeneration.

Diesel Particulate Filter (DPF)

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

Regeneration

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

Passive Rolling Regeneration

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

Parked Regeneration Switch

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

Inhibit Regeneration Switch (optional)

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

DPF Soot Loading Percentage

ECM calculation of the soot level in DPF.

DPF Ash Loading Percentage

ECM calculation of the ash level in DPF.

DPF Status Lamp

The DPF Status Lamp provides information on the need to regenerate the DPF. There are several DPF loading status levels. The lamp changes states from OFF, to solid ON, to flashing. The lamp is used in combination with the alarm sound.

High Exhaust System Temperature (HEST) Indicator

The HEST indicator alerts the operator when the exhaust temperature is elevated above 400 °C (752 °F). This may or may not be due to DPF regeneration.

Onboard Filter Cleanliness Test (ServiceMaxx™ software)

This test checks the status of the DPF if the soot level is within a Regen Needed limit. The test will automatically start a Parked Regen.

NOTE: The KOER Standard Test must be run before performing this test.

Engine speed is ramped up to increase exhaust flow through the DPF while the DPFDP sensor monitors the pressure difference across the DPF. The test runs for about 30 minutes.

The following conditions are required for an Onboard Filter Cleanliness Test:

- Engine running for more than 11 seconds
- Engine Coolant Temperature above 65°C (149°F)
- Vehicle stationary
- Inhibit DTCs must not be active: Refer to Fault Code Inhibitors
- PTO not active (switch must be off)
- Regen inhibit switch not active (switch must be off)
- Parking brake must be applied
- Soot load under 120%
- Brake pedal not depressed
- Accelerator pedal not depressed
- Driveline disengaged

NOTE: Test abort flag will display if one of the above conditions is not met.

- If the soot level is within normal range and the test completes and displays “Test Completed Successful”, no further action is required.
- If the soot level is above the threshold, the engine will abort the test and ServiceMaxx™ software will display a "Soot Load out of Range" return code.

Alert Levels of DPF Soot Loading

WARNING: To prevent personal injury or death, keep clear of exhaust system components while running the Diesel Oxidation Catalyst (DOC) Cleaning Procedure. The temperature of some of the exhaust system components may rise to 816 °C (1,500 °F) while running the procedure. You should take extreme caution while working on or around exhaust system components after testing has been completed.

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

Levels	Conditions	Action
Regeneration lamp on solid	Exhaust regeneration required	Drive on highway at highway speeds so the system can autoregenerate. OR Start a parked regeneration to prevent loss of power.

Alert Levels of DPF Soot Loading (cont.)

Regeneration lamp flashing	DPF is full	Pull vehicle safely off roadway and start a parked regeneration to prevent loss of power.
Regeneration lamp flashing Audio alarm beeps five times every minute	DPF is full Engine performance is limited	Pull vehicle safely off roadway and start a parked regeneration to prevent engine stopping.
Engine STOP lamp on solid Audio alarm beeps continuously	DPF is overfull Engine may shutdown soon	Pull vehicle safely off roadway turn on flashers, place warning devices and stop engine, do not use parked regeneration. Call for service.
When the High Exhaust System Temperature lamp is illuminated, the exhaust is above 400 °C (752 °F) and a regeneration could be in process.		

Pinpoint Diagnostics With ServiceMaxx™ Software

SPN 3251 / FMI 0 – DPF high flow resistance

SPN 3251 / FMI 0 sets if DPF is face plugged or soot loading is overfull. As a preventive measure, this fault disables regeneration until the next key on cycle.

Pin-point AFT System Fault

1. Inspect DPF for damage (tempered and leakage).
2. Inspect DPFDP, DPFIT, and DPDOT sensors for damage, loose connection, and sensor / harness rupture.
3. Check for active or previously active faults indicating high soot load in DPF. Any of SPN 3719 FMI 0,15,16 or SPN 3936 FMI 0 faults indicate high soot load in DPF.
4. Perform Onboard Filter Cleanliness test using EST. If test result confirms excessive soot load, service DPF.

SPN 3251 / FMI 21 – DPF low flow resistance

SPN 3251 / FMI 21 sets when the measured DPF differential pressure is less than a minimum value for a certain exhaust flow rate.

Pin-point AFT System Fault

1. Inspect exhaust and DPFDP sensor for damage. Check for leaks in exhaust or DPFDP sensor hose. Check that DPFDP sensor hoses are not reversed.
2. Check for active DPFDP sensor DTC. See DPFDP Sensor (page 354) in this section of the manual.
3. Check for damaged DPF. Remove and inspect for cracks that could allow exhaust gas to bypass the filter.

SPN 3719 / FMI 0 – DPF load: above critical level 1 - engine de-rate

SPN 3719 / FMI 0 sets when Level 3 DPF soot loading is over 100% full and engine de-rate has been enabled. DPF regeneration is required.

Pin-point AFT System Fault

1. Check for active DTC that could prevent AFT System from regenerating.
2. Do a Manual Parked Regeneration Procedure (page 212).

SPN 3719 / FMI 15 – DPF servicing required

SPN 3719 / FMI 15 sets when Level 1 DPF soot loading is above 80% full and a DPF regeneration is required.

Pin-point AFT System Fault

1. Check for active DTC that could prevent AFT system regeneration.
2. Drive vehicle at highway speeds for 20 to 30 minutes until the regeneration lamp is not illuminated or do a Manual Parked Regeneration Procedure (page 212).

SPN 3719 / FMI 16 – DPF load: above warning level

SPN 3719 / FMI 16 sets when Level 2 DPF soot loading is 100% full and a DPF regeneration is required.

Pin-point AFT System Fault

1. Check for active DTC that could prevent AFT system regeneration.
2. Do a Manual Parked Regeneration Procedure (page 212).

SPN 3720 / FMI 0 – DPF Ash load at maximum limit (Remove DPF for cleaning)

SPN 3720 FMI 0 sets when the DPF is full of ash and must be removed and cleaned.

Pin-point AFT System Fault

1. Remove DPF filter and clean out the ash in a cleaning station.
2. Load DPF Servicing session. Enter DPF serial number, cleaning, and installation date.
3. Click the DPF has been serviced button.

SPN 3936 / FMI 0 – DPF load: above critical level 2 - further engine de-rate

SPN 3936 / FMI 0 sets when level 4 DPF soot loading is overfull and engine shutdown is enabled. DPF regeneration functionality has been disabled.

Pin-point AFT System Fault

1. Inspect DPFDP sensor for damage or loose connection.
2. Remove DPF and service the filter.
3. Check for active DTC that could prevent the AFT system from regenerating.
4. Do an Onboard Cleanliness Test to reset soot and ash monitors.

SPN 5298 / FMI 2 – Reduced DOC efficiency - engine de-rate

SPN 5298 / FMI 2 sets when ability of DOC to convert hydrocarbon into heat reduces to a level that it cannot carry on normal regeneration process effectively. This also de-rates the engine.

Pin-point AFT System Fault

1. Inspect exhaust system for leaks or damage.
2. Inspect DPFDP, DPFIT, DPFOT, and DOCIT sensors for damage, loose connection, and sensor / harness rupture.
3. Check for active DTC that can prevent the AFT system from regenerating.
4. Perform Onboard Filter Cleanliness test using EST.
5. If DTC sets after Onboard Filter Cleanliness test. Remove the DOC and service it.

SPN 5319 / FMI 31 – DPF Ash load at maximum limit (Remove DPF for cleaning)

DTC sets if AFT system monitors indicate that DPF still needs a Regen, after completing one.

Pin-point AFT System Fault

1. Turn ignition switch to ON, engine OFF. Check for Biased DPFDP sensor. See “Appendix A: Performance Specifications” (page 813).
   - If DPFDP sensor is not within specification, see DPFDP Sensor (page 354) in this section.
2. Remove DPF for ash cleaning.

SPN 3936 FMI 2 - DPF System Feedback Control Fault

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter (DPF) system min. deviation and max. deviation fault	Temperature error in Diesel Oxidation Catalyst (DOC) PI temperature controller system (temperature error = Actual Diesel Oxidation Catalyst Inlet Temperature (DOCIT) minus 200°C (392°F)	DPF in active regeneration (post injection enabled)	0.1 second
		Accumulated time for which temperature error in DOC PI temperature controller system is greater than modeled threshold value > 5 minutes	
		The following SPN/FMIs are not active: 110/3, 110/4, 132/3, 132/4, 172/3, 172/4, 3242/3, 3242/4, 3246/3, 3246/4, 4765/3, 4765/4, 3251/3, 3251/4, and 3251/10.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DPF system is showing a temperature deviation fault when compared to an estimated temperature.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Fault Fact

If aftertreatment system has had excess fuel, oil, coolant, metal, or other contamination; inspect the entire aftertreatment system for causal damage before re-installing. Inspect for overheated aftertreatment components, cracked exhaust system welds, leaking exhaust system seams or other damage. The root cause of the contamination must be diagnosed and repaired prior to finalizing repairs to the aftertreatment system.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3936 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3936 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Test ETV for proper operation. Using EST with ServiceMaxx™ software, perform Output State Test (page 513). Is ETV functioning correctly?	Yes: Go to Step 4. No: Replace ETV. After repairs are complete, retest for SPN 3936 FMI 2.

Step	Action	Decision
4	Inspect exhaust system for leaks. Is exhaust system free of leaks?	Yes: Go to Step 5. No: Repair leaks. After repairs are complete, retest for SPN 3936 FMI 2.

Step	Action	Decision
5	Inspect Diesel Oxidation Catalyst (DOC) for plugging and / or internal damage. Is DOC free of plugging and / or internal damage?	Yes: After doing all diagnostic steps, if SPN 3936 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair and / or replace DOC. After repairs are complete, retest for SPN 3936 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 3936 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3936 FMI 8 - DPF Regenerations are Occurring too Frequently

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter (DPF) very frequent regenerations	Ratio of actual regeneration frequency and modeled regeneration frequency < 0.2	Previous regeneration event has been successful. Aftertreatment system in active regeneration The following SPN/FMIs are not active: 3242/2, 3242/3, 3242/4, 3242/10, 3246/2, 3246/3, 3246/4, 4765/3, 4765/4, 3251/3, 3251/4, 3251/10.	0.1 second

Fault Overview

Fault sets when the Engine Control Module (ECM) determines that regeneration events are occurring too frequently.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

SPN FMIs: 105 / 2, 105 / 3, 105 / 4, 132 / 2, 132 / 3, 132 / 4, 132 / 11, 132 / 13, 132 / 14, and 2659 / 20

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3936 FMI 8 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3936 FMI 8. No: Go to Step 3.

Step	Action	Decision
3	Inspect exhaust system for restrictions, leaks, or physical damage. Is exhaust system free of restrictions, leaks, and physical damage?	Yes: Go to Step 4. No: Repair restrictions, leaks, or physical damage. After repairs are complete, retest for SPN 3936 FMI 8.

Step	Action	Decision
4	Inspect connections at Diesel Particulate Filter Differential Pressure (DPFDP) sensor. With key OFF, disconnect DPFDP sensor. Check DPFDP sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3936 FMI 8.

Step	Action	Decision
5	Inspect air intake system and air filter for restrictions, air leaks, or physical damage. Is air intake system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to Step 6. No: Repair restrictions, air leaks or physical damage. After repairs are complete, retest for SPN 3936 FMI 8.

Step	Action	Decision
6	On systems with separate DOC and DPF; do DPF filter inspection. Is the DPF free of ash and other contaminants?	Yes: Go to Step 7. No: Clean or replace as required. After cleaning or replacement is complete, retest for SPN 3936 FMI 8.

Step	Action	Decision
7	Test for turbocharger low boost condition. Do Turbocharger Checks (Underboost) (page 177). Was turbocharger performance within specifications?	Yes: Go to Step 8. No: Replace turbocharger assembly. After repairs are complete, retest for SPN 3936 FMI 8.

Step	Action	Decision
8	Test wastegate for proper operation. Perform Wastegate Checks (page 177). Does wastegate operate as expected?	Yes: Go to Step 9. No: Replace turbocharger assembly. After repairs are complete, retest for SPN 3936 FMI 8.

Step	Action	Decision
9	Using EST with ServiceMaxx™ software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort message in ServiceMaxx™?	Yes: Go to Step 10. No: Correct Parked Regen Inhibitors and restart OBFCT.

<table>
<tr><th>Step</th><th colspan="3">Action</th><th>Decision</th></tr>
<tr><td rowspan="7">10</td><td colspan="3">While running OBFCT, inspect for exhaust leaks and monitor the following signals during test:
Are Parked Regen Checks within specification during OBFCT?</td><td rowspan="2">If Parked Regen Checks are within specifications: Go to Step 11.</td></tr>
<tr><td>Parked Regen Checks</td><td>Specifications</td><td>Pass / Fail</td></tr>
<tr><td>Engine Condition</td><td>Smooth, not stumbling</td><td></td><td rowspan="5">If Parked Regen Checks are out of specifications: Repair conditions causing Parked Regen Check to be out of specification. After repairs are complete, retest for SPN 3936 FMI 8.</td></tr>
<tr><td>Engine Coolant Temperature (ECT)</td><td>Above 149°F (65°C) per ServiceMaxx™</td><td></td></tr>
<tr><td>DOCIT</td><td>Above 500°F (260°C) after 5-10 minutes</td><td></td></tr>
<tr><td>DOCOT</td><td>Above 986°F (530°C) after 5-10 minutes</td><td></td></tr>
<tr><td>DPFOT</td><td>Below 1292°F (700°C)</td><td></td></tr>
</table>

Step	Action	Decision
11	After OBFCT is complete, does DPFDP signal measure below 0.5 psi at high idle?	Yes: After doing all diagnostic steps, if SPN 3936 FMI 8 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Remove DPF and inspect for restrictions. If restricted, clean or replace as required. After cleaning or replacement is complete, retest for SPN 3936 FMI 8.

NOTE: After doing all diagnostic steps, if SPN 3936 FMI 8 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3936 FMI 20 - DPF Feedback - Feedback Max Authority

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Oxidation Catalyst Outlet Temperature (DOCOT) closed loop feedback control.	Duration of time spent in thermal management regeneration mode (Level 1 Regeneration) > 2.33 hours	< 180 lb ft torque and < 2800 RPM < and for time > 5 seconds	0.1 second
		DPF in regeneration (Level 1 or Level 2)	
		Engine is running and regeneration is not inhibited.	
		The following SPN / FMIs are not active: 3242/3, 3242/4, 4765/3, and 4765/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the time spent in thermal management regeneration mode is above the predetermined threshold.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Fault Fact

If aftertreatment system has had excess fuel, oil, coolant, metal, or other contamination; inspect the entire aftertreatment system for causal damage before re-installing. Inspect for overheated aftertreatment components, cracked exhaust system welds, leaking exhaust system seams or other damage. The root cause of the contamination must be diagnosed and repaired prior to finalizing repairs to the aftertreatment system.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3936 FMI 20 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3936 FMI 20. No: Go to Step 3.

Step	Action	Decision
3	Inspect exhaust system for leaks or physical damage. Is exhaust system free of leaks and physical damage?	Yes: Go to Step 4. No: Repair exhaust leak of physical damage. After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
4	Inspect Diesel Oxidation Catalyst (DOC) for plugging, melting, or other physical damage. Is DOC free of plugging, melting, and / or other physical damage?	Yes: After doing all diagnostic steps, if SPN 3936 FMI 20 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace DOC. After repairs are complete, retest for SPN 3936 FMI 20.

NOTE: After doing all diagnostic steps, if SPN 3936 FMI 20 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4766 FMI 10 - Catalyst System Efficiency Below Threshold

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment 1 Diesel Oxidation Catalyst (DOC) Hydrocarbon Conversion Efficiency	Calculated Aftertreatment 1 Diesel Oxidation Catalyst (DOC) Hydrocarbon Conversion Efficiency </= 25%	Minimum time In active regeneration > 10 minutes and percent time regeneration post injection must occur to calculate DOCHC conversion >/=75%	Immediate
		Average temperature of DOC inlet and DOC outlet > 300°C and < 550°C and percent time spent above average DOC inlet and DOC outlet temperature range >/= 60%	
		Engine exhaust flow rate > 50 g/sec and < 900 g/sec and percent time spent in specified exhaust flow rate range to calculate DOC HC conversion efficiency >/=60%	
		Modeled Engine exhaust oxygen concentration >/= 3% and <21% percent time spent in specified engine exhaust oxygen concentration range to calculate DOC HC conversion efficiency >/= 60%	
		Regeneration post injection fuel flow rate change > 0.5 g/sec and < 2 g/sec and percent time spent in specified regeneration post injection fuel flow range to calculate DOC HC conversion efficiency >/= 30%	
		Engine speed range > 800 rpm and < 220 rpm and percent time spent in specific engine speed range to calculate DOC HC conversion efficiency >/= 40%	
		Minimum engine air inlet temperature to enable DOC efficiency model >/= -40°C	
		Minimum ambient pressure to enable DOC efficiency model >/= 75 kPa	

SPN 4766 FMI 10 - Catalyst System Efficiency Below Threshold (cont.)

		Monitor efficiency calculation is performed until regeneration status is complete and DPF outlet temperature minus DPF inlet temperature < 50°C and DPF outlet temperature minus DOC inlet temperature < 50°C	
		The following SPN / FMIs are not active: SPN FMIs 110/3, 110/4, 132/2, 132/3, 132/4, 172/2, 172/3, 172/4, 4765/2, 4765/3, 4765/4, 4765/10, 3242/2, 3242/3, 3242.4, 3242/10, 3246/2,3246/3, 3246/4, 3246/10, 3251/3, 3251/4, and 3251/10.	

Fault Overview

N / A

Fault Fact

If aftertreatment system has had excess fuel, oil, coolant, metal, or other contamination; inspect the entire aftertreatment system for causal damage before re-installing. Inspect for overheated aftertreatment components, cracked exhaust system welds, leaking exhaust system seams or other damage. The root cause of the contamination must be diagnosed and repaired prior to finalizing repairs to the aftertreatment system.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 4766 FMI 10 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 4766 FMI 10. No: Go to Step 3.

Step	Action	Decision
3	Inspect air intake system including MAF sensor for air leaks, contamination and / or physical damage. Is air intake system free of leaks, contamination and physical damage?	Yes: Go to Step 4. No: Repair exhaust leak of physical damage. After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
4	**CAUTION:** Do not perform an On Board Filter Cleanliness Test (OBFCT) or Parked Regeneration if liquid oil or fuel is present or suspected to be present in the DPF. Liquid oil or fuel will ignite during an OBFCT causing fire or damage to vehicle or other equipment. Using Electronic Service Tool (EST) with ServiceMaxx™ software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™	Yes: Go to Step 5. No: Correct and restart OBFCT(page 212).
5	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi at high idle?	Yes: Perform KOER MAF Sensor Calibration procedure(page 76). After calibration is complete, retest for SPN 4766 FMI 10. No: Remove DPF and DPC and inspect for restriction, damage, or evidence of defect. If restricted, damaged, or defective, clean or replace components as necessary. If cleaning DPF, use appropriate DPF cleaning procedure. After repairs are complete, retest for SPN 4766 FMI 10.

NOTE: After doing all diagnostic steps, if SPN 4766 FMI 10 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 5319 FMI 17 - DPF Incomplete Regeneration

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
DPF Incomplete Regeneration	Soot load (Aftertreatment 1 DPF differential pressure sensor Based) after a "Successful Regeneration Event" > 55g	Exhaust gas volume flow > 500,000 L/hr	0.1 seconds
	Definition of a "Successful Regeneration Event": Regeneration is considered to be successful if ALL of the conditions listed in the entry conditions are met.	Diesel Particulate Filter (DPF) soot load estimation rate > 0.01 * 10 g/seconds	
		Average value of aftertreatment 1 DPF inlet temperature AND DPF outlet temperature < 788°F (420°C)	
		Distance since last regeneration {Calibrated out} < 4,294,967,296 miles	
		Time since last regeneration event > 2 minutes	
		Maximum time monitor is run after last "Successful Regen" < 9 minutes	
		Engine Coolant Temperature (ECT) > -40°F (-40°C)	
		Minimum time in Level 1 OR Level 2 regeneration = 19 minutes and 40 seconds	
		Minimum time in stationery regeneration = 30 minutes	
		Time after all entry conditions (listed above) are satisfied < 0.5 seconds	
		Regeneration not active	
		The following SPN / FMIs are not active: 110/3, 110/4,132/3, 132/4, 172/3, 172/4, 4765/3, 4765/4, 3242/3, 3242.4, 3246/3, 3246/4, 3251/3, 3251/4, and 3251/10.	
		Aftertreatment 1 Diesel Oxidation Catalyst (DOC) inlet temperature > 572°F (300°C)	

SPN 5319 FMI 17 - DPF Incomplete Regeneration (cont.)

		AND for cumulative time during regeneration AND > 12 minutes	
		Aftertreatment 1 DOC outlet temperature > 968°F (520°C)	
		AND for cumulative time during regeneration AND > 12 minutes	

Fault Overview

Fault sets when DPF regeneration cannot be completed successfully.

Amber Warning Lamp (AWL) Reaction

When fault is active, the AWL will illuminate.

Fault Fact

N / A

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 5319 FMI 17 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 5319 FMI 17. No: Go to Step 3.

Step	Action	Decision
3	Inspect exhaust system for missing Diesel Oxidation Catalyst (DOC), leaks, or physical damage. Is DOC in place, and exhaust system free of leaks and physical damage?	Yes: Go to Step 4. No: Replace DOC, repair exhaust leaks, or repair physical damage. After repairs are complete, retest for SPN 5319 FMI 17.

Step	Action	Decision
4	Inspect connections at Diesel Particulate Filter Differential Pressure (DPFDP) sensor. With key OFF, disconnect DPFDP sensor connector. Check DPFDP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Is the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5319 FMI 17.

Step	Action	Decision
5	Check DPFDP sensor hoses for correct routing and restrictions. Inspect the DPFDP hoses for kinks, improper hose routing, reversed hoses or damage. See DPFDP sensor locator for correct routing of hoses. Are the DPFDP hoses routed correctly and free of damage?	Yes: Go to step 6. No: Repair DPFDP hoses. After repairs are complete, retest for SPN 5319 FMI 17.

Step	Action	Decision
6	Remove DOC and inspect for face plugging or damage to the catalyst. Is the DOC free of plugging and other damage?	Yes: Go to step 7. No: Replace the DOC. After repairs are complete, retest for SPN 5319 FMI 17.

Step	Action	Decision
7	Check for biased DPFDP sensor. Do DPFDP sensor biased check (page 358). Are DPFDP sensor and circuits within specification?	Yes: After doing all diagnostic steps, if SPN 5319 FMI 17 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5319 FMI 17.

NOTE: After doing all diagnostic steps, if SPN 5319 FMI 17 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 5319 FMI 31 - DPF Incomplete Regeneration

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
DPF Incomplete Regeneration	Soot load (Aftertreatment 1 DPF differential pressure sensor Based) after a "Successful Regeneration Event" > 55g	Exhaust gas volume flow > 500,000 L/hr	0.1 seconds
	Definition of a "Successful Regeneration Event": Regeneration is considered to be successful if ALL of the conditions listed in the entry conditions are met.	Diesel Particulate Filter (DPF) soot load estimation rate > 0.01 * 10 g/seconds	
		Average value of aftertreatment 1 DPF inlet temperature AND DPF outlet temperature < 788°F (420°C)	
		Distance since last regeneration {Calibrated out} < 4,294,967,296 miles	
		Time since last regeneration event > 2 minutes	
		Maximum time monitor is run after last "Successful Regen" < 9 minutes	
		Engine Coolant Temperature (ECT) > -40°F (-40°C)	
		Minimum time in Level 1 OR Level 2 regeneration = 19 minutes and 40 seconds	

SPN 5319 FMI 31 - DPF Incomplete Regeneration (cont.)

		Minimum time in stationery regeneration = 30 minutes	
		Time after all entry conditions (listed above) are satisfied < 0.5 seconds	
		Regeneration not active	
		The following SPN / FMI are not active: 110/3, 110/4, 132/3, 132/4, 172/3, 172/4, 4765/3, 4765/4, 3242/3, 3242.4, 3246/3, 3246/4, 3251/3, 3251/4, and 3251/10	
		Aftertreatment 1 Diesel Oxidation Catalyst (DOC) inlet temperature > 572°F (300°C)	
		AND for cumulative time during regeneration AND > 12 minutes	
		Aftertreatment 1 DOC outlet temperature > 968°F (520°C)	
		AND for cumulative time during regeneration AND > 12 minutes	

Fault Overview

Fault sets when DPF regeneration cannot be completed successfully.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the MIL will illuminate.

Fault Fact

N / A

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 5319 FMI 31 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 5319 FMI 31. No: Go to Step 3.

Step	Action	Decision
3	Inspect exhaust system for missing Diesel Oxidation Catalyst (DOC), leaks, or physical damage. Is DOC in place, and exhaust system free of leaks and physical damage?	Yes: Go to Step 4. No: Replace DOC, repair exhaust leaks, or repair physical damage. After repairs are complete, retest for SPN 5319 FMI 31.

Step	Action	Decision
4	Inspect connections at Diesel Particulate Filter Differential Pressure (DPFDP) sensor. With key OFF, disconnect DPFDP sensor connector. Check DPFDP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Is the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5319 FMI 31.

Step	Action	Decision
5	Check DPFDP sensor hoses for correct routing and restrictions. Inspect the DPFDP hoses for kinks, improper hose routing, reversed hoses or damage. See DPFDP sensor locator for correct routing of hoses. Are the DPFDP hoses routed correctly and free of damage?	Yes: Go to step 6. No: Repair DPFDP hoses. After repairs are complete, retest for SPN 5319 FMI 31.

Step	Action	Decision
6	Remove DOC and inspect for face plugging or damage to the catalyst. Is the DOC free of plugging and other damage?	Yes: Go to step 7. No: Replace the DOC. After repairs are complete, retest for SPN 5319 FMI 31.

Step	Action	Decision
7	Check for biased DPFDP sensor. Do DPFDP sensor biased check (page 358). Are DPFDP sensor and circuits within specification?	Yes: After doing all diagnostic steps, if SPN 5319 FMI 31 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5319 FMI 31.

NOTE: After doing all diagnostic steps, if SPN 5319 FMI 31 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

AMS (Air Management System)

SPN	FMI	Condition	Possible Causes	Actions
1209	0	EBP above desired level	• Charge Air Cooler (CAC) system leaks (hoses and cooler) • Restricted exhaust system • Turbocharger 2 Wastegate (TC2WG) not working • Mass Air Flow (MAF) sensor	Pin-Point Diagnostics (page 243)
1692	0	Boost High / above desired level detected	• Restricted exhaust system • TC1WC not working • MAF sensor	Pin-Point Diagnostics (page 243)
1692	17	KOER STD - Boost unable to achieve desired set-point	• CAC system leaks (hoses and cooler) • Exhaust or intake air system leaks • Restricted exhaust system • TC2WG not working	Pin-Point Diagnostics (page 243)
1692	18	Boost unable to achieve desired set-point	• CAC system leaks (hoses and cooler) • Exhaust or intake air system leaks • Restricted exhaust system • TC2WG not working	Pin-Point Diagnostics (page 243)

2659	10	EGR Slow Response Fault	• Exhaust Gas Recirculation (EGR) valve sticking • Engine Throttle Valve (ETV) sticking • EGR system leaks or restrictions • Biased MAF, IMP, or IMT sensor • Wastegate stuck open • Intake leak (filter to turbo)	Step-Based Diagnostics (page 248)

2659	15	EGR High Flow Rate Detected	• Air intake leak • Biased Engine Throttle Position (ETP), Exhaust Gas Recirculation Position (EGRP), Intake Manifold Pressure (IMP), or Mass Air Flow (MAF) sensor • EGR valve sticking or stuck	Step-Based Diagnostics (page 252)
2659	17	EGR Low Flow Rate Detected	• Restricted air flow (intake or exhaust) • Biased Engine Throttle Position (ETP), Exhaust Gas Recirculation Position (EGRP), Intake Manifold Pressure (IMP), or Mass Air Flow (MAF) sensor • EGR valve sticking or stuck	Step-Based Diagnostics (page 255)
2659	20	EGR High Flow Rate detected	• Restricted air flow (intake or exhaust) • CAC system leaks (hoses and cooler) • Biased ETP, EGRP, IMP, or MAF sensor • EGR valve sticking or stuck	Step-Based Diagnostics (page 257)
2659	21	EGR Low Flow Rate detected	• Restricted air flow (intake or exhaust) • Restricted EGR cooler • Biased ETP, EGRP, IMP, or MAF sensor • EGR valve sticking or stuck	Step-Based Diagnostics (page 260)
5543	4	EBPC valve electrical fault	Failed TMV or circuits	Pin-Point Diagnostics (page 243)

5543	7	EBPC Actuator Fault	Failed TMV or circuits	Pin-Point Diagnostics (page 243)
5543	12	EBPC Actuator Fault	Failed TMV or circuits	Pin-Point Diagnostics (page 243)
5543	16	EBP Value Internal Temperature Fault	• Restricted coolant flow • Exhaust leak • Biased Thermal Management Valve (TMV)	Step-Based Diagnostics (page 262)
5543	19	EBPC Valve not detected on J1939	• Controller Area Network (CAN) circuit issue • Failed TMV	Step-Based Diagnostics (page 266)
5543	20	EBP valve electrical fault	• Valve or circuit issue	Step-Based Diagnostics (page 269)

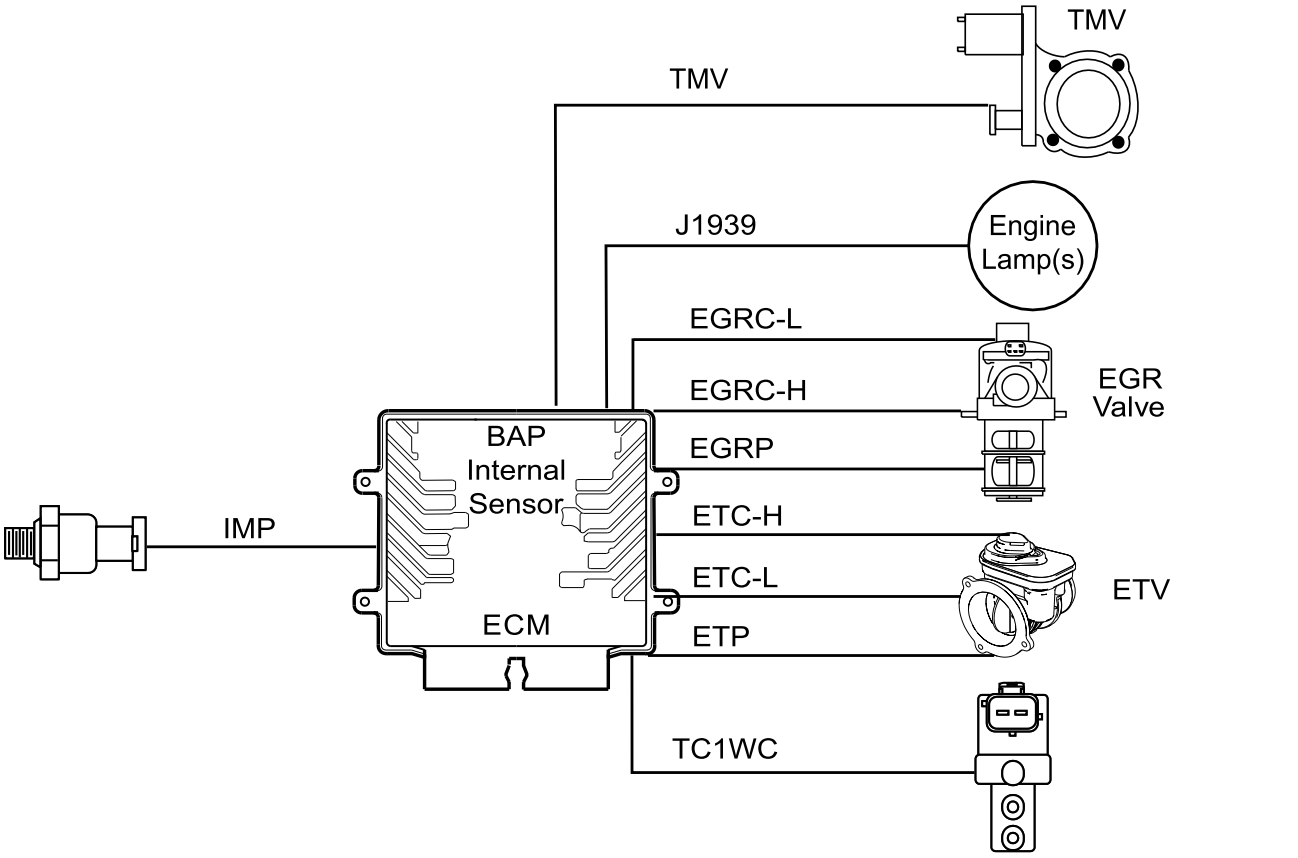


Figure 81 AMS Diagram

Overview

The Air Management System (AMS) controls the intake air flow and pressure. The EGR recirculates exhaust gases into the intake stream for cooler combustion which reduces the formation of Nitrogen Oxide (NOx) gases. The TC2WG is used to control the turbocharger waste gate, which increases boost pressures for increased performance or relieves excessive exhaust backpressures. The dual stage turbocharger provides faster turbo response and quicker acceleration with less lag. The Thermal Management Valve is used to increase exhaust back pressure and speed engine warming.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 500-Ohm Resistor Harness
- 00–00956–08 - 180-Pin Breakout Box
- Breakout Harness ZTSE6005 (TMV)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

Pinpoint Diagnostics

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

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, open the Continuous Monitor session.
2. Verify sensor is within Key On Engine Off (KOEO) specification. See “Appendix A: Performance Specifications (page 813).”
3. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
    - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the DTC goes pending or active.
    - If DTC is pending or active, proceed to the next step.
4. Disconnect engine harness from sensor.

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

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

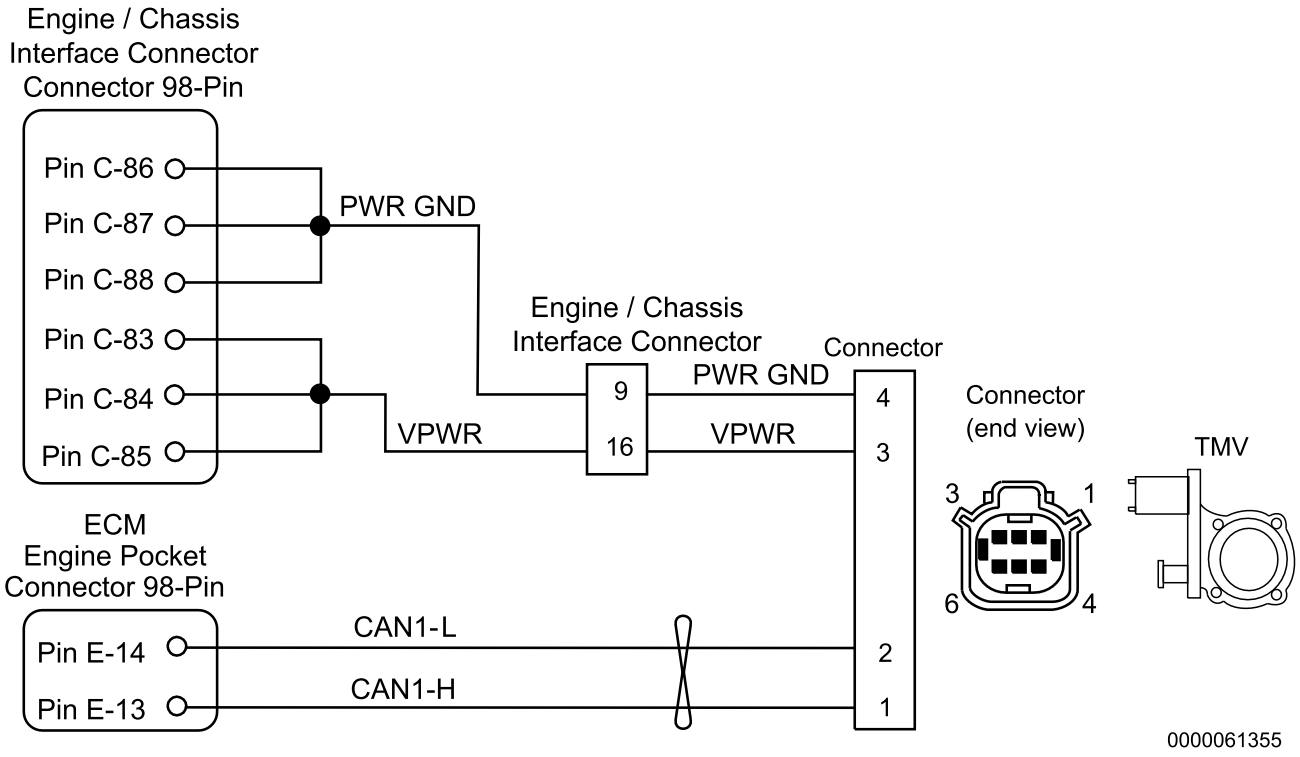


Figure 82 TMV Circuit Diagram

TMV - Standard and Output State Test

Connect Breakout Harness ZTSE6005 between ECM and TMV actuator. Run Key On Engine Off (KOEO) Standard test and KOEO Output State Low and High test. Use EST with ServiceMaxx™ software to monitor TMV percent.

Test	Spec	Comment
Output State HIGH	100%	If < 90%, check for OPEN or short. Do Harness Resistance Check (page 245).
Output State LOW	0%	If > 10%, check for OPEN or short. Do Harness Resistance Check (page 245).

Connector Voltage Check

Connect Breakout Harness ZTSE6005. Leave actuator disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	1V to 4V	The sum of 1 to GND and 2 to GND should equal 4V to 5V.
2 to GND	1V to 4V	The sum of 1 to GND and 2 to GND should equal 4V to 5V.
3 to GND	5V +/- .5V	If > 5.5V check for SHORT to PWR If < 4.5V check for OPEN or SHORT to GND. Do Harness Resistance Checks (page 245).

Connector Voltage Check (cont.)

4 to B+	B+	If < B+ check for SHORT to power or OPEN circuit. Do Harness Resistance Checks (page 245).

If checks are within specification, do TMV Actuator - Output State Test (page 244).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE6005. Leave actuator disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Disconnect battery GND and B+ ECM connector. Connect 180-Pin Breakout Box and Breakout Harness ZTSE6005. Leave ECM and actuator disconnected. Use DMM to measure resistance.

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

Test Point	Spec	Comment
1 to E-13	< 5 Ω	If > 5 Ω check for OPEN circuit.
2 to E-14	< 5 Ω	If > 5 Ω check for OPEN circuit.
3 to C-83	< 5 Ω	If > 5 Ω check for OPEN circuit.
3 to C-84	< 5 Ω	If > 5 Ω check for OPEN circuit.
3 to C-85	< 5 Ω	If > 5 Ω check for OPEN circuit.
4 to C-86	< 5 Ω	If > 5 Ω check for OPEN circuit.
4 to C-87	< 5 Ω	If > 5 Ω check for OPEN circuit.
4 to C-88	< 5 Ω	If > 5 Ω check for OPEN circuit.

SPN 1209 and FMI 0 - EBP above desired level

Pin-Point AMS Fault

1. Check for other active or inactive IMP, EGRP, ETP, MAF, or EGR Control (EGRC) signal DTC. Repair any fault before continuing with this procedure.
2. Check for biased sensors. Verify if the IMP, EGRP, ETP, and MAF are within the Key ON, Engine OFF (KOEO) specifications. See KOEO for the applicable engine horsepower in “Appendix A: Performance Specifications” (page 813).
3. Check TC2WG operation. See KOEO for the applicable engine horsepower in “Appendix A: Performance Specifications” (page 813).

SPN 1209 and FMI 0 - EBP above desired level (cont.)

4. Check for restricted exhaust. See Full Load Rated Speed for the applicable engine horsepower in “Appendix A: Performance Specifications” (page 813).

SPN 1692 and FMI 0 - Boost high / above desired level detected

Pin-point AMS Fault

1. Check for other active or inactive IMP, EGRP, ETP, MAF, or EGRC signal DTC. Repair any fault before continuing with this procedure.
2. Check for the biased sensors. Verify if the IMP, EGRP, ETP and MAF are within the KOEO specifications. See KOEO for the applicable engine horsepower in “Appendix A: Performance Specifications” (page 813).
3. Check EGR Valve Operation. Monitor EGRC signal. Run KOEO Output State Low and High. See EGR Valve (page 458) in this section.
4. Check TC1WC Operation. See KOEO for the applicable engine horsepower in “Appendix A: Performance Specifications” (page 813).
5. Check for restricted exhaust. See Full Load Rated Speed for the applicable engine horsepower in “Appendix A: Performance Specifications” (page 813).

SPN 1692 and FMI 17 - KOER STD - Boost unable to achieve desired set-point Pin-Point AMS Fault

Pin-Point AMS Fault

1. Check for other active or inactive IMP, EGRP, ETP, MAF, or EGRC signal DTC. Repair any fault before continuing with this procedure.
2. Check for biased sensors. Verify if the IMP, EGRP, ETP, and MAF are within the KOEO specifications. See KOEO for the applicable engine horsepower in “Appendix A: Performance Specifications” (page 813).
3. Check TC2WG Operation. See KOEO for the applicable engine horsepower in “Appendix A: Performance Specifications” (page 813). Run KOEO Output State Low and High. See TC2WG Solenoid (page 698) in this section.
4. Check for restricted exhaust. See Full Load Rated Speed for the applicable engine horsepower in “Appendix A: Performance Specifications” (page 813).

SPN 1692 and FMI 18 - Boost unable to achieve desired set-point

Pin-Point AMS Fault

1. Check for other active or inactive IMP, EGR, ETP, MAF, or EGRC signal DTC. Repair any fault before continuing with this procedure.
2. Check for biased sensors. Verify if the IMP, EGRP, ETP, MAF are within the KOEO specifications. See KOEO for the applicable engine horsepower in “Appendix A: Performance Specifications” (page 813).
3. Check TC2WG Operation. See KOEO for the applicable engine horsepower in “Appendix A: Performance Specifications” (page 813). Run KOEO Output State Low and High. See TC2WG Solenoid (page 698) in this section.

SPN 1692 and FMI 18 - Boost unable to achieve desired set-point (cont.)

4. Check for restricted exhaust. See Full Load Rated Speed for the applicable engine horsepower in “Appendix A: Performance Specifications” (page 813).

SPN 2659 and FMI 17 -EGR Flow Rate unable to achieve desired set-point

Pin-Point AMS Fault

1. Check for other active or inactive IMP, EGRP, ETP, MAF, or EGRC signal DTC. Repair any fault before continuing with this procedure.
2. Check for the biased sensors. Verify if the IMP, EGRP, ETP, and MAF are within the KOEO specifications. See KOEO for the applicable engine horsepower in “Appendix A: Performance Specifications” (page 813).
3. Check EGRC Operation. Monitor EGRC signal. Run KOEO Output State Low and High. See EGR Valve (page 458) in this section.
4. Check intake and exhaust system for leaks.

SPN 2659 and FMI 20 - EGR high flow rate detected

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

Pin-Point AMS Fault

1. Check for other active or inactive IMP, TC2WG, or EGR DTC. Repair any electrical fault before continuing with this procedure.
2. Check for biased sensor. Verify BAP and IMP are within KOEO specification. See KOEO for the applicable engine horsepower in the “Appendix A: Performance Specifications” (page 813).
3. Check EGR operation. Monitor EGRP signal and run KOEO Output State test HIGH and LOW. See EGR Valve (page 458) in this section.

SPN 2659 and FMI 21 - EGR low flow rate detected

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

Pin-Point AMS Fault

1. Check for other active or inactive IMP, TC2WG, or EGR DTC. Repair any electrical fault before continuing with this procedure.
2. Check for biased sensor. Verify BAP and IMP are within KOEO Specification. See KOEO for the applicable engine horsepower in the “Appendix A: Performance Specifications” (page 813).
3. Check for restricted EGR cooler. See EGR Cooler Inspection (page 83) in the “Engine Symptoms Diagnostics” section of this manual.
4. Check EGR operation. Monitor EGRP signal and run KOEO Output State test HIGH and LOW. See EGR Valve (page 458) in this section.
5. Check for restricted exhaust. See Full Load Rated Speed for the applicable engine horsepower in the “Appendix A: Performance Specifications” (page 813).

SPN 2659 FMI 10 - EGR Slow Response Fault

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Exhaust Gas Recirculation (EGR) mass flow rate slow response	Sum of integral absolute value of EGR control deviation error Mass Air Flow (MAF) setpoint minus actual value as indicated by MAF sensor => 950	Ambient pressure > 11 psi (76 kPa)	Immediate
		Air Inlet Temperature (AIT) > 19°F (-7°C) and < 122°F (50°C)	
		ECT > 122°F (50°C) and < 239°F (115°C)	
		Engine Throttle Position (ETP) {calibrated out} < 100%	
		Exhaust Back Pressure Control Valve (EBPV) < 20%	
		Not in regeneration mode	
		Torque between 400-800 N•m and RPM between 700-2200 rpm	
		Number of monitoring events >= 3	
		Duration of monitoring event = 3.5 seconds	
		Engine torque command gradient > 40 N•m/sec and < 10000 N•m/sec	
		The following SPN/FMIs are not active: 110/3, 110/4, 172/3, 172/4, 132/3, 132/4, 108/3, 108/4, 105/3, 105/4, 27/3, 27/4, 27/7, 412/3, 412/4, 173/3, and 173/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the EGR valve is not responding as expected.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2659 FMI 10 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2659 FMI 10. No: Go to Step 3.

Step	Action	Decision
3	Inspect EGR valve for sticking. Perform Standard and Output State Test (page 463) while monitoring the EGR valve for movement. Does EGR valve move when actuated?	Yes: Go to Step 4. No: Replace EGR valve. After repairs are complete, retest for SPN 2659 FMI 10.

Step	Action	Decision
4	Inspect Engine Throttle Valve (ETV) for sticking. Perform Standard and Output State test while monitoring the ETV for movement. Does ETV move when actuated?	Yes: Go to Step 5. No: Replace ETV. After repairs are complete, retest for SPN 2659 FMI 10.

Step	Action	Decision
5	Verify proper turbocharger wastegate operation. Perform Wastegate Checks (page 177). Does wastegate operate properly?	Yes: Go to Step 6. No: Replace turbocharger. After repairs are complete, retest for SPN 2659 FMI 10.

Step	Action	Decision
6	Inspect air intake system between turbocharger and air filter for air leaks. Is air intake system between turbocharger and air filter free of leaks?	Yes: Go to Step 7. No: Repair air leak. After repairs are complete, retest for SPN 2659 FMI 10.

Step	Action	Decision
7	Inspect connections at the Intake Manifold Temperature (IMT) sensor. With key OFF, disconnect IMT connector. Check IMT and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the IMT connector, harness, and terminals clean and undamaged?	Yes: Go to Step 8. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2659 FMI 10.

Step	Action	Decision
8	Test IMT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 622). Are IMT circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 9. No: Repair circuits as required. After repairs are complete, retest for SPN 2659 FMI 10.

Step	Action	Decision
9	Connect breakout harness 4993 between IMT sensor and IMT sensor connector. Do Key ON, Engine OFF (KOEO) voltage check of IMT sensor between sensor signal and ground. Is voltage within specification?	Yes: Go to Step 10. No: Replace IMT sensor. After repairs are complete, retest for SPN 2659 FMI 10.

Step	Action	Decision
10	Inspect connections at the Intake Manifold Pressure (IMP) sensor. With key OFF, disconnect IMP connector. Check IMP and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the IMP connector, harness, and terminals clean and undamaged?	Yes: Go to Step 11. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2659 FMI 10.

Step	Action	Decision
11	Test IMP circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 605). Are IMP circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 12. No: Repair circuits as required. After repairs are complete, retest for SPN 2659 FMI 10.

Step	Action	Decision
12	Connect breakout harness 4850 between IMP sensor and IMP sensor connector. Do KOEO voltage check of IMP sensor between sensor signal and ground. See Appendix B: Signal Values (page 819). Is voltage within specification?	Yes: Go to Step 13. No: Replace IMP sensor. After repairs are complete, retest for SPN 2659 FMI 10.

Step	Action	Decision
13	Inspect connections at the Mass Air Flow (MAF) sensor. With key OFF, disconnect MAF connector. Check MAF and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the MAF connector, harness, and terminals clean and undamaged?	Yes: Go to Step 14. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2659 FMI 10.

Step	Action	Decision
14	Test MAF circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 664). Are MAF circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 15. No: Repair circuits as required. After repairs are complete, retest for SPN 2659 FMI 10.

Step	Action	Decision
15	Connect breakout harness 4960 between MAF sensor and MAF sensor connector. Do KOEO voltage check of MAF sensor between sensor signal and ground. See Appendix B: Signal Values. Is voltage within specification?	Yes: Go to Step 16. No: Replace MAF sensor. After repairs are complete, retest for SPN 2659 FMI 10.

Step	Action	Decision
16	Inspect Exhaust Gas Recirculation (EGR) system for leaks. Is EGR system free of leaks?	Yes: After doing all diagnostic steps, if SPN 2659 FMI 10 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair EGR system leak(s). After repairs are complete, retest for SPN 2659 FMI 10.

NOTE: After doing all diagnostic steps, if SPN 2659 FMI 10 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2659 FMI 15 - EGR High Flow Rate Detected

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Exhaust Gas Recirculation (EGR) high flow	EGR control error (Actual Value as indicated by MAF sensor minus Mass Air Flow (MAF) Set point) < -100 kg/hr	Ambient pressure > 11 psi (75.3 kPa)	1.4 seconds
		Air Inlet Temperature (AIT) > 19°F (-7°C) and < 122°F (50°C)	
		Not in regeneration mode	
		EGR set-point > -3% and < 3%	
		Load > 300 N•m and < 800 N•m	
		Engine speed > 1000 rpm and < 2000 rpm	
		Engine Coolant Temperature (ECT) > 104°F (40°C) and < 239°F (115°C)	
		Engine speed gradient > 50 rpm/sec and < 110 rpm/sec	
		Engine torque command gradient >40 N•m/sec and < 70 N•m/sec	
		EGR valve position set-point < 20%	
		Engine Throttle Position (ETP) set-point < 100%	
		EGR control in closed loop mode	
		ETP in closed loop mode	
		The following SPN/FMIs are not active: 110/3, 110/4, 172/3, 172/4, 132/3, 132/4, 108/3, 108/4, 105/3, 105/4, 27/3, 27/4, 27/7, 412/3, 412/4, 173/3, and 173/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the EGR valve is not responding as expected.

Amber Warning Lamp (AWL) Reaction

When fault is active, the Amber Warning Lamp (AWL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2659 FMI 15 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2659 FMI 15. No: Go to Step 3.

Step	Action	Decision
3	Inspect air intake system including Charge Air Cooler (CAC) for restrictions or leaks. Inspect exhaust system for restrictions. Are intake system and exhaust system free of restrictions or leaks?	Yes: Go to Step 4. No: Repair restrictions or leaks as necessary. After repairs are complete, retest for SPN 2659 FMI 15.

Step	Action	Decision
4	Check for biased ETP, EGRP, IMP, and MAF sensor or circuit. Using EST with ServiceMaxx™ software. Do Key On Engine Off (KOEO) Continuous Monitor Test (page 819). Verify sensor voltages are within specifications. Are ETP, EGRP, IMP, and MAF sensors within specifications?	Yes: Go to Step 5. No: Repair or replace component, connector, harness, or terminal damage as necessary. After repairs are complete, retest for SPN 2659 FMI 15.

Step	Action	Decision
5	Remove Manifold Mixer assembly. Connect EGR valve harness connector. Run KOEO Output State Test (page 463)while observing EGR valve. Does EGR valve function normally?	Yes: After doing all diagnostic steps, if SPN 2659 FMI 15 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace EGR valve. After repairs are complete, retest for SPN 2659 FMI 15.

NOTE: After doing all diagnostic steps, if SPN 2659 FMI 15 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2659 FMI 17 - EGR Low Flow Rate Detected

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Exhaust Gas Recirculation (EGR) low flow rate detected	EGR control error. Actual value as indicated by Mass Air Flow (MAF) sensor minus Mass Air Flow (MAF) set point > 327.6 kg/hr	Ambient pressure > 11 psi (75.3 kPa)	12 seconds
		Air Inlet Temperature (AIT) > 19°F (-7°C) and < 122°F (50°C)	
		Not in regeneration mode	
		Engine speed > 2000 rpm and load >200 N•m	
		ECT > 122°F (50°C) and < 239°F (115°C)	
		Engine speed gradient < 30 rpm/sec	
		Engine torque command gradient >40 N•m/sec	
		EGR valve position set-point >/= 0%	
		Engine Throttle Position (ETP) set-point >/= 84.20%	
		EGR control in closed loop mode	
		ETP in closed loop mode	
		The following SPN/FMIs are not active: 110/3, 110/4, 172/3, 172/4, 132/3, 132/4, 108/3, 108/4, 105/3, 105/4, 27/3, 27/4, 27/7, 412/3, 412/4, 173/3, and 173/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the EGR valve is not responding as expected.

Amber Warning Lamp (AWL) Reaction

When fault is active, the Amber Warning Lamp (AWL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2659 FMI 17 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2659 FMI 17 No: Go to Step 3.

Step	Action	Decision
3	Inspect air intake system and exhaust system for restrictions. Are intake system and exhaust system free of restrictions?	Yes: Go to Step 4. No: Repair restrictions or leaks as necessary. After repairs are complete, retest for SPN 2659 FMI 17.

Step	Action	Decision
4	Check for biased ETP, EGRP, IMP, and MAF sensor or circuit. Using EST with ServiceMaxx™ software. Do Key On Engine Off (KOEO) Continuous Monitor Test (page 819). Verify sensor voltages are within specifications. Are ETP, EGRP, IMP, and MAF sensors within specifications?	Yes: Go to Step 5. No: Repair or replace component, connector, harness, or terminal damage as necessary. After repairs are complete, retest for SPN 2659 FMI 17.

Step	Action	Decision
5	Remove Manifold Mixer assembly. Connect EGR valve harness connector. Run KOEO Output State Test (page 463)while observing EGR valve. Does EGR valve function normally?	Yes: After doing all diagnostic steps, if SPN 2659 FMI 17 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace EGR valve. After repairs are complete, retest for SPN 2659 FMI 17.

NOTE: After doing all diagnostic steps, if SPN 2659 FMI 17 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2659 FMI 20 - EGR High Flow Rate Detected

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Exhaust Gas Recirculation (EGR) high flow rate detected	EGR control error. Actual value as indicated by Mass Air Flow (MAF) sensor minus Mass Air Flow (MAF) set point < -100 kg/hr	Ambient pressure > 11 psi (75.3 kPa)	1.4 seconds
		Air Inlet Temperature (AIT) > 19°F (-7°C) and < 122°F (50°C)	
		Not in regeneration mode	
		EGR set-point > -3% and < 3%	
		Load > 300 N•m and < 800 N•m	
		Engine speed > 1000 rpm and < 2000 rpm	
		ECT > 122°F (50°C) and < 239°F (115°C)	
		Engine speed gradient > 50 rpm/sec and < 100 rpm/sec	
		Engine torque command gradient >40 N•m/sec and < 70 N•m/sec	
		EGR valve position set-point < 20%	
		Engine Throttle Position (ETP) set-point < 100%	
		EGR control in closed loop mode	
		ETP in closed loop mode	
		The following SPN/FMIs are not active: 110/3, 110/4, 172/3, 172/4, 132/3, 132/4, 108/3, 108/4, 105/3, 105/4, 27/3, 27/4, 27/7, 412/3, 412/4, 173/3, and 173/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the EGR valve is not responding as expected.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate..

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2659 FMI 20 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2659 FMI 20 No: Go to Step 3.

Step	Action	Decision
3	Inspect air intake system including Charge Air Cooler (CAC) for restrictions or leaks. Inspect exhaust system for restrictions. Are intake system and exhaust system free of restrictions or leaks?	Yes: Go to Step 4. No: Repair restrictions or leaks as necessary. After repairs are complete, retest for SPN 2659 FMI 20.

Step	Action	Decision
4	Check for biased ETP, EGRP, IMP, and MAF sensor or circuit. Using EST with ServiceMaxx™ software. Do Key On Engine Off (KOEO) Continuous Monitor Test (page 819). Verify sensor voltages are within specifications. Are ETP, EGRP, IMP, and MAF sensors within specifications?	Yes: Go to Step 5. No: Repair or replace component, connector, harness, or terminal damage as necessary. After repairs are complete, retest for SPN 2659 FMI 20.

Step	Action	Decision
5	Remove Manifold Mixer assembly. Connect EGR valve harness connector. Run KOEO Output State Test (page 463)while observing EGR valve. Does EGR valve function normally?	Yes: After doing all diagnostic steps, if SPN 2659 FMI 20 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace EGR valve. After repairs are complete, retest for SPN 2659 FMI 20.

NOTE: After doing all diagnostic steps, if SPN 2659 FMI 20 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2659 FMI 21 - EGR Low Flow Rate Detected

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Exhaust Gas Recirculation (EGR) low flow rate detected	EGR control error. Actual value as indicated by Mass Air Flow (MAF) sensor minus Mass Air Flow (MAF) set point > 327.6 kg/hr	Ambient pressure > 11 psi (75.3 kPa)	12 seconds
		Air Inlet Temperature (AIT) > 19°F (-7°C) and < 122°F (50°C)	
		Not in regeneration mode	
		Engine speed > 2000 rpm and load >200 N•m	
		ECT > 122°F (50°C) and < 239°F (115°C)	
		Engine speed gradient < 30 rpm/sec	
		Engine torque command gradient >40 N•m/sec	
		EGR valve position set-point >/= 0%	
		Engine Throttle Position (ETP) set-point >/= 84.20%	
		EGR control in closed loop mode	
		ETP in closed loop mode	
		The following SPN/FMIs are not active: 110/3, 110/4, 172/3, 172/4, 132/3, 132/4, 108/3, 108/4, 105/3, 105/4, 27/3, 27/4, 27/7, 412/3, 412/4, 173/3, and 173/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the EGR valve is not responding as expected.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2659 FMI 21 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2659 FMI 21 No: Go to Step 3.

Step	Action	Decision
3	Inspect air intake system and exhaust system for restrictions. Are intake system and exhaust system free of restrictions?	Yes: Go to Step 4. No: Repair restrictions or leaks as necessary. After repairs are complete, retest for SPN 2659 FMI 21.

Step	Action	Decision
4	Check for biased ETP, EGRP, IMP, and MAF sensor or circuit. Using EST with ServiceMaxx™ software. Do Key On Engine Off (KOEO) Continuous Monitor Test (page 819). Verify sensor voltages are within specifications. Are ETP, EGRP, IMP, and MAF sensors within specifications?	Yes: Go to Step 5. No: Repair or replace component, connector, harness, or terminal damage as necessary. After repairs are complete, retest for SPN 2659 FMI 21.

Step	Action	Decision
5	Remove Manifold Mixer assembly. Connect EGR valve harness connector. Run KOEO Output State Test (page 463)while observing EGR valve. Does EGR valve function normally?	Yes: After doing all diagnostic steps, if SPN 2659 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace EGR valve. After repairs are complete, retest for SPN 2659 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 2659 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 5543 FMI 16 - EBP Valve Internal Temperature Fault

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Exhaust brake actuator command	Exhaust brake control circuit internal temperature < -40°F (-40°C) or > 257°F (125°C)	Key ON The following SPN/FMIs are not active: 5543/19 and 5543/20.	2 seconds

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the Exhaust Back Pressure Valve (EBPV) temperature is either greater than or less than a predetermined minimum or maximum threshold.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Thermal Management Valve (TMV) Programmable Parameters

Set the following programmable parameters using ServiceMaxx™ software:

- 70003 - Vehicle Retarder Control Mode - Set to 1 - Exhaust Brake Latched
- 70101 - Exhaust Brake Switch Signal Feature Enable - Set to 1 - EBE Hard-Wire Signal Feature Enabled
- 72001 - Exhaust Back-Pressure Control Mode - Set to 1 - Enable
- 72012 - Engine Assisted Windshield Defrost Feature - Set to 1 - Enable

Set the following programmable parameters in DLB® software:

- 595AGC - BC PROG, ENGINE EXHAUST BRAKE

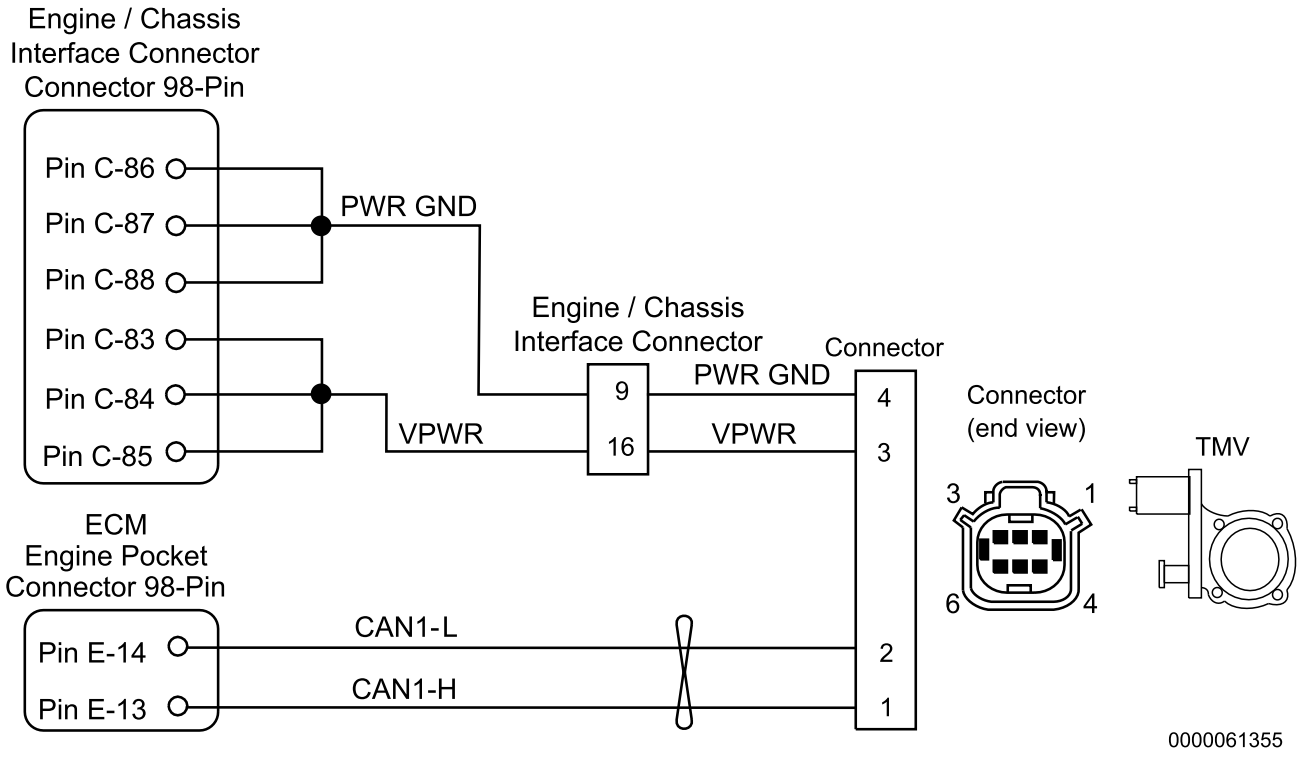


Figure 83 TMV Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 5543 FMI 16 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 5543 FMI 16. No: Go to Step 3.

Step	Action	Decision
3	Inspect exhaust system for restrictions, leaks, or physical damage. Is exhaust system free of restrictions, leaks, and physical damage?	Yes: Go to Step 4. No: Repair restrictions, leaks or physical damage. After repairs are complete, retest for SPN 5543 FMI 16.

Step	Action	Decision
4	Visually inspect coolant hoses to Thermal Management Valve (TMV) for leaks, kinks, or physical restrictions. Are hoses free of leaks, kinks, and physical restrictions?	Yes: Go to Step 5. No: Repair leaks, kinks, and / or physical restrictions. After repairs are complete, retest for SPN 5543 FMI 16.

Step	Action	Decision
5	**WARNING: To prevent personal injury or death, make sure the engine has cooled before removing components.** **WARNING: To prevent personal injury or death, carefully remove coolant hoses. Coolant in hoses could splash out and create slippery conditions.** Disconnect TMV coolant hoses from engine and check for coolant flow restrictions through hoses and valve. Are coolant hoses and valve free of coolant flow restrictions? **NOTE:** Upon completion of diagnostic procedure, check and fill cooling system as needed.	Yes: Go to Step 6. No: Repair coolant hoses and / or valve for coolant flow restrictions. After repairs are complete, retest for SPN 5543 FMI 16.

Step	Action	Decision
6	Inspect connections at the Thermal Management Valve (TMV). With key OFF, disconnect TMV connector. Check TMV and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the TMV connector, harness, and terminals clean and undamaged?	Yes: Go to Step 7. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5543 FMI 16.

Step	Action	Decision
7	Test TMV circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 244). Are TMV circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 8. No: Repair circuits as necessary. After repairs are complete, retest for SPN 5543 FMI 16.

Step	Action	Decision
8	Test TMV for proper operation. Perform TMV actuator test (page 244). Does TMV operate properly and within specifications?	Yes: After doing all diagnostic steps, if SPN 5543 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace TMV. Using EST with ServiceMaxx™ and DLB® software, set programmable parameters (page 262).

NOTE: After doing all diagnostic steps, if SPN 5543 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 5543 FMI 19 - EBPC valve not detected on J1939

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Exhaust Back Pressure Control (EBPC) Bus timeout error detected	Controller Area Network (CAN) Bus timeout error detected	Key ON The following SPN/FMIs are not active: 5543/16 and 5543/20.	2 seconds

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the CAN BUS is not currently active.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

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Drive Cycle to Determine Fault Status

N / A

Thermal Management Valve (TMV) Programmable Parameters

Set the following programmable parameters using ServiceMaxx™ software:

- 70003 - Vehicle Retarder Control Mode - Set to 1 - Exhaust Brake Latched
- 70101 - Exhaust Brake Switch Signal Feature Enable - Set to 1 - EBE Hard-Wire Signal Feature Enabled
- 72001 - Exhaust Back-Pressure Control Mode - Set to 1 - Enable
- 72012 - Engine Assisted Windshield Defrost Feature - Set to 1 - Enable

Set the following programmable parameters in DLB® software:

- 595AGC - BC PROG, ENGINE EXHAUST BRAKE

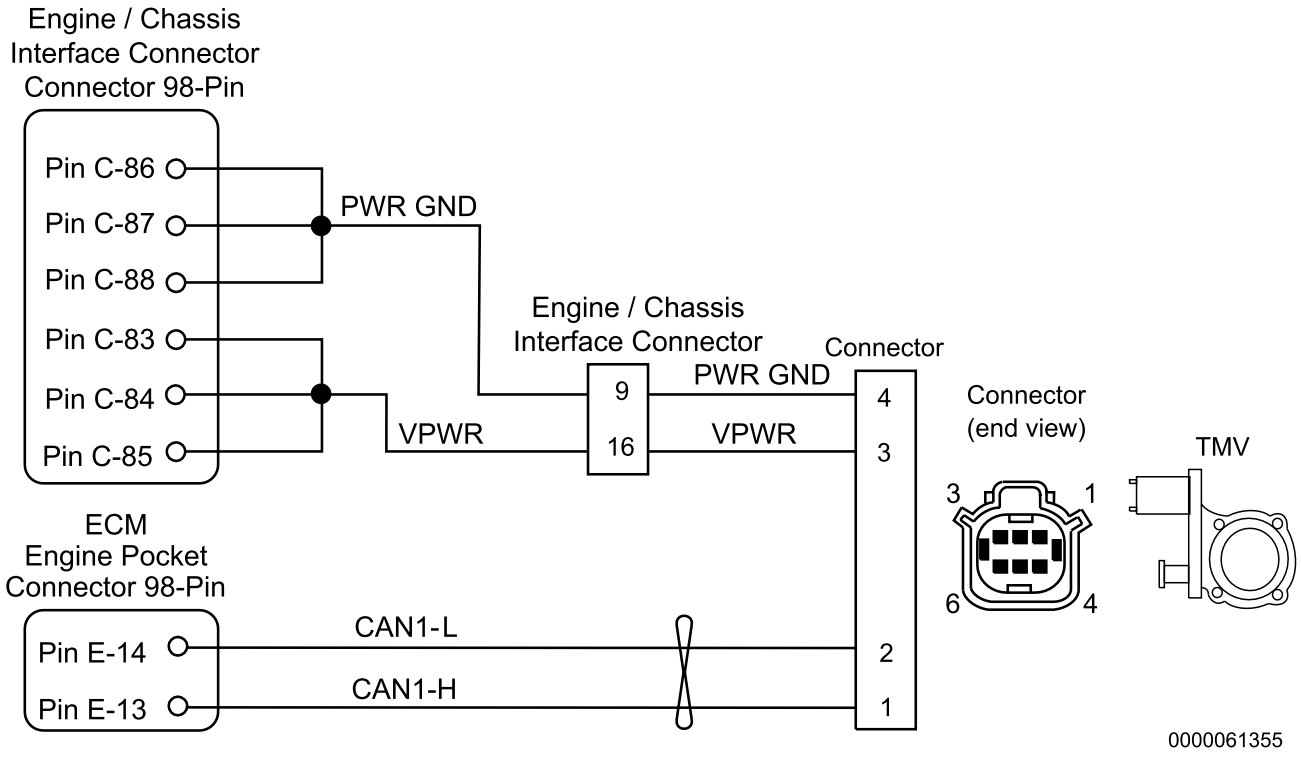

Figure 84 TMV Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 5543 FMI 19 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 5543 FMI 19. No: Go to Step 3.

Step	Action	Decision
3	With ServiceMaxx™, refer to Sniffer window in lower right corner of screen. With Key ON Engine OFF (KOEO), are modules present in the Module Name column?	Yes: Go to Step 4. No: Repair CAN wiring for open, short, high resistance, or tampering.

Step	Action	Decision
4	With ServiceMaxx™, refer to Sniffer window in lower right corner of screen. With KOEO, is EBPC missing from the Module Name column?	Yes: Go to Step 5. No: After doing all diagnostic steps, if SPN 5543 FMI 19 remains, verify each step completed correctly and the proper decision was made. Notify supervisor for further action.

Step	Action	Decision
5	Inspect connections at Thermal Management Valve (TMV). With key OFF, disconnect TMV connector. Check TMV valve and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins, or broken connector housing. Are TMV connector, harness, and terminals clean and undamaged?	Yes: Replace TMV. Using EST with ServiceMaxx™ and DLB® software, set programmable parameters (page 266). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5543 FMI 19.

NOTE: After doing all diagnostic steps, if SPN 5543 FMI 19 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 5543 FMI 20 - EBP valve electrical fault

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Smart actuator spring error or valve gear train error	Exhaust brake position error > 10% or < -10% and position error fault as indicated by smart actuator > +/- 1.8 degrees	Key ON	2 seconds
		The following SPN/FMIs are not active: 5543/16 and 5543/19.	2 seconds

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the Exhaust Back Pressure Valve (EBPV) has a fault.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Thermal Management Valve (TMV) Programmable Parameters

Set the following programmable parameters using ServiceMaxx™ software:

- 70003 - Vehicle Retarder Control Mode - Set to 1 - Exhaust Brake Latched
- 70101 - Exhaust Brake Switch Signal Feature Enable - Set to 1 - EBE Hard-Wire Signal Feature Enabled
- 72001 - Exhaust Back-Pressure Control Mode - Set to 1 - Enable
- 72012 - Engine Assisted Windshield Defrost Feature - Set to 1 - Enable

Set the following programmable parameters in DLB® software:

- 595AGC - BC PROG, ENGINE EXHAUST BRAKE

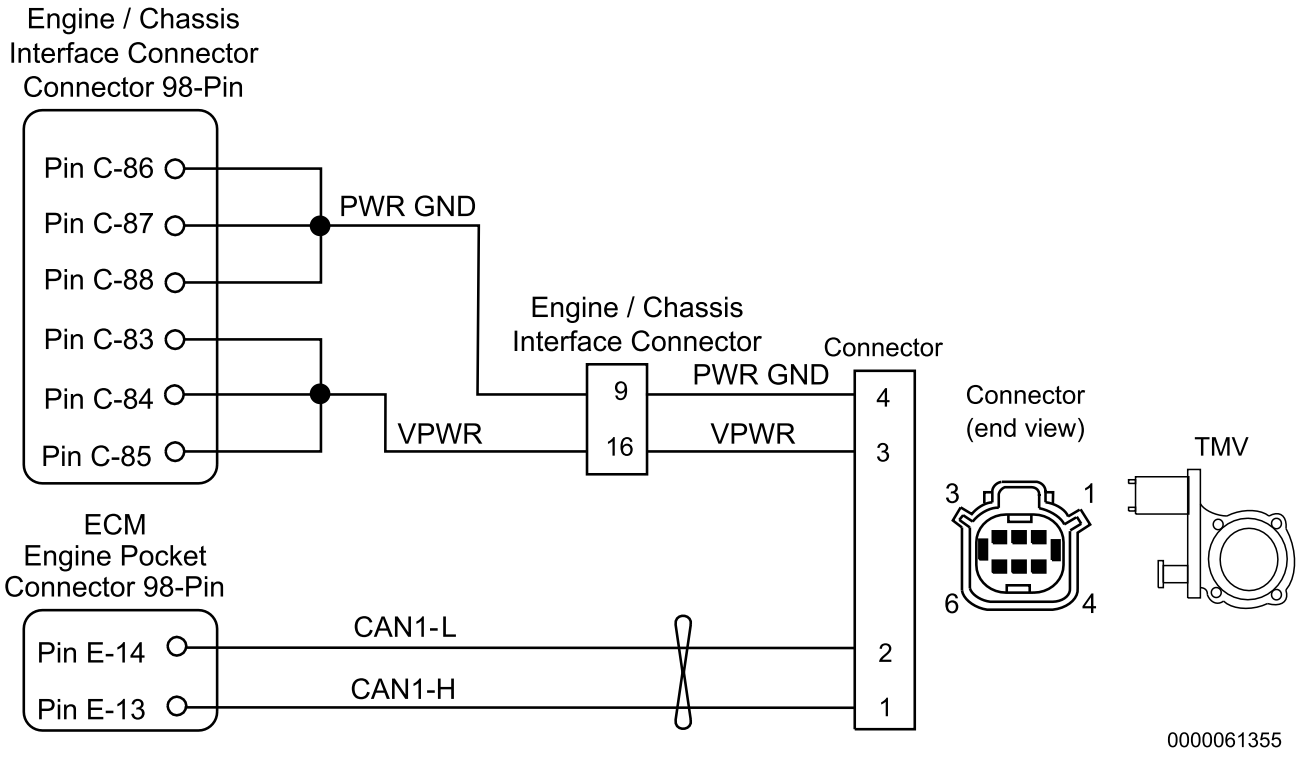

Figure 85 TMV Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 5543 FMI 20 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 5543 FMI 20. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at the Thermal Management Valve (TMV). With key OFF, disconnect TMV connector. Check TMV and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the TMV connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5543 FMI 20.

Step	Action	Decision
4	Test TMV circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 244). Are TMV circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5. No: Repair circuits as necessary. After repairs are complete, retest for SPN 5543 FMI 20.

Step	Action	Decision
5	Test TMV for proper operation. Perform TMV actuator test (page 244). Does TMV operate properly and within specifications?	Yes: After doing all diagnostic steps, if SPN 5543 FMI 20 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace TMV. Using EST with ServiceMaxx™ and DLB® software, set programmable parameters (page 269).

NOTE: After doing all diagnostic steps, if SPN 5543 FMI 20 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

APP (Accelerator Pedal Position) Sensor

SPN	FMI	Condition
91	2	APP1 and APP2 signal conflict
91	3	APP1 signal Out of Range HIGH
91	4	APP1 signal Out of Range LOW
91	7	APP1 and IVS signal conflict
2623	3	APP2 signal Out of Range HIGH
2623	4	APP2 signal Out of Range LOW

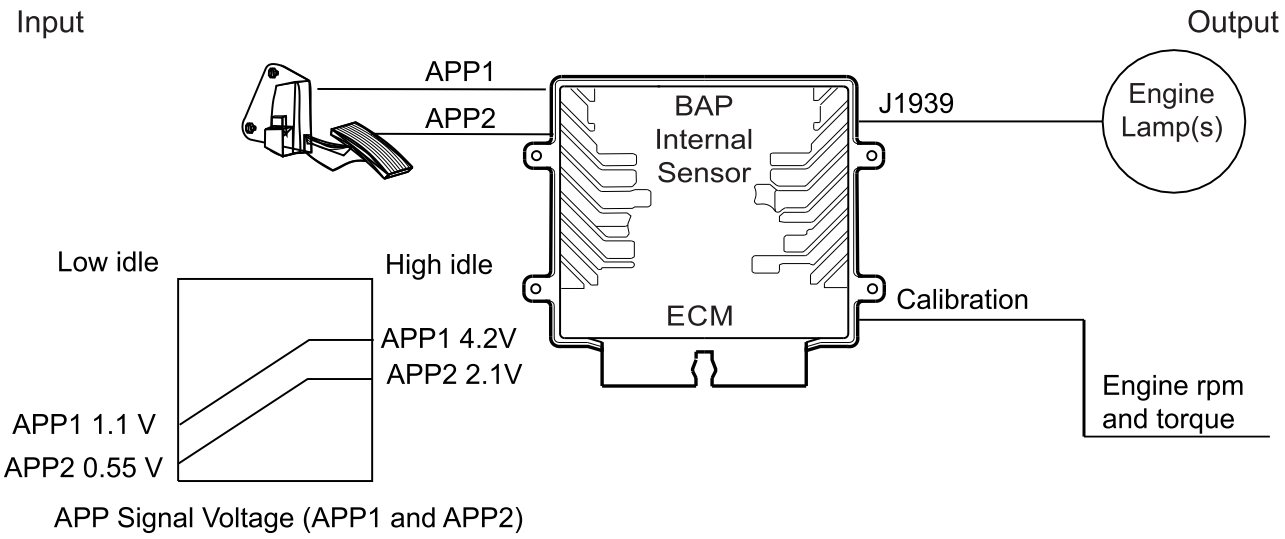

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Figure 86 Function diagram for the APP sensor

The APP sensor function diagram includes the following:

- Accelerator Pedal Position (APP) sensor
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Engine Lamp(s)

Function

The APP sensor is controlled by the operator. The ECM uses APP input to control engine acceleration based on the operator's demand for power.

Sensor Location

The APP sensor is installed in the vehicle cab on the accelerator pedal.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 00-00956-08 – 180-Pin Breakout Box
- 3-Banana Plug Harness ZTSE4498
- Breakout Harness ZTSE4485A (APP)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

APP Sensor End Diagnostics

SPN	FMI	Condition	Possible Causes
91	2	APP1 and APP2 signal conflict	• APP1 and APP2 mismatched • Biased sensor or circuit
91	3	APP1 signal Out of Range HIGH	• APP1 signal shorted to Power (PWR) • Signal Ground (SIG GND) circuit OPEN • Failed sensor
91	4	APP1 signal Out of Range LOW	• APP1 signal circuit OPEN or short to Ground (GND) • Reference Voltage (VREF) circuit OPEN or short to GND • Failed sensor
91	7	APP1 and IVS signal conflict	• APP1 and IVS mismatched • Biased sensor or circuit
2623	3	APP2 signal Out of Range HIGH	• APP2 signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor
2623	4	APP2 signal Out of Range LOW	• APP2 signal circuit OPEN or short to GND • VREF circuit OPEN or short to GND • Failed sensor

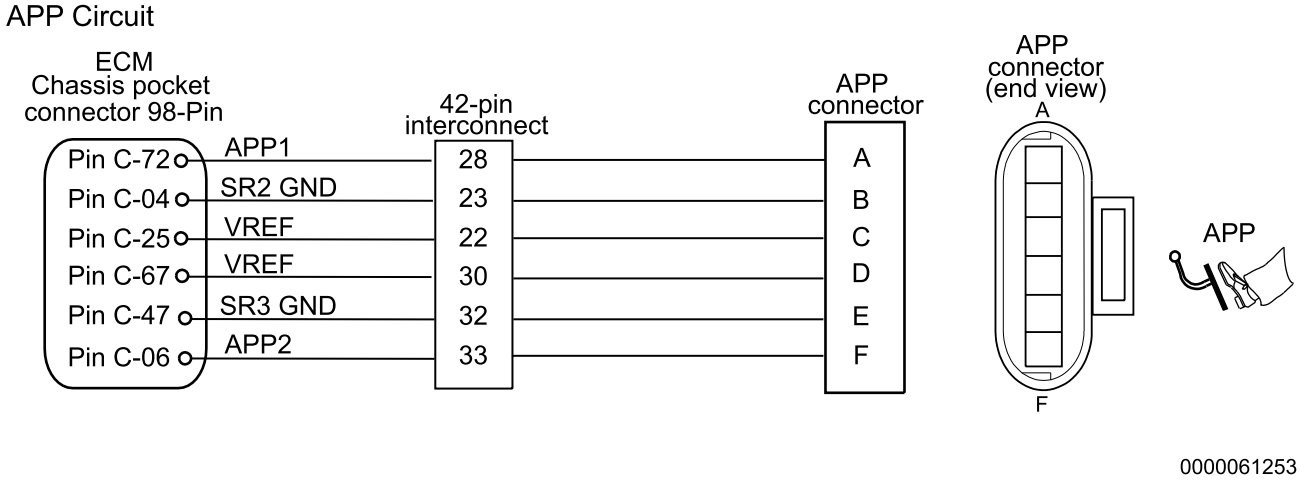


Figure 87 APP sensor circuit diagram

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

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, open the Continuous Monitor session.
2. Verify sensor voltage is within KOEO specification. See “Appendix A: Performance Specifications” (page 813).
3. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal will spike and the DTC will go active.
   - If DTC is active, proceed to the next step.
4. Disconnect engine harness from sensor.

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

5. Connect Breakout Harness ZTSE4485A to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect Breakout Harness ZTSE4485A to engine harness. Leave sensor disconnected. Turn the ignition switch to ON. Use Electronic Service Tool (EST) with ServiceMaxx™ software to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC Short breakout harness across A and C	SPN 91 FMI 3	If SPN 91 / FMI 4 is active, check APP1 signal for OPEN. Do Harness Resistance Check (page 278).
EST - Check DTC Short breakout harness across F and C	SPN 2623 FMI 3	If SPN 2623 / FMI 4 is active, check APP2 signal for OPEN. Do Harness Resistance Check (page 278).
EST - Check DTC	SPN 2623 FMI 3	If SPN 2623 / FMI 3 is active, check APP2 signal for short to PWR.
EST - Check DTC	SPN 91 FMI 4	If SPN 91 / FMI 3 is active, check APP1 signal for short to PWR.
DMM – Measure volts C to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 278).
DMM – Measure resistance B to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 278).
DMM – Measure voltage D to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 278).
DMM – Measure voltage E to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 278).
If checks are within specification, connect sensor, clear DTCs, and cycle the pedal a few times. If active DTC returns, replace sensor.		

APP Pin-point Diagnostics

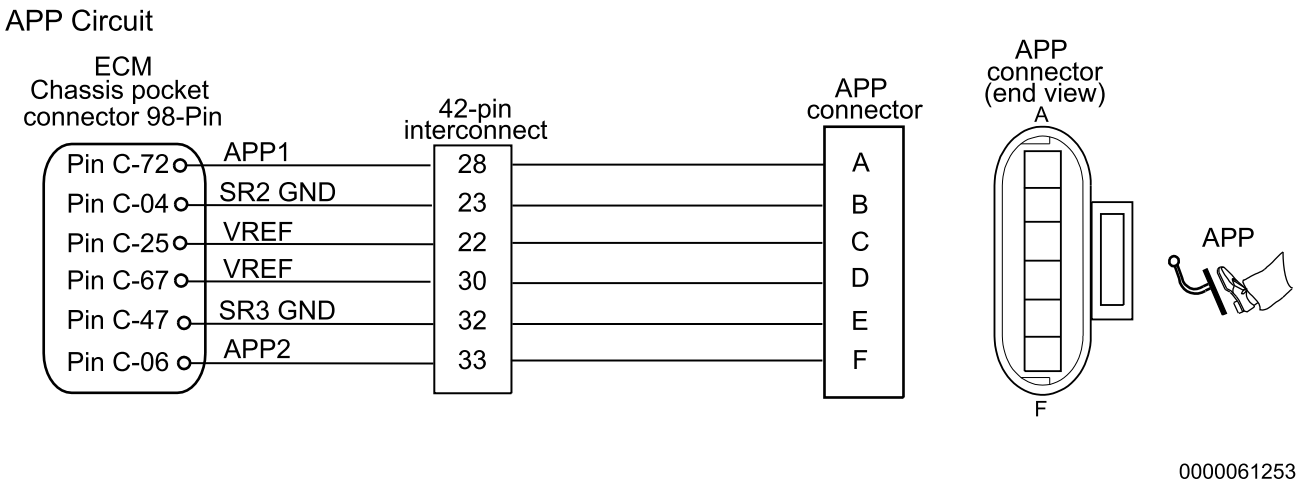


Figure 88 APP sensor circuit diagram

Connector Voltage Check

Connect Breakout Harness ZTSE4485A. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
A to GND	0 V	If > 0.25 V, check for short to PWR.
B to B+	B+	If < B+, check for short to power, or open circuit. Do Harness Resistance Check (page 278).
C to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 278).
D to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 278).
E to B+	B+	If < B+, check for short to power, or open circuit. Do Harness Resistance Check (page 278).
F to GND	0 V	If > 0.25 V, check for short to PWR.

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4485A. Leave sensor disconnected. Use DMM to measure resistance.

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

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

Harness Resistance Check

Turn ignition switch to OFF. Disconnect both battery GND cables. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4485A. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
A to C-72	< 5 Ω	If > 5 Ω, check APP signal circuit for OPEN.
B to C-04	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
C to C-25	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
D to C-67	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
E to C-47	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
F to C-06	< 5 Ω	If > 5 Ω, check APP2 signal circuit for OPEN.

Operational Voltage Check

Connect 180-Pin Breakout Box and Breakout Harness ZTSE4485A between ECM and sensor. Turn ignition switch to ON. Use DMM to measure voltage and EST to read signal.

Test Point	Condition	DMM	EST Value
APP	Foot off pedal	1.14 V ± 0.25 V	0%
A to GND or C-72 to GND	Pedal to floor	4.32 V ± 0.25 V	100%
F to GND or C-06 to GND	Foot off pedal	0.56 V ± 0.25 V	0%
	Pedal to floor	2.16 V ± 0.25 V	100%

APP Circuit Operation

The APP sensor is a dual potentiometer sensor that provides dual independent linear output voltages. It operates from +5V power supplied by the ECM. The ECM converts analog voltages APP1 and APP2 into normalized pedal percentage Primary Track and Secondary Track. It also compares the APP1 and APP2 signals for conflict. If a conflict occurs, the ECM sets a DTC. Any malfunction of the APP sensor circuit illuminates the AWL.

Accelerator Pedal Position (APP) sensor

The APP sensor is a potentiometer sensor supplied with a 5-volt reference voltage at Pin C from ECM Pin C-25, and to Pin D from the ECM Pin C-67. The sensor is grounded at Pin B from ECM Pin C-04, and Pin E from ECM Pin C-47. The sensor returns a variable voltage signal from Pin A to ECM Pin C-72, and from Pin F to ECM Pin C-06.

Fault Detection / Management

Normally, Secondary Track APP2 voltage is half of Primary Track APP1 voltage. Pedal operation is based on Primary APP input with Secondary APP2 input. If ECM determines Out of Range fault in the Primary Track, the ECM defaults to Secondary Track with limitation of operation to 50%. Similarly, if the ECM detects Out of Range fault on Secondary Track, the ECM will limit the Primary Track with limitation of operation to 50%. If both tracks fail Out of Range or if the ECM detects and In-range fault (disagreement in the state of APP1 and APP2), the engine will be allowed to operate at low idle only.

NOTE: If multiple APP DTCs are present, verify the APP part number is correct for the specific vehicle model.

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

ATA (American Trucking Association) Data Link (SAE J1587)

SPN	FMI	Condition
None		No communication to EGC

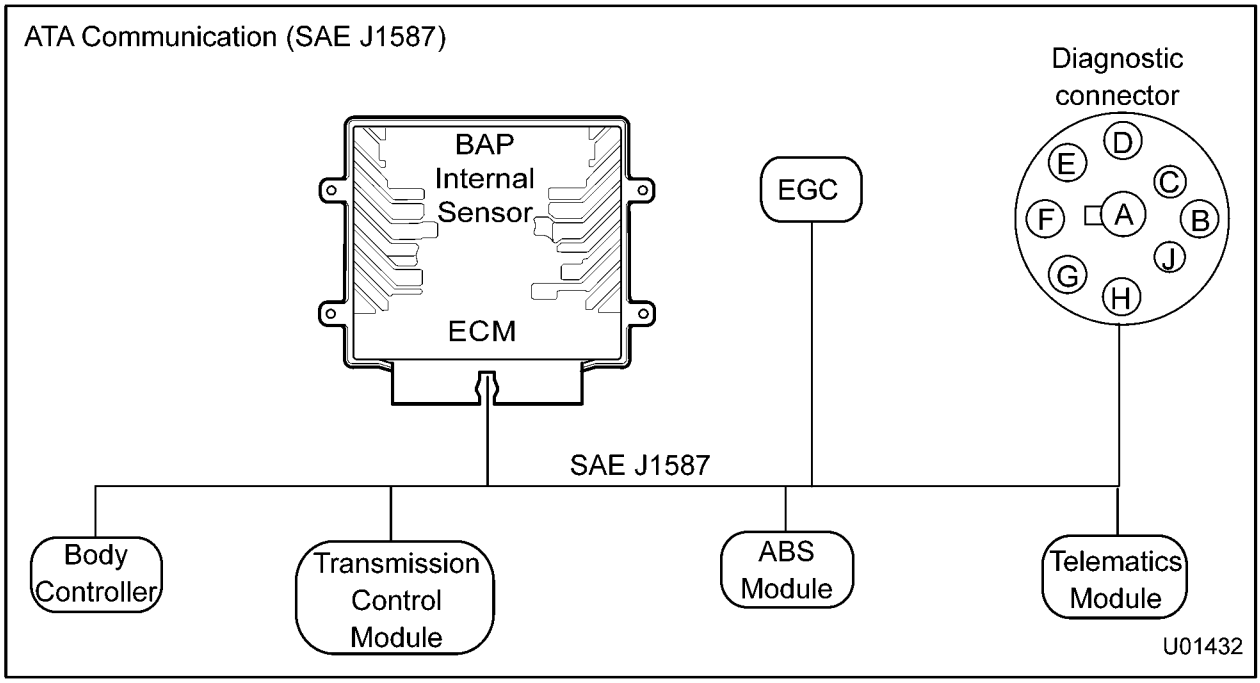


Figure 89 Function diagram for ATA (SAE J1587)

The function diagram for ATA (SAE J1587) includes the following:

- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Electronic Gauge Cluster (EGC)
- Diagnostic Connector
- Body Controller (BC)
- Transmission Control Module
- Antilock Brake System (ABS) Module
- Telematics Module

Function

The ATA (SAE J1587) data link provides communication between the ECM and an ATA (SAE J1587) compatible EGC module. The Electronic Service Tool (EST) can access this data link at the Diagnostic Connector.

Location

The ATA (SAE J1587) circuits are connected to the ECM, EGC and Diagnostic Connector. The Diagnostic Connector is located under the dash on the driver's side.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

ATA (SAE J1587) Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
None	None	No communication with EST	• Battery Positive (B+) circuit OPEN or short to GND • GND circuit OPEN • ATA (SAE J1587) circuits OPEN or short to PWR or GND

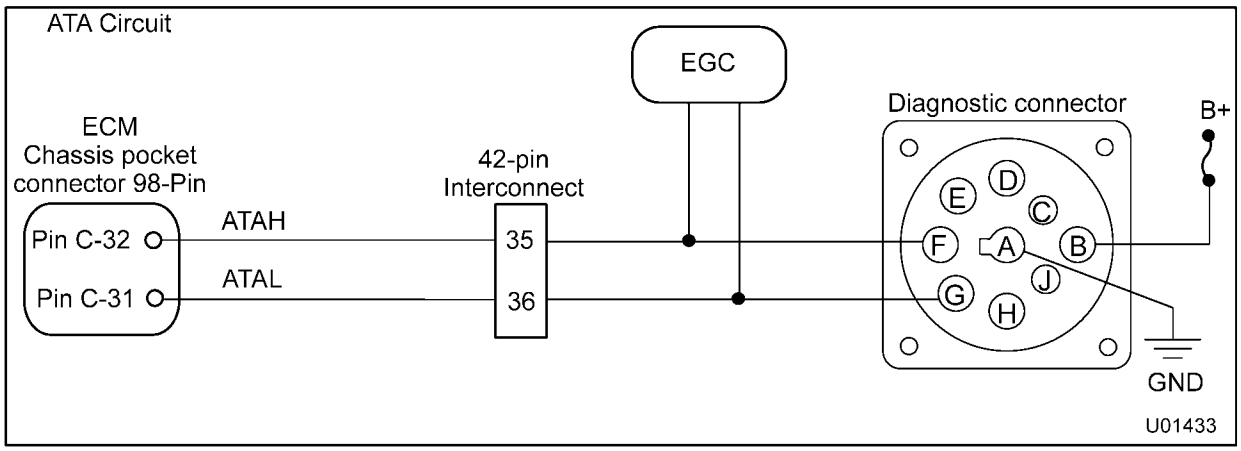


Figure 90 ATA (SAE J1587) circuit diagram

Connector Voltage Check - EST

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

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

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box. Leave ECM disconnected.

Test Point	Spec	Comment
F to C-32	< 5 Ω	If > 5 Ω, check ATAH for OPEN in circuit.
F to GND	> 1 kΩ	If < 1 kΩ, check ATAH for short to GND.
G to C-31	< 5 Ω	If > 5 Ω, check ATAL for OPEN in circuit.
G to GND	> 1 kΩ	If < 1 kΩ, check ATAL for short to GND.
A to GND	< 5 Ω	If > 5 Ω, check GND for OPEN in circuit.

ATA (SAE J1587) Operation

Diagnostic Connector

The fuse-protected B+ signal is supplied to the Diagnostic Connector through Pin B and ground is through Pin A. American Trucking Association High (ATAH) signal runs from ECM Pin C-32 and Diagnostic Connector Pin F. American Trucking Association Low (ATAL) signal runs from ECM Pin C-31 and Diagnostic Connector Pin G.

Electronic Gauge Cluster (EGC)

There are two types of EGC modules. One uses Controller Area Network CAN (J1939) communication and the other uses ATA (SAE J1587) communication. The following information is sent through data communication:

- Amber Warn Engine Lamp (AWL)
- Red Stop Lamp
- Software identification
- Total idle hours
- Idle fuel
- Vehicle Identification Number (VIN)
- Total miles
- Total fuel used
- Battery voltage
- Estimated fan speed
- Accelerator Pedal Position (APP) percent
- Speedometer
- Tachometer (TACH)
- Change oil message
- Oil pressure gauge
- Engine Coolant Temperature (ECT) gauge

Fault Detection / Management

There are no engine DTCs for ATA (SAE J1587) communication faults. See *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.

Repair Information

The ATA (SAE J1587) circuits use a twisted wire pair. All repairs must maintain one complete twist per inch along the entire length of the circuit. This circuit is polarized, one positive and one negative. Reversing the polarity of this circuit will disrupt communication.

Brake Switch Circuits

SPN	FMI	Condition
597	2	Brake switch circuit fault

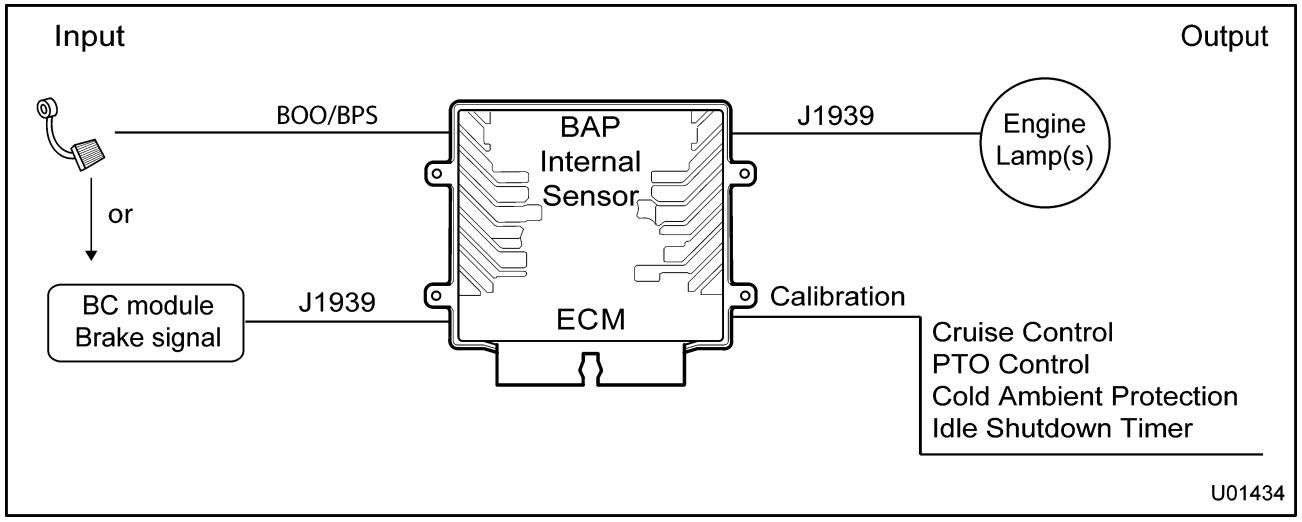


Figure 91 Function diagram for brake switch circuits

The brake switch circuit function diagram includes the following:

- Brake On / Off (BOO) switch
- Brake Pressure Switch (BPS)
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Body Controller (BC)
- Output - cancels Cruise Control (CCS)
- Output - cancels Power Takeoff (PTO) control
- Output - cancels Cold Ambient Protection (CAP)
- Output - cancels Idle Shutdown Timer (IST)
- Engine Lamp(s)

Function

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

Location

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

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 00–00956–08 – 180-Pin Breakout Box
- International® Electronic Engine Terminal Test Kit ZTSE4435C
- Digital Multimeter (DMM)

Brake Switch Circuits Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
597	2	Brake Switch circuit fault	• OPEN in B+ circuit to the switches or blown fuse • BPS circuit OPEN or short to PWR or GND • Failed switch

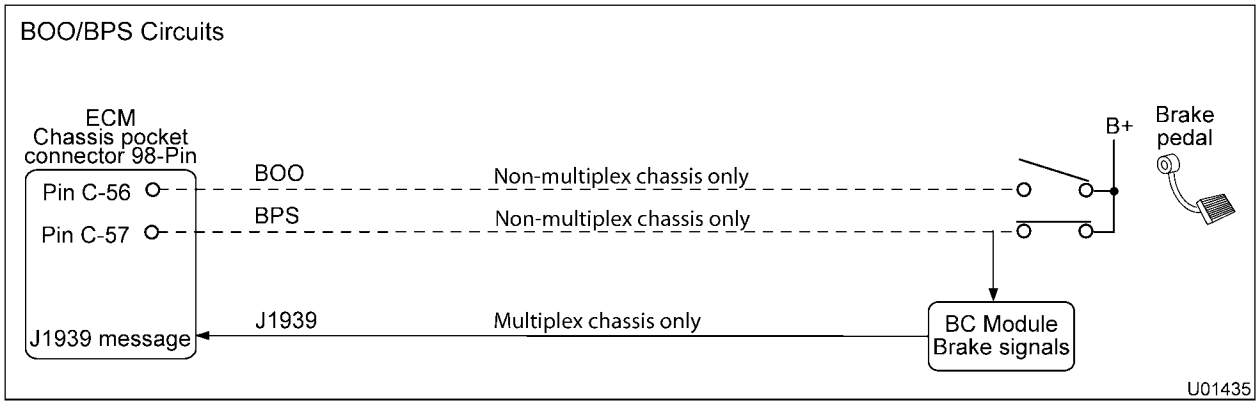


Figure 92 Brake switch circuit diagram

1. Connect EST to the Diagnostic Connector.
2. Turn ignition switch to ON.
   - If SPN 597 FMI 2 is displayed, continue to Brake Switch Circuits check.

Brake Switch Circuits

Turn the ignition switch to ON. Connect ServiceMaxx™ software. Open Switch session to monitor BOO (BOO only applies to nonmultiplex chassis) and BPS signals.

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

See *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for circuit information. If the brake circuits are hard-wired to the ECM and do not go through the BC module, do Voltage Check (page 288).

Voltage Check

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

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

Harness Resistance Check

Turn ignition switch to OFF, connect 180-Pin Breakout Box, leave ECM, BOO (BOO only applies to nonmultiplex chassis) and BPS disconnected. Use DMM to measure resistance.

Test Point	Spec	Comments
BOO		
C-56 to switch	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C-56 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
BPS		
C-57 to switch	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C-57 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Brake Switch Circuit Operation

Fault Detection / Management

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

On multiplex vehicles, the BPS circuit is wired directly to the BC module, and the state of the switch is communicated to the ECM through the CAN (J1939) network.

CACOT (Charge Air Cooler Outlet Temperature) Sensor

SPN	FMI	Condition	Possible Causes	Actions
2630	2	CACOT signal erratic, intermittent, or incorrect	• Biased CACOT sensor or circuit	Step-Based Diagnostics (page 293)
2630	3	CACOT signal out of range HIGH	• CACOT signal open or short to battery • CACOT signal return open • Sensor unplugged	Step-Based Diagnostics (page 297)
2630	4	CACOT signal out of range LOW	• CACOT signal circuit short to GND • Failed sensor	Step-Based Diagnostics (page 300)
2630	16	CACOT Undercooling	• Restricted airflow over heat exchanger fin • Failed engine fan and / or fan shroud • Air dam issues • Winter front	Step-Based Diagnostics (page 303)
2630	21	CACOT signal drifted LOW	• Biased CACOT sensor or circuit	Step-Based Diagnostics (page 307)

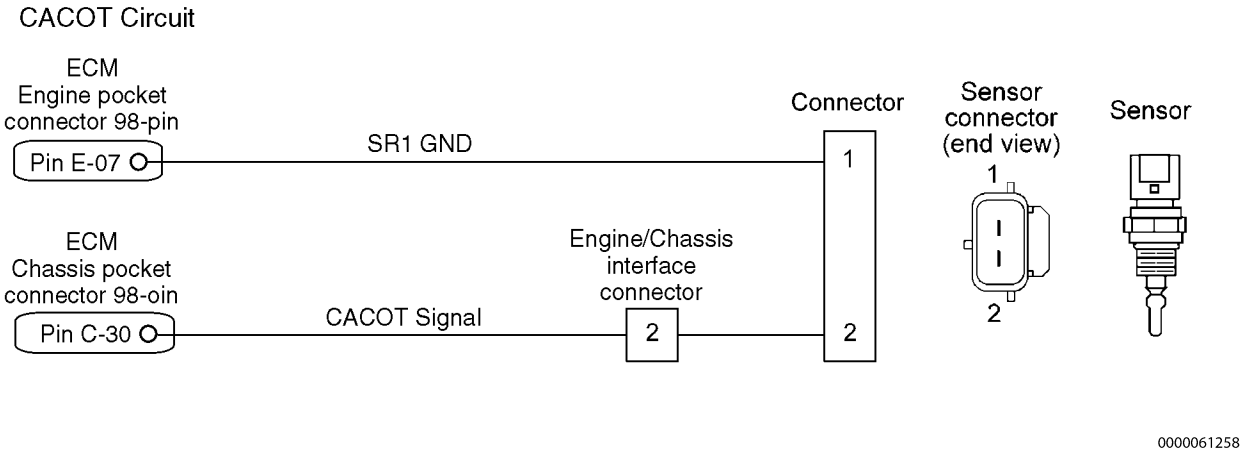
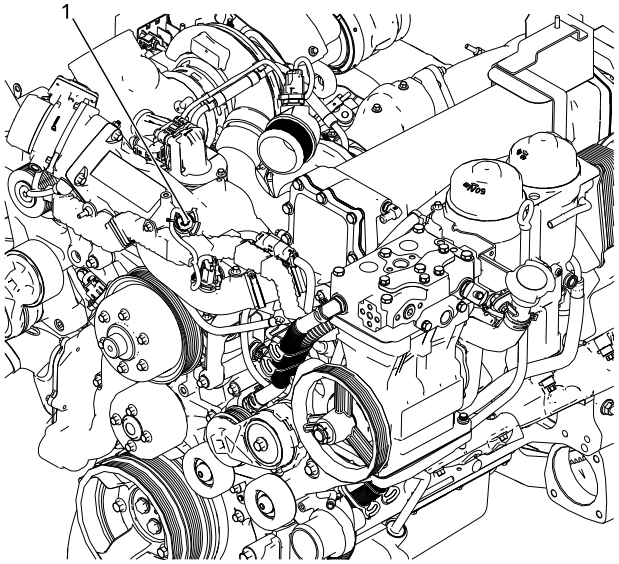


Figure 93 CACOT Circuit Diagram

Overview

The Charge Air Cooler Outlet Temperature (CACOT) sensor is a thermistor sensor that measures charged-air temperature entering the Engine Throttle Valve (ETV). As temperature increases, resistance drops, causing the voltage signal interpreted by the Engine Control Module (ECM) to vary. The ECM monitors this signal for Exhaust Gas Recirculation (EGR) system control and CAC performance.



0000061244

Figure 94 CACOT Sensor Location

1. CACOT Sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 00–00956–08 - 180-Pin Breakout Box
- Breakout Harness ZTSE4993 (CACOT)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

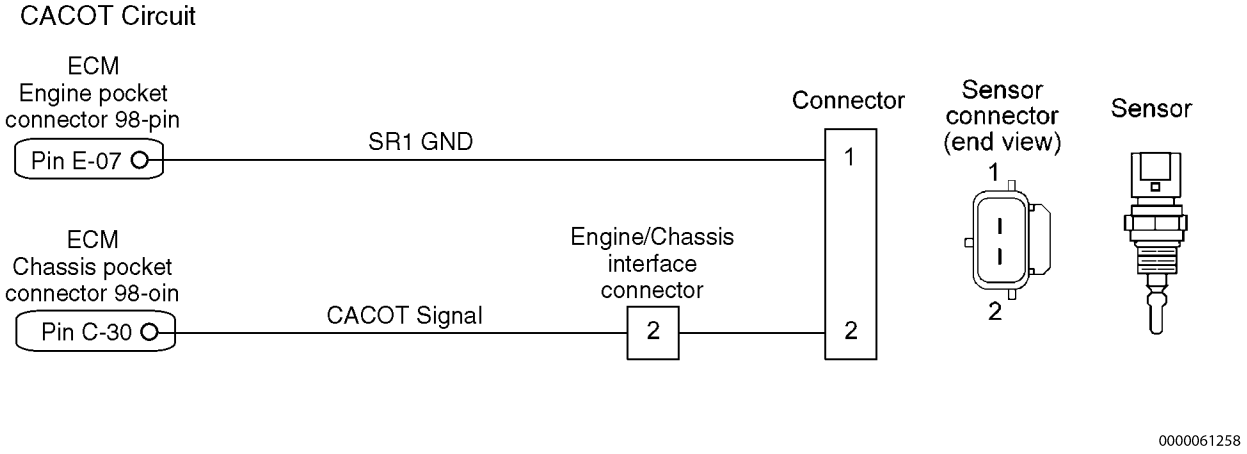


Figure 95 CACOT Circuit Diagram

Connector Voltage Check

Connect Breakout Harness ZTSE4993. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to B+	B+	If < B+, check for short to power, or OPEN circuit. Go to Harness Resistance Check (page 292).
2 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 292). If > 5 V and < 8 V, check that DMM leads are connected correctly. If > 8 V check for short to B+.

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4993. Leave sensor disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4993. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-07	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to C-30	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 2630 FMI 2 - CACOT Signal erratic, intermittent, or incorrect

<table>
<tr><th>Condition / Description</th><th>Setting Criteria</th><th>Enable Conditions / Values</th><th>Time Required</th></tr>
<tr><td rowspan="7">Comparison of sensor reading to other sensor readings after a calibrated cold soak period.</td><td rowspan="2">Sum of failed temperature sensor comparisons as listed below: Charge Air Cooler Outlet Temperature (CACOT) vs. Air Inlet Temperature (AIT), Turbocharger Outlet Temperature (TCOT), Intake Manifold Temperature (IMT), Exhaust Gas Recirculation Temperature (EGRT) >= 4</td><td>{[Comparison of Air Inlet Temperature (AIT) with Intake Manifold Temperature (IMT) > 27°F (15°C), Comparison of AIT with Engine Charge Air Cooler Outlet temperature > 27°F (15°C), Comparison of AIT with Engine Turbocharger Outlet temperature > 27°F (15°C), Comparison of AIT with Engine Exhaust Gas Recirculation temperature > 27°F (15°C), Comparison of Intake Manifold Temperature (IMT) with Charge Air Cooler Outlet Temperature (CACOT) > 27°F (15°C), Comparison of IMT with Turbocharger Outlet Temperature (TCOT) > 27°F (15°C), Comparison of IMT with Engine Exhaust Gas Recirculation Temperature (EGRT) > 27°F (15°C), Comparison of CACOT with TCOT > 27°F (15°C), Comparison of CACOT with EGRT > 27°F (15°C), Comparison of TCOT with EGRT > 27°F (15°C),], and sum of True Conditions from comparisons listed above} >5</td><td rowspan="7">0.5 seconds</td></tr>
<tr><td>Engine Off soak time > 8 hours</td></tr>
<tr><td>Comparison of CACOT and IMT sensor reading > 36°F (20°C)</td><td>Time in Key ON engine OFF state < 60 seconds</td></tr>
<tr><td>Comparison of CACOT and TCOT sensor reading > 36°F (20°C)</td><td>Engine NOT in running state</td></tr>
<tr><td>Comparison of CACOT and EGRT sensor reading > 36°F (20°C)</td><td rowspan="2">The following SPN / FMIs are not active: 172/3, 172/4, 2629/3, 2629/4, 2630/3, 2630/4, 105/3, 105/4, 412/3, and 412/4.</td></tr>
<tr><td>Comparison of CACOT and AIT sensor reading > 36°F (20°C)</td></tr>
</table>

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the CACOT value is erratic or incorrect when compared to other related sensor values.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

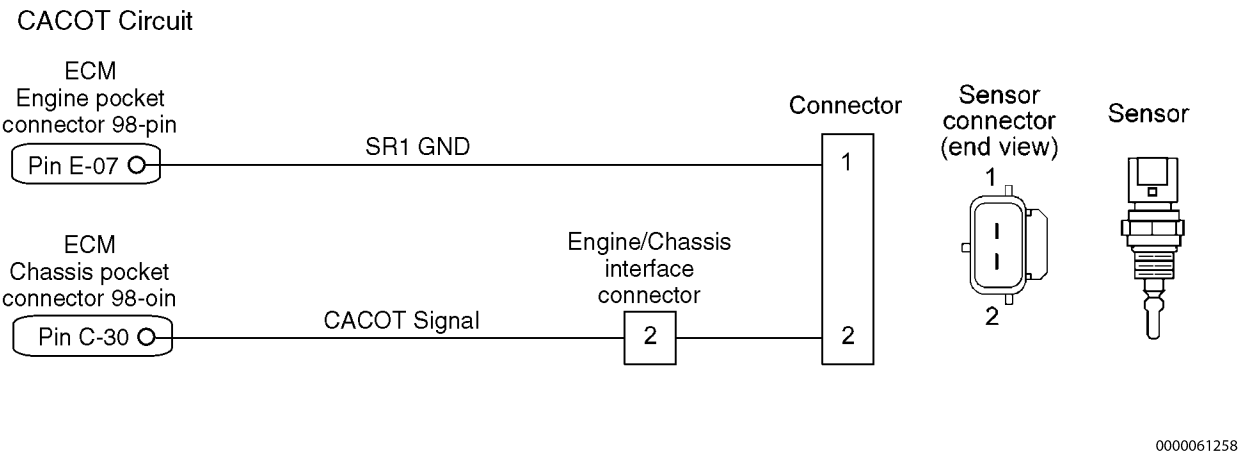


Figure 96 CACOT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2630 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2630 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Charge Air Cooler Outlet Temperature (CACOT) sensor. With Key OFF, disconnect CACOT sensor connector. Check CACOT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are CACOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2630 FMI 2.

Step	Action	Decision
4	Test CACOT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 292). Are CACOT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 2630 FMI 2.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test. Does circuit operate properly?	Yes: Go to Step 6.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 2630 FMI 2.

Step	Action	Decision
6	Test CACOT sensor. Connect breakout harness 4993 between CACOT sensor and CACOT sensor connector. Perform KOEO voltage check of CACOT sensor between CACOT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 2630 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace CACOT sensor. After repairs are complete, retest for SPN 2630 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 2630 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2630 FMI 3 - CACOT signal out of range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Charge Air Cooler Outlet Temperature (CACOT) out of range HIGH.	CACOT sensor voltage > 4.6 volts	Key ON	2 Seconds

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the CACOT sensor voltage is greater than 4.6 volts.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

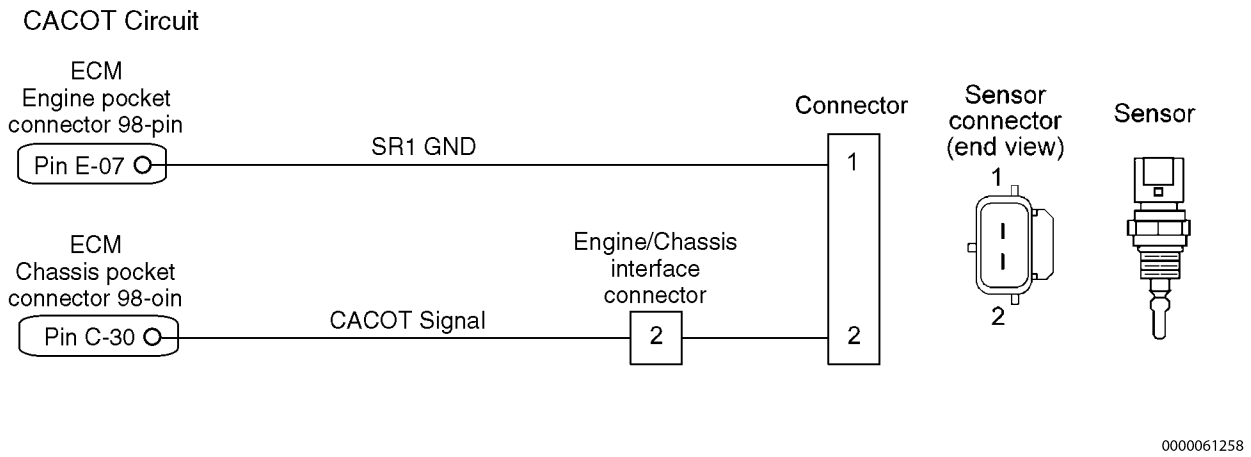


Figure 97 CACOT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2630 FMI 3 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2630 FMI 3. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Charge Air Cooler Outlet Temperature (CACOT) sensor. With Key OFF, disconnect CACOT sensor connector. Check CACOT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are CACOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2630 FMI 3.

Step	Action	Decision
4	Test CACOT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 292). Are CACOT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 2630 FMI 3.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test. Does circuit operate properly?	Yes: Replace CACOT sensor. After repairs are complete, retest for SPN 2630 FMI 3. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 2630 FMI 3.

NOTE: After doing all diagnostic steps, if SPN 2630 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2630 FMI 4 - CACOT signal out of range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Charge Air Cooler Outlet Temperature (CACOT) out of range LOW.	CACOT sensor voltage < 0.04 volts	Key ON	2 seconds

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the CACOT sensor voltage is less than 0.04 volts.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

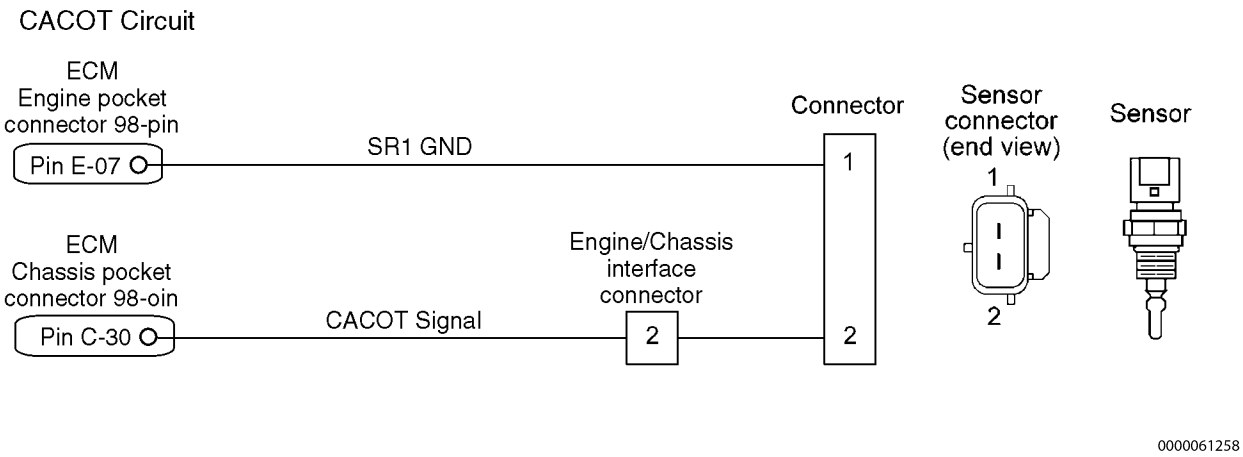


Figure 98 CACOT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2630 FMI 4 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2630 FMI 4. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Charge Air Cooler Outlet Temperature (CACOT) sensor. With Key OFF, disconnect CACOT sensor connector. Check CACOT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are CACOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2630 FMI 4.

Step	Action	Decision
4	Test CACOT circuits for short conditions. Do connector voltage checks and resistance checks (page 292). Are CACOT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 2630 FMI 4.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test. Does circuit operate properly?	Yes: Replace CACOT sensor. After repairs are complete, retest for SPN 2630 FMI 3. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 2630 FMI 4.

NOTE: After doing all diagnostic steps, if SPN 2630 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2630 FMI 16 - CACOT Undercooling

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Charge Air Cooler (CAC) efficiency LOW.	CAC efficiency < 35%	Ambient Pressure > 11 psi (75 kPa)	100 seconds
		Intake Air Temperature (IAT) > 19°F (-7°C) and < 122°F (50°C)	
		Engine Coolant Temperature (ECT) > 122°F (50°C) and < 239°F (115°C)	
		Engine Throttle Position (ETP) < 100%	
		Exhaust Backpressure Control Valve < 10%	
		Vehicle Speed > 30 mph	
		Torque > 600 N•m and RPM > 1200 rpm	
		Turbocharger 1 Compressor Outlet Temperature (TC1OT) value change per time > -58°F (-50°C) / seconds and < 122°F (50°C) seconds.	
		Intake Manifold Pressure (IMP) > 0 psi (0 kPa)	
		Intake Air Heater (IAH) OFF	
		PTO Mode NOT active	
		Not in regeneration mode	
		The following SPN / FMIs are not active: SPN FMIs 110/3, 110/4, 172/2, 172/3, 172/4, 132/3, 132/4, 108/3, 108/4, 102/2, 102/3, 102/4, 51/3, 51/4, 51/7, 1189/3, 1189/4, 1189/5, 2629/2, 2629/3, 2629/4, 102/7, 102/16, and 102/18.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the Charge Air Cooler (CAC) efficiency is below the programmed threshold.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

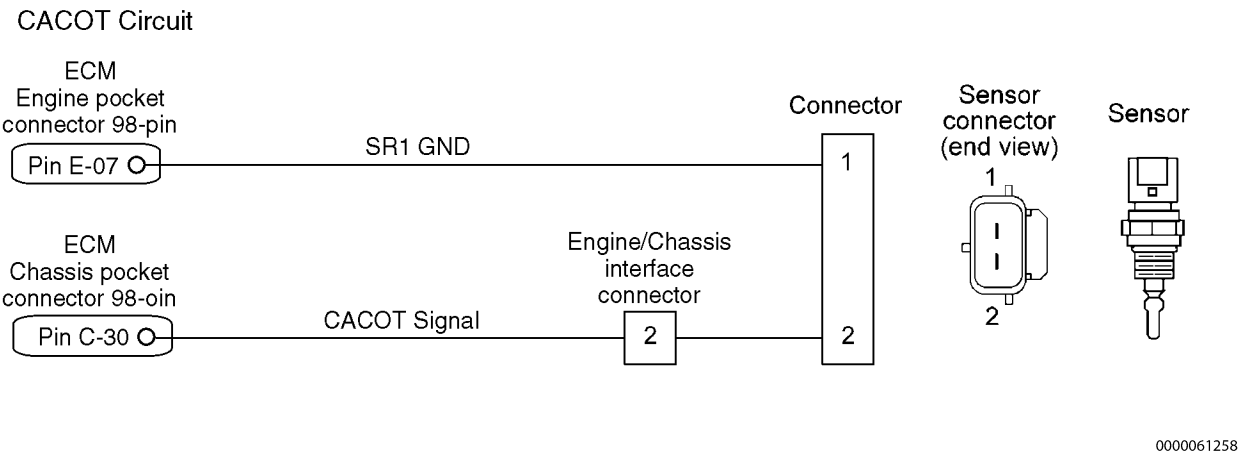


Figure 99 CACOT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2630 FMI 16 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2630 FMI 16. No: Go to Step 3.

Step	Action	Decision
3	Inspect truck grille for an obstructions that may reduce air flow to the CAC. Is truck grille free of obstructions?	Yes: Go to Step 4. No: Repair or remove obstruction from grille. After repairs are complete, retest for SPN 2630 FMI 16.

Step	Action	Decision
4	Check engine fan, fan shroud, and air dams for damage and proper operation. Are engine fan, fan shroud, and air dams intact and operating properly?	Yes: After doing all diagnostic steps, if SPN 2630 FMI 16 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Repair or replace engine fan, fan shroud, and / or air dams. After repairs are complete, retest for SPN 2630 FMI 16.

NOTE: After doing all diagnostic steps, if SPN 2630 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2630 FMI 21 - CACOT signal Drifted LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Charge Air Cooler Outlet Temperature (CACOT) stuck in range.	CACOT < -40°F (-40°C)	Minimum engine speed value > 1325 rpm	1 second
		Minimum engine Torque command > 710 N•m	
		Accumulator threshold for monitor enablement > 40 seconds	
		Minimum Intake Manifold Pressure (IMP) > 21.75 psi (150 kPa)	
		The following SPN / FMIs are not active: SPN FMIs 108/3, 108/4, 172/2, 172/3, 172/4, 2630/2, 2630/3, and 2629/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the CACOT is below programmed threshold.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

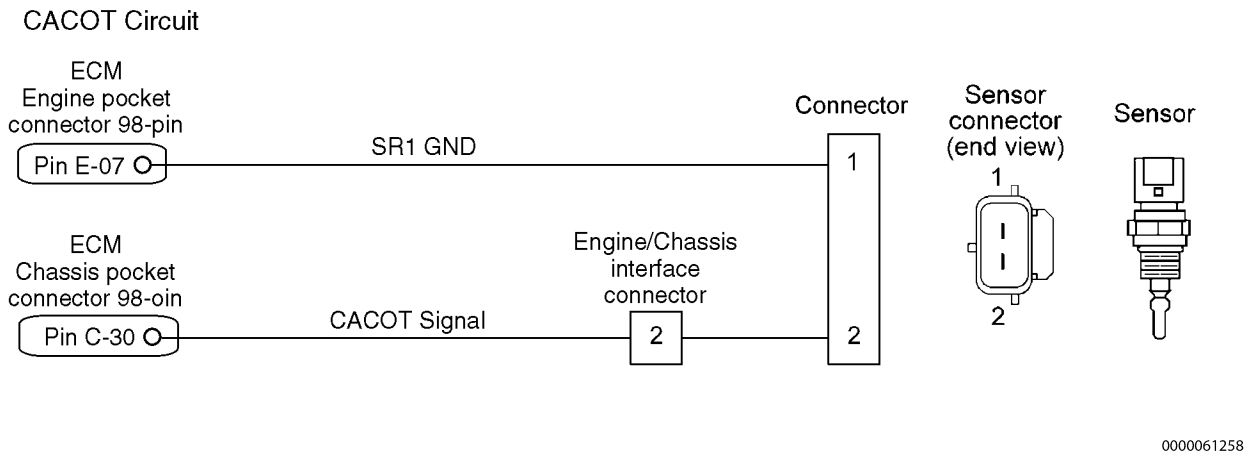


Figure 100 CACOT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2630 FMI 21 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2630 FMI 21. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Charge Air Cooler Outlet Temperature (CACOT) sensor. With Key OFF, disconnect CACOT sensor connector. Check CACOT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are CACOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2630 FMI 21.

Step	Action	Decision
4	Test CACOT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 292). Are CACOT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 2630 FMI 21.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test. Does circuit operate properly?	Yes: Go to Step 6.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 2630 FMI 21.

Step	Action	Decision
6	Test CACOT sensor. Connect breakout harness 4993 between CACOT sensor and CACOT sensor connector. Perform KOEO voltage check of CACOT sensor between CACOT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 2630 FMI 21 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace CACOT sensor. After repairs are complete, retest for SPN 2630 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 2630 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

CAN (Controller Area Network) Communications (J1939)

SPN	FMI	Condition
639	14	J1939 Data Link Error (ECM unable to transmit)

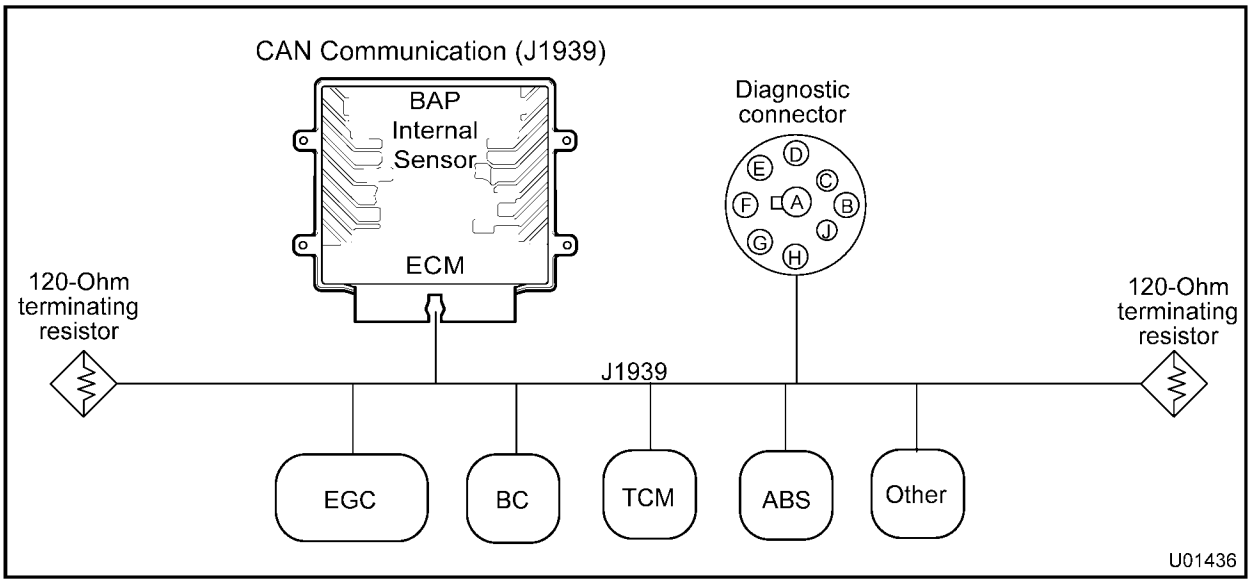


Figure 101 Function diagram for the CAN (J1939)

The CAN (J1939) function diagram includes the following:

- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Transmission Control Module (TCM)
- Body Controller (BC) module
- Antilock Brake System (ABS)
- Electronic Gauge Cluster (EGC)
- Diagnostic Connector
- 120-Ohm terminating resistors
- Other nodes (modules)

Function

The CAN (J1939) network provides a communication link between all connecting modules. The Diagnostic Connector uses this network system to communicate with the ECM.

Location

The CAN (J1939) circuits run throughout the chassis harness. The Diagnostic Connector is located under the dash on the driver's side.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

CAN (J1939) Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
None	None	No communication with Electronic Service Tool (EST)	• B+ circuit OPEN or short to GND • GND circuit OPEN • CAN (J1939) circuits OPEN to Diagnostic Connector
639	14	ECM unable to send CAN (J1939) messages	• CAN (J1939) circuit OPEN • CAN-H shorted to GND • CAN-L shorted to VBAT • CAN-H shorted to CAN-L • ECM not powering up or failed module • Failed resistor

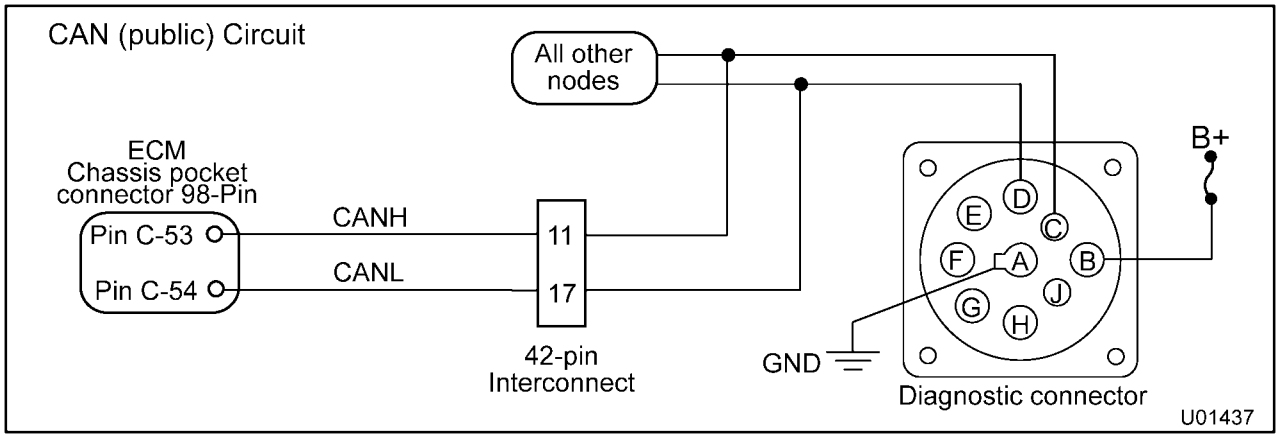


Figure 102 CAN (J1939) communication circuit diagram

Connector Voltage Check

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

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

EST Communication Check

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

NOTE:

- If communication to ECM is established, check CAN (J1939) circuits to disconnected module for correct wiring. See *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.
- If communication to ECM is not established, go to next test point.

Test Point	Comment
Disconnect TCM	See above note.
Disconnect ABS	See above note.
Disconnect BC	See above note.
Disconnect EGC	See above note.
Disconnect other nodes	See above note.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box. Leave ECM disconnected.

Test Point	Spec	Comment
C to D	60 Ω ± 5 Ω	If > 65 Ω, check CANH and CANL for faulty resistor or circuit.
C to C-53	< 5 Ω	If > 5 Ω, check CANH for OPEN in circuit.
C to GND	> 1 kΩ	If < 1 kΩ, check CANH for short to GND.
D to C-54	< 5 Ω	If > 5 Ω, check CANL for OPEN in circuit.
D to GND	> 1 kΩ	If < 1 kΩ, check CANL for short to GND.
A to GND	< 5 Ω	If > 5 Ω, check GND for OPEN in circuit.

CAN (J1939) Circuit Operation

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

The Electronic Service Tool (EST) with ServiceMaxx™ software communicates with the ECM through the Diagnostic Connector. The EST, through the CAN (J1939) network, is able to retrieve Diagnostic Trouble Codes (DTCs), run diagnostic tests, and view signal's from all inputs and outputs of the ECM.

CAN (J1939) supports the following functions:

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

CAN (J1939) versus ATA (SAE J1587)

The CAN (J1939) network is set up to communicate with many different modules. The network branches into many different locations with each path ending in a module connection or a 120-ohm terminating resistor. The termination resistors are used to reduce reflections.

The CAN (J1939) system is set up to only communicate between the ECM and specific engine controls.

Diagnostic Connector

The Diagnostic Connector provides an interface for the EST. The Electronic Service Tool (EST) with ServiceMaxx™ software communicates with the joining modules through the CAN (J1939) network for diagnostics and module programming. The Diagnostic Connector is supplied with fused B+ at Pin B and GND at Pin A. CANH runs between ECM Pin C-53 and Diagnostic Connector Pin C. CANL between C-54 and Diagnostic Connector Pin D.

Electronic Gauge Cluster (EGC)

There are two types of EGC modules, one uses CAN (J1939) communications and the other uses ATA (SAE J1587) communications. The following information is sent through data communication:

- Amber Warning Lamp (AWL)
- Coolant Level lamp
- Wait to Start lamp
- Red Stop Lamp (RSL)
- Speedometer
- Tachometer (TACH)
- Odometer / hourmeter
- Change oil message
- Oil pressure gauge
- Engine Oil Temperature (EOT) gauge
- Engine Coolant Temperature (ECT) gauge

Body Controller (BC) or Multiplex System Module (MSM)

Many EGC lamps and driver operated switches are wired to one of these modules, then communicated through CAN (J1939) to the ECM or EGC. Some of these control circuits include the following:

- Wait to Start lamp
- Fuel Pressure lamp
- OWL
- Soot Load lamp
- Cruise control
- Self-test input (cruise switches)
- Driveline Disengagement Switch (DDS)

- Brake pedal (BC only) hardwired to the ECM on vehicles using the MSM
- A/C Demand (ACD)
- Remote Accelerator Pedal
- In-Cab PTO / throttle switch
- AFT regeneration switch

Repair Information

The CAN (J1939) circuits use a twisted wire pair. All repairs must maintain one complete twist per inch along the entire length of the circuit. This circuit is polarized, one positive and one negative. Reversing the polarity of this circuit disrupts communications.

CCS (Cruise Control Switches)

SPN	FMI	Condition
596	2	SCCS switch circuit fault
596	19	Cruise Control Enable Switch not detected on J1939

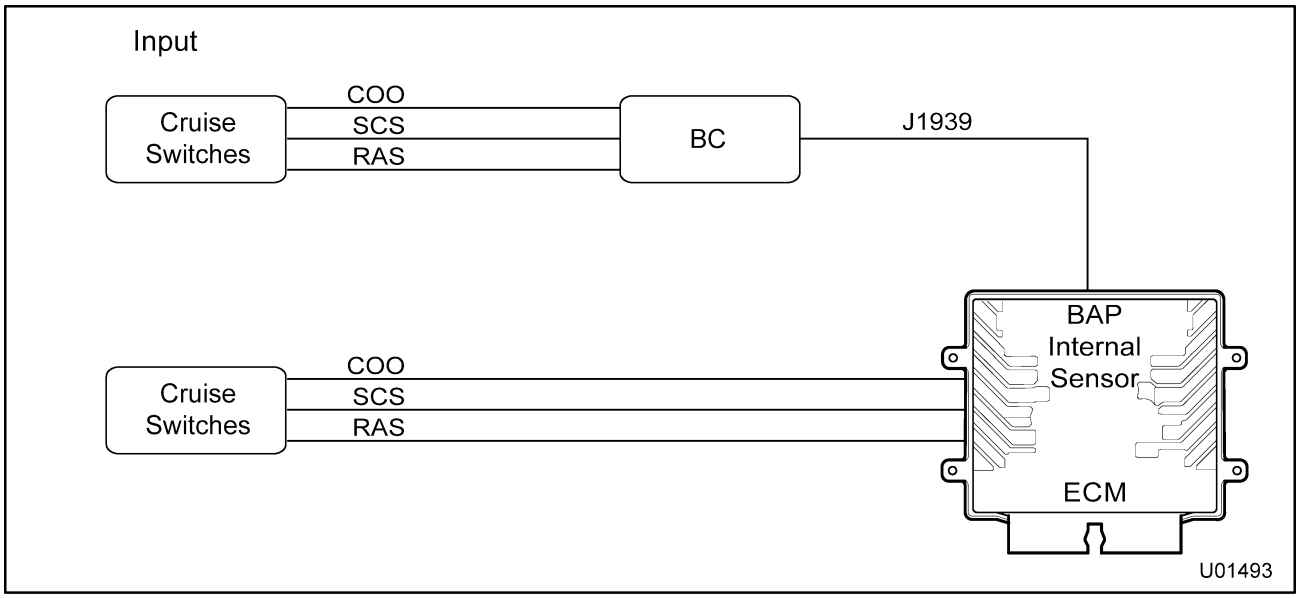


Figure 103 Function diagram for cruise control switches

The Cruise Control System (CCS) function diagram includes the following:

- Cruise On / Off (COO)
- Cruise Set / Coast (SCS)
- Cruise Resume / Accel (RAS)
- Body Controller (BC)
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor

Function

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

Location

The cruise control switches can be hard wired to the ECM or wired to the BC.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- 00-00956-08 – 180-Pin Breakout Box
- Digital Multimeter (DMM)

Cruise Control Switches Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
596	2	SCCS switch circuit fault	• COO, SCS, or RAS switch short circuit • COO, SCS, or RAS switch OPEN circuit • COO, SCS, or RAS failed switch
596	19	Cruise Control Enable Switch not detected on J1939	• See Body Controller in *Electrical System Troubleshooting Guide*.

1. Turn ignition switch to ON. Connect the EST to the Diagnostic Connector.
   - If SPN 596 FMI 2 is displayed, continue to Switch Checks.
   - If SPN 596 FMI 19 is displayed, see Body Controller in *Electrical System Troubleshooting Guide*.

Switch Checks

Connect the EST to the Diagnostic Connector. Turn ignition switch to ON. Monitor status of test point signals using signals session in ServiceMaxx™ software.

Test Point	Spec	Comments
COO switch	Unlatched = OFF Latched = ON	If not within specification, continue to Circuit End Voltage Check.
SCS switch	Normal state = Released Pressed = ON	If not within specification, continue to Circuit End Voltage Check.
RAS switch	Normal state = OFF Pressed = ON	If not within specification, continue to Circuit End Voltage Check.

Circuit End Voltage Check

Connect the 180-Pin Breakout Box. Turn ignition switch to ON and COO switch ON. Use DMM to measure voltage.

Test Point	Spec	Comments
C-77 to GND	SCS Normal State = 0 V SCS Pressed = B+	If > 0 V, check for short to PWR circuit. If < B+, check for open or short to GND circuit.
C-75 to GND	RAS Normal State = 0 V RAS Pressed = B+	If > 0 V, check for short to PWR circuit. If < B+, check for open or short to GND circuit.
C-81 to GND	COO Unlatched = 0 V COO Latched = B+	If > 0 V, check for short to PWR circuit. If < B+, check for open or short to GND circuit.

CKP (Crankshaft Position) Sensor

SPN	FMI	Condition
637	8	CKP incorrect signal signature
637	10	CKP signal inactive

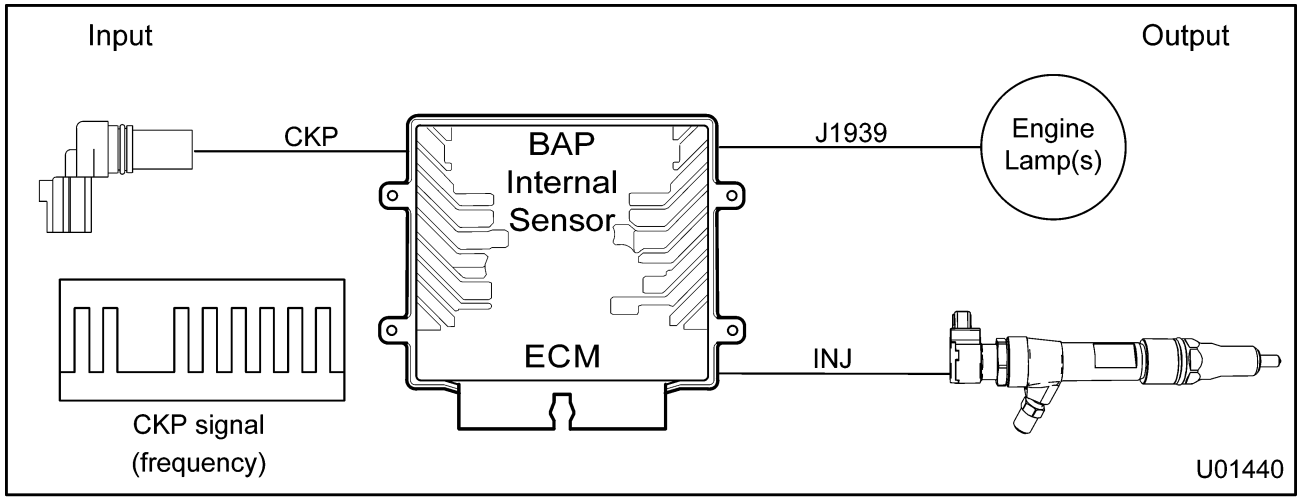


Figure 104 Function diagram for the CKP sensor

The CKP sensor function diagram includes the following:

- Crankshaft Position (CKP) sensor
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Fuel injectors (INJ)
- Engine Lamp(s)

Function

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

Sensor Location

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

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 00–00956–08 – 180-Pin Breakout Box
- International® Electronic Engine Terminal Test Kit ZTSE4435C

CKP Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
637	8	CKP incorrect signal signature	• Failed sensor
637	10	CKP signal inactive	• Electrical noise detected on CKP signal

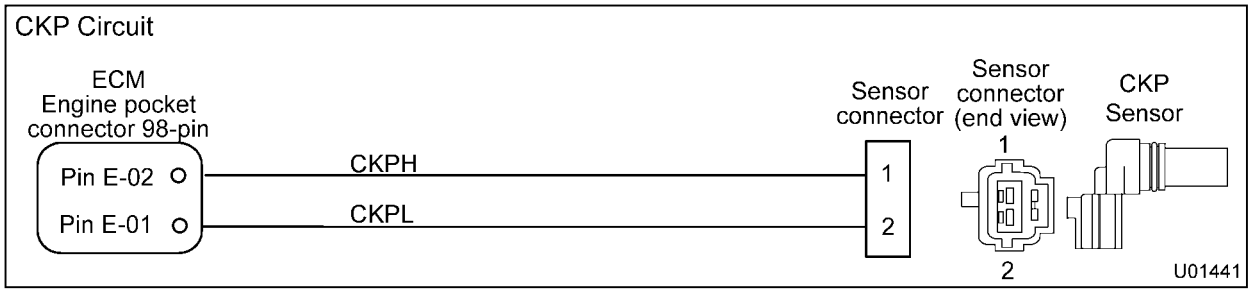


Figure 105 CKP circuit diagram

Sensor and Circuit Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-02 to E-01	280 Ω to 560 Ω	If < 280 Ω, check for failed sensor. Do Harness Resistance check (page 320). If > 560 Ω, check for OPEN circuit or failed sensor. Do Harness Resistance check (page 320).

Harness Resistance Check

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

Test Point	Spec	Comment
E-01 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-01 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E-02 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-02 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

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

Operational Check

Connect 180-Pin Breakout Box between ECM and sensor. Use DMM set to AC Volts-Hz.

Test Point	Condition	Spec
E-02 to E-01	Engine crank	100 Hz to 250 Hz (100 rpm to 250 rpm)
	Low idle	650 Hz to 750 Hz (650 rpm to 750 rpm)
	High idle	2900 Hz to 3000 Hz (2900 rpm to 3000 rpm)

CKP Circuit Operation

The CKP sensor contains a permanent magnet that creates a magnetic field. The signal is created when the timing disk rotates and breaks the magnetic field created by the sensor. The ECM Pins for the CKP sensor are CKPL E-01 and CKPH E-02.

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

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

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

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

Fault / Detection Management

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

CMP (Camshaft Position) Sensor

CMP Diagnostics

SPN	FMI	Condition	Possible Causes	Actions
636	2	CMP and CKP Synchronization Error	• OPEN or shorted CMP circuits	Pin-Point Diagnostics (page 324)
636	7	CMP to CKP incorrect reference	• Failed harness	Pin-Point Diagnostics (page 324)
636	10	CMP signal inactive	• CMP sensor or circuit failure	Step-Based Diagnostics (page 326)

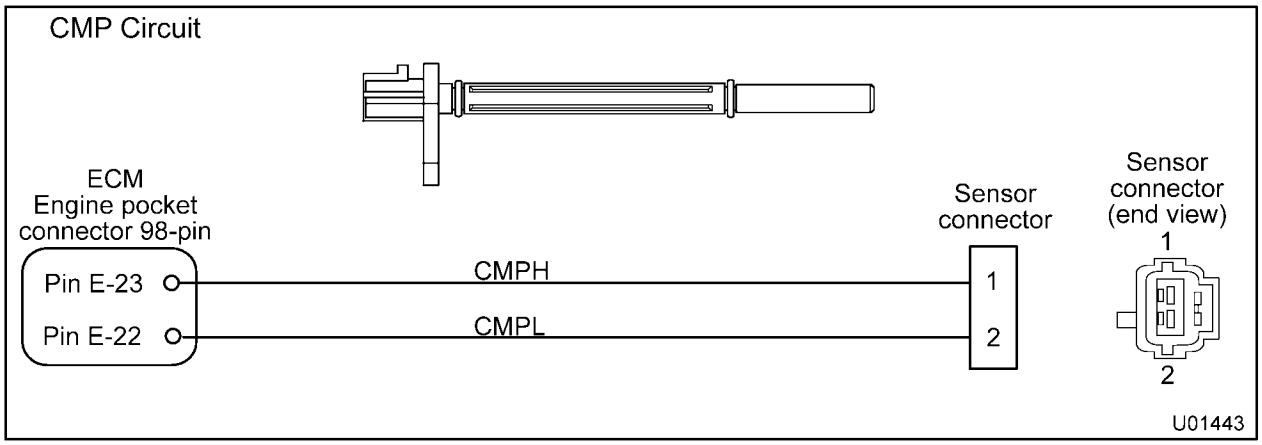
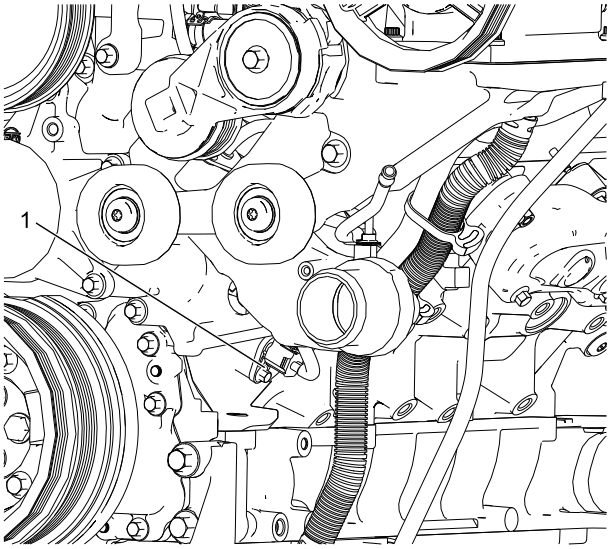


Figure 106 CMP Circuit Diagram

Overview

The CMP sensor provides the ECM with a camshaft speed and position signal. The ECM uses this signal with the Crankshaft Position (CKP) signal to calculate crankshaft speed and position. The CMP sensor provides the ECM with a signal that indicates camshaft speed and position. The CMP sensor contains a permanent magnet that creates a magnetic field. The signal is created when a peg on the camshaft disk rotates and breaks the magnetic field. This identifies camshaft position.



0000061259

Figure 107 CMP Sensor Location

1. CMP Sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 00–00956–08 - 180-Pin Breakout Box
- International® Electronic Engine Terminal Test Kit ZTSE4435C

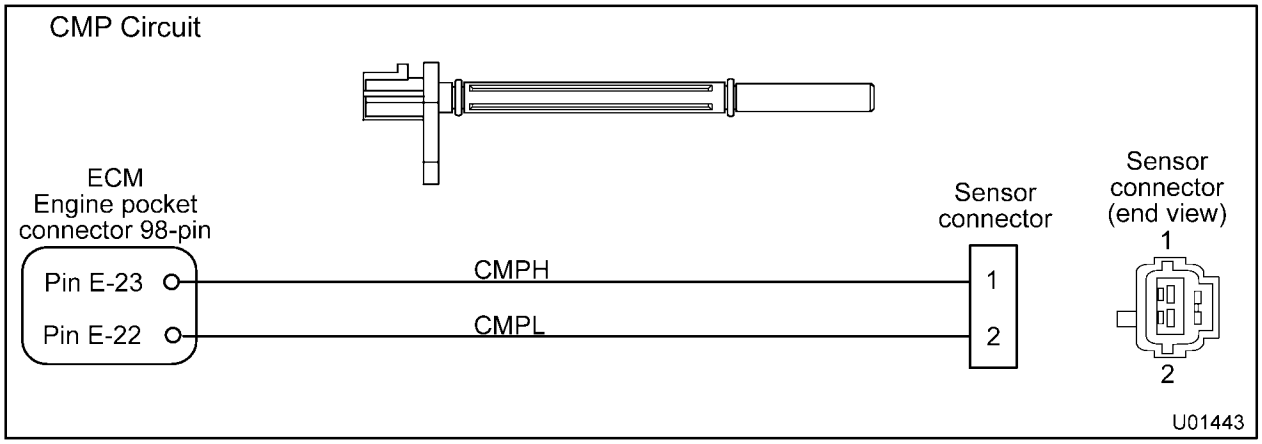


Figure 108 CMP Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

Sensor and Circuit Resistance Check

Turn the ignition switch to OFF. Connect 180-Pin Breakout Box. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
C-22 to C-23	616 Ω to 1275 Ω	If < 616 Ω, check for failed sensor. Do Harness Resistance Check (page 324). If > 1275 Ω, check for OPEN circuit or failed sensor. Do Harness Resistance Check (page 324).

Harness Resistance Check

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

Test Point	Spec	Comment
C-22 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C-22 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
C-23 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C-23 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Operational Check

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

Connect 180-Pin Breakout Box between ECM and sensor. Use DMM set to AC volts - RPM2.

Test Point	Condition	Spec
C-22 to C-23	Engine crank	100 rpm to 250 rpm
	Low idle	650 rpm to 700 rpm
	High idle	3000 rpm

SPN 636 FMI 10 - CMP signal inactive

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Camshaft Position (CMP) sensor signal inactive. The functional camshaft diagnosis cannot detect a failure when a camshaft sensor delivers no signal at all. Missing signal will be detected if the camshaft edge counter is not incremented at least once per engine cycle.	Fault is set if camshaft signal is missing	Key ON	8 engine revolutions
		Crankshaft acquistion synchronized (LV_CRK_SYN = 1)	
		Cam diagnostics enabled (LV_INH_DIAG_PLAUS_CAM_IN(EX)[i] = 0)	
		Inhibition condition for the camshaft sensor plausibility diagnosis (intake) (LV_INH_DIAG_EXT_PLAUS_CAM_IN(EX)[i] = 0)	
		Cam / Crank diagnosis not inhibited during fail safe delay (LV_INH_DIAG_ENSD = 0)	
		Number of engine cycles to detect error (C_NR_CYC_ENG_PLAUS_CAM_MAX != 0)	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the CMP signal is missing.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Fault Fact:

CMP sensor circuits are shielded wires. Check circuits for short to shielding if short to ground is present.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

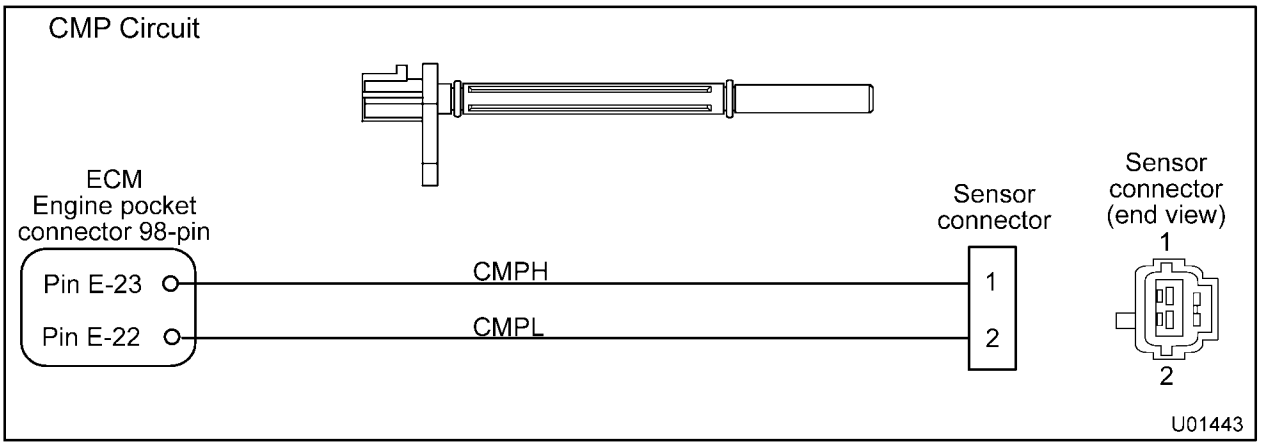


Figure 109 CMP Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 636 FMI 10 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 636 FMI 10. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at CMP sensor. Key OFF, disconnect CMP sensor connector. Check CMP sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Is fuel return system operating properly?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 636 FMI 10.

Step	Action	Decision
4	Test CMP circuits for open, short, or high resistance conditions. Do Sensor and Circuit Resistance checks and Harness Resistance Checks (page 324). Are CMP circuits within specifications?	Yes: Replace CMP sensor. After repairs are complete, retest for SPN 636 FMI 10. No: Repair circuits as required. After repairs are complete, retest for SPN 636 FMI 10.

NOTE: After doing all diagnostic steps, if SPN 636 FMI 10 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Cylinder Balance

Cylinder Balance Diagnostics

SPN	FMI	Condition	Possible Causes	Actions
1322	31	Misfire – Multiple Cylinder	• Intake / exhaust restrictions • Base engine compression imbalance • Coolant consumption • Contaminated fuel • Electrical harness issue • Failed injectors	Step-Based Diagnostics (page 332)
1323 – 1330	31	Misfire – Cylinder #	• Electrical fault • Low fuel pressure • Fuel quality • Failed injector • Mechanical fault	Pin-Point Diagnostics (page 331)
3387 – 3394	20	Cylinder Balance max limit exceeded	• Electrical fault • Low fuel pressure • Fuel quality • EGR valve stuck open • Fuel system • Failed injector • Base engine compression imbalance • Mechanical fault	Pin-Point Diagnostics (page 331)

3387 – 3394	21	Cylinder Balance below min limit	• Electrical fault • Low fuel pressure • Fuel quality • EGR valve stuck open • Fuel system • Failed injector • Base engine compression imbalance • Mechanical fault	Pin-Point Diagnostics (page 331)

Overview

Power cylinder sealing, valve train condition, and fuel delivery influence torque contributions from each power cylinder. Variations in these factors can cause unevenness in torque and horsepower from one cylinder to the next. Power cylinder unevenness also causes increased engine noise and vibration, especially at low idle.

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

Pin-Point Diagnostics With ServiceMaxx™ Software

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

Pin-Point Cylinder Balance Fault

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

   Note: These checks can be verified quickly by using the Fuel Pressure Test Gauge with shutoff valve. See Fuel Delivery and Pressure Test (page 145) in the “Hard Start and No Start Diagnostics” section of this manual.
4. Check Fuel Rail Pressure (FRP) and voltage.
   - Check FRP voltage at Key On, Engine Off (KOEO). Run KOEO Standard Test.

     See “Appendix A: Performance Specifications” (page 813).
   - Check FRP system pressure during Key On, Engine-Running (KOER). Run KOER Standard Test.

     See “Appendix A: Performance Specifications” (page 813).
5. Inspect the EGR valve. Verify valve is not stuck open.
   - Run KOEO Standard Test
   - Run KOER Air Management Test.

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

1. Run KOER Injector Disable Test to identify imbalanced cylinder. See “Performance Diagnostics” (page 160) section.
2. Do Relative Compression Test to verify if cylinder imbalance is mechanical issue or injector issue. See “Performance Diagnostics” (page 160) section.

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

SPN 1322 FMI 31 - Misfire – Multiple Cylinder

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Misfire - Multiple Cylinder	[Average segment time for cylinder compared with average segment time of other cylinders and > 0.0007880 - for automatic transmission 0.0002790 - for manual transmission. On more than 1 cylinder]	Engine Coolant Temperature (ECT) > 86°F (30°C) and < 248°F (120°C)	5 consecutive idle events
		Engine speed > 650 RPM < 800 RPM	
		Vehicle speed < 2 mph	
		Diesel Particulate Filter regeneration inactive	
		Accelerator Pedal Position (APP) < 5%	
		Fuel injection quantity > 2 mg/stk and < 28 mg/stk	
		Power Take-Off (PTO) mode inactive	
		Manifold Absolute Pressure (MAP) < 16.7 psi (115 kPa)	
		Engine running time > 15 seconds	
		Max allowed instantaneous torque set-point change < 15 N•m	
		Misfire monitor restarts after 160 engine revolutions	
		Cylinder cutout service bay test inactive	
		The following SPN FMIs are not active: 105/3, 105/4, 108/3, 108/4, 110/3, 110/4, 102/3, 102/4, 651-658/3, 651-658/4, 636/2, and 636/8.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines there are misfires in multiple cylinders when comparing several sensor readings.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 1322 FMI 31 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 1322 FMI 31. No: Go to Step 3.

Step	Action	Decision
3	Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage, including air cleaner cleanliness and Mass Air Flow (MAF) sensor for dirt and oil residue. Is air intake system, exhaust system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to Step 4. No: Repair restrictions, air leaks, or physical damage. After repairs are complete, retest for SPN 1322 FMI 31.

Step	Action	Decision
4	Determine the cause of rough engine idle or misfire. Do a Relative Compression Test (page 184). Are all engine cylinder performance readings similar?	Yes: Go to Step 5. No: Repair mechanical problem with cylinder(s) indicating low performance. After problem is repaired, retest for SPN 1322 FMI 31.

Step	Action	Decision
5	Check for engine coolant consumption. Check engine coolant level. Determine if vehicle has recent history of coolant consumption (coolant loss with no visible signs of leakage). Is engine coolant at an acceptable level with no recent history of coolant consumption?	Yes: Go to Step 6. No: Repair cause of coolant consumption. After problem is repaired, retest for SPN 1322 FMI 31.

Step	Action	Decision
6	Check for fuel and fuel quality, including fuel level check. Visually inspect by removing fuel cap from all tanks, check Water In Fuel (WIF) light, and sample for dirty or aerated fuel. Is there sufficient supply of good quality fuel?	Yes: Go to Step 7. No: Remove dirty or aerated fuel and fill with good quality fuel. After fuel replacement is complete, retest for SPN 1322 FMI 31.

Step	Action	Decision
7	Check for failed injectors or electrical harness issues. Perform Cylinder Cutout Test (page 73). Do one or more cylinders have Rotations Per Minute (RPM) readings significantly different than the rest?	Yes: Go to Step 8. No: After doing all diagnostic steps, if SPN 1322 FMI 31 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Step	Action	Decision
8	Isolate electrical failure to injector or harness. Remove valve cover, disconnect harness from injector, and perform harness resistance checks (page 632) on the suspect injector harness. Are injector circuits within specification?	Yes: Replace injector(s) of cylinders identified in cylinder cutout test. No: Repair injector wiring harness as indicated. After repairs are complete, retest for SPN 1322 FMI 31.

NOTE: After doing all diagnostic steps, if SPN 1322 FMI 31 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

DOCIT (Diesel Oxidation Catalyst Inlet Temperature) Sensor

DOCIT Sensor End Diagnostics

SPN	FMI	Condition	Possible Causes	Actions
4765	2	DOCIT signal erratic, intermittent, or incorrect	• DOCIT biased sensor or circuit	Step-Based Diagnostics (page 341)
4765	3	DOCIT signal Out of Range HIGH	• DOCIT signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor	Pin-Point Diagnostics (page 338)
4765	4	DOCIT signal Out of Range LOW	• DOCIT signal circuit short to GND • Failed sensor	Pin-Point Diagnostics (page 338)
4765	8	DOCIT signal abnormal rate of change	• DOCIT biased sensor or circuit	Step-Based Diagnostics (page 344)
4765	10	DOCIT in range stuck fault	• Overfueling from engine • Oil contamination • Fuel contamination • Coolant contamination • DOCIT biased sensor or circuit • DPFIT biased sensor or circuit	Step-Based Diagnostics (page 347)
4765	21	DOCIT signal drifted LOW	• DOCIT biased sensor or circuit	Step-Based Diagnostics (page 351)

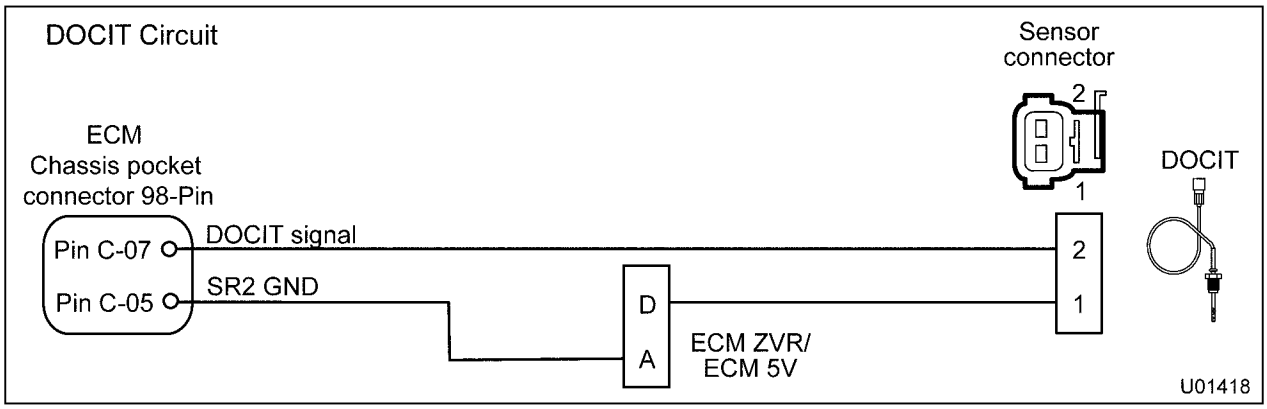


Figure 110 DOCIT Circuit Diagram

Overview

The Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor is a thermistor-style sensor that measures temperature between the Pre-Diesel Oxidation Catalyst (Pre-DOC) and the Diesel Oxidation Catalyst (DOC). As temperature increases, resistance values drop. This change of resistance varies the voltage that is sent to the Engine Control Module (ECM). The DOCIT sensor works with the Diesel Oxidation Catalyst Outlet Temperature (DOCOT), Diesel Particulate Filter Outlet Temperature (DPFOT), and Diesel Particulate Filter Differential Pressure (DPFDP) sensors to indicate operation and control the regeneration cycles of the Aftertreatment (AFT) system via the ECM.

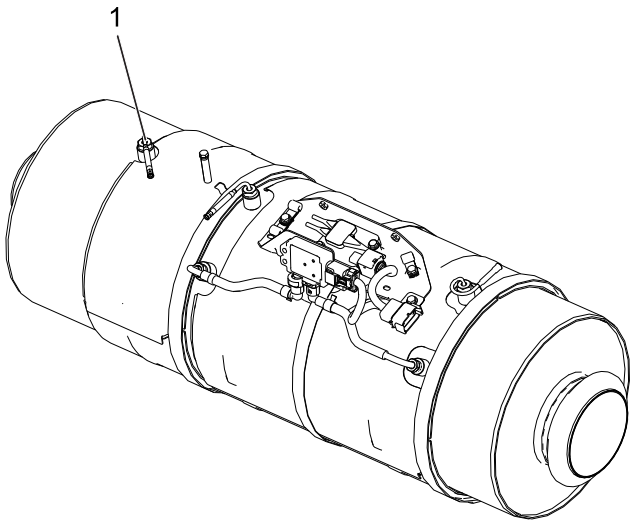


Figure 111 DOCIT Sensor Location

1. DOCIT Sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 00–00956–08 – 180-Pin Breakout Box
- Breakout Harness ZTSE4760A (DOCIT)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

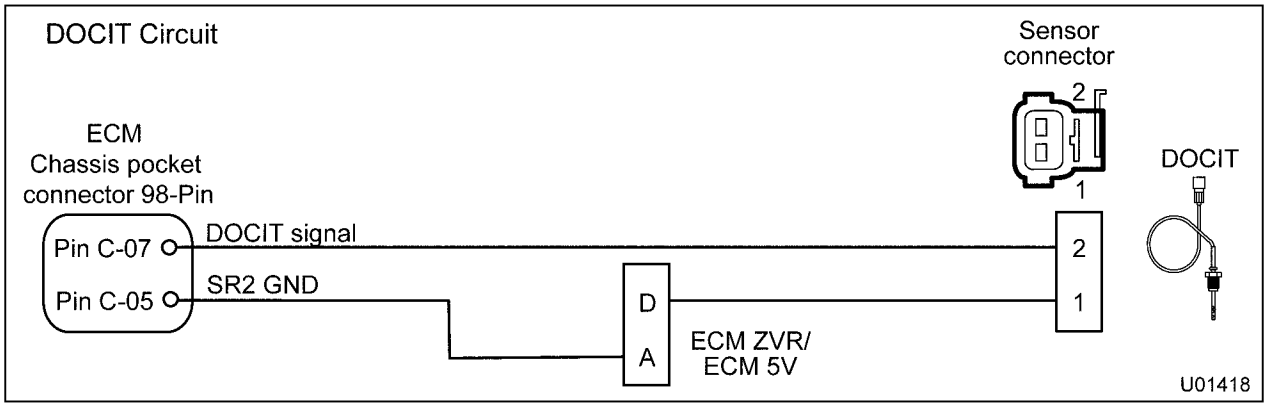


Figure 112 DOCIT Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

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

1. Using ServiceMaxx™ software, open the Aftertreatment session.
2. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.

3. Disconnect engine harness from sensor.

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

4. Connect Breakout Harness ZTSE4760A to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect sensor Breakout Harness ZTSE4760A. Leave sensor disconnected. Turn the ignition switch to ON. Use ServiceMaxx™ to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	SPN 4765 FMI 3	If SPN 4765 and FMI 4 is active, check DOCIT signal for short to GND. Do Harness Resistance Check (page 340).
EST - Check DTC Short 3-Banana plug harness across 1 and GND	SPN 4765 FMI 4	If SPN 4765 and FMI 3 is active, check DOCIT signal for OPEN. Do Harness Resistance Check (page 340).
EST - Check DTC Short 3-Banana plug ZTSE4498 harness across 1 and 2	SPN 4765 FMI 4	If SPN 4765 and FMI 3 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 340).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

Connector Voltage Check

Connect Breakout Harness ZTSE4760A. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to B+	B+	If < B+ check for short to PWR or open circuit. Do Harness Resistance Check (page 340).
2 to GND	4.0V to 4.5V	If < 4.0 V, check for OPEN or short to GND. Do Harness Resistance Check (page 340).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4760A. Leave sensor disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4760A. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to C-05	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to C-07	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 4765 FMI 2 - DOCIT signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of sensor reading to other sensor readings after a calibrated cold soak period.	Diesel Oxidation Catalyst Inlet Temperature (DOCIT) minus Exhaust Gas Temperature (EGT) > 2°F (1°C)	Key OFF engine soak time > 8 hours	1 second
		Time in key ON engine OFF state < 3 seconds	
	DOCIT minus Diesel Particulate Filter Inlet Temperature (DPFIT) > 27°F (15°C)	Engine not in running state	
	DOCIT MINUS Diesel Particulate Filter Outlet Temperature (DPFOT) > 27°F (15°C)	The following SPN/FMIs are not active: 173/3, 173/4, 4765/3, 4765/4, 3242/3, 3242/4, 3246/3, and 3246/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DOCIT value is erratic or incorrect when compared to other related sensor values.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

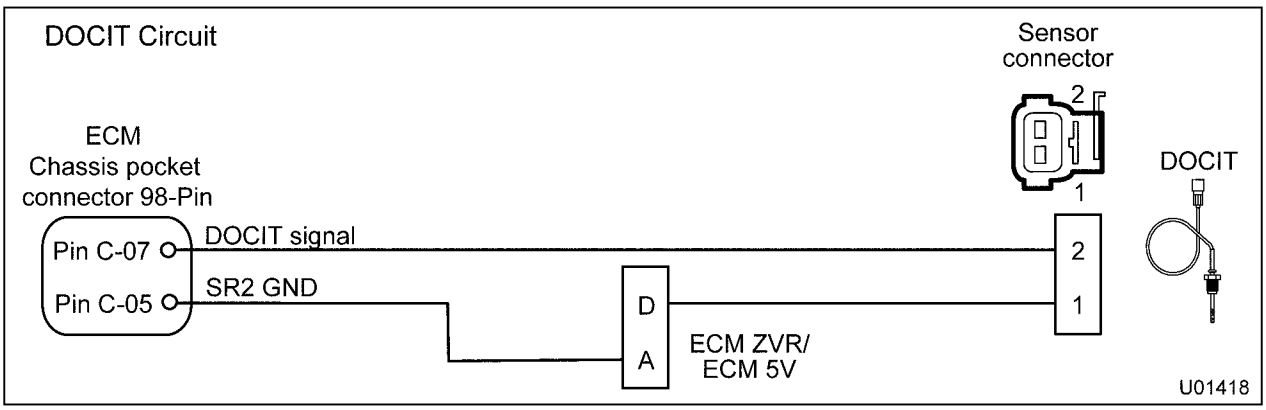


Figure 113 DOCIT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 4765 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 4765 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor. With key OFF, disconnect DOCIT sensor connector. Check DOCIT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DOCIT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4765 FMI 2.

Step	Action	Decision
4	Test DOCIT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 339). Are DOCIT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 4765 FMI 2.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test (Key On, Engine Off (KOEO) Tests, page 68). Does circuit operate properly?	Yes: Go to Step 6. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 4765 FMI 2.

Step	Action	Decision
6	Test DOCIT sensor. Connect breakout harness 4760A between DOCIT sensor and DOCIT sensor connector. Perform KOEO voltage check (Key On, Engine Off (KOEO) Tests, page 68)of DOCIT sensor between DOCIT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 4765 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace DOCIT sensor. After repairs are complete, retest for SPN 4765 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 4765 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4765 FMI 8 - DOCIT signal abnormal rate of change

Fault Overview

Fault sets when the ECM determines the Diesel Oxidation Catalyst Inlet Temperature (DOCIT) value is erratic or incorrect when compared to other related sensor values.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

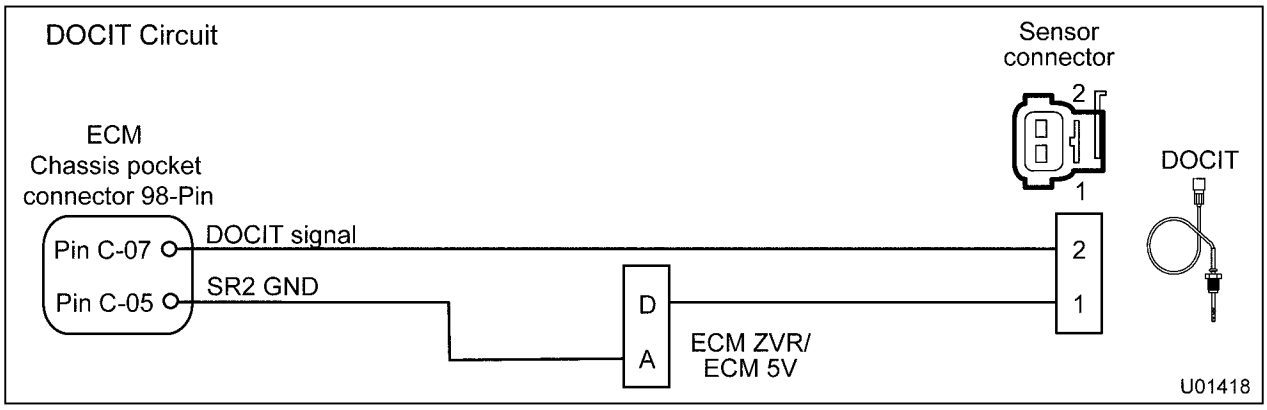


Figure 114 DOCIT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 4765 FMI 8 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 4765 FMI 8. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor. With key OFF, disconnect DOCIT sensor connector. Check DOCIT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DOCIT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4765 FMI 8.

Step	Action	Decision
4	Test DOCIT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 339). Are DOCIT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 4765 FMI 8.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test (Key On, Engine Off (KOEO) Tests, page 68). Does circuit operate properly?	Yes: Go to Step 6. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 4765 FMI 8.

Step	Action	Decision
6	Test DOCIT sensor. Connect breakout harness 4760A between DOCIT sensor and DOCIT sensor connector. Perform KOEO voltage check (Key On, Engine Off (KOEO) Tests, page 68) of DOCIT sensor between DOCIT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 4765 FMI 8 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace DOCIT sensor. After repairs are complete, retest for SPN 4765 FMI 8.

NOTE: After doing all diagnostic steps, if SPN 4765 FMI 8 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4765 FMI 10 - DOCIT in range stuck fault

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Stuck in range LOW fault detected	Diesel Particulate Filter Inlet Temperature (DPFIT) minus Diesel Oxidation Catalyst Inlet Temperature (DOCIT) > 216°F (120°C).	Time in Level 1 regen > 5 seconds	60 seconds
		Not in Level 2 regen since module powered ON and average DPFIT and Diesel Particulate Filter Outlet Temperature (DPFOT) < 630°F (332°C)	
		The following SPN/FMIs are not active: 4765/3, 4765/4, 4765/10, 3242/3, and 3242/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DOCIT signal value has been stuck in a certain range for an extended period of time.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Fault Fact

If aftertreatment system has had excess fuel, oil, coolant, metal, or other contamination, inspect the entire aftertreatment system for causal damage before re-installing. Inspect for overheated aftertreatment components, cracked exhaust system welds, leaking exhaust system seams, or other damage. The root cause of the contamination must be diagnosed and repaired prior to finalizing repairs to the aftertreatment system.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

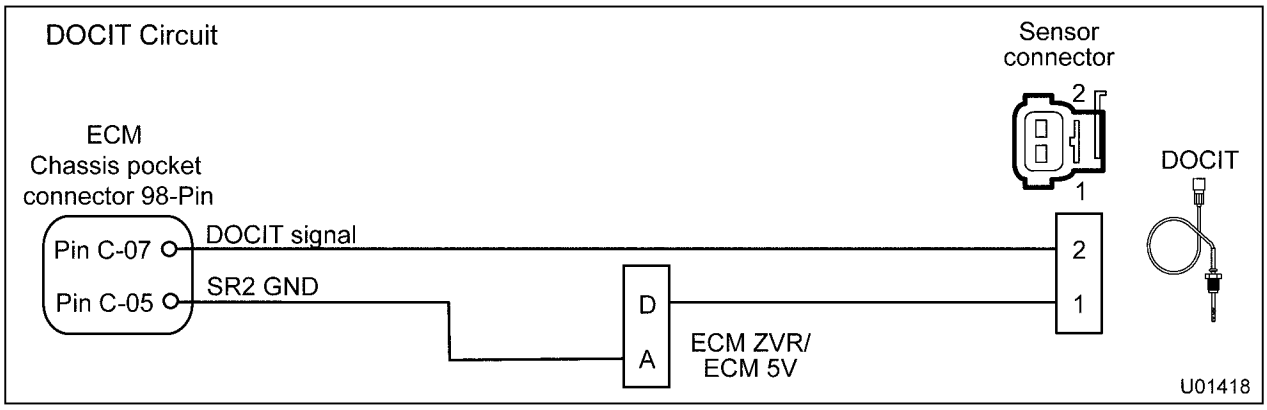


Figure 115 DOCIT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 4765 FMI 10 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 4765 FMI 10. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor. With key OFF, disconnect DOCIT sensor connector. Check DOCIT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DOCIT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4765 FMI 10.

Step	Action	Decision
4	Inspect connections at Diesel Particulate Filter Inlet Temperature (DPFIT) sensor. With key OFF, disconnect DPFIT sensor connector. Check DPFIT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DPFIT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4765 FMI 10.

Step	Action	Decision
5	Test DOCIT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 339). Are DOCIT circuits within specifications?	Yes: Go to Step 6. No: Repair circuits as required. After repairs are complete, retest for SPN 4765 FMI 10.

Step	Action	Decision
6	Test for intermittent DOCIT circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test (Key On, Engine Off (KOEO) Tests, page 68). Does circuit operate properly?	Yes: Go to Step 7. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 4765 FMI 10.

Step	Action	Decision
7	Test DOCIT sensor. Connect breakout harness 4760A between DOCIT sensor and DOCIT sensor connector. Perform KOEO voltage check (Key On, Engine Off (KOEO) Tests, page 68) of DOCIT sensor between DOCIT signal and ground. Is voltage within specification?	Yes: Go to Step 8. No: Replace DOCIT sensor. After repairs are complete, retest for SPN 4765 FMI 10.

Step	Action	Decision
8	Test DPFIT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 339). Are DPFIT circuits within specifications?	Yes: Go to Step 9. No: Repair circuits as required. After repairs are complete, retest for SPN 4765 FMI 10.

Step	Action	Decision
9	Test for intermittent DPFIT circuit operation using EST with ServiceMaxx™ software. Perform the KOEO Continuous Monitor Test (Key On, Engine Off (KOEO) Tests, page 68). Does circuit operate properly?	Yes: Go to Step 10. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 4765 FMI 10.

Step	Action	Decision
10	Test DPFIT sensor. Connect breakout harness 4760A between DPFIT sensor and DPFIT sensor connector. Perform KOEO voltage check (Key On, Engine Off (KOEO) Tests, page 68) of DPFIT sensor between DPFIT signal and ground. Is voltage within specification?	Yes: Go to Step 11. No: Replace DPFIT sensor. After repairs are complete, retest for SPN 4765 FMI 10.

Step	Action	Decision
11	Inspect Diesel Oxidation Catalyst (DOC) for fuel, coolant, or oil contamination. Is DOC free of of contamination?	Yes: Go to Step 12. No: Replace DOC. After repairs are complete, retest for SPN 4765 FMI 10.

Step	Action	Decision
12	Clean Diesel Particulate Filter (DPF) by performing DPF Cleaning Procedure. After procedure is complete, retest for SPN 4765 FMI 10. Is SPN 4765 FMI 10 still active?	Yes: After doing all diagnostic steps, if SPN 4765 FMI 10 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair cause of oil, coolant, or fuel contamination in the exhaust system.

NOTE: After doing all diagnostic steps, if SPN 4765 FMI 10 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4765 FMI 21 - DOCIT signal drifted LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Oxidation Catalyst Inlet Temperature (DOCIT) stuck in range	DOCIT < 104°F (40°C)	Minimum engine speed value for incrementing accumulator > 1325 rpm	0.5 seconds
		Minimum engine torque command for incrementing accumulator > 350 N•m	
		Accumulator threshold for monitor enablement > 5 minutes	
		Minimum Intake Manifold Pressure (IMP) > 7.25 psi (50 kPa)	
		The following SPN/FMIs are not active: 108/3, 108/4, 172/2, 172/3, 172/4, 4765/2, 4765/3, and 4765/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DOCIT signal value has drifted below its expected value.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

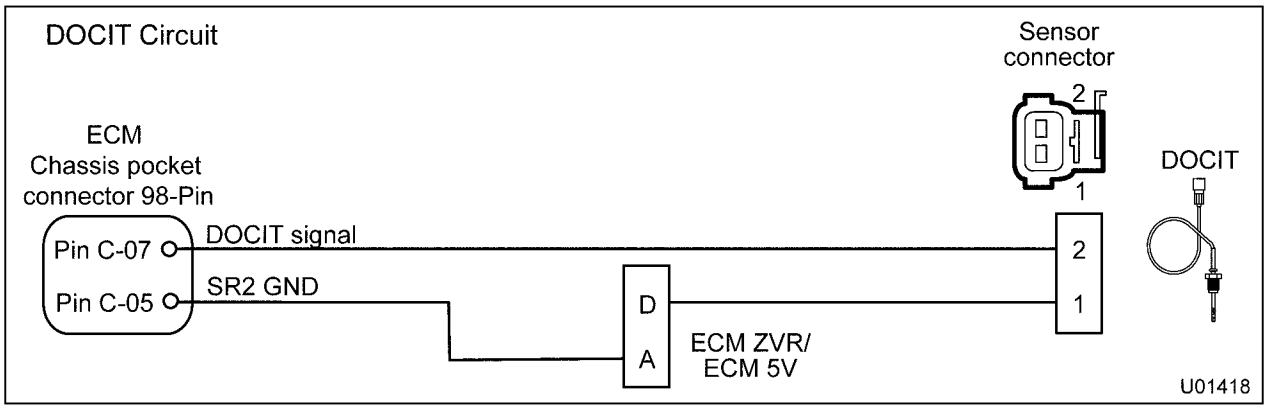


Figure 116 DOCIT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 4765 FMI 21 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 4765 FMI 21. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor. With key OFF, disconnect DOCIT sensor connector. Check DOCIT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DOCIT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4765 FMI 21.

Step	Action	Decision
4	Test DOCIT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 339). Are DOCIT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 4765 FMI 21.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test (Key On, Engine Off (KOEO) Tests, page 68). Does circuit operate properly?	Yes: Go to Step 6. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 4765 FMI 21.

Step	Action	Decision
6	Test DOCIT sensor. Connect breakout harness 4760A between DOCIT sensor and DOCIT sensor connector. Perform KOEO voltage check (Key On, Engine Off (KOEO) Tests, page 68) of DOCIT sensor between DOCIT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 4765 FMI 21 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace DOCIT sensor. After repairs are complete, retest for SPN 4765 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 4765 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

DPFDP (Diesel Particulate Filter Differential Pressure) Sensor

DPFDP Sensor End Diagnostics

SPN	FMI	Condition	Possible Causes	Actions
3251	0	DPFDP excessively high (Plugged filter)	• Biased DPFDP sensor • DOC / DPF face plugged • High DPF soot load	Pin-Point Diagnostics (page 357)
3251	1	DPFDP Negative Delta Pressure	• DPFDP sensor lines reversed • Leaking or restricted DPFDP hoses • Biased circuit or sensor • Exhaust leaks	Step-Based Diagnostics (page 360)
3251	3	DPFDP signal Out of Range HIGH	• DPFDP signal short to power • SIG GND circuit OPEN • Failed sensor	Pin-Point Diagnostics (page 357)
3251	4	DPFDP signal Out of Range LOW	• DPFDP signal OPEN or short to GND • Failed sensor • Damaged or missing DPF	Pin-Point Diagnostics (page 357)
3251	8	DPFDP signal abnormal rate of change	• DPFDP sensor hoses restricted or open • Biased sensor or circuit	Pin-Point Diagnostics (page 357)
3251	10	DPFDP in range stuck fault	• DPFDP sensor lines reversed • Leaking or restricted DPFDP hoses • Biased circuit or sensor • Exhaust leaks • Cracked DPF brick	Step-Based Diagnostics (page 363)

3251	18	DPFDP excessively LOW (sensor / circuit fault or missing DPF)	• DPFDP sensor lines reversed • Leaking or restricted DPFDP hoses • Biased circuit or sensor • Cracked DPF brick • Biased Mass Air Flow (MAF) sensor	Step-Based Diagnostics (page 367)
3251	21	DPFDP excessively LOW (sensor / circuit fault or missing DPF)	• DPFDP sensor lines reversed • Leaking or restricted DPFDP hoses • Biased circuit or sensor • Cracked DPF brick • Biased Mass Air Flow (MAF) sensor	Step-Based Diagnostics (page 371)

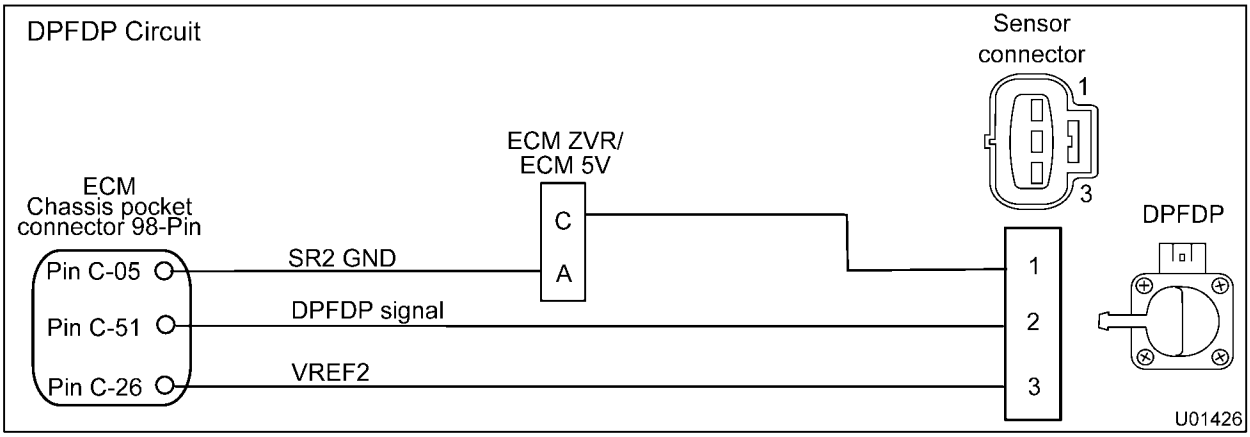


Figure 117 DPFDP circuit diagram

Overview

The DPFDP sensor provides a feedback signal to the ECM indicating pressure difference between the inlet and outlet of the DPF. Before and during a catalyst regeneration, the ECM monitors this sensor along with DOCIT, DPFIT, DPFOT, and MAF.

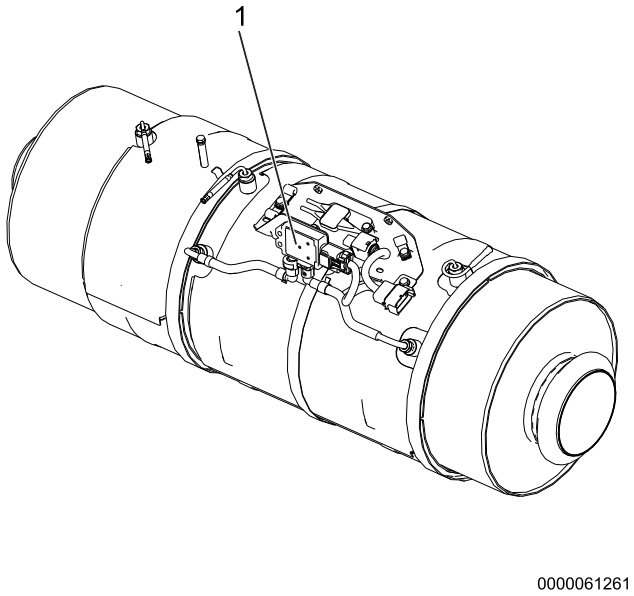


Figure 118 DPFDP Sensor Location

1. DPFDP Sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 00-00956-08 – 180-Pin Breakout Box
- Breakout Harness ZTSE4761A (DPFDP)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

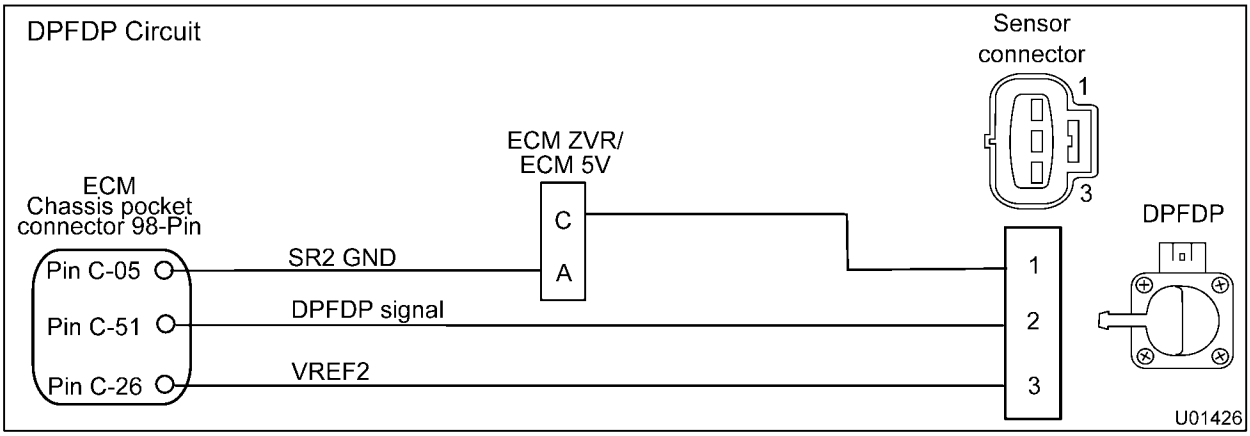


Figure 119 DPFDP circuit diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

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

1. Inspect DPFDP sensor and tubes for damage or incorrect assembly.
2. Using ServiceMaxx™, open the Aftertreatment session.
3. Verify sensor voltage is within KOEO specification. See “Appendix A: Performance Specifications” (page 813).
4. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
5. Disconnect engine harness from sensor.

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

6. Connect Breakout Harness ZTSE4761A to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect sensor Breakout Harness ZTSE4761A. Leave sensor disconnected. Turn the ignition switch to ON. Use EST with ServiceMaxx™ software to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	SPN 3251 FMI 3	If SPN 3251 and FMI 4 is active, check DPFDP signal for short to PWR.
DMM - Measure volts 3 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 359).
EST - Check DTC Short breakout harness across 2 and 3	SPN 3251 FMI 4	If SPN 3251 and FMI 3 is active, check DPFDP signal for OPEN. Do Harness Resistance Check (page 359).
DMM - Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 359).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

Connector Voltage Check

Connect Breakout Harness ZTSE4761A. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to B+	B+	If < B+, check for short to power, or open circuit.
3 to GND	5 V +/- 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 359).
2 to GND	2.5 V +/- 0.5 V	If > 3 V, check for short to PWR. If < 2 V, check for short to GND. Do Harness Resistance Check (page 10).

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4761A. Leave sensor disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4761A. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to C-05	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
2 to C-51	< 5 Ω	If > 5 Ω, check DPFDP signal circuit for OPEN.
3 to C-26	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.

SPN 3251 FMI 1 - DPFDP Negative Delta Pressure

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter Differential Pressure (DPFDP) excessively low	DPFDP < -.07 psi (0.5 kPa)	Engine Speed > 1000 rpm	1 second
		Engine Run Timer > 0 seconds	
		Fuel Injection command quantity > 40 mg/stk	
		Air Inlet Temperature (AIT) > 16°F (-9°C)	
		The following SPN / FMIs are not active: 172/3, 172/4, 3251/3, 3251/4, and 3251/10.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DPFDP signal is lower than allowed.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

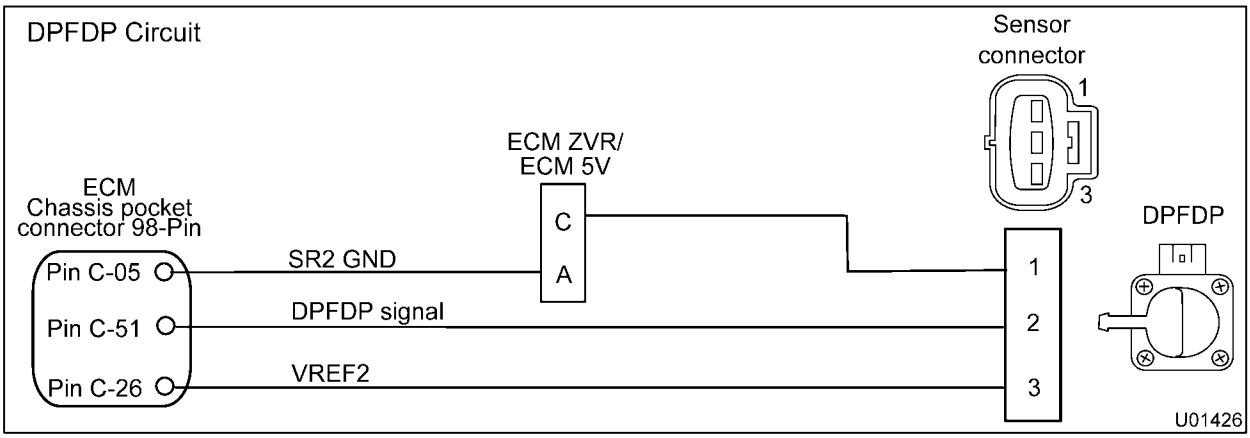


Figure 120 DPFDP Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3251 FMI 1 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3251 FMI 1. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Diesel Particulate Filter Delta Pressure (DPFDP) sensor. Key OFF, disconnect IMP connector. Check DPFDP and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DPFDP connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 1.

Step	Action	Decision
4	Check for biased Diesel Particulate Filter Differential Pressure (DPFDP) sensor. Do DPFDP sensor KOEO check(page 71). Are DPFDP sensor and circuits within specification?	Yes: Go to Step 7. No: Go to Step 5.

Step	Action	Decision
5	Test DPFDP circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 358). Are DPFDP circuits within specifications?	Yes: Go to Step 6. No: Repair circuits as required. After repairs are complete, retest for SPN 3251 FMI 1.

Step	Action	Decision
6	Test DPFDP sensor. Connect breakout harness 4761A between DPFDP sensor and DPFDP sensor connector. Perform KOEO voltage check of DPFDP sensor between DPFDP signal and ground (page 71). Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 3251 FMI 1 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace DPFDP sensor. After repairs are complete, retest for SPN 3251 FMI 1.

Step	Action	Decision
7	Check DPFDP sensor hoses for correct routing and restrictions. Inspect the DPFDP hoses for kinks, improper hose routing, reversed hoses or damage. See DPFDP sensor locator for correct routing of hoses. Are the DPFDP hoses routed correctly and free of damage?	Yes: Go to Step 8. No: Repair DPFDP hoses. After repairs are complete, retest for SPN 3251 FMI 1.

Step	Action	Decision
8	Inspect exhaust system for leaks. Is exhaust system free of leaks?	Yes: After doing all diagnostic steps, if SPN 3251 FMI 1 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair leaks. After repairs are complete, retest for SPN 3251 FMI 1.

NOTE: After doing all diagnostic steps, if SPN 3251 FMI 1 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3251 FMI 10 - DPFDP in range stuck fault

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter Differential Pressure (DPFDP) stuck in range fault.	DPFDP during engine idle test vs. engine part load test < .2 psi (1.5 kPa)	Engine Coolant Temperature (ECT) > 77°F (25°C)	0.0001 seconds
		Air Inlet Temperature (AIT) > 16°F (-9°C)	
		Average of Diesel Particulate Filter Inlet Temperature (DPFIT) and Diesel Particulate Filter Outlet Temperature (DPFOT) < 752°F(400°C)	
		Minimum Time after regeneration event > 5 minutes	
		RPM between 600-800 and torque between 0-250 N•m > 10 seconds	
		RPM between 2000-3000 and torque between 500-1200 N•m > 7 seconds	
		The following SPN/FMIs are not active: 4765/2, 4765/3, 4765/4, 4765/10, 3242/2, 3242/3, 3242/4, 3242/10, 3246/3, 3246/4, 3246/10, 3251/3, 3251/4, and 3251/21.	
	or DPFDP > 0.07 psi (0.5 kpa)	Key ON, Engine OFF	1 second
		AIT > 16°F (-9°C)	
		Average DPFIT and DPFOT < 212°F (100°C)	
		The following SPN/FMIs are not active: 3251/3 and 3251/4.	

SPN 3251 FMI 10 - DPFDP in range stuck fault (cont.)

	or DPFDP < -0.07 psi (-0.5 kpa)	Key ON	1 second
		AIT > 16°F (-9°C)	
		Engine Speed > 1000 rpm	
		Time after engine start > 0 seconds	
		Minimum engine fuel injection command > 40 mg/stk	
		The following SPN/FMIs are not active: 3251/3, 3251/4, 172/3, and 172/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DPFDP sensor signal is stuck in a certain range when compared to other sensor signal readings.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

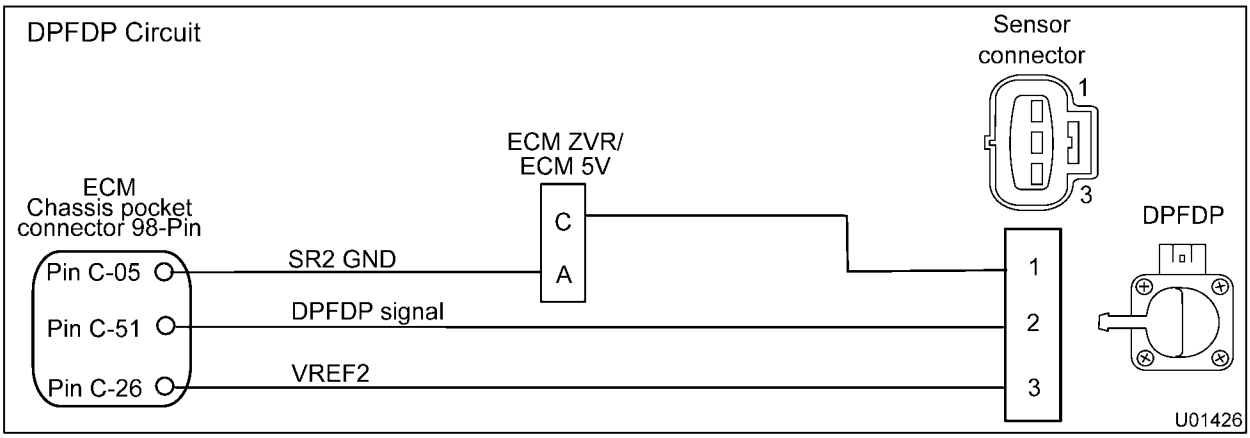


Figure 121 DPFDP Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3251 FMI 10 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3251 FMI 10. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Diesel Particulate Filter Delta Pressure (DPFDP) sensor. Key OFF, disconnect IMP connector. Check DPFDP and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DPFDP connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 10.

Step	Action	Decision
4	Check for biased Diesel Particulate Filter Differential Pressure (DPFDP) sensor. Do DPFDP sensor KOEO check (page 71). Are DPFDP sensor and circuits within specification?	Yes: Go to Step 7. No: Go to Step 5.

Step	Action	Decision
5	Test DPFDP circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 358). Are DPFDP circuits within specifications?	Yes: Go to Step 6. No: Repair circuits as required. After repairs are complete, retest for SPN 3251 FMI 10.

Step	Action	Decision
6	Test DPFDP sensor. Connect breakout harness 4761A between DPFDP sensor and DPFDP sensor connector. Perform KOEO voltage check of DPFDP sensor between DPFDP signal and ground (page 71). Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 3251 FMI 10 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace DPFDP sensor. After repairs are complete, retest for SPN 3251 FMI 10.

Step	Action	Decision
7	Check DPFDP sensor hoses for correct routing and restrictions. Inspect the DPFDP hoses for kinks, improper hose routing, reversed hoses or damage. See DPFDP sensor locator for correct routing of hoses. Are the DPFDP hoses routed correctly and free of damage?	Yes: Go to Step 8. No: Repair DPFDP hoses. After repairs are complete, retest for SPN 3251 FMI 10.

Step	Action	Decision
8	Inspect exhaust system for leaks. Is exhaust system free of leaks?	Yes: Go to Step 9. No: Repair leaks. After repairs are complete, retest for SPN 3251 FMI 10.

Step	Action	Decision
9	Inspect Diesel Particulate Filter (DPF). Use “DPF and DOC Reuse Guidelines” in “Aftertreatment Symptom-Based Diagnostic and Inspection Manual” for EPA 10 (0000003081). Is DPF reusable by the DPF and DOC Reuse Guidelines?	Yes: After doing all diagnostic steps, if SPN 3251 FMI 10 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace DPF. After repairs are complete, retest for SPN 3251 FMI 10.

NOTE: After doing all diagnostic steps, if SPN 3251 FMI 10 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3251 FMI 18 - DPFDP excessively LOW (Sensor / circuit fault or missing DPF)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter (DPF) filtration performance	Differential pressure across Diesel Particulate Filter (DPF) < threshold defined as a function of engine exhaust gas flow rate and estimated soot load [Table A058] + Air Inlet Temperature (AIT) modifier [Table A059] + ambient pressure modifier table [Table A060]	Average Diesel Particulate Filter Inlet Temperature (DPFIT) and Diesel Particulate Filter Outlet Temperature (DPFOT) < 788°F (420°C)	22 seconds
		Engine Run Timer > 300 seconds	
		Diesel Oxidation Catalyst Inlet Temperature (DOCIT) > 392°F (200°C)	
		Engine Coolant Temperature (ECT) > 122°F (50°C)	
		DPF soot load (estimated by model) > 4.5 g and < 21 g	
		Air Inlet Temperature (AIT) > -40°F (-40°C) and < 392°F (200°C)	
		Ambient pressure < 11 psi (75 kPa)	
		Monitor enablement zone based on exhaust flow based table [Table A061]	
		Not in active regeneration	
		The following SPN / FMIs are not active: 110/3, 110/4, 132/2, 132/3, 132/4, 172/2, 172/3, 172/4, 4765/2, 4765/3, 4765/4, 3242/2, 3242/3, 3242/4, 3246/2, 3246/3, 3246/4, 3251/3, 3251/4, and 3251/10.	
	Differential pressure across Diesel Particulate Filter (DPF) < Threshold defined as a function of engine exhaust gas flow rate and estimated soot load [Table A058] + Engine Air Intake Temperature modifier [Table A059] + Ambient pressure	Average Diesel Particulate Filter Inlet Temperature (DPFIT) and Diesel Particulate Filter Outlet Temperature (DPFOT) < 788°F (420°C)	25 seconds
		Diesel Oxidation Catalyst Inlet Temperature (DOCIT) > 392°F (200°C)	
		Engine Coolant Temperature (ECT) > 122°F (50°C)	

SPN 3251 FMI 18 - DPFDP excessively LOW (Sensor / circuit fault or missing DPF) (cont.)

		Monitor enablement zone based on exhaust flow based table [Table A061]	
		Not in active regeneration	
		The following SPN/FMIs are not active: 110/3, 110/4, 132/2, 132/3, 132/4, 172/2, 172/3, 172/4, 4765/2, 4765/3, 4765/4, 3242/2, 3242/3, 3242/4, 3246/2, 3246/3, 3246/4, 3251/3, 3251/4, and 3251/10.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DPFDP signal is lower than allowed.

Amber Warning Lamp (AWL) Reaction

When fault is active, the Amber Warning Lamp (AWL) will be illuminated.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

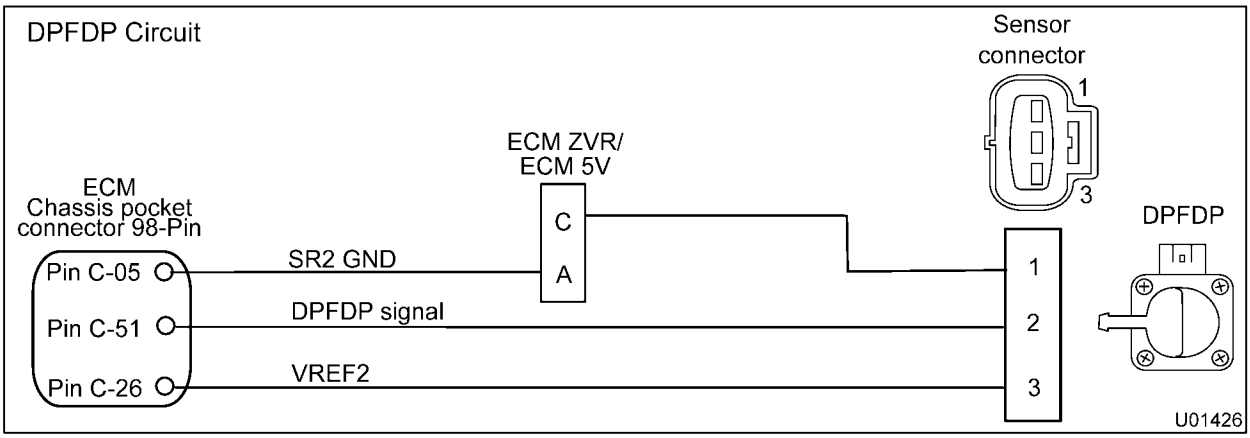


Figure 122 DPFDP Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3251 FMI 18 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3251 FMI 18. No: Go to Step 3.

Step	Action	Decision
3	Inspect exhaust system for missing Diesel Particulate Filter (DPF), leaks, or physical damage. Is DPF in place, and exhaust system free of leaks and physical damage?	Yes: Go to Step 4. No: Replace DPF, repair exhaust leaks, or repair physical damage. After repairs are complete, retest for SPN 3251 FMI 18.

Step	Action	Decision
4	Inspect connections at Diesel Particulate Filter Differential Pressure (DPFDP) sensor. Key OFF, disconnect DPFDP sensor connector. Check DPFDP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Is the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 18.

Step	Action	Decision
5	Check DPFDP sensor hoses for correct routing and restrictions. Inspect the DPFDP hoses for kinks, improper hose routing, reversed hoses or damage. See DPFDP sensor locator for correct routing of hoses. Are the DPFDP hoses routed correctly and free of damage?	Yes: Go to Step 6. Repair DPFDP hoses. After repairs are complete, retest for SPN 3251 FMI 18.

Step	Action	Decision
6	Remove DPF and inspect the outlet of the DPF filter for damage and soot leakage. Is the DPF free of damage and soot leakage?	Yes: Go to Step 7. No: Replace the DPF. After repairs are complete, retest for SPN 3251 FMI 18.

Step	Action	Decision
7	Check for biased Diesel Particulate Filter Differential Pressure (DPFDP) sensor. Do DPFDP sensor KOEO check(page 71). Are DPFDP sensor and circuits within specification?	Yes: Go to Step 8. No: Repair DPFDP sensor or circuits. After repairs are complete, retest for SPN 3251 FMI 18.

Step	Action	Decision
8	Using ServiceMaxx™ software, calibrate MAF sensor. Do MAF Calibration Procedure (page 662). Did MAF calibration complete successfully?	Yes: After doing all diagnostic steps, if SPN 3251 FMI 18 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Refer to MAF / AIT Sensor diagnostics, SPN 132 FMI 14, MAF sensor Calibration failed.

NOTE: After doing all diagnostic steps, if SPN 3251 FMI 18 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3251 FMI 21 - DPFDP excessively LOW (Sensor / circuit fault or missing DPF)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter (DPF) filtration performance	Differential pressure across Diesel Particulate Filter (DPF) < threshold defined as a function of engine exhaust gas flow rate and estimated soot load [Table A058] + Air Inlet Temperature (AIT) modifier [Table A059] + ambient pressure modifier table [Table A060]	Average Diesel Particulate Filter Inlet Temperature (DPFIT) and Diesel Particulate Filter Outlet Temperature (DPFOT) < 788°F (420°C)	22 seconds
		Engine Run Timer > 300 seconds	
		Diesel Oxidation Catalyst Inlet Temperature (DOCIT) > 392°F (200°C)	
		Engine Coolant Temperature (ECT) > 122°F (50°C)	
		DPF soot load (estimated by model) > 4.5 g and < 21 g	
		Air Inlet Temperature (AIT) > -40°F (-40°C) and < 392°F (200°C)	
		Ambient pressure < 11 psi (75 kPa)	
		Monitor enablement zone based on exhaust flow based table [Table A061]	
		Not in active regeneration	
		The following SPN/FMIs are not active: 110/3, 110/4, 132/2, 132/3, 132/4, 172/2, 172/3, 172/4, 4765/2, 4765/3, 4765/4, 3242/2, 3242/3, 3242/4, 3246/2, 3246/3, 3246/4, 3251/3, 3251/4, and 3251/10.	
	Differential pressure across Diesel Particulate Filter (DPF) < Threshold defined as a function of engine exhaust gas flow rate and estimated soot load [Table A058] + Engine Air Intake Temperature modifier [Table A059] + ambient pressure	Average Diesel Particulate Filter Inlet Temperature (DPFIT) and Diesel Particulate Filter Outlet Temperature (DPFOT) < 788°F (420°C)	25 seconds
		Diesel Oxidation Catalyst Inlet Temperature (DOCIT) > 392°F (200°C)	
		Engine Coolant Temperature (ECT) > 122°F (50°C)	

SPN 3251 FMI 21 - DPFDP excessively LOW (Sensor / circuit fault or missing DPF) (cont.)

		Monitor enablement zone based on exhaust flow based table [Table A061]	
		Not in active regeneration	
		The following SPN/FMIs are not active: 110/3, 110/4, 132/2, 132/3, 132/4, 172/2, 172/3, 172/4, 4765/2, 4765/3, 4765/4, 3242/2, 3242/3, 3242/4, 3246/2, 3246/3, 3246/4, 3251/3, 3251/4, and 3251/10.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DPFDP signal is lower than allowed.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

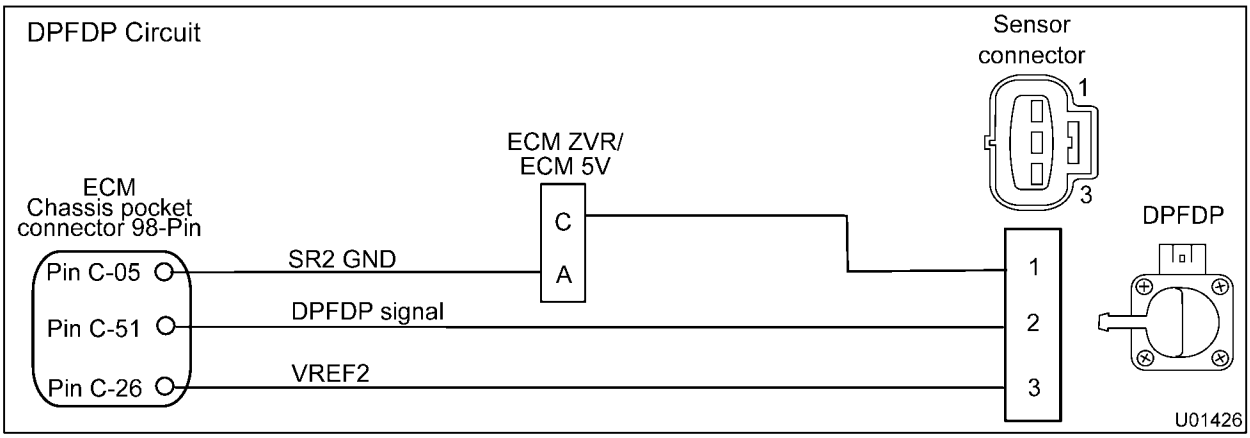


Figure 123 DPFDP Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3251 FMI 21 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3251 FMI 21. No: Go to Step 3.

Step	Action	Decision
3	Inspect exhaust system for missing Diesel Particulate Filter (DPF), leaks, or physical damage. Is DPF in place, and exhaust system free of leaks and physical damage?	Yes: Go to Step 4. No: Replace DPF, repair exhaust leaks, or repair physical damage. After repairs are complete, retest for SPN 3251 FMI 21.

Step	Action	Decision
4	Inspect connections at Diesel Particulate Filter Differential Pressure (DPFDP) sensor. Key OFF, disconnect DPFDP sensor connector. Check DPFDP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Is the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 21.

Step	Action	Decision
5	Check DPFDP sensor hoses for correct routing and restrictions. Inspect the DPFDP hoses for kinks, improper hose routing, reversed hoses or damage. See DPFDP sensor locator for correct routing of hoses. Are the DPFDP hoses routed correctly and free of damage?	Yes: Go to Step 6. Repair DPFDP hoses. After repairs are complete, retest for SPN 3251 FMI 21.

Step	Action	Decision
6	Remove DPF and inspect the outlet of the DPF filter for damage and soot leakage. Is the DPF free of damage and soot leakage?	Yes: Go to Step 7. No: Replace the DPF. After repairs are complete, retest for SPN 3251 FMI 21.

Step	Action	Decision
7	Check for biased Diesel Particulate Filter Differential Pressure (DPFDP) sensor. Do DPFDP sensor KOEO check(page 71). Are DPFDP sensor and circuits within specification?	Yes: Go to Step 8. No: Repair DPFDP sensor or circuits. After repairs are complete, retest for SPN 3251 FMI 21.

Step	Action	Decision
8	Using ServiceMaxx™ software, calibrate MAF sensor. Do MAF Calibration Procedure (page 662). Did MAF calibration complete successfully?	Yes: After doing all diagnostic steps, if SPN 3251 FMI 21 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Refer to MAF / AIT Sensor diagnostics, SPN 132 FMI 14, MAF sensor Calibration failed.

NOTE: After doing all diagnostic steps, if SPN 3251 FMI 21 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

DPFIT (Diesel Particulate Filter Inlet Temperature) Sensor

DPFIT Sensor End Diagnostics

SPN	FMI	Condition	Possible Causes	Actions
3242	2	DPFIT signal erratic, intermittent, or incorrect	• DPFIT biased circuit or sensor	Step-Based Diagnostics (page 379)
3242	3	DPFIT signal Out of Range HIGH	• DPFIT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor	Pin-Point Diagnostics (page 377)
3242	4	DPFIT signal Out of Range LOW	• DPFIT signal circuit short to GND • Failed sensor	Pin-Point Diagnostics (page 377)
3242	10	DPFIT in range stuck LOW fault	• DPFIT biased circuit or sensor • DPFOT biased circuit or sensor • Engine overfueling • DPF plugged • DOC efficiency failure • DPF contaminated from external fuel	Step-Based Diagnostics (page 382)
3242	21	DPFIT in range stuck fault	• DPFIT biased circuit or sensor	Step-Based Diagnostics (page 387)

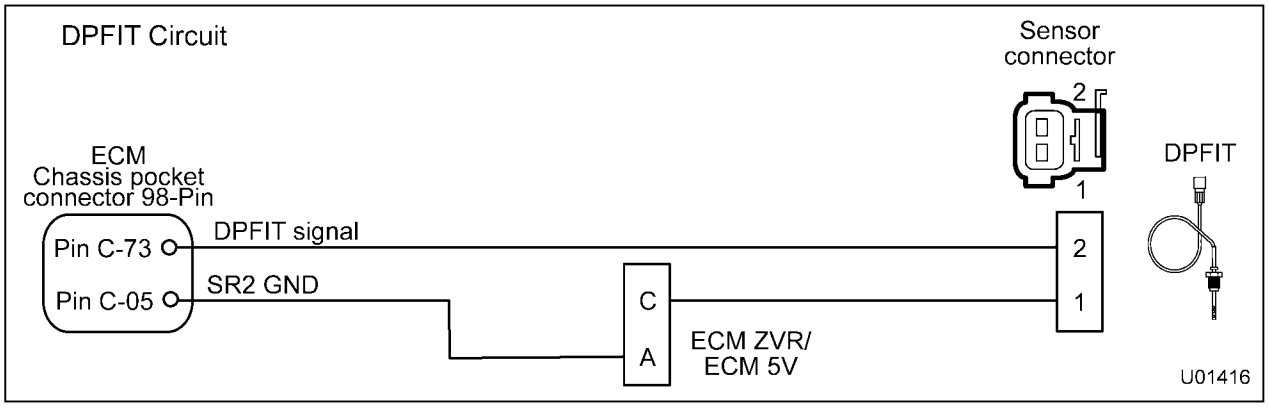


Figure 124 DPFIT Circuit Diagram

Overview

The Diesel Particulate Filter Inlet Temperature (DPFIT) sensor is a thermistor-style sensor that measures temperature between the Diesel Oxidation Catalyst (DOC) and the Diesel Particulate Filter (DPF). As temperature increases, resistance values drop. This change of resistance varies the voltage that is sent to the Engine Control Module (ECM). The DPFIT sensor works with the Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor, Diesel Particulate Filter Outlet Temperature (DPFOT) sensor, Diesel Particulate Filter Differential Pressure (DPFDP) sensor, Exhaust Gas Recirculation Pressure (EGRP) sensor, and Engine Throttle Valve (ETV) to indicate operation and control the regeneration cycles of the Aftertreatment (AFT) system via the ECM.

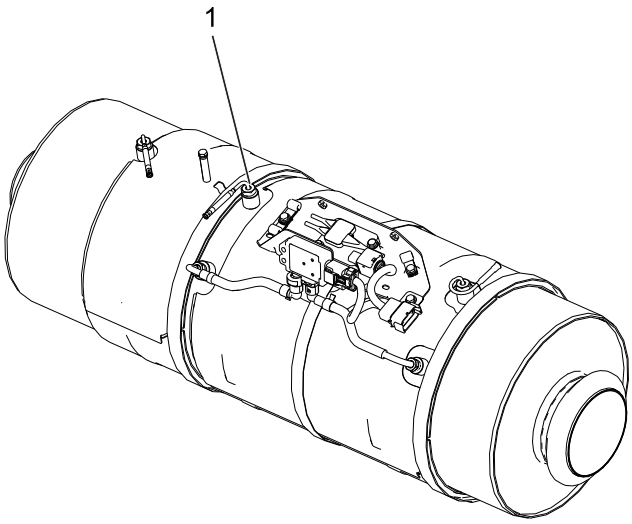


Figure 125 DPFIT Sensor Location

1. DPFIT Sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 00–00956–08 – 180-Pin Breakout Box
- Breakout Harness ZTSE4760A (DPFIT)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

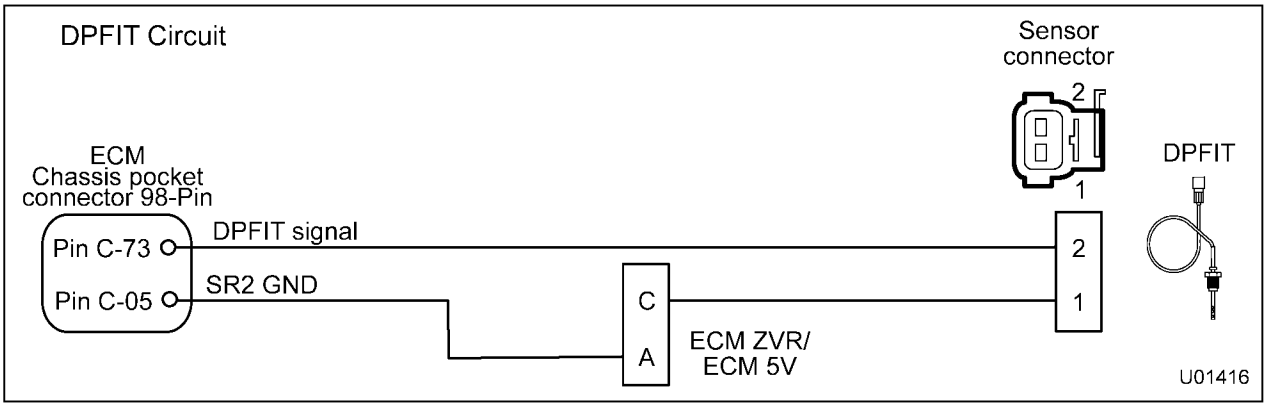


Figure 126 DPFIT Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

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

1. Using ServiceMaxx™, open the Aftertreatment session.
2. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the Diagnostic Trouble Code (DTC) goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor.

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

4. Connect Breakout Harness ZTSE4760A to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect sensor Breakout Harness ZTSE4760A. Leave sensor disconnected. Turn ignition switch to ON. Use ServiceMaxx™ to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	SPN 3242 FMI 3	If SPN 3242 and FMI 4 is active, check DPFIT signal for short to GND. Do Harness Resistance Checks (page 378).
EST - Check DTC Short 3-Banana plug harness across 1 and GND	SPN 3242 FMI 4	If SPN 3242 and FMI 3 is active, check DPFIT signal for OPEN. Do Harness Resistance Check (page 378).
EST - Check DTC Short 3-Banana plug harness across 1 and 2	SPN 3242 FMI 4	If SPN 3242 and FMI 3 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 378).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

Connector Voltage Check

Connect Breakout Harness ZTSE4760A. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to B+	B+	If < B+ check for short to PWR or OPEN circuit. Do Harness Resistance Check (page 378).
2 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 378).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4760A. Leave sensor disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4760A. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to C-05	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to C-73	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 3242 FMI 2 - DFPIT signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of sensor reading to other sensor readings after a calibrated cold soak period.	Diesel Particulate Filter Inlet Temperature (DPFIT) minus Exhaust Gas Temperature (EGT) > 2°F (1°C)	Key OFF Engine soak time > 8 hours	1 second
		Time in key ON engine OFF state < 3 seconds	
	DPFIT minus Diesel Oxidation Catalyst Inlet Temperature (DOCIT) > 27°F (15°C)	Engine NOT in running state	
	DPFIT minus Diesel Particulate Filter Outlet Temperature (DPFOT) > 27°F (15°C)	The following SPN/FMIs are not active: 173/4, 4765/3, 4765/4, 3242/3, 3242/4, 3246/3, and 3246/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DPFIT value is erratic or incorrect when compared to other related sensor values.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

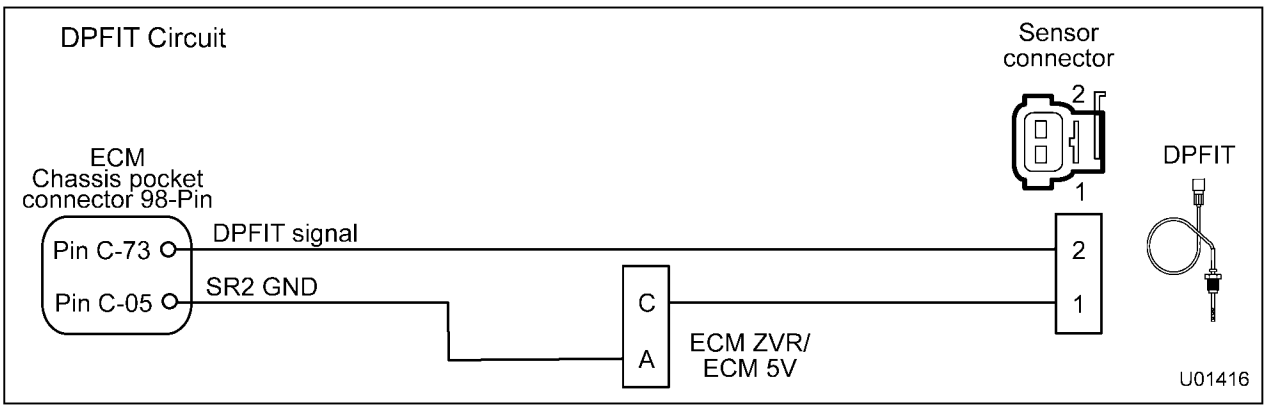


Figure 127 DPFIT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3242 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3242 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Diesel Particulate Filter Inlet Temperature (DPFIT) sensor. With key OFF, disconnect DPFIT sensor connector. Check DPFIT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DPFIT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3242 FMI 2.

Step	Action	Decision
4	Test DPFIT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 378). Are DPFIT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 3242 FMI 2.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test (Key On, Engine Off (KOEO) Tests, page 68). Does circuit operate properly?	Yes: Go to Step 6. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 3242 FMI 2.

Step	Action	Decision
6	Test DPFIT sensor. Connect breakout harness 4760A between DPFIT sensor and DPFIT sensor connector. Perform KOEO voltage check(Key On, Engine Off (KOEO) Tests, page 68) of DPFIT sensor between DPFIT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 3242 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace DPFIT sensor. After repairs are complete, retest for SPN 3242 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 3242 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3242 FMI 10 - DPFIT stuck in range LOW fault

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Stuck in range LOW fault detection	Diesel Particulate Filter Outlet Temperature (DPFOT) minus DPFIT > 378°F (210°C).	Torque < 250 N•m	60 seconds
		Engine run time after start < 20 minutes	
		Key OFF engine soak time > 8 hours	
		Not in active regen mode (Level 1 or 2)	
		The following SPN/FMIs are not active: 3242/3, 3242/4, 3246/3, 3246/4, and 3246/10.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DPFIT signal value has been stuck in a low range for an extended period of time.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Fault Fact

If aftertreatment system has had excess fuel, oil, coolant, metal, or other contamination; inspect the entire aftertreatment system for causal damage before re-installing. Inspect for overheated aftertreatment components, cracked exhaust system welds, leaking exhaust system seams or other damage. The root cause of the contamination must be diagnosed and repaired prior to finalizing repairs to the aftertreatment system.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

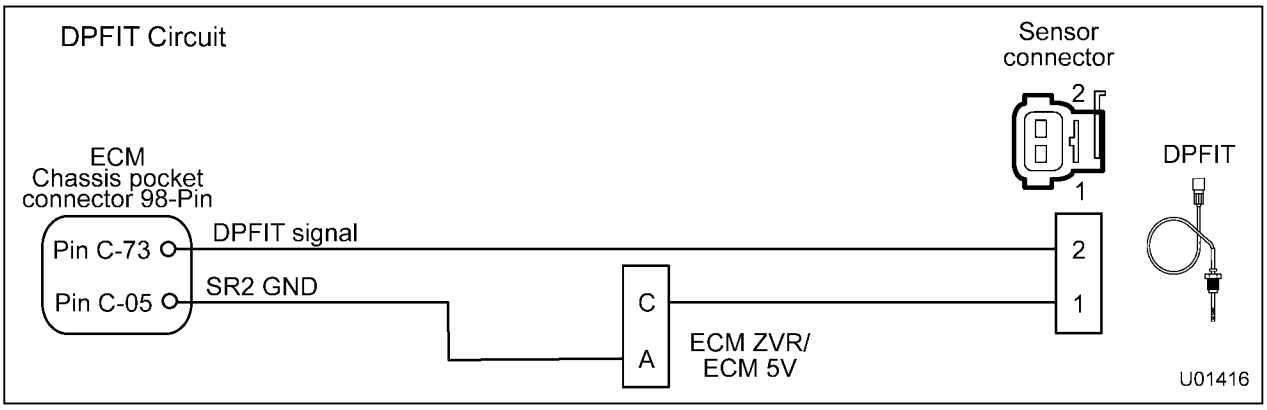


Figure 128 DPFIT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx software, check for other fault codes. Is SPN 3242 FMI 10 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3242 FMI 10. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at DPFIT sensor and Diesel Particulate Filter Outlet Temperature (DPFOT) sensor. With key OFF, disconnect DPFIT and DPFOT sensor connectors. Check DPFIT and DPFOT sensors and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DPFIT and DPFOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3242 FMI 10.

Step	Action	Decision
4	Test DPFIT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 378). Are DPFIT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 3242 FMI 10.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test (Key On, Engine Off (KOEO) Tests, page 68). Does circuit operate properly?	Yes: Go to Step 6. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 3242 FMI 10.

Step	Action	Decision
6	Test DPFIT sensor. Connect breakout harness 4760A between DPFIT sensor and DPFIT sensor connector. Perform KOEO voltage check(Key On, Engine Off (KOEO) Tests, page 68) of DPFIT sensor between DPFIT signal and ground. Is voltage within specification?	Yes: Go to Step 7. No: Replace DPFIT sensor. After repairs are complete, retest for SPN 3242 FMI 10.

Step	Action	Decision
7	Test DPFOT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 393). Are DPFOT circuits within specifications?	Yes: Go to Step 8. No: Repair circuits as required. After repairs are complete, retest for SPN 3242 FMI 10.

Step	Action	Decision
8	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the KOEO Continuous Monitor Test (Key On, Engine Off (KOEO) Tests, page 68). Does circuit operate properly?	Yes: Go to Step 9. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 3242 FMI 10.

Step	Action	Decision
9	Test DPFOT sensor. Connect breakout harness 4760A between DPFOT sensor and DPFOT sensor connector. Perform KOEO voltage check (Key On, Engine Off (KOEO) Tests, page 68) of DPFOT sensor between DPFOT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 3242 FMI 10 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace DPFOT sensor. After repairs are complete, retest for SPN 3242 FMI 10.

NOTE: After doing all diagnostic steps, if SPN 3242 FMI 10 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3242 FMI 21 - DPFIT signal Drifted LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter Inlet Temperature (DPFIT) signal Drifted LOW	DPFIT < 86°F (40°C)	Minimum engine speed value for incrementing accumulator > 1325 rpm	0.5 second
		Minimum engine torque command for incrementing accumulator > 350 N•m	
		Accumulator threshold for monitor enablement > 5 minutes	
		Intake Manifold Pressure (IMP) > 7.25 PSI (50 kPa)	
		The following SPN/FMIs are not active: 108/3, 108/4, 172/2, 172/3, 172/4, 3243/2, 3242/2, 3242/3, and 3242/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DPFIT is below programmed threshold.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

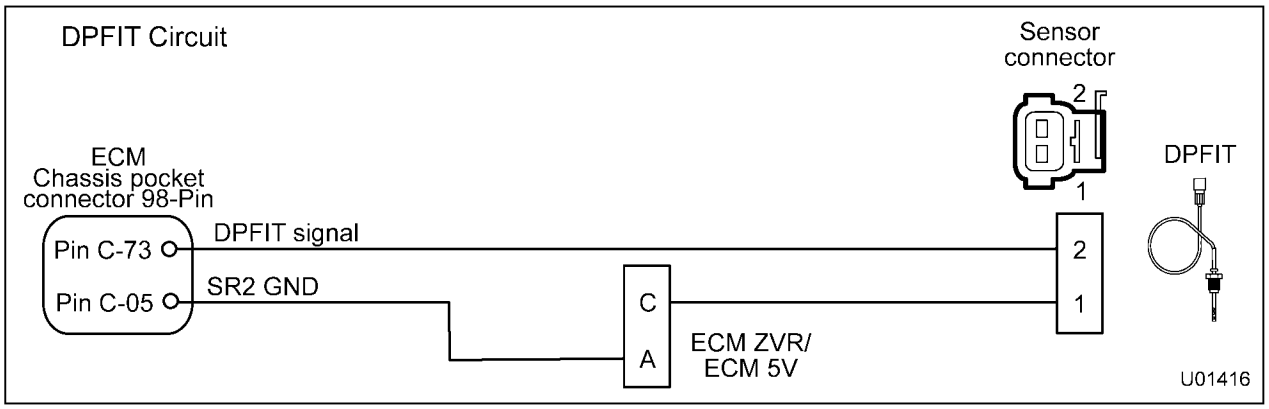


Figure 129 DPFIT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3242 FMI 21 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3242 FMI 21. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at DPFIT sensor. With key OFF, disconnect DPFIT sensor connector. Check DPFIT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DPFIT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3242 FMI 21.

Step	Action	Decision
4	Test DPFIT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 378). Are DPFIT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 3242 FMI 21.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test (Key On, Engine Off (KOEO) Tests, page 68). Does circuit operate properly?	Yes: Go to Step 6. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 3242 FMI 21.

Step	Action	Decision
6	Test DPFIT sensor. Connect breakout harness 4760A between DPFIT sensor and DPFIT sensor connector. Perform KOEO voltage check (Key On, Engine Off (KOEO) Tests, page 68) of DPFIT sensor between DPFIT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 3242 FMI 21 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace DPFIT sensor. After repairs are complete, retest for SPN 3242 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 3242 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

DPFOT (Diesel Particulate Filter Outlet Temperature) Sensor

SPN	FMI	Condition	Possible Causes	Actions
3246	2	DPFOT Signal erratic, intermittent, or incorrect	• Biased DPFOT sensor or circuit	Step-Based Diagnostics (page 394)
3246	3	DPFOT signal Out of Range HIGH	• DPFOT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor	Pin-Point Diagnostics (page 392)
3246	4	DPFOT signal Out of Range LOW	• DPFOT signal circuit short to GND • Failed sensor	Pin-Point Diagnostics (page 392)
3246	10	DPFOT signal abnormal rate of change	• Biased / failed DPFIT or DPFOT sensor or circuit • Exhaust system leaks	Step-Based Diagnostics (page 397)
3246	21	DPFOT signal Drifted LOW	• Biased DPFOT sensor or circuit	Step-Based Diagnostics (page 401)

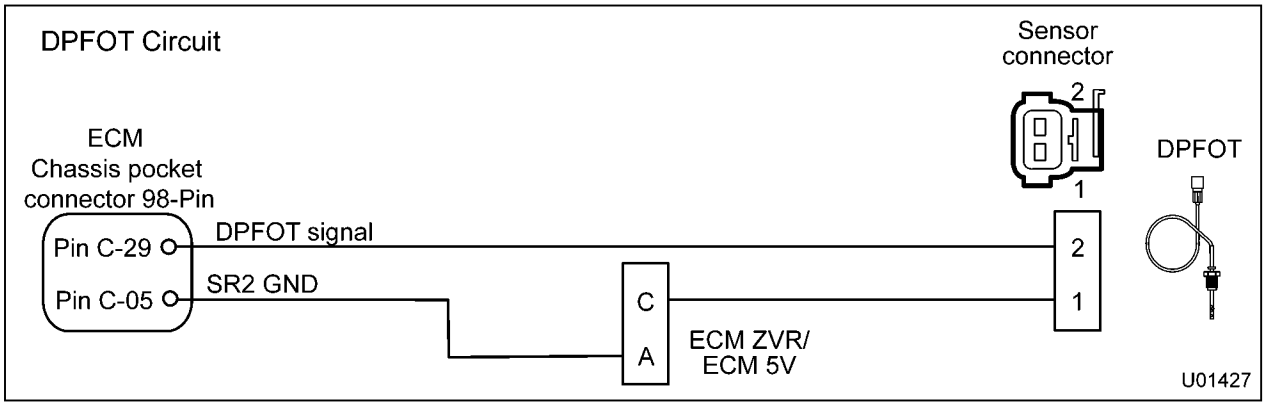


Figure 130 DPFOT Circuit Diagram

Overview

DPFOT sensor provides a feedback signal to the ECM indicating Diesel Particulate Filter (DPF) Outlet Temperature. During catalyst regeneration, the ECM monitors this sensor along with DOCIT, DPFIT, DPFDP, EGRP, and ETV.

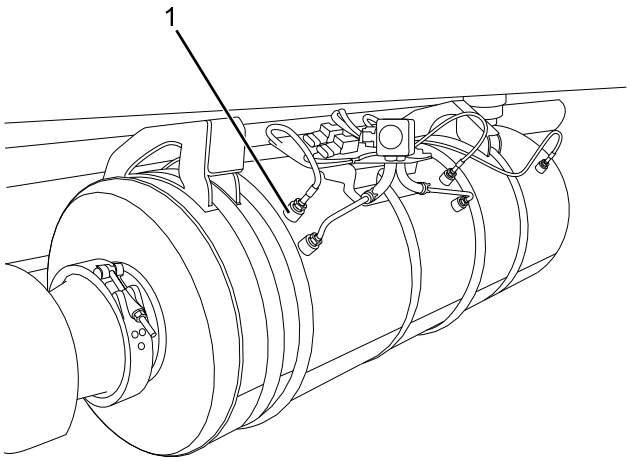


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Figure 131 DPFOT Sensor Location

1. DPFOT Sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 00–00956–08 - 180-Pin Breakout Box
- Breakout Harness ZTSE4760A (DPFOT)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

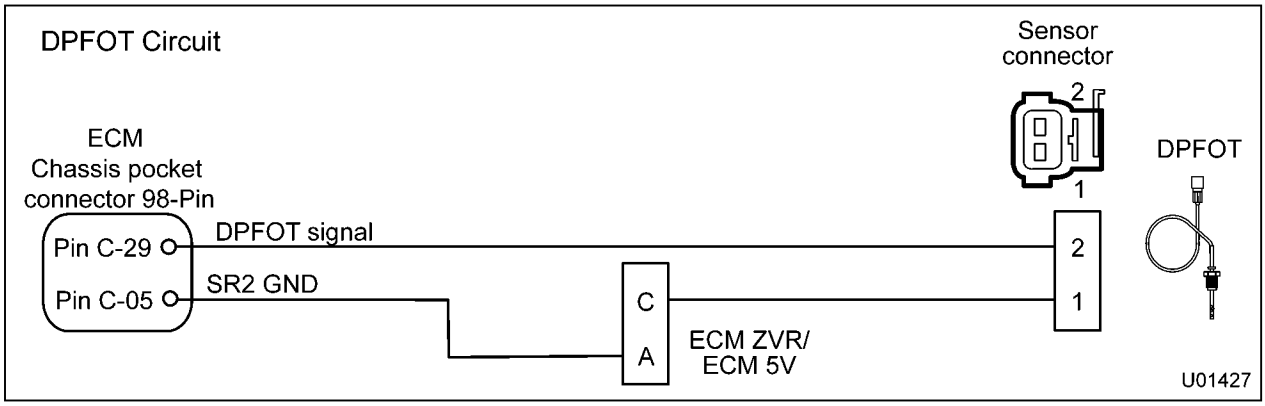


Figure 132 DPFOT Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

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

1. Using ServiceMaxx™, open the Aftertreatment session.
2. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the Diagnostic Trouble Code (DTC) goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor.

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

4. Connect to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect sensor breakout harness. Leave sensor disconnected. Turn the ignition switch to ON. Use Electronic Service Tool (EST) with ServiceMaxx™ software to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	SPN 3246 FMI 3	If SPN 3246 and FMI 4 is active, check DPFOT signal for short to GND. Do Harness Resistance Check (page 393).
EST - Check DTC Short 3-Banana plug harness across 1 and GND	SPN 3246 FMI 4	If SPN 3246 and FMI 3 is active, check DPFOT signal for OPEN. Do Harness Resistance Check (page 393).
EST - Check DTC Short 3-Banana plug harness across 1 and 2	SPN 3246 FMI 4	If SPN 3246 and FMI 3 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 393).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

Connector Voltage Check

Connect Breakout Harness ZTSE4760A. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to B+	B+	If < B+, check for short to PWR.
2 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 393).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4760A. Leave sensor disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4760A. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to C-05	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to C-29	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 3246 FMI 2 - DPFOT Signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of sensor reading to other sensor readings after a calibrated cold soak period.	Comparison of Diesel Particulate Filter Outlet Temperature (DPFOT) and Exhaust Gas Temperature (EGT) > 2°F (1°C)	Key ON	1 second
	Comparison of DPFOT and Diesel Particulate Filter Inlet Temperature (DPFIT) > 27°F (15°C)	Key OFF Engine soak time > 8 hours	
	Comparison of DPFOT and Diesel Oxidation Catalyst Inlet Temperature (DOCIT) > 27°F (15°C)	Time in key ON engine OFF state < 3 seconds	
		Engine NOT in running state	
		The following SPN / FMIs are not active: SPN FMIs 173/3, 173/4, 4765/3, 4765/4, 3242/3, 3242/4, 3246/3, and 3246/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DPFOT value is erratic or incorrect when compared to other related sensor values.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

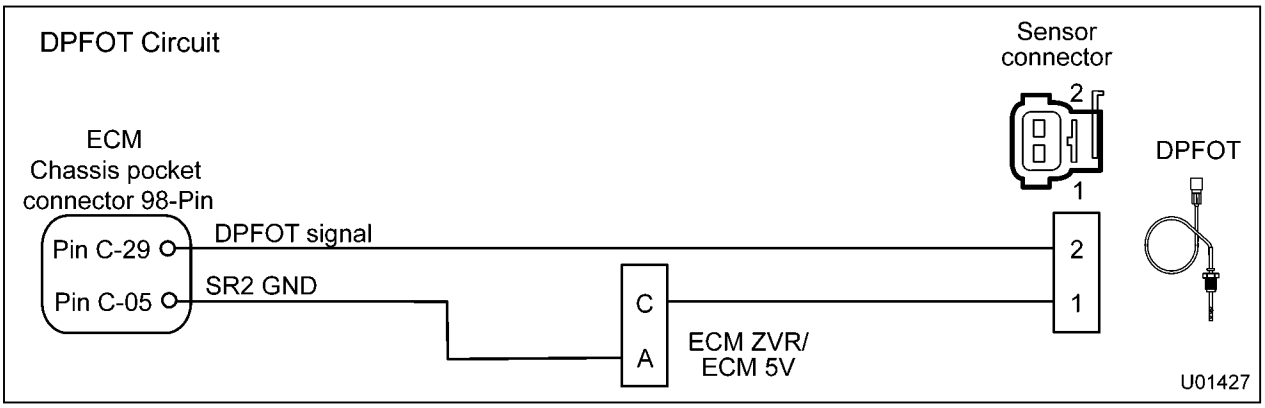


Figure 133 DPFOT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3246 FMI 2 the only fault code active?	Yes: Go to step 3. No: Go to step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3246 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Diesel Particulate Filter Outlet Temperature (DPFOT) sensor. With Key OFF, disconnect DPFOT sensor connector. Check DPFOT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DPFOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3246 FMI 2.

Step	Action	Decision
4	Test DPFOT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 393). Are DPFOT circuits within specifications?	Yes: Go to step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 3246 FMI 2.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test. Does circuit operate properly?	Yes: Go to step 6.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 3246 FMI 2.

Step	Action	Decision
6	Test DPFOT sensor. Connect breakout harness 4760A between DPFOT sensor and DPFOT sensor connector. Perform KOEO voltage check of DPFOT sensor between DPFOT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 3246 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace DPFOT sensor. After repairs are complete, retest for SPN 3246 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 3246 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3246 FMI 10 - DPFOT signal abnormal rate of change

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Stuck in range low fault detection.	Diesel Particulate Filter Inlet Temperature (DPFIT) value minus DPFOT value > 360°F (200°C)	Monitor Operation defined as function of speed / load	60 Seconds
		Engine run time after start < 20 minutes	
		Engine OFF timer > 8 hours	
		NOT in active regen mode	
		The following SPN / FMIs are not active: 3242/3, 3242/4, 3246/3, 3246/4, and 3242/10.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DPFIT and DPFOT values have a difference in temperature greater than 360°F (200°C).

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

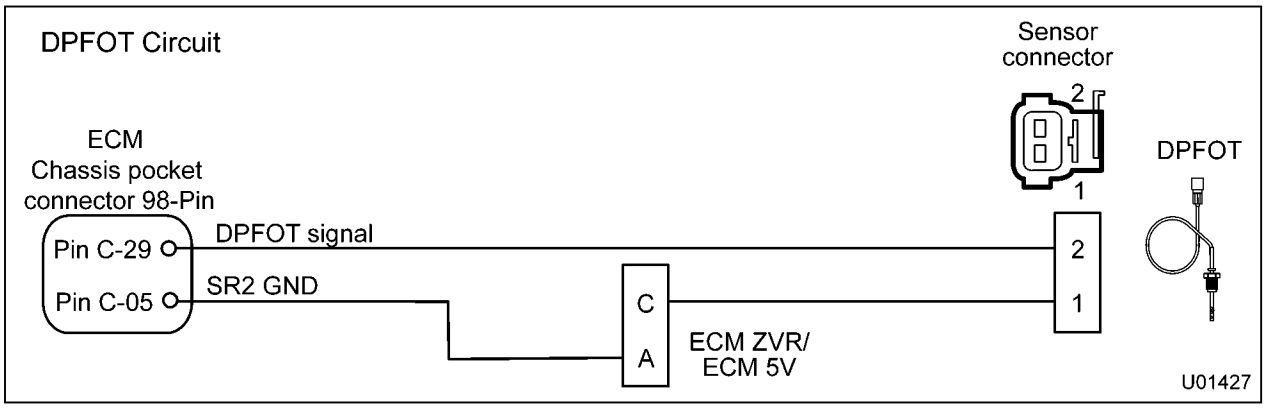


Figure 134 DPFOT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx software, check for other fault codes. Is SPN 3246 FMI 10 the only fault code active?	Yes: Go to step 3. No: Go to step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3246 FMI 10. No: Go to step 3.

Step	Action	Decision
3	Inspect exhaust system for leaks or physical damage. Is exhaust system free of leaks and physical damage?	Yes: Go to Step 4. No: Repair exhaust leak or physical damage. After repairs are complete, retest for SPN 3246 FMI 10.

Step	Action	Decision
4	Inspect connections at DPFIT sensor and DPFOT sensor. Key OFF, disconnect DPFIT and DPFOT sensor connectors. Check DPFIT and DPFOT sensors and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DPFIT and DPFOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3246 FMI 10.

Step	Action	Decision
5	Test DPFIT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 393). Are DPFIT circuits within specifications?	Yes: Go to step 8. No: Repair circuits as required. After repairs are complete, retest for SPN 3246 FMI 10.

Step	Action	Decision
6	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test. Does circuit operate properly?	Yes: Go to step 6. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required and retest for SPN 3246 FMI 10.

Step	Action	Decision
7	Test DPFIT sensor. Connect breakout harness 4760A between DPFIT sensor and DPFIT sensor connector. Perform KOEO voltage check of DPFIT sensor between DPFIT signal and ground. Is voltage within specification?	Yes: Go to step 7. No: Replace DPFIT sensor. After repairs are complete, retest for SPN 3246 FMI 10.

Step	Action	Decision
8	Test DPFOT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 393). Are DPFOT circuits within specifications?	Yes: Go to step 8. No: Repair circuits as required. After repairs are complete, retest for SPN 3246 FMI 10.

Step	Action	Decision
9	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test. Does circuit operate properly?	Yes: Go to step 9. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 3246 FMI 10.

Step	Action	Decision
10	Test DPFOT sensor. Connect breakout harness 4760A between DPFOT sensor and DPFOT sensor connector. Perform KOEO voltage check of DPFOT sensor between DPFOT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 3246 FMI 10 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace DPFOT sensor. After repairs are complete, retest for SPN 3246 FMI 10.

NOTE: After doing all diagnostic steps, if SPN 3246 FMI 10 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3246 FMI 21 - DPFOT signal Drifted LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter Inlet Temperature (DPFIT) stuck in range fault.	DPFIT < 32°F (0°C)	Minimum engine speed > 1325 rpm	0.5 seconds
		Minimum engine Torque command > 350 N•m	
		Minimum Intake Manifold Pressure > 7 psi (50 kPa)	
		Accumulator threshold for monitor enablement > 5 minutes	
		The following SPN / FMIs are not active: 108/3, 108/4, 172/2, 172/3, 172/4, 3243/2, 3243/3, and 3243/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DPFIT is below programmed threshold.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

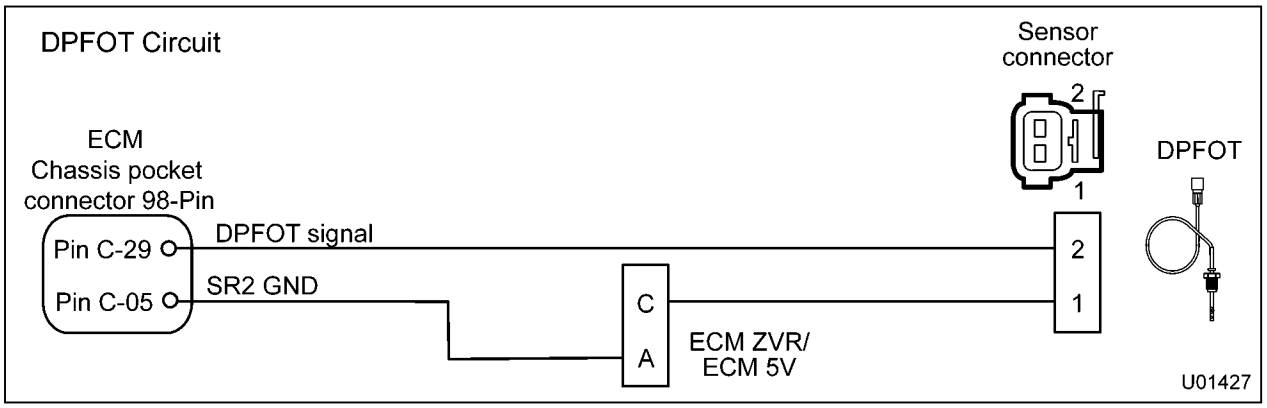


Figure 135 DPFOT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3246 FMI 21 the only fault code active?	Yes: Go to step 3. No: Go to step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3246 FMI 21. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at DPFOT sensor. Key OFF, disconnect DPFOT sensor connector. Check DPFOT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DPFOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3246 FMI 21.

Step	Action	Decision
4	Test DPFOT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 393). Are DPFOT circuits within specifications?	Yes: Go to step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 3246 FMI 21.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test. Does circuit operate properly?	Yes: Go to step 6.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 3246 FMI 21.

Step	Action	Decision
6	Test DPFOT sensor. Connect breakout harness 4760A between DPFOT sensor and DPFOT sensor connector. Perform KOEO voltage check of DPFOT sensor between DPFOT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 3246 FMI 21 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace DPFOT sensor. After repairs are complete, retest for SPN 3246 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 3246 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

ECL (Engine Coolant Level) Sensor

SPN	FMI	Condition
111	1	Low Engine Coolant Level
111	2	ECL signal erratic, intermittent or incorrect
111	3	ECL signal Out of Range HIGH
111	4	ECL signal Out of Range LOW

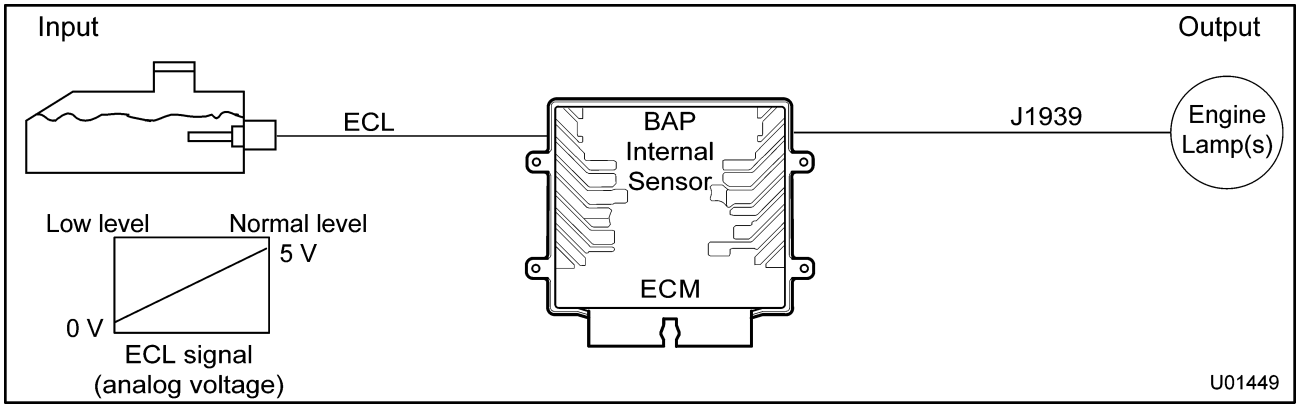


Figure 136 Function diagram for the ECL system

The ECL system function diagram includes the following:

- Engine Coolant Level (ECL) sensor
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Engine Lamp(s)

Function

The ECM monitors Engine Coolant Level (ECL). The ECM will alert the operator when the ECL value is greater or equal to the closed switch value or less than or equal to the open switch value for a certain amount of time. The ECM can be programmed to shut the engine off when coolant is low.

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

Location

The ECL sensor is installed in the plastic or metal deaeration tank.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)

- 00–00956–08 – 180-Pin Breakout Box

ECL Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
111	1	Low Engine Coolant Level	• Cooling system leak
111	2	ECL signal erratic, intermittent or incorrect	• ECL circuit OPEN or short to GND or PWR • Failed sensor
111	3	ECL signal Out of Range HIGH	• ECL signal circuit OPEN or short to PWR • SR2 GND circuit OPEN • Failed sensor
111	4	ECL signal Out of Range LOW	• ECL signal circuit short to GND • Failed sensor

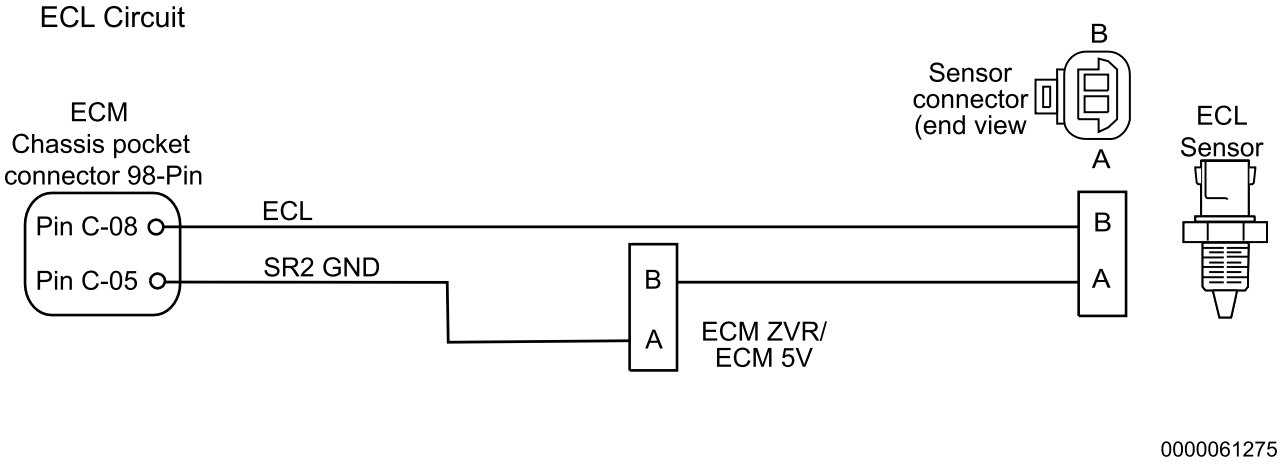


Figure 137 ECL circuit diagram

Connector Voltage Check

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

Test Point	Spec	Comment
A to B+	B+	If < B+, check for short to power, or open circuit.
B to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 407).

Connector Resistance Check to GND

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

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

Sensor Resistance Check

Disconnect ECL connector and measure across sensor.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
A to C-05	< 5 Ω	If > 5 Ω, check for OPEN circuit.
B to C-08	< 5 Ω	If > 5 Ω, check for OPEN circuit.

ECL Circuit Operation

The ECL sensor uses a floating ball with a magnetic switch. When the coolant level is full, the float will rise and the magnet pulls the level switch open. This allows a 5–volt signal at ECM Pin C-08. When the level is low, the sensor closes and ECM Pin C-08 is 0 volts.

Fault Detection / Management

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

ECM (Engine Control Module) PWR Relay

SPN	FMI	Condition
158	15	ECM Switched voltage too HIGH
158	17	ECM Switched voltage too LOW

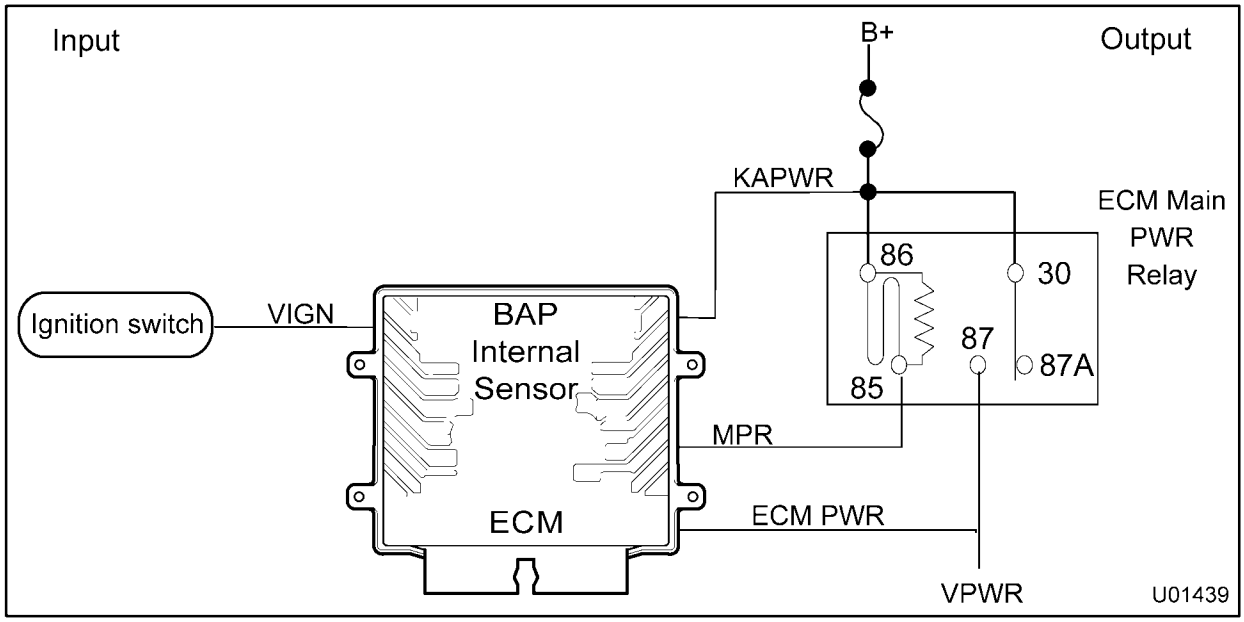


Figure 138 Function diagram for the ECM PWR

The ECM PWR function diagram includes the following:

- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- ECM Main Power Relay (MPR)
- Ignition switch or power relay
- Battery
- Fuses

Function

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

ECM Location

The ECM is installed on the right side of engine compartment on the air cleaner bracket.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 00-00956-08 – 180-Pin Breakout Box
- Breakout Harness ZTSE4674 (ECM Relay)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

ECM PWR Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
158	15	ECM Switched voltage too HIGH	• Jump starting using more than system voltage • Batteries wired incorrectly • Charging system fault
158	17	ECM Switched voltage too LOW	• Low discharged batteries • Inoperative alternator / charging system fault • High resistance in ECM powering circuits (ECM PWR, ECM GND, or VIGN)

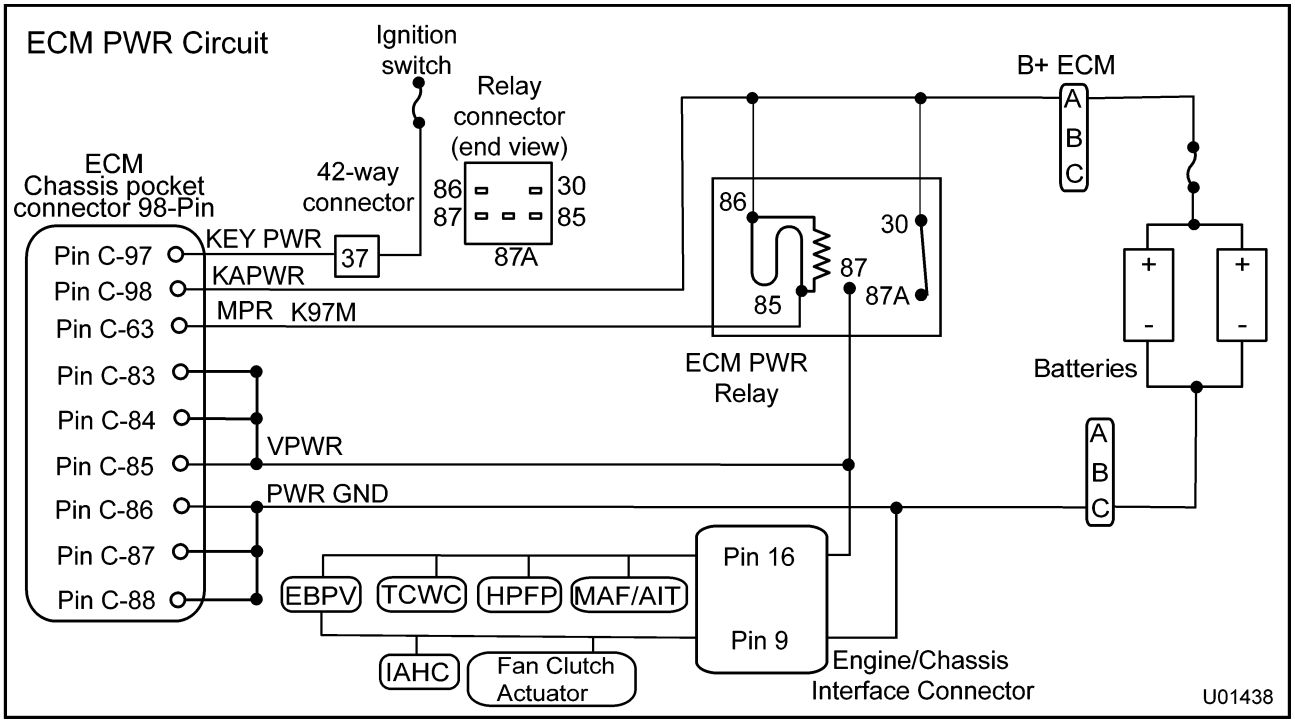


Figure 139 ECM PWR circuit diagram

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

Voltage Check at Relay

Connect Breakout Harness ZTSE4674 between relay and relay socket. Turn the ignition switch to ON. Use DMM to measure voltage.

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

Test Point	Spec	Comment
86 to GND	B+	If 0 V, check power circuit to relay coil for OPEN or short to GND, or blown fuse. If < B+, check for failed circuitry between batteries and relay. Do Harness Resistance Check (page 412).
30 to GND	B+	If 0 V, check power circuit to relay switch for OPEN or short to GND, or blown fuse. If < B+, check for failed circuitry between batteries and relay. Do Harness Resistance Check (page 412).
85 to GND	0 V to 2 V	If > 2 V, check MPR control circuit for OPEN or short to PWR. Do Harness Resistance Check (page 412).
87 to GND	B+	If < B+ but > 0 V, replace relay.
		If B+, check ECM PWR and ECM GND circuits at the ECM. Do Voltage Check at ECM.

Voltage Check at ECM

Connect 180-Pin Breakout Box between ECM and chassis harness. Turn the ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
C-97 to B+	B+	If < B+, check VIGN circuit for OPEN or short to GND, or blown fuse.
C-86 to B+	B+	If < B+, check for short to power or open circuit. Do Harness Resistance Check (page 412).
C-87 to B+	B+	
C-88 to B+	B+	
C-63 to GND	0 V to 2 V	If > 2 V, check MPR control circuit for OPEN or short to PWR. Do Harness Resistance Check (page 412).
C-83 to GND	B+	If < B+, check for OPEN circuit, failed relay, or blown fuse. Do Harness Resistance Check (page 412).
C-84 to GND	B+	
C-85 to GND	B+	
C-63 to GND	0 V to 2 V	If > 2 V, check MPR control circuit for OPEN or short to PWR. Do Harness Resistance Check (page 412).
C-98 to GND	B+	If < B+, check for OPEN circuit.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4674. Leave ECM, ECM and PWR relay, disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
C-63 to 85	< 5 Ω	If > 5 Ω, check MPR control circuit for OPEN.
C-63 to GND	> 1 kΩ	If < 1 kΩ, check MPR control circuit for short to GND.
C-83 to 87	< 5 Ω	If > 5 Ω, check ECM PWR circuit for OPEN.
C-83 to GND	> 1 kΩ	If < 1 kΩ, check ECM PWR circuit for short to GND.
C-84 to 87	< 5 Ω	If > 5 Ω, check ECM PWR circuit for OPEN.
C-84 to GND	> 1 kΩ	If < 1 kΩ, check ECM PWR circuit for short to GND.
C-85 to 87	< 5 Ω	If > 5 Ω, check ECM PWR circuit for OPEN.
C-85 to GND	> 1 kΩ	If < 1 kΩ, check ECM PWR circuit for short to GND.
C-86 to GND	< 5 Ω	If > 5 Ω, check ECM GND circuit for OPEN.
C-87 to GND	< 5 Ω	If > 5 Ω, check ECM GND circuit for OPEN.
C-88 to GND	< 5 Ω	If > 5 Ω, check ECM GND circuit for OPEN.
C-98 to 86	< 5 Ω	If > 5 Ω, check ECM KAPWR circuit for OPEN.

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

Harness Resistance Check on Relay Power Circuits

Turn ignition switch to OFF. Disconnect both battery GND cables and the inline connector on battery and cable. Use DMM to measure resistance.

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

ECM PWR Circuit Operation

The ECM receives VIGN power at Pin C-97. This signals the ECM to provide a ground path from Pin C-63 to C-85 to switch the ECM MPR. Switching the relay provides power from the battery positive terminal, through a fuse and relay contacts 30 and 87, to Pins C-83, C-84, and C-85.

The ECM is grounded to the battery negative terminal at ECM Pin C-86, C-87, and C-88.

Fault Detection / Management

The ECM internally monitors battery voltage. When the ECM continuously receives less than 10.79 volts or more than 15.13 volts, a DTC is set.

ECM (Engine Control Module) Self-Diagnostics

SPN	FMI	Condition	Possible Causes	Actions
108	3	BARO signal out of range HIGH	• Failed ECM	Pin-Point Diagnostics (page 417)
108	4	BARO signal out of range LOW	• Failed ECM	Pin-Point Diagnostics (page 417)
628	12	ECM memory failure	• Failed ECM	Pin-Point Diagnostics (page 417)
628	14	ECM Programming- EFRC Error	• Failed ECM	Pin-Point Diagnostics (page 417)
629	2	ECM Error - Level 2 monitoring	• Failed ECM	Pin-Point Diagnostics (page 417)
629	9	Engine Off Timer Error	• Failed ECM	Step-Based Diagnostics (page 419)
629	10	ECM Error - performance bank B	• Failed ECM	Pin-Point Diagnostics (page 418)
629	12	ECM Error - SPI	• Failed ECM	Pin-Point Diagnostics (page 418)
629	31	ECM Error - Level 3 monitoring	• Failed ECM	Pin-Point Diagnostics (page 418)
1136	0	ECM Error - over temperature	• Failed ECM	Pin-Point Diagnostics (page 418)
1136	1	ECM Error - under temperature	• Failed ECM	Pin-Point Diagnostics (page 418)

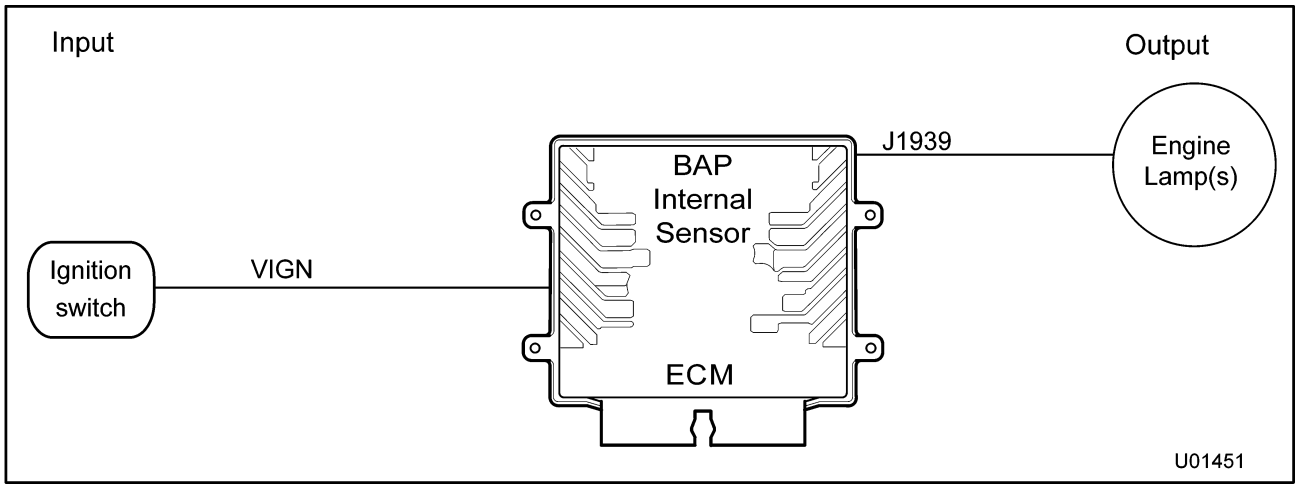


Figure 140 Function diagram for the ECM

The ECM does the following:

- Monitors and controls engine operation and performance

- Enables Power Takeoff (PTO) and Cruise Control (CCS)
- Communicates engine and vehicle information to the instrument cluster
- Enables electronically controlled transmission (if equipped)
- Enables diagnostic programming tools

Fault Detection / Management

The ECM automatically performs diagnostic self-checks. The ECM self-test includes memory, programming, and internal power supply checks. The ECM sets 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 SPN 108 / FMI3 /4, SPN 628 / FMI 14, SPN 629 / FMI 2, SPN 629 / FMI 9, or SPN 629 / FMI 31 are set by the ECM, the Malfunction Indicator Lamp (MIL) is illuminated. When SPN 1136 / FMI 0 and SPN 629 / FMI 12 are set by the ECM, the Amber Warning Lamp (AWL) is illuminated.

Pinpoint Diagnostics With ServiceMaxx™ Software

SPN 108 / FMI 3- BARO signal Out of Range HIGH

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

Pin-point ECM Self-Diagnostic Fault

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

SPN 108 / FMI 4 - BARO signal Out of Range LOW

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

Pin-point ECM Self-Diagnostic Fault

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

SPN 628 / FMI 12 - ECM Memory Error

Pin-point ECM Self-Diagnostic Fault

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

SPN 628 / FMI 14 - ECM Programming - EFRC Error

Pin-point ECM Self-Diagnostic Fault

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

SPN 629 / FMI 2 - ECM Error - Level 2 Monitoring

Pin-point ECM Self-Diagnostic Fault

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

SPN 629 / FMI 10 - ECM Error - Fuel Injector Circuit Performance Bank B

Pin-point ECM Self-Diagnostic Fault

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

SPN 629 / FMI 12 - ECM Error - SPI

Pin-point ECM Self-Diagnostic Fault

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

SPN 629 / FMI 31 - ECM Error - Level 3 Monitoring

Pin-point ECM Self-Diagnostic Fault

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

SPN 1136 / FMI 0 - ECM Error - Over temperature

Checks whether the internal temperature is above the maximum threshold.

Pin-point ECM Self-Diagnostic Fault

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

SPN 1136 / FMI 1 - ECM Error - Under temperature

Checks whether the internal temperature is below the minimum threshold.

Pin-point ECM Self-Diagnostic Fault

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

SPN 629 FMI 9 - Engine Off Timer Error

<table>
<tr><th>Condition / Description</th><th>Setting Criteria</th><th>Enable Conditions / Values</th><th>Time Required</th></tr>
<tr><td rowspan="3">Comparison of Engine OFF timer count to Engine Control Module (ECM) timer count in 10 seconds interval</td><td>Absolute difference of Engine OFF timer count and ECM timer count in 10 seconds interval > 0 seconds</td><td>Key ON</td><td rowspan="3">N / A</td></tr>
<tr><td rowspan="2">Engine OFF timer value lower than ECM power latch time at previous ECM power cycle</td><td>Engine Running (Refer to Operations summary document)</td></tr>
<tr><td>Engine OFF timer value < 18.2 hours</td></tr>
</table>

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the ECM off timer count is abnormal when compared to ECM power latch time.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 629 FMI 9 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 629 FMI 9. No: Go to Step 3.

Step	Action	Decision
3	Clear fault codes and retest for SPN 629 FMI 9. Is fault code SPN 629 FMI 9 still present?	Yes: Replace ECM. After repairs are complete, retest for SPN 629 FMI 9. No: Return vehicle to service.

NOTE: After doing all diagnostic steps, if SPN 629 FMI 9 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

ECT1 (Engine Coolant Temperature 1) Sensor

SPN	FMI	Condition	Possible Causes	Actions
110	2	ECT1 signal erratic, intermittent, or incorrect	• ECT1 biased sensor or circuit	Step-Based Diagnostics (page 426)
110	3	ECT1 signal Out of Range HIGH	• ECT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor	Pin-Point Diagnostics (page 424)
110	4	ECT1 signal Out of Range LOW	• ECT signal circuit short to GND • Failed sensor	Pin-Point Diagnostics (page 424)
110	10	ECT1 signal abnormal rate of change	• ECT1 biased sensor or circuit	Pin-Point Diagnostics (page 424)
110	16	Engine Coolant System above OBD maximum temperature	• Low coolant • Restricted airflow across radiator • Failed cooling fan • Failed thermostat • Failed water pump	Step-Based Diagnostics (page 429)
110	17	Engine Coolant System below OBD monitoring temperature	• Thermostat stuck open • Cooling fan stuck ON	Step-Based Diagnostics (page 432)
110	18	Engine Coolant System below closed loop minimum temperature	• Thermostat stuck open • Engine fan stuck ON	Step-Based Diagnostics (page 436)
1659	20	ECT1 below expected: Check thermostat	• Stuck or sticking thermostat • Engine fan stuck ON • Failed ECT1 sensor	Step-Based Diagnostics (page 440)

ECT Circuit

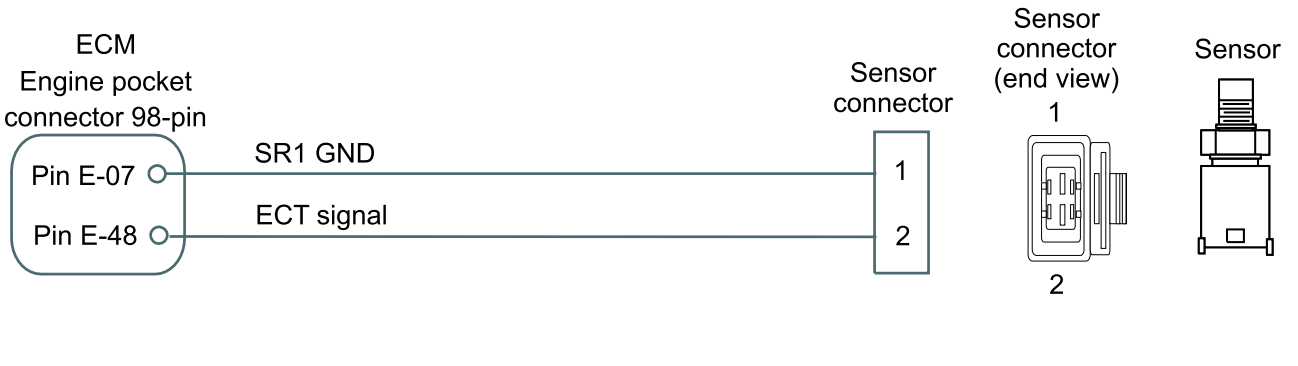
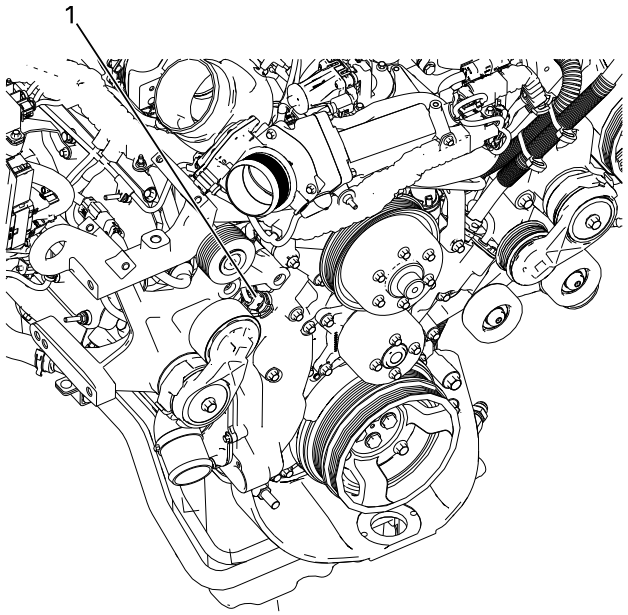


Figure 141 ECT1 Circuit Diagram

Overview

The Engine Coolant Temperature 1 (ECT1) sensor is a thermistor sensor that measures engine coolant temperature. The Engine Control Module (ECM) monitors this signal for Exhaust Gas Recirculation (EGR) system control and CAC performance. The ECT1 signal value is also compared to several other temperature sensor values to determine if sensor is operating properly.



0000061279

Figure 142 ECT1 Sensor Location

1. ECT1 Sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 00–00956–08 – 180-Pin Breakout Box
- Breakout Harness ZTSE4602 (ECT)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

ECT Circuit

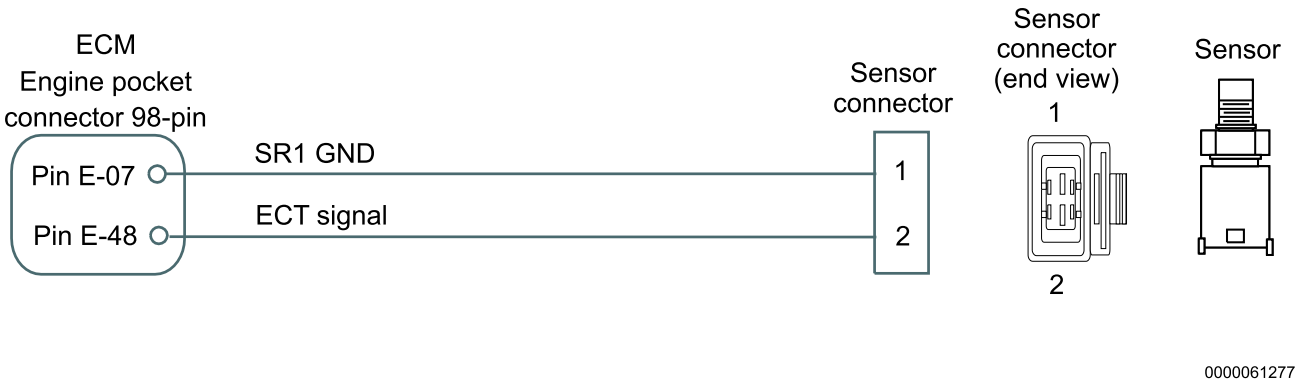


Figure 143 ECT1 Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

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

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, open the Continuous Monitor session.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If code is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the DTC will go active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor.

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

4. Connect Breakout Harness ZTSE4602 to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect Breakout Harness ZTSE4602. Leave sensor disconnected. Turn ignition switch to ON. Use Electronic Service Tool (EST) with ServiceMaxx™ software to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	SPN 110 FMI 3	If SPN 110 / FMI 4 is active, check ECT signal for short to GND. Do Harness Resistance Check (page 425).
EST - Check DTC Short 3-banana plug harness across 2 and GND	SPN 110 FMI 4	If SPN 110 / FMI 3 is active, check ECT signal for OPEN. Do Harness Resistance Check (page 425).
EST - Check DTC Short 3-banana plug harness across 1 and 2	SPN 110 FMI 4	If SPN 110 / FMI 3 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 425).
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.		

Connector Voltage Check

Connect Breakout Harness ZTSE4602. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to B+	B+	If < B+ check for short to PWR or OPEN circuit. Do Harness Resistance Check (page 425).
2 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 425).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4602. Leave sensor disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4602. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-07	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to E-48	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 110 FMI 2 - ECT1 signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of Engine Coolant Temperature 1 (ECT1) sensor output with other sensors after a calibratable cold soak period.	[Absolute value of {Engine Coolant Temperature (ECT) sensor output minus Engine Oil Temperature (EOT) sensor output} > 36°F (20°C) and absolute value of {ECT sensor output minus Engine Fuel Temperature (EFT) sensor output }] > 36°F (20°C)	Engine OFF soak time > 8 hours	2 seconds
		Time in Key ON engine OFF state < 60 seconds	
		Engine not in running state not { Air Inlet Temperature (AIT) < 77°F (25°C)	
		and (MAX [Engine Oil Temperature (EOT), EFT] minus AIT)} > 9°F (5°C)	
		Absolute [ECT minus EOT] > 27°F (15°C) or absolute [EOT minus EFT] < 27°F (15°C) or absolute [EFT minus ECT] < 27°F (15°C)	
		Monitor on hold until SPN/FMI 173/2 has been completed	
		The following SPN / FMIs are not active: 110/3,110/4,174/3,174/4,175/3 and 175/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the ECT1 signal value is incorrect when compared to other sensor values.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

ECT Circuit

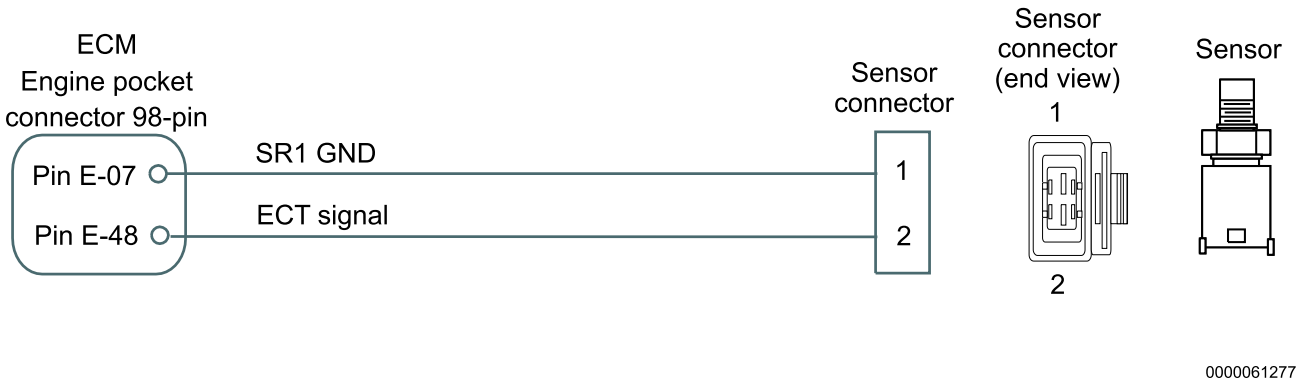


Figure 144 ECT1 Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 110 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 110 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Engine Coolant Temperature 1 (ECT1) sensor. With key OFF, disconnect ECT1 sensor connector. Check ECT1 sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are ECT1 sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 110 FMI 2.

Step	Action	Decision
4	Test ECT1 circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 425). Are ECT1 circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 110 FMI 2.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test(page 71). Does circuit operate properly?	Yes: Go to Step 6.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 110 FMI 2.

Step	Action	Decision
6	Test ECT1 sensor. Connect breakout harness 4602 between ECT1 sensor and ECT1 sensor connector. Perform KOEO voltage check of ECT1 sensor between ECT1 signal and ground(page 71). Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 110 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace ECT1 sensor. After repairs are complete, retest for SPN 110 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 110 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 110 FMI 16 - Engine Coolant System above OBD maximum temperature

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Coolant Temperature (ECT) stuck in range high monitor	{ECT >/= 225°F (107°C) AND time spent in 2400-2800 rpm and 88-90 mg/stk fueling < 6 minutes and 40 seconds	Air Inlet Temperature (AIT) >/= -40°F (-40°C)	30 seconds
		Engine OFF soak time >/= 2 hours or time spent in 2400-2800 rpm and 88-90 mg/stk fueling </= 6 minutes and 40 seconds	
		Engine run mode active timer > 2 minutes	
		Exhaust Brake Position Control </= 0%	
		Battery voltage > 7 volts and < 18 volts	
		1. Mass of fuel >/= 13 mg/stk and 2. Engine speed >/= 850 rpm. Condition 1 and 2 listed above true for at least 3 minutes.	
		Inlet Air Heater (IAH) OFF	
		Cold ambient protection mode not active	
		PTO Mode NOT active	
		Not in active regeneration mode	
		Percentage time spent below 850 rpm within a drive cycle < 35% or cumulative time spent below 850 rpm within a drive cycle < 14 minutes and 10 seconds	
		The following SPN FMIs are NOT active: 191/3, 191/4,175/3, 175/4, 4765/3, 4765/4, 172/3, 172/4, 132/3, 132/4, 173/3, 173/4, 2630/3, 2630/4, 110/3, 110/4, 729/2, 636/2, 636/7, 636/8, 637/8, 637/10, 158/15, and 158/17.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the ECT1 signal value is above the maximum On-Board Diagnostics (OBD) temperature threshold.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

ECT Circuit

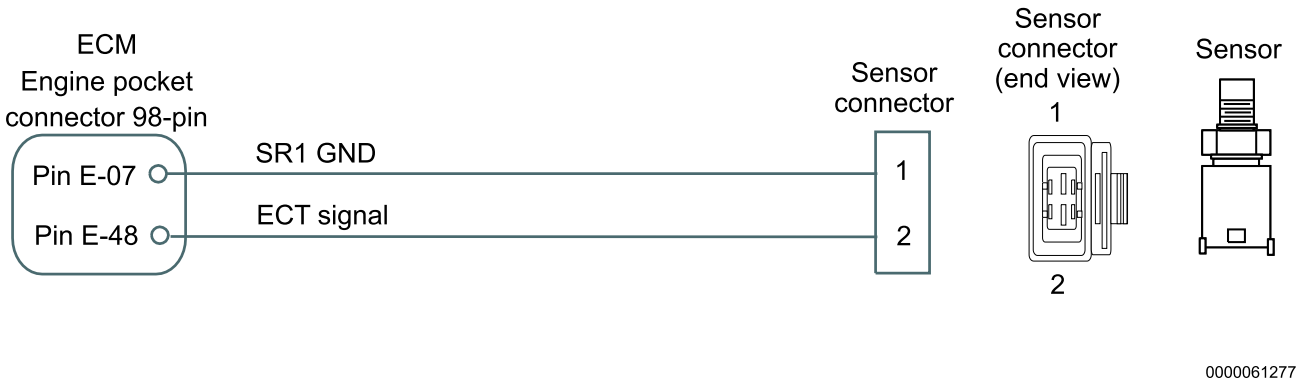


Figure 145 ECT1 Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 110 FMI 16 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 110 FMI 16.
		No: Go to Step 3.

Step	Action	Decision
3	Inspect cooling system. Refer to Coolant Over-temperature (page 89). Is cooling system operating correctly?	Yes: After doing all diagnostic steps, if SPN 110 FMI 16 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Repair cooling system as required. After repairs are complete, retest for SPN 110 FMI 16.

NOTE: After doing all diagnostic steps, if SPN 110 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 110 FMI 17- Engine Coolant System below OBD monitoring temperature

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Coolant Temperature 1 (ECT1) stuck in range low monitor	Engine Coolant temperature < 104°F (40°C)	Air Inlet Temperature (AIT) >/= -40°F (-40°C)	30 seconds
		ECT1 at startup </= 104°F (40°C)	
		Modeled ECT1 > 104°F (40°C)	
		Engine run mode active timer > 2 minutes	
		Exhaust Brake Position Control </= 0%	
		1. Mass of Fuel >=13 mg / stk and 2. Engine Speed} >= 850 rpm Condition 1 and 2 listed Above True for at least 3 minutes	
		Battery voltage > 7 volts and < 18 volts	
		Percentage time spent below 850 rpm within a drive cycle < 35 % or cumulative time spent below 850 rpm within a drive cycle < 14 minutes and 10 seconds	
		NOT in active regeneration mode	
		Cold ambient protection mode not active	
		Power Take-Off (PTO) mode NOT active	
		Percentage time spent below 850 rpm within a drive cycle < 35% or cumulative time spent below 850 rpm within a drive cycle < 14 minutes and 10 seconds	
		The following SPN FMIs are NOT active: 191/3, 191/4,175/3, 175/4, 4765/3, 4765/4, 172/3, 172/4, 132/3, 132/4, 173/3, 173/4, 2630/3, 2630/4, 110/3, 110/4, 1659/18, 729/2, 636/2, 636/7, 636/8, 637/8, 637/10, 158/15, and 158/17.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the ECT1 signal is below the minimum OBD temperature threshold.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Fault Fact

Properly operating cabin heaters can cause this fault to set.

Associated Faults

637 / 3, 637 / 4, 637 / 5

Drive Cycle to Determine Fault Status

N / A

ECT Circuit

Figure 146 ECT1 Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 110 FMI 17 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 110 FMI 17. No: Go to Step 3.

Step	Action	Decision
3	Determine if engine cooling fan is stuck ON (fan ON when engine is cold). Inspect fan assembly for binding or other issues that would cause the fan to remain engaged. Is engine fan operating correctly (not fully engaged - just freewheeling) when engine is cold?	Yes: Go to Step 4. No: Replace fan assembly. After repairs are complete, retest for SPN 110 FMI 17.

Step	Action	Decision
4	Determine if thermostat is stuck open. Remove and inspect thermostats following the procedure found in the *Engine Service Manual*. Do thermostats operate correctly?	Yes: After doing all diagnostic steps, if SPN 110 FMI 17 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace thermostats as needed. After repairs are complete, retest for SPN 110 FMI 17.

NOTE: After doing all diagnostic steps, if SPN 110 FMI 17 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 110 FMI 18 - Engine Coolant System below closed loop minimum temperature

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Minimum closed loop coolant temp not reached	Engine Coolant Temperature 1 (ECT1) < 68°F (20°C)	Air Inlet Temperature (AIT) >/= -40°F (40°C)	30 Seconds
		ECT1 at startup </= 68°F (20°C)	
		Modeled ECT1 > 68°F (20°C)	
		Engine run mode active timer > 2 minutes	
		Exhaust Brake Position Control </= 0%	
		Battery voltage > 7 volts and < 18 volts	
		1. Mass of Fuel >/= 13 mg/stk and 2. Engine Speed >/= 850 rpm. Condition 1 and 2 listed above true for at least 3 minutes	
		NOT in active regeneration mode	
		Cold Ambient protection Mode not active	
		PTO Mode NOT active	
		Percentage time spent below 850 rpm within a drive cycle < 35% or cumulative time spent below 850 rpm within a drive cycle < 14 minutes and 10 seconds	
		The following SPN FMIs are NOT active: 191/3, 191/4,175/3, 175/4, 4765/3, 4765/4, 172/3, 172/4, 132/3, 132/4, 173/3, 173/4, 2630/3, 2630/4, 110/3, 110/4, 729/2, 636/2, 636/7, 636/8, 637/8, 637/10, 158/15, and 158/17.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the ECT1 signal value is below the minimum temperature allowed for closed-loop operation.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Fault Fact

Properly operating cabin heaters can cause this fault to set.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

ECT Circuit

Figure 147 ECT1 Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 110 FMI 18 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 110 FMI 18. No: Go to Step 3.

Step	Action	Decision
3	Determine if engine cooling fan is stuck ON (fan ON when engine is cold). Inspect fan assembly for binding or other issues that would cause the fan to remain engaged. Is engine fan operating correctly (not fully engaged - just freewheeling) when engine is cold?	Yes: Go to Step 4. No: Replace fan assembly. After repairs are complete, retest for SPN 110 FMI 18.

Step	Action	Decision
4	Determine if thermostat is stuck open. Remove and inspect thermostats following the procedure found in the *Engine Service Manual*. Do thermostats operate correctly?	Yes: After doing all diagnostic steps, if SPN 110 FMI 18 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace thermostats as needed. After repairs are complete, retest for SPN 110 FMI 18.

NOTE: After doing all diagnostic steps, if SPN 110 FMI 18 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1659 FMI 20 - ECT1 below expected: Check thermostat

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Thermostat Monitor	Engine Coolant Temperature 1 (ECT1) < 171°F (77°C)	Modeled ECT > 190°F (88°C)	30 Seconds
		Air Inlet Temperature (AIT) > 19°F (-7°C)	
		Engine Speed >/= 0 rpm	
		ECT1 at engine startup >/= 48°F (9°C) and </= 136°F (58°C)	
		Ambient Pressure > 10.7 psi (73.6 kPa)	
		Engine Run Mode Active Timer > 2 minutes	
		Exhaust Brake Position Control </= 0 %	
		Time spent below 850 rpm within a drive cycle < 35% or cumulative time spent below 850 rpm within a drive cycle < 14 minutes and 10 seconds	
		NOT in active regeneration mode	
		PTO mode NOT active	
		Battery voltage > 7 volts AND < 18 volts	
		1. Mass of Fuel >=13 mg/stk and 2. Engine Speed <=850 rpm. Condition 1 and 2 listed above true for at least 3 minutes.	
		Inlet Air Heater (IAH) OFF	
		The following SPN/FMIs are not active: 191/3, 191/4, 175/3, 175/4, 4765/3, 4765/4, 172/3, 172/4, 132/3, 132/4, 173/3, 173/4, 2630/3, 2630/4, 110/3, 110/4, 729/2, 636/2, 636/7, 636/8, 637/8, 637/10, 158/15, and 158/17.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the ECT1 signal value is below the expected value when compared to other sensors.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Fault Fact

Properly operating cabin heaters can cause this fault to set.

Associated Faults

SPN 647 FMI 3, SPN 647 FMI 4, and SPN 647 FMI 5

Drive Cycle to Determine Fault Status

N / A

ECT Circuit

Figure 148 ECT1 Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 1659 FMI 20 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 1659 FMI 20. No: Go to Step 3.

Step	Action	Decision
3	Determine if engine cooling fan is stuck ON (fan ON when engine is cold). Inspect fan assembly for binding or other issues that would cause the fan to remain engaged. Is engine fan operating correctly (not fully engaged - just freewheeling) when engine is cold?	Yes: Go to Step 4. No: Replace fan assembly. After repairs are complete, retest for SPN 1659 FMI 20.

Step	Action	Decision
4	Determine if thermostat is stuck open. Remove and inspect thermostats following the procedure found in the *Engine Service Manual*. Do thermostats operate correctly?	Yes: After doing all diagnostic steps, if SPN 1659 FMI 20 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace thermostats as needed. After repairs are complete, retest for SPN 1659 FMI 20.

NOTE: After doing all diagnostic steps, if SPN 1659 FMI 20 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

EFC (Engine Fan Control)

SPN	FMI	Condition
647	3	EFC short to PWR
647	4	EFC short to GND
647	5	EFC open load / circuit

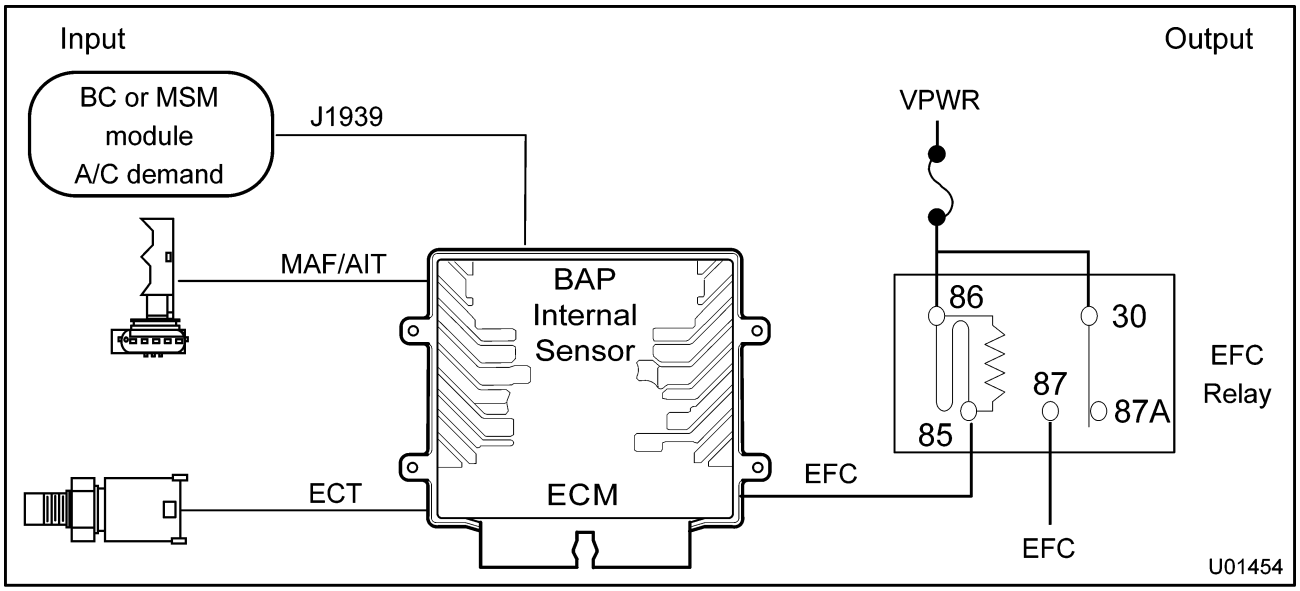


Figure 149 Function diagram for EFC

The EFC function diagram includes the following:

- Engine Fan Control (EFC)
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Body Controller (BC)
- Multiplex System Module (MSM)
- Engine Coolant Temperature 1 (ECT1) sensor
- Air Inlet Temperature (AIT) signal from the Mass Air Flow (MAF) sensor
- Engine Fan (EFC) relay

Function

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

Location

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

Tools

- Digital Multimeter (DMM)
- 00-00956-08 – 180-Pin Breakout Box
- Breakout Harness ZTSE4674 (EFC)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

EFC Circuit Diagnostics

SPN	FMI	Condition	Possible Causes
647	3	EFC short to PWR	• EFC relay control circuit shorted to PWR
647	4	EFC short to GND	• EFC relay control circuit shorted to GND
647	5	EFC open load / circuit	• EFC relay control circuit OPEN • EFC relay coil PWR circuit OPEN • Blown fuse • Failed relay coil

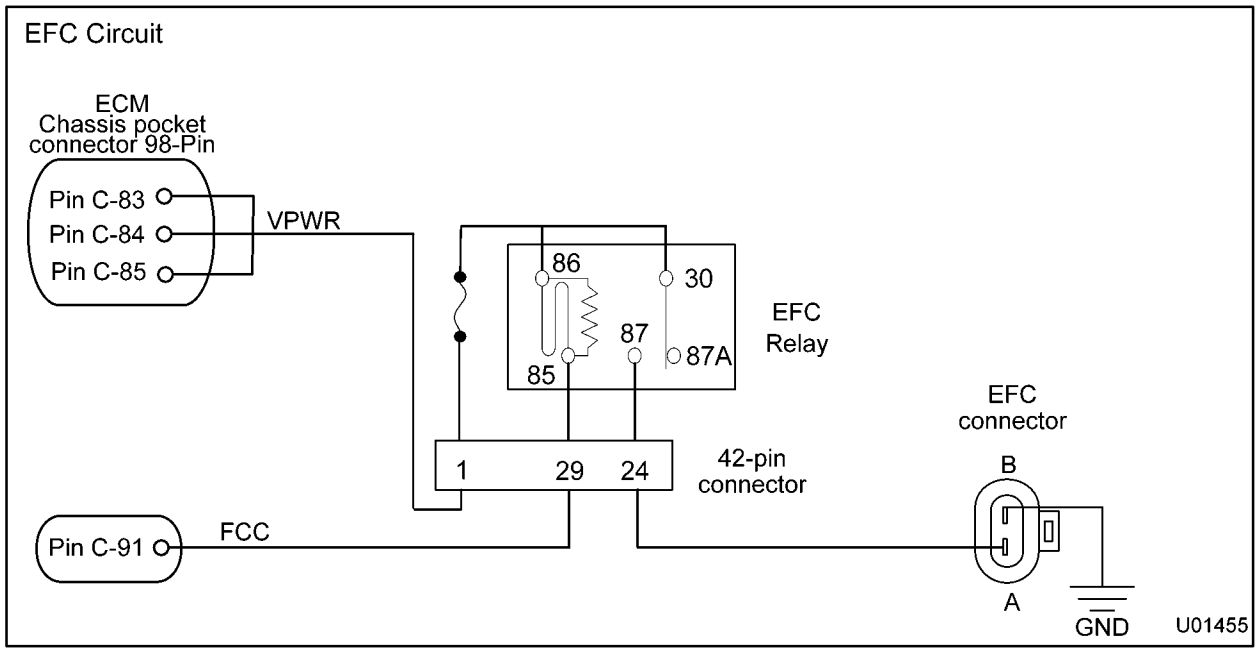


Figure 150 EFC circuit diagram

Voltage Check at EFC Connector Output State Test

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

Test Point	Spec	Comment
A to B+	B+	If < B+, check for short to power or open circuit. Do Harness Resistance Check (page 447).
B to B+	B+	If < B+, check for short to power or open circuit. Do Harness Resistance Check (page 447).
Run Output State Test HIGH.		
A to B+	B+	If < B+, check for short to power or open circuit. Do Harness Resistance Check (page 447).
Run Output State Test LOW.		
A to GND	B+	If < B+, check for OPEN circuit between relay and EFC, or EFC circuit for OPEN, or blown fuse, or failed relay. Do Harness Resistance Check (page 447).
A to B	B+	If < B+, check GND circuit for OPEN. Do Harness Resistance Check (page 447).

Voltage Check at Relay - Output State Test

Connect Breakout Harness ZTSE4674 between relay and relay socket. Connect EFC and turn the ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
30 to GND	B+	If < B+, check power circuit to relay switch for OPEN or short to GND, or blown fuse.
86 to GND	B+	If < B+, check power circuit to relay coil for OPEN or short to GND, or blown fuse.
Run Output State Test HIGH.		
85 to GND	B+	If < B+, check EFC circuit for short to GND. Do Harness Resistance Check (page 447).
Run Output State Test LOW.		
85 to GND	0.06 V to 2 V	If > 2 V, check EFC circuit for OPEN. Do Harness Resistance Check (page 447).
87 to GND	B+	If < B+, replace relay.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and relay harness. Leave ECM and relay disconnected.

Test Point	Spec	Comment
C-91 to 85	< 5 Ω	If > 5 Ω, check for OPEN circuit between ECM and relay terminal.
87 to A (fan)	< 5 Ω	If > 5 Ω, check for OPEN circuit between relay terminal and A (fan).
30 to C-1, 3 and 5	< 5 Ω	If > 5 Ω, check VPWR for OPEN in circuit.
30 to GND	> 1 kΩ	If < 1 kΩ, check VPWR for short to GND.
86 to C-1, 3 and 5	< 5 Ω	If > 5 Ω, check VPWR for OPEN in circuit.
86 to GND	> 1 kΩ	If < 1 kΩ, check VPWR for short to GND.
See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for fuse information.		

EFC Circuit Operation

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

ECM Pin C-91 controls the EFC to shut off by supplying a ground path to the EFC relay coil Pin 85. VPWR powers the other side of the relay coil, Pin 86. VPWR is sent through the relay switch, which deactivates the EFC.

EFC Programmable Parameters

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

- Engine fan control - indicates to the onboard electronics whether the vehicle has the electronic engine fan control feature.
- A/C fan activation - allows fan activation through the ECM when requested from the BC during A/C operation.
- Disable - enables or disables the EFC feature.
- Fan on temperature - indicates at what coolant temperature the fan is electronically activated.
- Fan off temperature - indicates at what coolant temperature the fan is electronically deactivated.

Fault Detection / Management

An open or short to ground in the EFC can be detected by the ECM during an on-demand engine standard test. The AIT and ECT are continuously monitored. If a fault is detected in the AIT or ECT circuit, the EFC control is disabled and the engine fan remains on.

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

EFT (Engine Fuel Temperature) Sensor

SPN	FMI	Condition	Possible Causes	Actions
174	2	EFT signal erratic, intermittent, or incorrect	• Biased EFT sensor or circuit	Step-Based Diagnostics (page 452)
174	3	EFT signal Out of Range HIGH	• EFT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor	Pin-Point Diagnostics (page 450)
174	4	EFT signal Out of Range LOW	• EFT signal circuit short to GND • Failed sensor	Pin-Point Diagnostics (page 450)
174	10	EFT signal abnormal rate of change	• More than 10 °C (50 °F) change within 0.1 second • Low fuel level • Restricted fuel lines • EFT biased sensor or circuit fault • Failed sensor	Pin-Point Diagnostics (page 450)
174	21	EFT signal drifted LOW	• Biased EFT sensor or circuit	Step-Based Diagnostics (page 455)

EFT Circuit

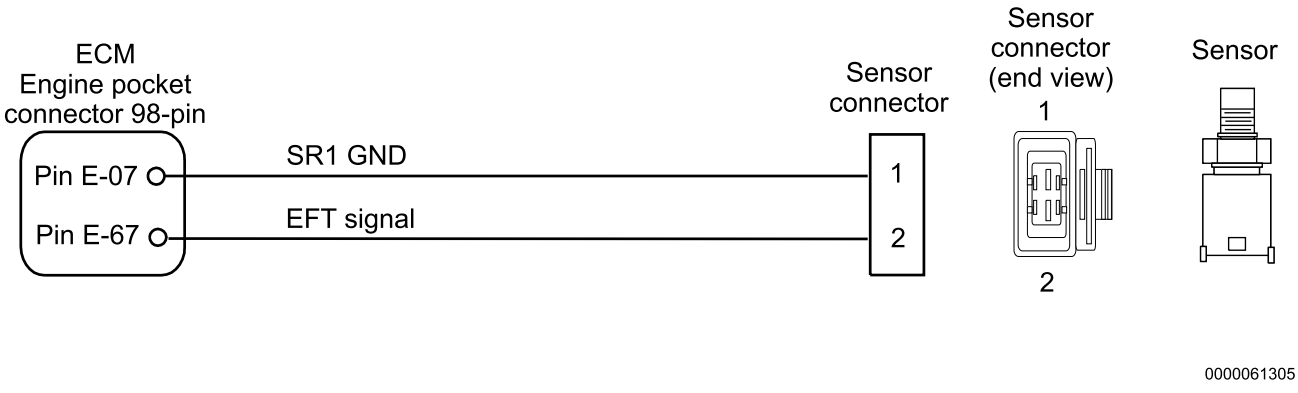


Figure 151 EFT Circuit Diagram

Overview

The EFT sensor is a thermistor type sensor that measures fuel temperature at the secondary fuel filter outlet. As fuel temperature increases, resistance in the sensor decreases, providing a variable voltage signal to the Engine Control Module (ECM).

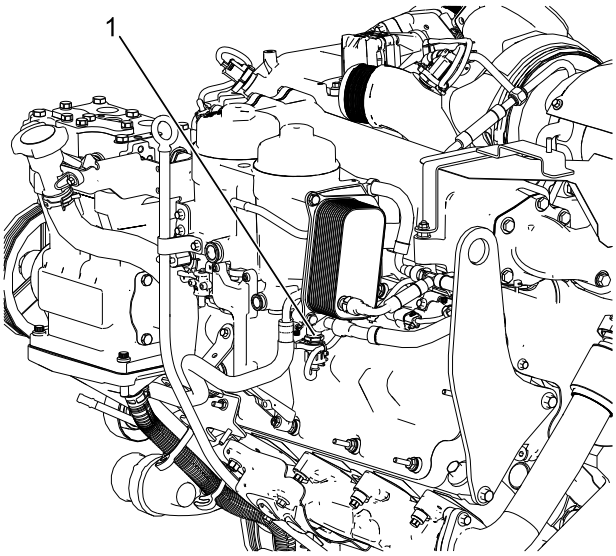


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Figure 152 EFT Sensor Location

1. EFT Sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 00-00956-08 180-Pin Breakout Box
- Breakout Harness ZTSE4602 (EFT)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

EFT Circuit

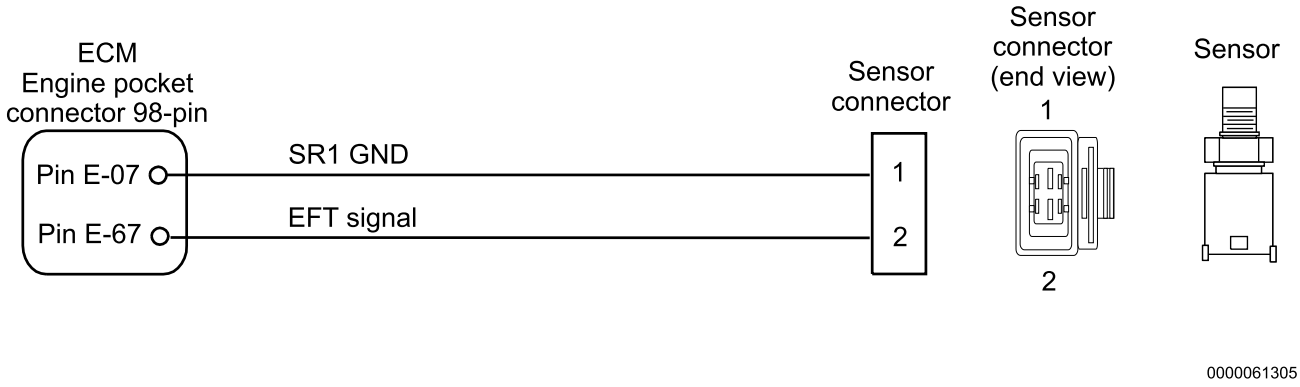

Figure 153 EFT Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

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

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, open the Continuous Monitor session.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If code is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the fault goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor.

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

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

Sensor Circuit Check

Connect Breakout Harness ZTSE4602. Leave sensor disconnected. Turn ignition switch to ON. Use Electronic Service Tool (EST) with ServiceMaxx™ software to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	SPN 174 FMI 3	If SPN 174 / FMI 4 is active, check EFT signal for short to GND. Do Harness Resistance Check (page 451).
EST - Check DTC Short 3-banana plug harness across 2 and GND	SPN 174 FMI 4	If SPN 174 / FMI 3 is active, check EFT signal for OPEN. Do Harness Resistance Check (page 451).
EST - Check DTC Short 3-banana plug harness across 1 and 2	SPN 174 FMI 4	If SPN 174 / FMI 3 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 451).
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.		

EFT Pin-point Diagnostics

Connector Voltage Check

Connect Breakout Harness ZTSE4602. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to B+	B+	If < B+, check for short to power, or open circuit.
2 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 451).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4602. Leave sensor disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4602. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-07	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to E-67	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 174 FMI 2 - EFT Signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of sensor reading to other sensor readings after a calibrated cold soak period.	Engine Fuel Temperature (EFT) sensor output minus Engine Coolant Temperature (ECT) sensor output > 36°F (20°C)	Engine off soak time > 8 hours	2 seconds
	EFT sensor output minus Engine Oil Temperature (EOT) sensor output > 36°F (20°C)	Time in Key ON Engine OFF (KOEO) state < 60 seconds	
		Engine NOT in running state	
		NOT Air Inlet Temperature (AIT) < 77°F (25°C) AND {MAX [Engine Oil Temperature (EOT), Engine Fuel Temperature (EFT) MINUS AIT]} > 9°F (5°C) [Absolute [Engine Coolant Temperature (ECT) MINUS EOT] < 27°F (15°C) OR Absolute [EOT MINUS EFT] < 27°F (15°C) OR Absolute [EFT MINUS ECT]} < 27°F (15°C)	
		Monitor on Hold until SPN / FMI 173/2 has been completed.	
		The following SPN / FMIs are not active: 110/3, 110/4, 173/3, 173/4, 175/3, and 175/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the EFT signal value is erratic or incorrect when compared to other related sensor values.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

EFT Circuit

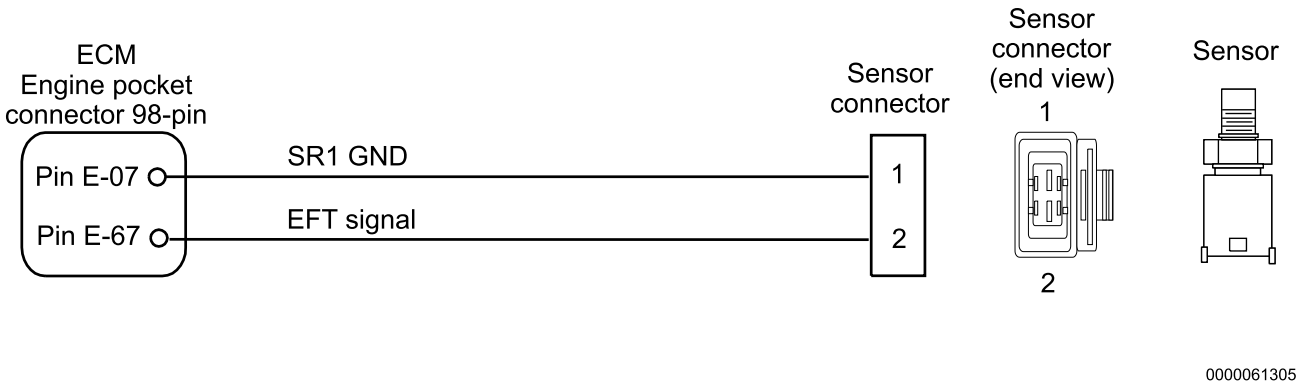

Figure 154 EFT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 174 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 174 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Engine Fuel Temperature sensor (EFT). With key OFF, disconnect EFT sensor connector. Check EFT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EFT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 174 FMI 2.

Step	Action	Decision
4	Test EFT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 451). Are EFT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 174 FMI 2.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test (page 71). Does circuit operate properly?	Yes: Go to Step 6. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 174 FMI 2.

Step	Action	Decision
6	Test EFT sensor. Connect breakout harness 4602 between EFT sensor and EFT sensor connector. Perform KOEO voltage check of EFT sensor between EFT signal and ground (page 71). Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 174 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace EFT sensor. After repairs are complete, retest for SPN 174 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 174 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 174 FMI 21 - EFT signal drifted LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Fuel Temperature (EFT) sensor stuck in range detection	EFT < -40°F (-40°C)	Engine speed > 1100 rpm	1 second
		Engine torque command > 300 N•m	
		Accumulated threshold for monitor enablement > 16 minutes and 40 seconds	
		The following SPN / FMIs are not active: 108/3, 108/4, 172/3, 172/4, 174/2, 174/3, and 174/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the EFT signal value is below the predetermined threshold.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

EFT Circuit

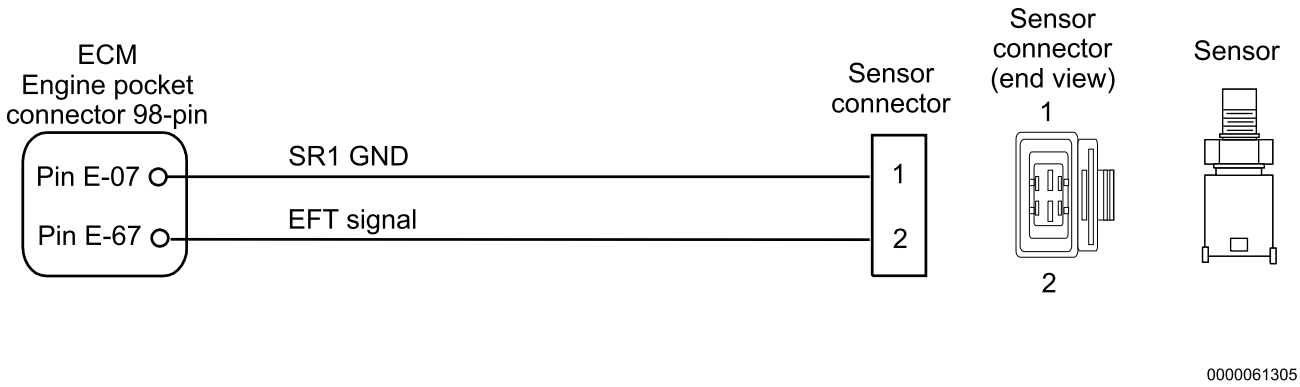

Figure 155 EFT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 174 FMI 21 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 174 FMI 21. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Engine Fuel Temperature sensor (EFT). With key OFF, disconnect EFT sensor connector. Check EFT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EFT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 174 FMI 21.

Step	Action	Decision
4	Test EFT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 451). Are EFT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 174 FMI 21.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test(page 71). Does circuit operate properly?	Yes: Go to Step 6.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 174 FMI 21.

Step	Action	Decision
6	Test EFT sensor. Connect breakout harness 4602 between EFT sensor and EFT sensor connector. Perform KOEO voltage check of EFT sensor between EFT signal and ground(page 71). Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 174 FMI 21 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace EFT sensor. After repairs are complete, retest for SPN 174 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 174 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

EGR (Exhaust Gas Recirculation) Valve

SPN	FMI	Condition	Possible Causes	Actions
27	3	EGRP signal Out of Range HIGH	• Failed H-Bridge circuit due to undervoltage, overcurrent, or overtemperature	Pin-Point Diagnostics (page 462)
27	4	EGRP signal Out of Range LOW	• EGRP signal circuit short to PWR • EGRP signal circuit OPEN or short to GND • VREF circuit OPEN or short to GND • Failed EGR assembly	Pin-Point Diagnostics (page 462)
27	7	EGRP Does Not Agree with Commanded Position	• EGRC circuit fault • Sticking or failed EGR valve	Step-Based Diagnostics (page 465)
27	10	EGRP signal abnormal rate of change	• EGRVCH control circuit fault • EGRVCL control circuit fault	Pin-Point Diagnostics (page 462)
2791	3	EGRC short to PWR	• Failed H-Bridge circuit due to undervoltage, overcurrent, or overtemperature.	Pin-Point Diagnostics (page 462)
2791	4	EGRC short to GND	• EGRP signal circuit OPEN or short to GND • Failed EGRP sensor • VREF circuit OPEN	Pin-Point Diagnostics (page 462)
2791	5	EGRC open load / circuit	• EGRP circuit fault • Failed ETC actuator	Pin-Point Diagnostics (page 462)
2791	7	EGR Valve unable to achieve commanded position	• EGRC-H Control Circuit Fault • EGRC-L Control Circuit Fault	Pin-Point Diagnostics (page 462)

2791	17	EGR Valve unable to achieve commanded position	• EGRC-H Control Circuit Fault • EGRC-L Control Circuit Fault	Pin-Point Diagnostics (page 462)

4752	4	EGR Cooler Efficiency: EGR Outlet Temp above expected	• Biased EGRT or IMT sensor • Low coolant level • EGR cooler failure	Step-Based Diagnostics (page 468)

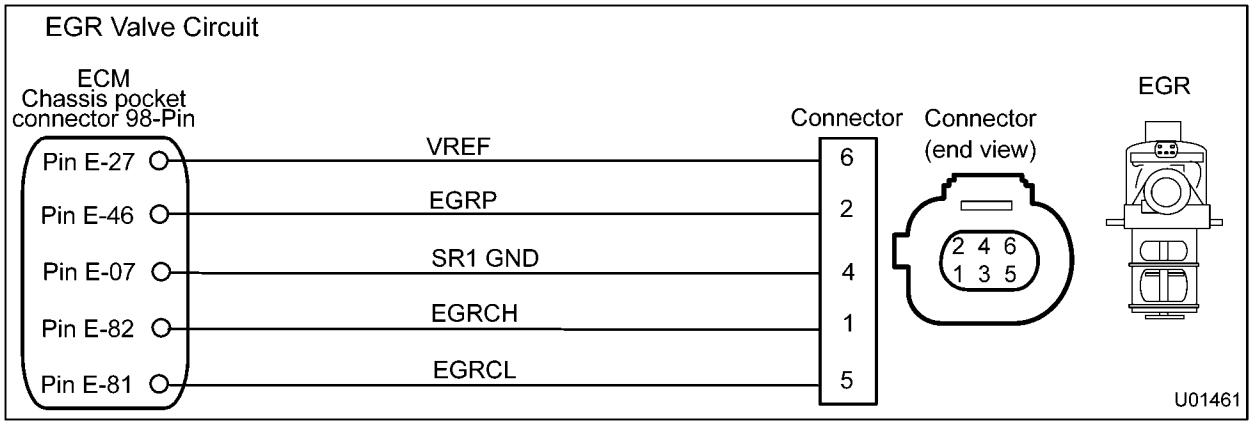

Figure 156 EGR Valve Circuit Diagram

Overview

Nitrogen Oxide (NO_X) in the atmosphere contributes to the production of smog. NO_X is formed when temperature in the combustion chamber gets too hot.

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

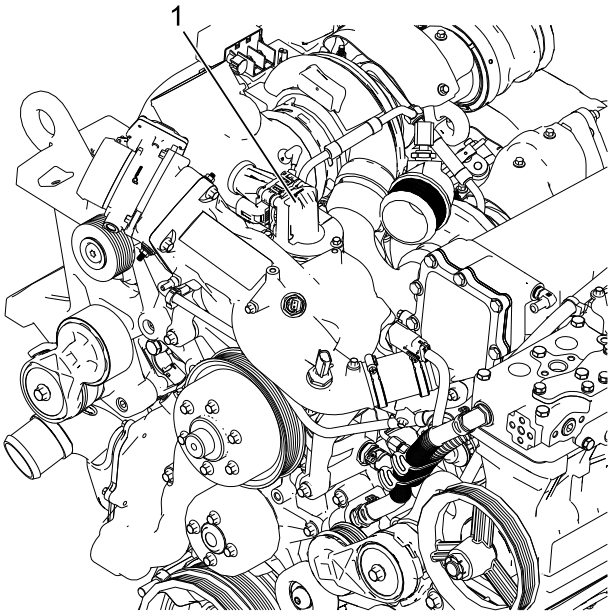

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Figure 157 EGR Valve Location

1. EGR Valve

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 500-Ohm Resistor Harness
- 00–00956–08 - 180-Pin Breakout Box
- Breakout Harness ZTSE4735A (EGR)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

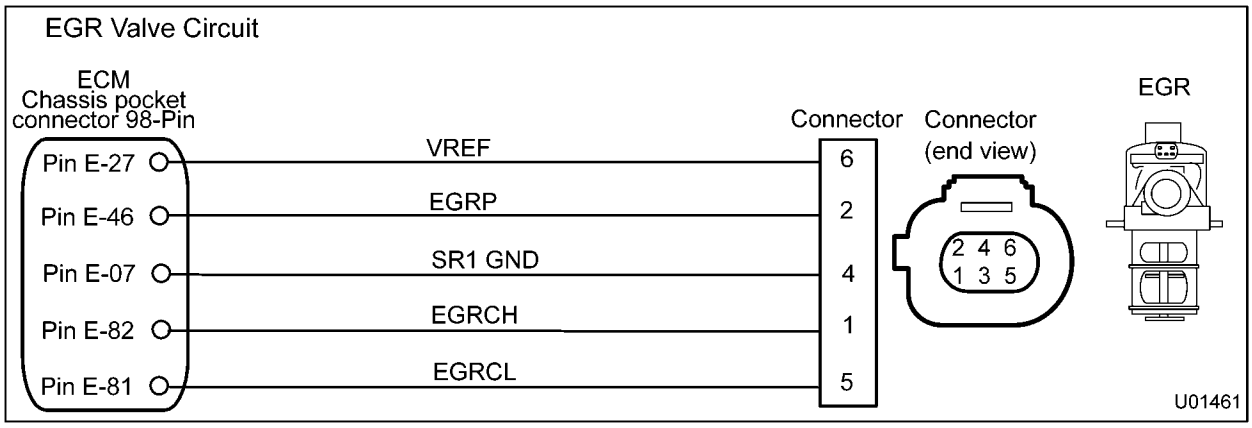


Figure 158 EGR Valve Circuit Diagram

Pinpoint Diagnostics

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

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, open the Continuous Monitor session.
2. Verify sensor is within Key On Engine Off (KOEO) specification. See “Appendix A: Performance Specifications” (page 813).
3. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the DTC goes pending or active.
   - If DTC is pending or active, proceed to the next step.
4. Disconnect engine harness from sensor.

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

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

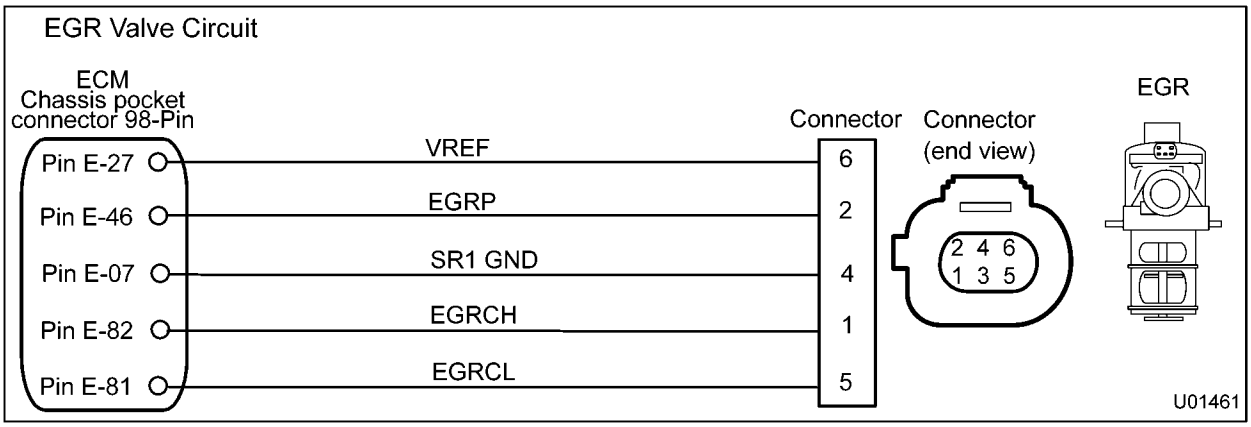


Figure 159 EGR Valve Circuit Diagram

EGR Valve Circuit Check

Connect Breakout Harness ZTSE4735A. Leave EGR actuator disconnected. Turn the ignition switch to ON. Use Electronic Service Tool (EST) with ServiceMaxx™ software to monitor signal and DMM to measure voltage during Continuous Monitor test.

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

Test Point	Spec	Comments
EST - Monitor EGRP	0 V	If > .039 V, check EGRP signal for short to PWR.
DMM - Measure volts 6 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 464).
EST - Monitor EGRP Short 500-ohm Resistor Harness across 1 and 5	5 V	If < 4.5 V, check EGRP signal for OPEN or short to GND. Do Harness Resistance Check (page 464).
DMM - Measure resistance 4 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 464).
If checks are within specification, do EGR Valve - Standard and Output State Test (page 463).		

EGR Valve - Standard and Output State Test

Connect Breakout Harness ZTSE4735A between ECM and EGR actuator. Run Key On Engine Off (KOEO). Use Electronic Service Tool (EST) with ServiceMaxx™ software to monitor EGRP percent.

Test	Spec	Comment
Output State HIGH	100%	If < 90%, check for OPEN or short in EGRC circuits. Do Harness Resistance Check (page 464).
Output State LOW	0%	If > 10%, check for OPEN or short in EGRC circuits. Do Harness Resistance Check (page 464).

Connector Voltage Check

Connect Breakout Harness ZTSE4735A. Leave actuator disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
4 to B+	B+	If < B+, check for short to power, or open circuit.
6 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 464).
5 to GND	B+	If < B+, check EGRVCL for OPEN or short to GND. Do Harness Resistance Check (page 464).
1 to GND	B+	If < B+, check EGRVCH for OPEN or short to GND. Do Harness Resistance Check (page 464).
2 to GND	0 V	If > 0.5 V, check EGRP for short to PWR. Do Harness Resistance Check (page 464).

If checks are within specification, do EGR Actuator - Output State Test (page 463).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4735A. Leave actuator disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Disconnect battery GND and B+ ECM connector. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4735A. Leave ECM and actuator disconnected. Use DMM to measure resistance.

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

Test Point	Spec	Comment
6 to E-27	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
4 to E-07	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
2 to E-46	< 5 Ω	If > 5 Ω, check EGRP signal circuit for OPEN.
5 to E-81	< 5 Ω	If > 5 Ω, check EGRVCL circuit for OPEN.
1 to E-82	< 5 Ω	If > 5 Ω, check EGRVCH circuit for OPEN.

SPN 27- FMI 7 - EGRP Does Not Agree with Commanded Position

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Exhaust Gas Recirculation Position (EGRP) error.	Absolute value of EGRP control error > 30%	Key ON	5 seconds
		EGRP control in closed loop	
		The following SPN / FMIs are not active: 27/3, 27/4,102/3, 102/4, 105/3, 105/4 108/3, 108/4 110/3, 110/4, 132/3, 132/4 173/3, 173/4, 412/3, 412/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the Exhaust Gas Recirculation (EGR) valve signal value is not correct when compared to the commanded position.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

SPNs 3509, 2791

Drive Cycle

N / A

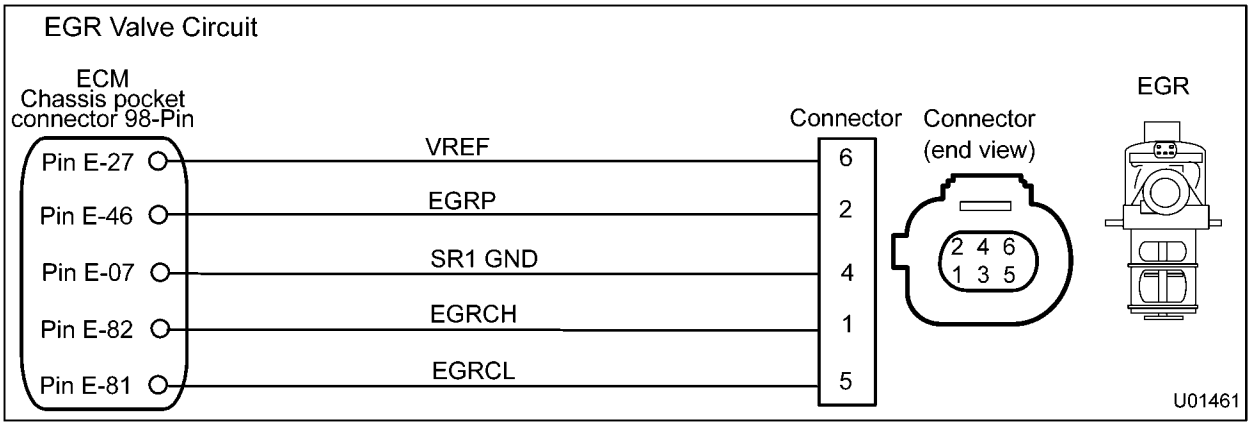


Figure 160 EGR Valve Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 27 FMI 7 the only fault code active?	Yes: Go to Step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 27 FMI 7.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 27 FMI 7. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Exhaust Gas Recirculation (EGR) valve. With Key OFF, disconnect EGR valve connector. Check EGR valve and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EGR valve connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 27 FMI 7.

Step	Action	Decision
4	Test EGRP circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 464). Are EGRP circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 27 FMI 7.

Step	Action	Decision
5	Using EST with ServiceMaxx™ software, do EGR Output State Test (page 463). Are voltage measurements within specification?	Yes: After doing all diagnostic steps, if SPN 27 FMI 7 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace EGR valve. After repairs are complete, retest for SPN 27 FMI 7.

NOTE: After doing all diagnostic steps, if SPN 27 FMI 7 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4752 - FMI 4 - EGR Cooler Efficiency: EGR outlet temp above expected

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Exhaust Gas Recirculation (EGR) cooler effectiveness monitor.	EGR cooler outlet temperature minus modeled EGR cooler outlet temperature > 471°F (244°C)	Ambient Pressure > 11 psi (75 kPa)	20 seconds
		Air Inlet Temperature > 19°F (-7°C) and < 122°F (50°C)	
		Engine Coolant Temperature (ECT) > 104°F (40°C) and < 239°F (115°C)	
		EGR valve position setpoint > 10%	
		Torque > 350 N•m and rpm between 1200-2400 rpm	
		EGR cooler outlet temperature, temperature gradient < 0.027°F/sec (0.015°C/sec)	
		SPN FMIs are not active: 110/3, 110/4, 412/2, 412/3, 412/4, 173/2, 173/3, 173/4, 132/2, 132/3, 132/4, 105/2, 105/3, 105/4, 27/3, and 27/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the EGR outlet temperature value is above threshold.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle

N / A

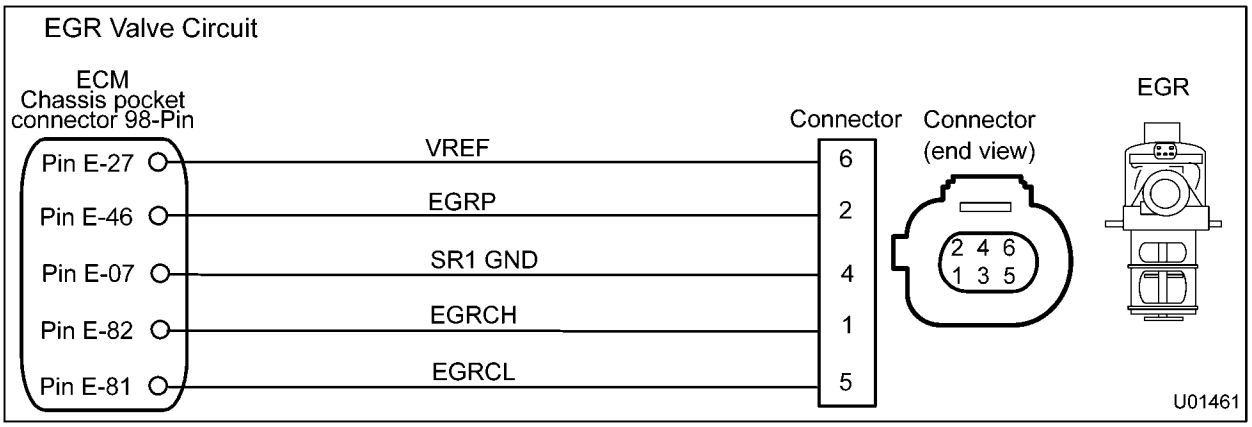


Figure 161 EGR Valve Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 4752 FMI 4 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 4752 FMI 4. No: Go to Step 3.

Step	Action	Decision
3	Inspect coolant level. Is coolant level within specifications?	Yes: Go to Step 4. No: Refer to Coolant System in Engine Symptoms Diagnostics to diagnose coolant loss problem.

Step	Action	Decision
4	Inspect connections at Exhaust Gas Recirculation Temperature (EGRT) sensor. With Key OFF, disconnect EGRT sensor connector. Check EGRT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EGRT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4752 FMI 4.

Step	Action	Decision
5	Test EGRT sensor. Connect breakout harness 4760A between EGRT sensor and EGRT sensor connector. Perform KOEO voltage check of EGRT sensor between EGRT signal and ground (Key On, Engine Off (KOEO) Tests, page 68). Is voltage within specification?	Yes: Go to Step 6. No: Replace EGRT sensor. After repairs are complete, retest for SPN 4752 FMI 4.

Step	Action	Decision
6	Test EGR Cooler. Perform EGR Cooler Inspection. Is EGR Cooler operating properly at this time?	Yes: After doing all diagnostic steps, if SPN 4752 FMI 4 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace EGR Cooler. After repairs are complete, retest for SPN 4752 FMI 4.

NOTE: After doing all diagnostic steps, if SPN 4752 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

EGRT (Exhaust Gas Recirculation Temperature) Sensor

EGRT Sensor End Diagnostics

SPN	FMI	Condition	Possible Causes	Actions
412	0	EGRT above Critical Temperature	• Plugged EGR cooler	Pin-Point Diagnostics (page 473)
412	2	EGRT signal erratic, intermittent, or incorrect	• EGRT biased circuit or sensor	Step-Based Diagnostics (page 475)
412	3	EGRT signal Out of Range HIGH	• EGRT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor	Pin-Point Diagnostics (page 473)
412	4	EGRT signal Out of Range LOW	• EGRT signal circuit short to GND • Failed sensor	Pin-Point Diagnostics (page 473)
412	10	EGRT signal Abnormal Rate of Change	• EGRT biased circuit or sensor	Pin-Point Diagnostics (page 473)
412	21	EGRT signal drifted LOW	• EGRT biased circuit or sensor	Step-Based Diagnostics (page 479)

EGRT Circuit

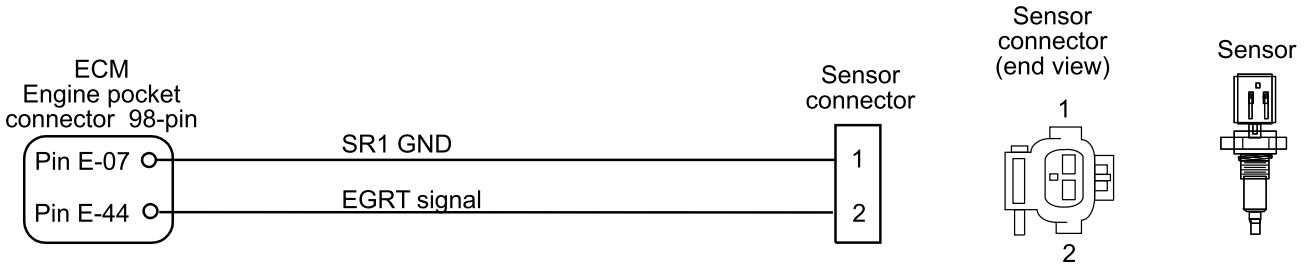
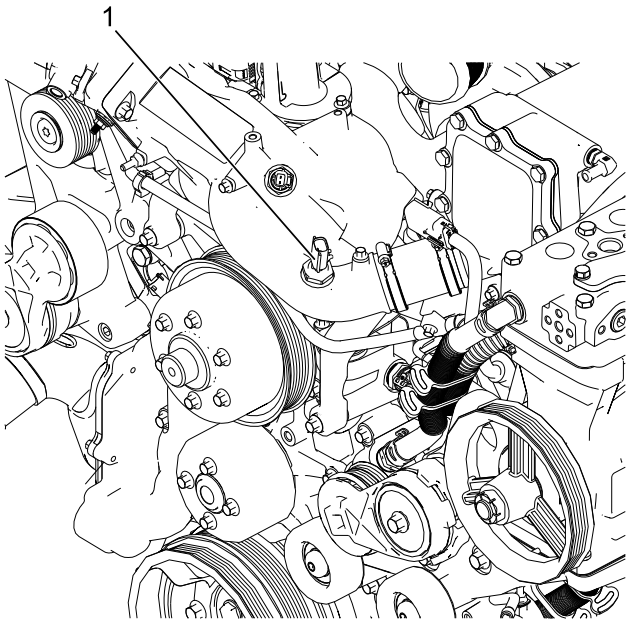


Figure 162 EGRT Circuit Diagram

Overview

The Exhaust Gas Recirculation Temperature (EGRT) sensor provides a feedback signal to the Engine Control Module (ECM) indicating intake manifold air temperature.



0000061313

Figure 163 EGRT Sensor Location

1. EGRT Sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 00–00956–08 - 180-Pin Breakout Box
- Breakout Harness ZTSE4760A (EGRT)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

EGRT Circuit

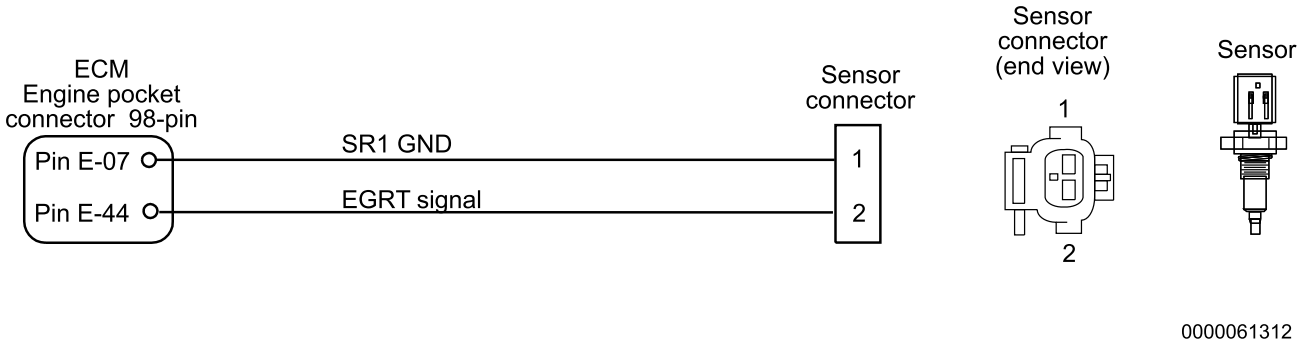


Figure 164 EGRT Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

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

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, open the Continuous Monitor session.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor.

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

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

SPN 412 FMI 0 – EGRT above Critical Temperature

EGR Cooler Check
1. Check for restricted EGR cooler. See EGR Cooler Inspection (page 83) in the “Engine Symptoms Diagnostics” section of this manual.

Sensor Circuit Check

Connect Breakout Harness ZTSE4760A. Leave sensor disconnected. Turn ignition switch to ON. Use Electronic Service Tool (EST) with ServiceMaxx™ software to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	SPN 412 FMI 3	If SPN 412 and FMI 4 is active, check EGRT signal for short to GND. Do Harness Resistance Check (page 474).
EST - Check DTC Short a 3-banana plug harness across 2 and GND	SPN 412 FMI 4	If SPN 412 and FMI 3 is active, check EGRT signal for OPEN. Do Harness Resistance Check (page 474).
EST - Check DTC Short a 3-banana plug harness across 1 and 2	SPN 412 FMI 4	If SPN 412 and FMI 3 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 474).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

EGRT Pin-point Diagnostics

Connector Voltage Check

Connect Breakout Harness ZTSE4760A. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to B+	B+	If < B+, check for short to power or open circuit.
2 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 474).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4760A. Leave sensor disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4760A. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-07	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to E-44	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 412 FMI 2 - EGRT Signal erratic, intermittent, or incorrect

<table>
<tr><th>Condition / Description</th><th>Setting Criteria</th><th>Enable Conditions / Values</th><th>Time Required</th></tr>
<tr><td rowspan="7">Comparison of sensor reading to other sensor readings after a calibrated cold soak period.</td><td>Sum of FAILED temperature sensor comparisons as listed below: Exhaust Gas Recirculation Temperature (EGRT) vs. Air Inlet Temperature (AIT), Turbocharger 1 Compressor Outlet Temperature (TC1COT), Charge Air Cooler Outlet Temperature (CACOT), Intake Manifold Temperature (IMT) >=4</td><td>Engine Off soak time > 8 hours</td><td rowspan="7">0.5 seconds</td></tr>
<tr><td>Comparison between EGRT and IMT > 36°F (20°C)</td><td>Time in Key ON engine OFF state < 60 seconds</td></tr>
<tr><td rowspan="2">Comparison between EGRT and AIT > 36°F (20°C)</td><td>Engine NOT in running state</td></tr>
<tr><td>{[Comparison of Air Inlet Temperature (AIT) with Intake Manifold Temperature (IMT) > 27°F (15°C), Comparison of AIT with Engine Charge Air Cooler Outlet temperature > 27°F (15°C), Comparison of AIT with Engine Turbocharger 1 Compressor Outlet temperature > 27°F (15°C), Comparison of AIT with Engine Exhaust Gas Recirculation temperature > 27°F (15°C), Comparison of Intake Manifold Temperature (IMT) with Charge Air Cooler Outlet Temperature (CACOT) > 27°F (15°C), Comparison of IMT with Turbocharger Outlet Temperature (TCOT) > 27°F (15°C), Comparison of IMT with Engine Exhaust Gas Recirculation Temperature (EGRT) > 27°F (15°C), Comparison of CACOT with TCOT > 27°F (15°C), Comparison of CACOT with EGRT > 27°F (15°C), Comparison of TC1COT with EGRT > 27°F (15°C),], and sum of True Conditions from comparisons listed above} >5 TBD</td></tr>
<tr><td>Comparison between EGRT and CACOT > 36°F (20°C)</td><td rowspan="2">The following SPN / FMIs are not active:172/3, 172/4, 2629/3, 2629/4, 2630/3, 2630/4, 105/3, 105/4, 412/3, and 412/4.</td></tr>
<tr><td>Comparison between EGRT and TC1COT > 36°F (20°C)</td></tr>
</table>

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the EGRT signal value is erratic or incorrect when compared to other related sensor values.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

EGRT Circuit

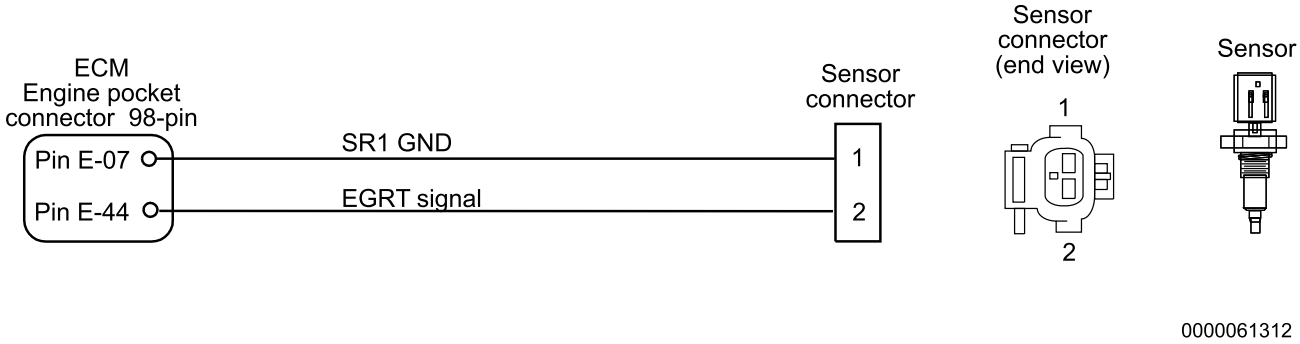


Figure 165 EGRT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 412 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 412 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Exhaust Gas Recirculation Temperature (EGRT) sensor. With Key OFF, disconnect EGRT sensor connector. Check EGRT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EGRT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 412 FMI 2.

Step	Action	Decision
4	Test EGRT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 474). Are EGRT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 412 FMI 2.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test(page 71). Does circuit operate properly?	Yes: Go to Step 6.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 412 FMI 2.

Step	Action	Decision
6	Test EGRT sensor. Connect breakout harness 4760A between EGRT sensor and EGRT sensor connector. Perform the KOEO voltage check of EGRT sensor between EGRT signal and ground(page 71). Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 412 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace EGRT sensor. After repairs are complete, retest for SPN 412 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 412 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 412 FMI 21 - EGRT Signal drifted LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Exhaust Gas Recirculation Temperature (EGRT) stuck in range	EGRT < -40°F (-40°C)	Minimum engine speed value for incrementing accumulator > 800 rpm	1 second
		Minimum engine torque command for incrementing accumulator > 300 N•m	
		Accumulator threshold for monitor enablement > 6 minutes and 40 seconds	
		Minimum Engine Intake Manifold Pressure > 3psi (20 kPa)	
		The following SPN / FMs arel not active: 108/3, 108/4, 172/2, 172/3, 172/4, 412/2, 412/3, and 412/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the EGRT signal value is below the predetermined threshold.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

EGRT Circuit

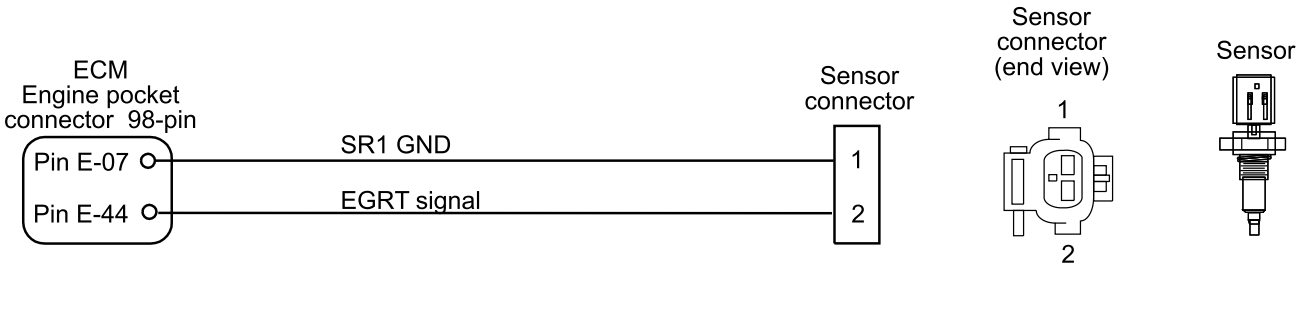


Figure 166 EGRT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 412 FMI 21 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 412 FMI 21. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Exhaust Gas Recirculation Temperature (EGRT) sensor. With Key OFF, disconnect EGRT sensor connector. Check EGRT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EGRT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 412 FMI 21.

Step	Action	Decision
4	Test EGRT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 474). Are EGRT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 412 FMI 21.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test(page 71). Does circuit operate properly?	Yes: Go to Step 6.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 412 FMI 21.

Step	Action	Decision
6	Test EGRT sensor. Connect breakout harness 4760A between EGRT sensor and EGRT sensor connector. Perform the KOEO voltage check of EGRT sensor between EGRT signal and ground (page 71). Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 412 FMI 21 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace EGRT sensor. After repairs are complete, retest for SPN 412 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 412 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

EGT (Exhaust Gas Temperature) Sensor

SPN	FMI	Condition	Possible Causes	Actions
173	0	Exhaust Gas System above Critical Temperature	• EGT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor	Pin-Point Diagnostics (page 484)
173	2	EGT signal erratic, intermittent, or incorrect	• Failed EGT sensor circuit • Failed sensor	Step-Based Diagnostics (page 486)
173	3	EGT signal Out of Range HIGH	• EGT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor	Pin-Point Diagnostics (page 484)
173	4	EGT signal Out of Range LOW	• EGT signal circuit short to GND • Failed sensor	Pin-Point Diagnostics (page 484)
173	21	EGT signal drifted LOW	• Failed EGT sensor circuit • Failed sensor	Step-Based Diagnostics (page 489)

EGT Circuit

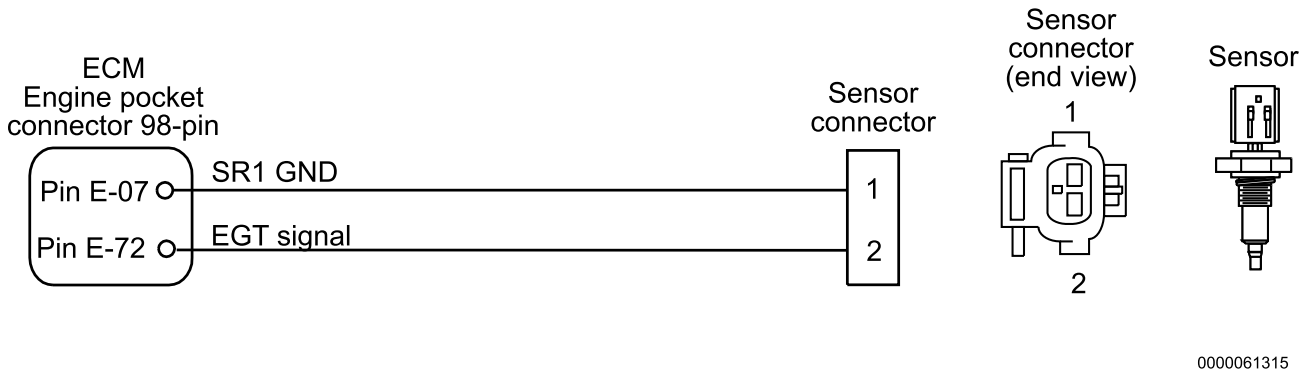


Figure 167 EGT Circuit Diagram

Overview

The EGT sensor provides a feedback signal to the ECM indicating exhaust gas temperature.

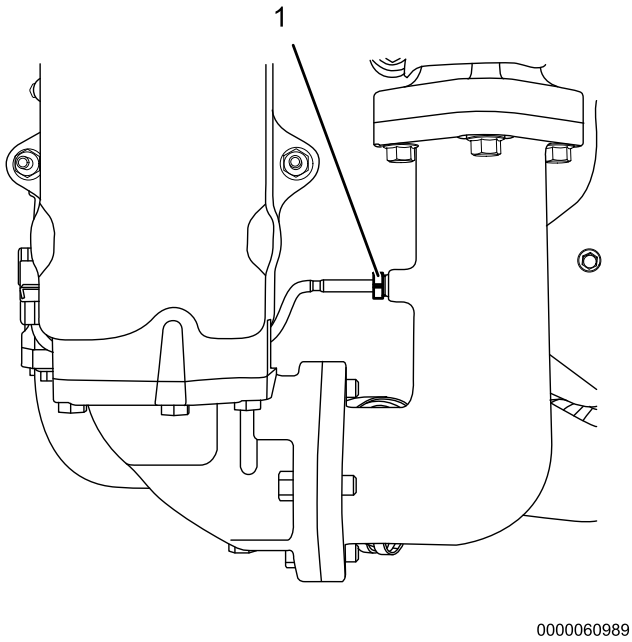


Figure 168 EGT Sensor Location

1. EGT Sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 00–00956–08 - 180-Pin Breakout Box
- Breakout Harness ZTSE4946 (EGT)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

EGT Circuit

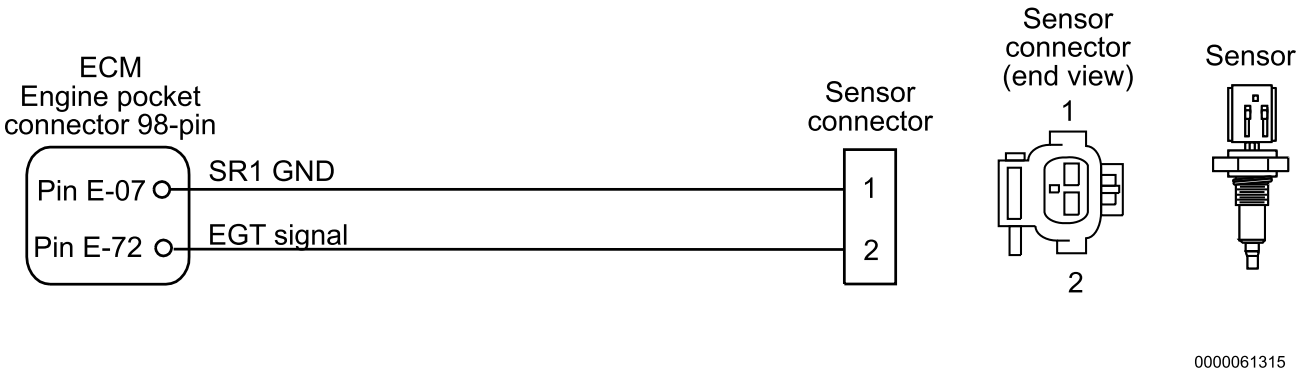


Figure 169 EGT Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

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

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, open the Continuous Monitor session.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor.

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

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

Sensor Circuit Check

Connect sensor Breakout Harness ZTSE4946. Leave sensor disconnected. Turn ignition switch to ON. Use Electronic Service Tool (EST) with ServiceMaxx™ software to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	SPN 173 FMI 3	If SPN 173 and FMI 4 is active, check EGT signal for short to GND. Do Harness Resistance Check (page 485).
EST - Check DTC Short a 3-banana plug harness across 2 and GND	SPN 173 FMI 4	If SPN 173 and FMI 3 is active, check EGT signal for OPEN. Do Harness Resistance Check (page 485).
EST - Check DTC Short a 3-banana plug harness across 1 and 2	SPN 173 FMI 4	If SPN 173 and FMI 3 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 485).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

Connector Voltage Check

Connect Breakout Harness ZTSE4946. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to B+	B+	If < B+, check for short to power, or open circuit.
2 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 485).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4946. Leave sensor disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4946. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-07	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to E-72	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 173 FMI 2 - EGT Signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of Exhaust Gas Temperature (EGT) sensor reading to modeled value.	Value of modeled EGT value MINUS actual EGT value > 662°F (350°C)	Ambient pressure > 9 psi (65 kPa)	45 seconds
		Air Inlet Temperature (AIT) > -40°F (-40°C) and < 122°F (50°C)	
		Engine Coolant Temperature (ECT) > 140°F (60°C) and < 239°F (115°C)	
		Not in active regeneration	
		PTO mode NOT active	
		Torque 150-650 N•m and RPM 700-1200 rpm	
		Engine Speed Gradient <0.2 rpm/sec for > 5 minutes	
		Engine Torque Command Gradient <0.2 Nm/sec for > 5 minutes	
		The following SPN/FMIs are not active: 110/3, 110/4, 108/3, 108/4, 132/2, 132/3, 132/4, 172/2, 172/3, 172/4, 173/3, 173/4, 2629/2, 2629/3, 2629/4, 2629/21, 4765/2, 4765/3, 4765/4, 4765/20, and 4765/21.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the EGT signal value is erratic or incorrect when compared to other related sensor values.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

EGT Circuit

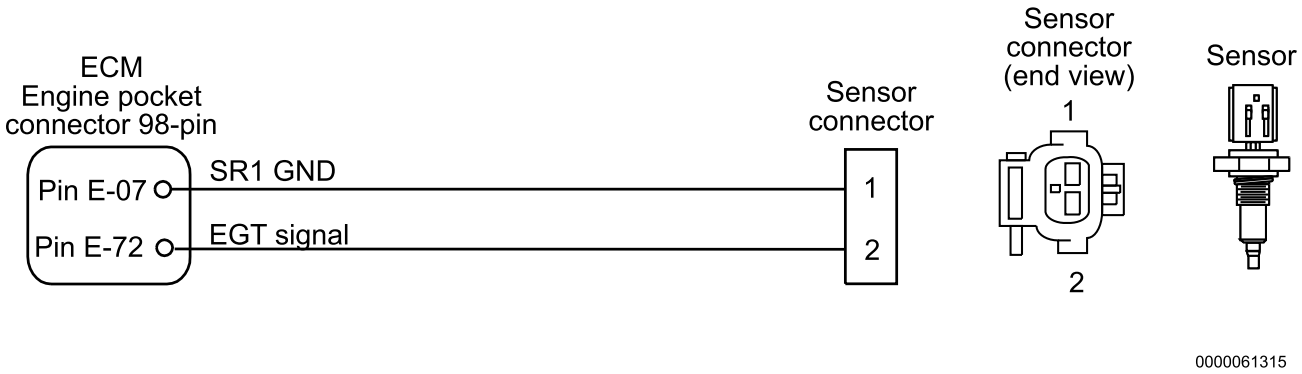


Figure 170 EGT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 173 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 173 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Exhaust Gas Temperature (EGT) sensor. Key OFF, disconnect EGT connector. Check EGT and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EGT connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 173 FMI 2.

Step	Action	Decision
4	Test EGT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 485). Are EGT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 173 FMI 2.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test(page 71). Does circuit operate properly?	Yes: After doing all diagnostic steps, if SPN 173 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuits as required. After repairs are complete, retest for SPN 173 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 173 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 173 FMI 21 - EGT Stuck in Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Exhaust Gas Temperature Stuck in Range Low	Engine Exhaust Gas Temperature < 392°F (200°C)	Minimum engine speed value for incrementing accumulator >1325 rpm	0.5 second
		Minimum engine Torque command for incrementing accumulator >710 N•m	
		Up / Down Accumulator output > 5 minutes	
		The following SPN / FMIs are not active: 108/3, 108/4, 172/2, 172/3, 172/4, 173/2, 173/3 and 173/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the EGT signal value is lower than expected over a predetermined amount of time.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

EGT Circuit

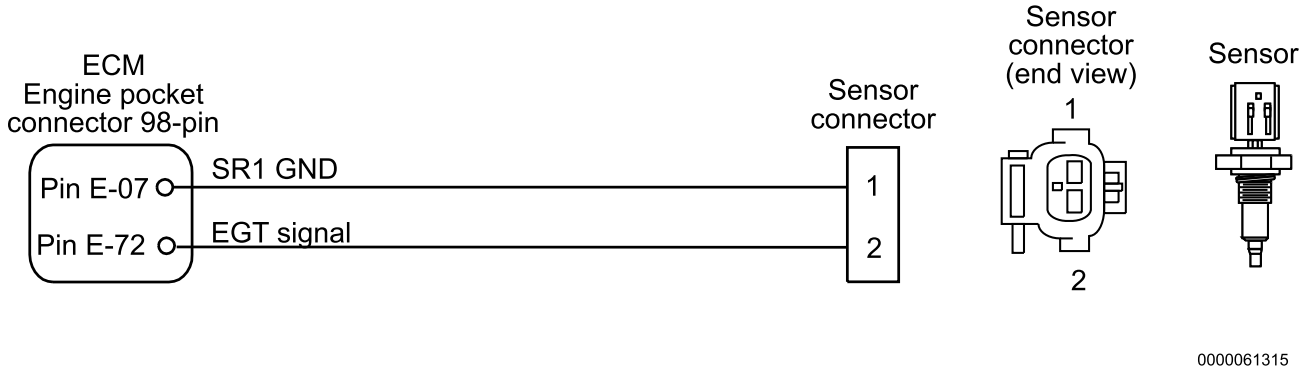


Figure 171 EGT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 173 FMI 21 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 173 FMI 21. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Exhaust Gas Temperature (EGT) sensor. Key OFF, disconnect EGT connector. Check EGT and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EGT connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 173 FMI 21.

Step	Action	Decision
4	Test EGT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 485). Are EGT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 173 FMI 21.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test(page 71). Does circuit operate properly?	Yes: After doing all diagnostic steps, if SPN 173 FMI 21 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuits as required. After repairs are complete, retest for SPN 173 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 173 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

EOP (Engine Oil Pressure) Sensor

SPN	FMI	Condition
100	3	EOP signal Out of Range HIGH
100	4	EOP signal Out of Range LOW
100	10	EOP signal abnormal rate of change

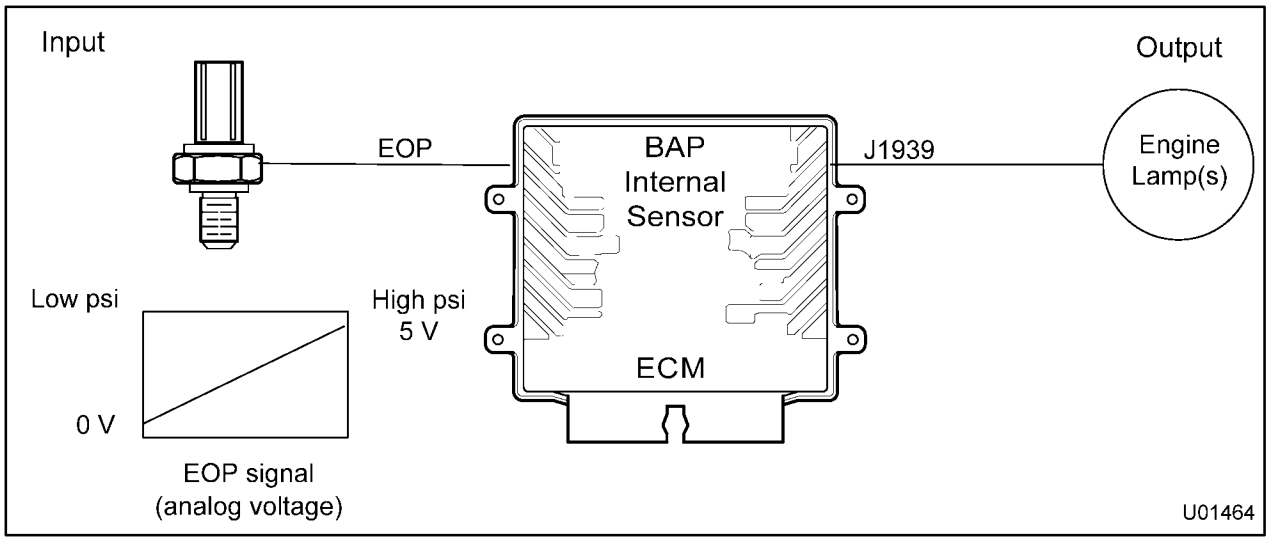


Figure 172 Function diagram for the EOP sensor

The EOP sensor function diagram includes the following:

- Engine Oil Pressure (EOP) sensor
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Engine Lamp(s)

Function

The EOP sensor provides a feedback signal to the ECM indicating engine oil pressure. During engine operation, the ECM monitors the EOP signal to determine if oil pressure is satisfactory. If oil pressure is below required pressure, the ECM turns on the Amber Warning Lamp (AWL).

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

Sensor Location

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

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 00-00956-08 – 180-Pin Breakout Box
- Breakout Harness ZTSE4850 (EOP)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

EOP Sensor End Diagnostics

SPN	FMI	Condition	Possible Causes
100	3	EOP signal Out of Range HIGH	• EOP signal circuit short to PWR • Failed sensor
100	4	EOP signal Out of Range LOW	• EOP signal circuit OPEN or short to GND • VREF circuit OPEN • Failed sensor
100	10	EOP signal abnormal rate of change	• EOP biased circuit or sensor • Engine oil circuit restricted

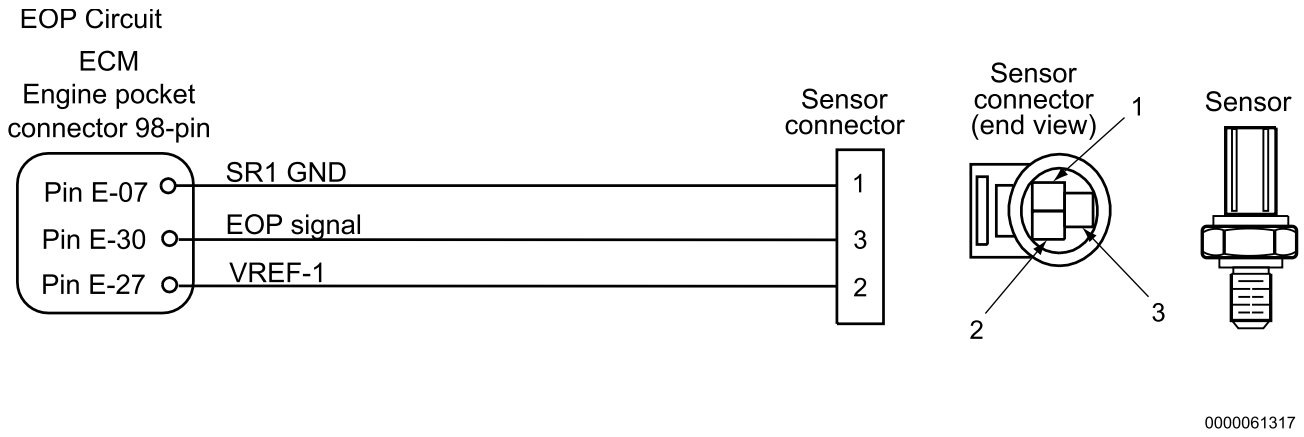


Figure 173 EOP circuit diagram

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

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, open the Continuous Monitor session.
2. Verify sensor voltage is within KOEO specification. See “Appendix A: Performance Specifications” (page 813).
3. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, wiggle the connector and all wires at suspected location. If the circuit is interrupted, the DTC goes active.
   - If DTC is active, proceed to the next step.

4. Disconnect engine harness from sensor.

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

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

Sensor Circuit Check

Connect sensor Breakout Harness ZTSE4850. Leave sensor disconnected. Turn ignition switch to ON. Use ServiceMaxx™ to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	SPN 100 FMI 3	If SPN 100 / FMI 3 is active, check EOP signal for short to PWR.
DMM – Measure volts 2 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 497).
EST - Check DTC Short Breakout Harness ZTSE4850 across 2 and 3	SPN 100 FMI 4	If SPN 100 / FMI 4 is active, check EOP signal for OPEN. Do Harness Resistance Check (page 497).
DMM – Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 497).
If checks are within specification, connect sensor and clear DTC. If active code remains, replace sensor.		

EOP Pin-point Diagnostics

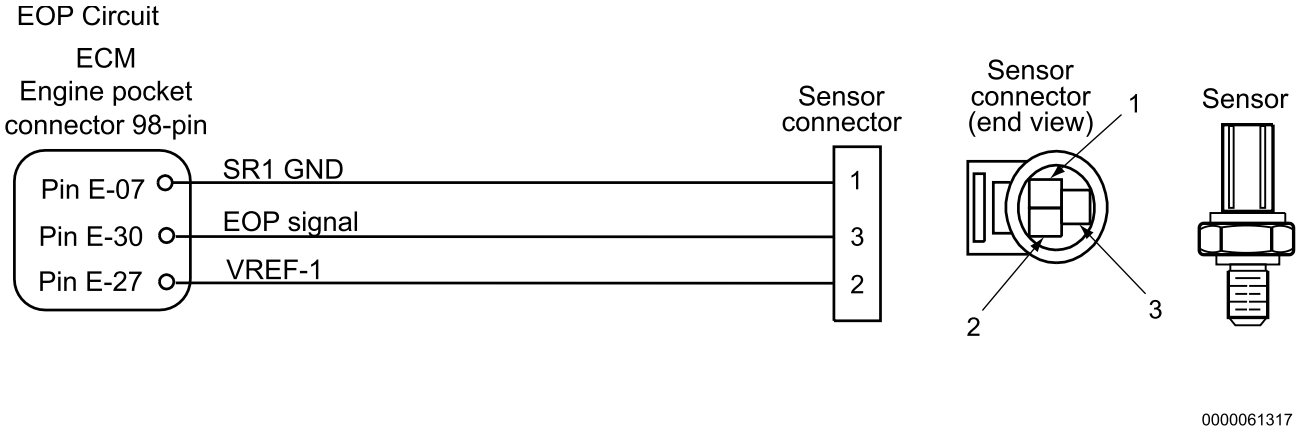


Figure 174 EOP circuit diagram

Connector Voltage Check

Connect Breakout Harness ZTSE4850. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to B+	B+	If < B+, check for short to power, or open circuit. Do Harness Resistance Check (page 497).
2 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 497).
3 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 497).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4850. Leave sensor disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4850. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-07	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
2 to E-27	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
3 to E-30	< 5 Ω	If > 5 Ω, check EOP signal circuit for OPEN.

EOP Circuit Operation

The EOP sensor is a variable capacitance sensor supplied with a 5-volt reference voltage at Pin 2 from ECM Pin E-27. The sensor is grounded at Pin 1 from ECM Pin E-07. The sensor returns a variable voltage signal from Pin 3 to ECM Pin E-30.

Fault Detection / Management

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

EOT (Engine Oil Temperature) Sensor

SPN	FMI	Condition	Possible Causes	Actions
175	2	EOT signal erratic, intermittent, or incorrect	• Biased EOT sensor or circuit	Step-Based Diagnostics (page 503)
175	3	EOT signal Out of Range HIGH	• EOT signal circuit short to GND • Failed sensor	Pin-Point Diagnostics (page 500)
175	4	EOT signal Out of Range LOW	• Biased EOT circuit or sensor	Pinpoint Diagnostics (page 500)
175	10	EOT abnormal rate of change	• EOT biased circuit or sensor • Engine oil circuit restricted	Pinpoint Diagnostics (page 500)
175	21	EOT signal drifted LOW	• Biased EOT sensor or circuit	Step-Based Diagnostics (page 506)

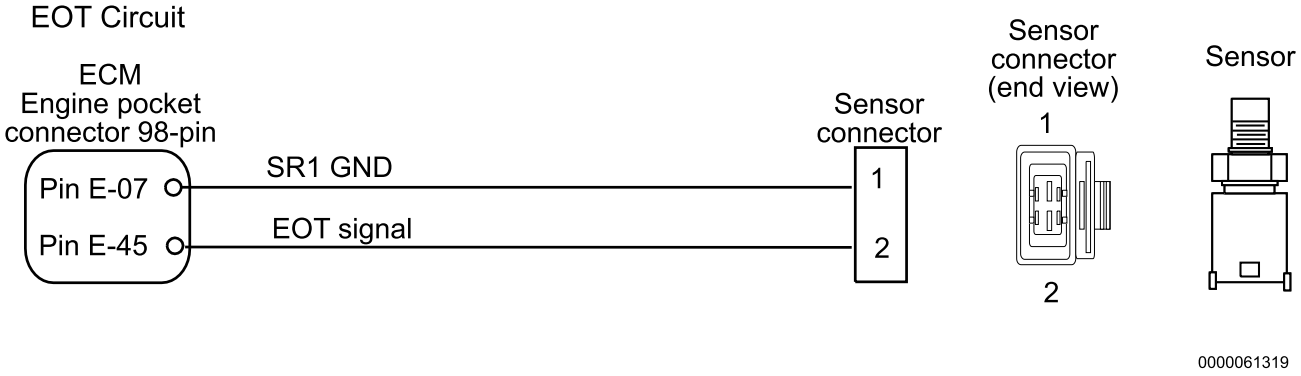


Figure 175 EOT Circuit Diagram

Overview

The EOT sensor provides a feedback signal to the ECM indicating engine oil temperature. The ECM monitors the EOT signal to control fuel quantity and timing throughout the operating range of the engine. The EOT signal allows the ECM to compensate for oil viscosity variations due to temperature changes in the operating environment, ensuring adequate power and torque are available for all operating conditions.

Fast Idle Advance

Fast idle advance increases engine idle speed up to 900 rpm for faster warmup to operating temperature. This occurs when the ECM monitors Engine Coolant Temperature (ECT) sensor input and adjusts fuel injector.

Low idle speed is increased proportionally when below 104°F (40°C) at 700 rpm to below -22°F (-30°C) at 900 rpm maximum.

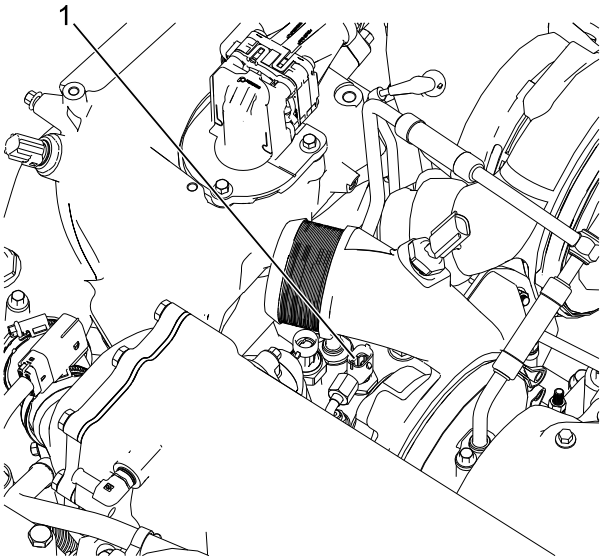


Figure 176 EOT Sensor Location

1. EOT Sensor (under crossover tube)

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 00–00956–08 - 180-Pin Breakout Box
- Breakout Harness ZTSE4602 (EOT)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

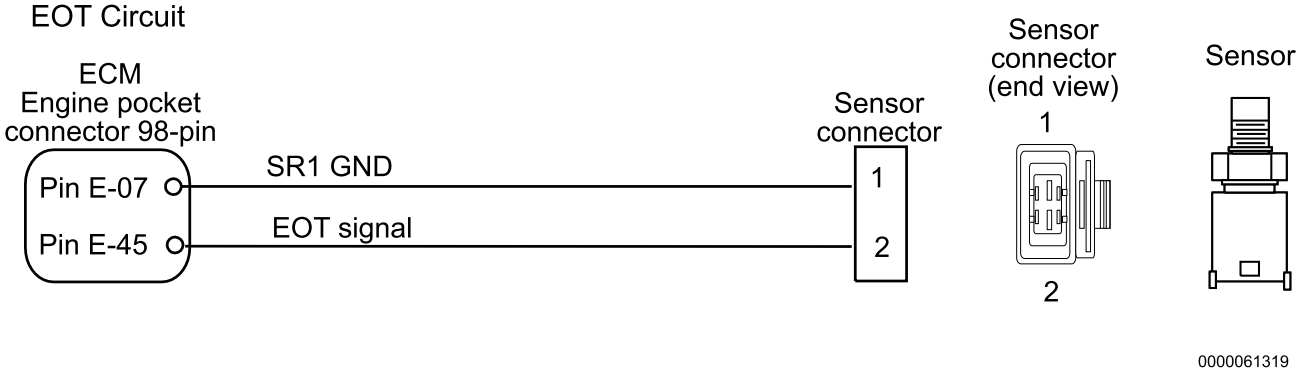


Figure 177 EOT Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

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

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, open the Continuous Monitor session.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, wiggle the connector and all wires at suspected location. If the circuit is interrupted, the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor.

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

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

Sensor Circuit Check

Connect sensor Breakout Harness ZTSE4602. Leave sensor disconnected. Turn ignition switch to ON. Use ServiceMaxx™ software to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST- Check DTC	SPN 175 FMI 4	If SPN 175 / FMI 4 is active, check EOT signal for short to GND. Do Harness Resistance Check (page 502).
EST - Check DTC Short 3-banana plug harness across 2 and GND	SPN 175 FMI 4	If SPN 175 / FMI 4 is active, check EOT signal for OPEN. Do Harness Resistance Check (page 502).
EST - Check DTC Short 3-banana plug harness across 1 and 2	SPN 175 FMI 4	If SPN 175 / FMI 4 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 502).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

EOT Pin-point Diagnostics

Connector Voltage Check

Connect Breakout Harness ZTSE4602. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to B+	B+	If < B+, check for short to power, or open circuit.
2 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 502).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4602. Leave sensor disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4602. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-07	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to E-45	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 175 FMI 2 - EOT Signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of sensor reading to other sensor readings after a calibrated cold soak period.	Engine Oil Temperature (EOT) sensor output MINUS Engine Coolant Temperature (ECT) > 36°F (20°C) and Engine Oil Temperature (EOT) sensor output MINUS Engine Fuel Temperature (EFT) sensor output > 36°F (20°C).	Engine off soak time > 8 hours	2 seconds
		Time in Key ON Engine OFF (KOEO) state < 60 seconds	
		(Absolute [Engine Coolant Temperature (ECT) minus Engine Oil Temperature (EOT)] < 27°F (15°C) or [absolute EOT minus Engine Fuel Temperature (EFT)] < 27°F (15°C) or [absolute EFT minus ECT] < 27°F (15°C)).	
		Not { Air Inlet Temperature (AIT) < 36°F (20°C) and (MAX [EOT, EFT] minus AIT) > 9°F (5°C)}	
		Monitor on Hold until SPN / FMI 173/2 has been completed	
		Engine NOT in running state	
		The following SPN / FMIs are not active: SPN FMIs 110/3, 110/4, 174/3, 174/4, 175/3, and 175/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the EOT signal value is erratic or incorrect when compared to other related sensor values.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Fault Fact

External oil heater can cause fault to set.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

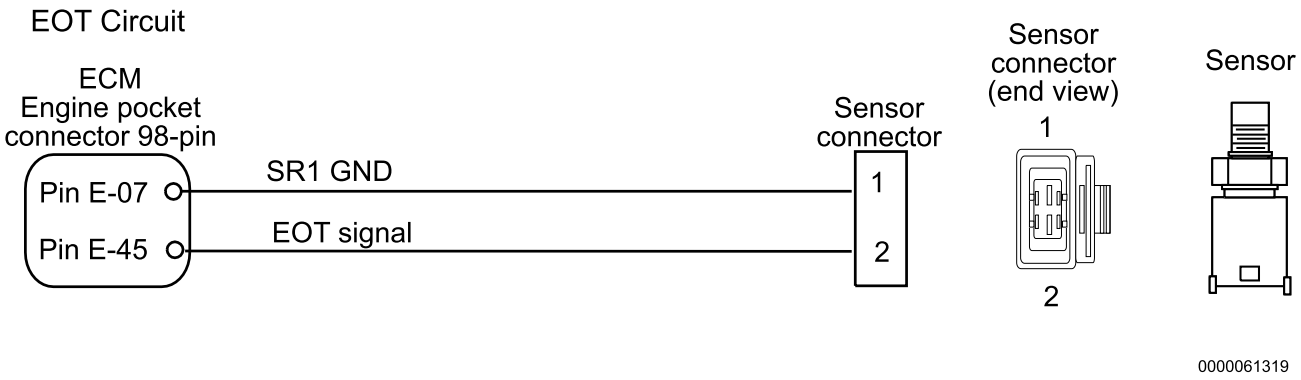


Figure 178 EOT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 175 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 175 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Engine Oil Temperature sensor (EOT). Key OFF, disconnect EOT sensor connector. Check EOT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 175 FMI 2.

Step	Action	Decision
4	Test EOT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 501). Are EOT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 175 FMI 2.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test(page 71). Does circuit operate properly?	Yes: Go to Step 6.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 175 FMI 2.

Step	Action	Decision
6	Test EOT sensor. Connect breakout harness 4602 between EOT sensor and EOT sensor connector. Perform KOEO voltage check of EOT sensor between EOT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 175 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace EOT sensor. After repairs are complete, retest for SPN 175 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 175 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 175 FMI 21 - EOT signal drifted LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Oil Temperature (EOT) sensor stuck in range detection	EOT < -40 F (-40 C)	Minimum engine speed value for incrementing accumulator > 1000 rpm	1 second
		Minimum engine torque command for incrementing accumulator > 300 N•m	
		Accumulated threshold for enabling monitor > 6 minutes	
		The following SPN / FMIs are not active: 108/3, 108/4, 172/3, 172/4, 175/2, 175/3, and 175/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the EOT signal is below the predetermined threshold.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

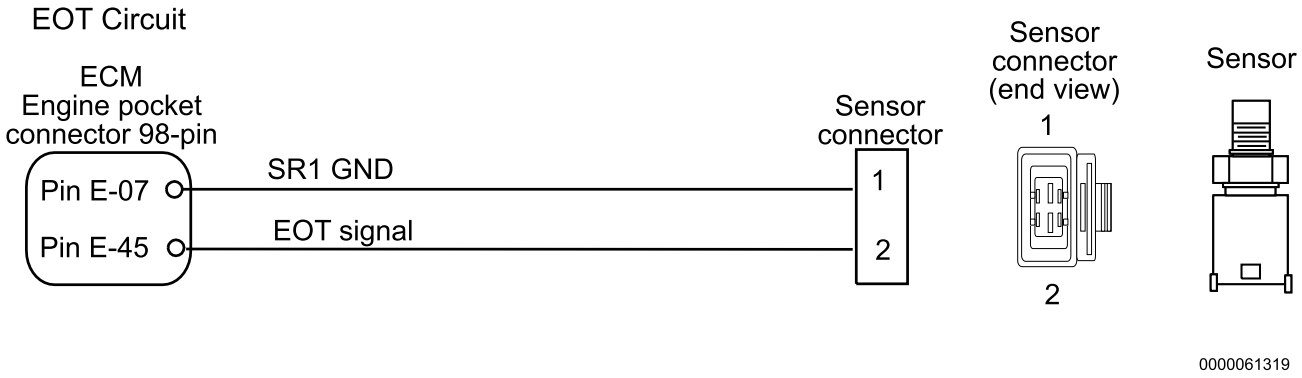


Figure 179 EOT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 175 FMI 21 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 175 FMI 21. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Engine Oil Temperature sensor (EOT). Key OFF, disconnect EOT sensor connector. Check EOT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 175 FMI 21.

Step	Action	Decision
4	Test EOT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 501). Are EOT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 175 FMI 21.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test(page 71). Does circuit operate properly?	Yes: Go to Step 6.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 175 FMI 21.

Step	Action	Decision
6	Test EOT sensor. Connect breakout harness 4602 between EOT sensor and EOT sensor connector. Perform KOEO voltage check of EOT sensor between EOT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 175 FMI 21 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace EOT sensor. After repairs are complete, retest for SPN 175 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 175 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

ETV (Engine Throttle Valve)

SPN	FMI	Condition	Possible Causes	Actions
51	3	ETP signal Out of Range HIGH	• ETP signal circuit short to PWR • Failed ETP sensor	Pin-Point Diagnostics (page 512)
51	4	ETP signal Out of Range LOW	• ETP signal circuit OPEN or short to GND • Failed ETP sensor • VREF circuit OPEN	Pin-Point Diagnostics (page 512)
51	7	ETP does not agree with commanded position	• Sticking or failed ETV • ETP circuit fault • ETC circuit fault	Step-Based Diagnostics (page 515)
51	10	ETP signal abnormal rate of change	• ETP circuit fault • Failed ETP actuator	Pin-Point Diagnostics (page 512)
3464	3	ETC short to PWR	• ETCH control circuit fault • ETCL control circuit fault	Pin-Point Diagnostics (page 512)
3464	4	ETC short to GND	• ETCH control circuit fault • ETCL control circuit fault	Pin-Point Diagnostics (page 512)
3464	5	ETC open load / circuit	• ETCH control circuit fault • ETCL control circuit fault	Pin-Point Diagnostics (page 512)

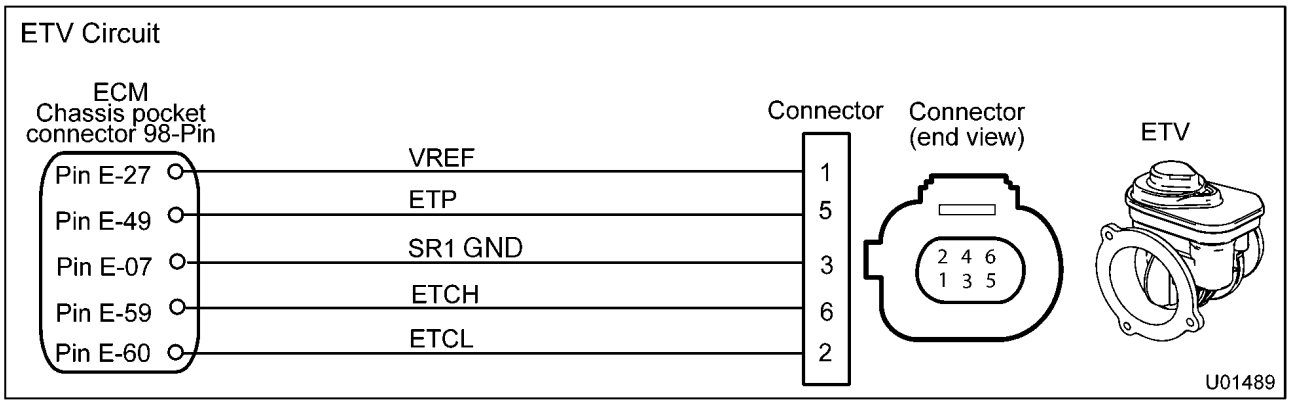


Figure 180 ETV Circuit Diagram

Overview

The ETV is a variable-position actuator that controls the flow of fresh air (boosted and cooled) into the engine's air intake path through the CAC to help heat the exhaust aftertreatment during regeneration, and to assist when heavy EGR is requested. The ETV and ETP sensor are integrated into one component. ETC is the control valve actuator and ETP is the valve position sensor.

ETP (Engine Throttle Position) sensor

The ETP sensor is a potentiometer sensor. The sensor returns a variable voltage signal.

ETV actuator

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

PWM voltage is supplied by a series of pulses. To control motor speed, it varies (modulates) the width of the pulses.

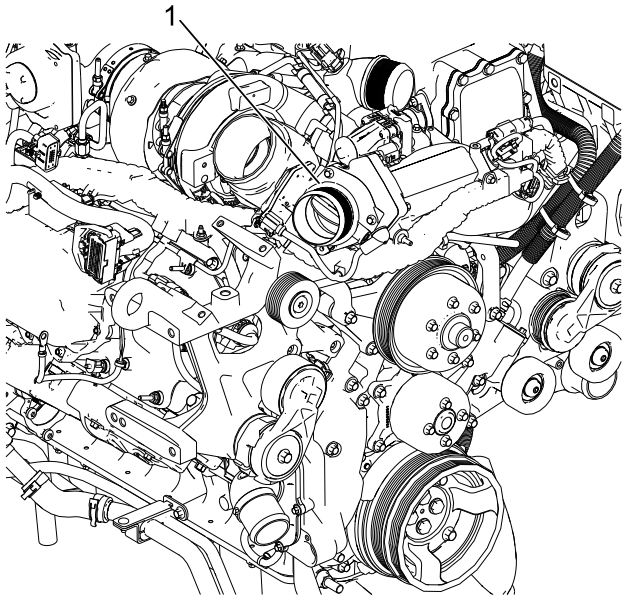
H-bridge is a bipolar circuit. The ECM controls the ETV to close by driving the ETCH circuit high and the ETCL circuit low. The opposite occurs when the valve is commanded open.

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

Fault Detection / Management

The ECM continuously monitors the ETP sensor. If the sensor signal is higher or lower than expected, the ECM sets a DTC and turns on the Amber Warning Lamp (AWL).

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



0000061323

Figure 181 ETV Location

1. ETV

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 00–00956–08 - 180-Pin Breakout Box
- Breakout Harness ZTSE4735A (ETC)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

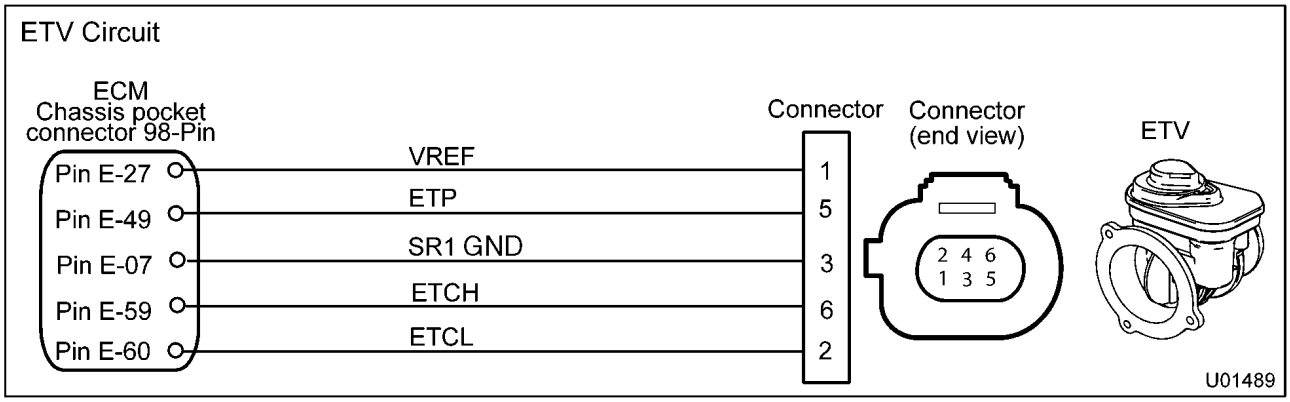


Figure 182 ETV Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

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

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, open the Continuous Monitor session.
2. Verify sensor voltage is within KOEO specification. See “Appendix A: Performance Specifications” (page 813).
3. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
4. Disconnect engine harness from sensor.

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

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

ETV Circuit Check

Connect Breakout Harness ZTSE4735A. Leave ETV connected. Turn the ignition switch to ON. Use Electronic Service Tool (EST) with ServiceMaxx™ software to monitor signal and DMM to measure voltage during Continuous Monitor test.

Test Point	Spec	Comments
EST- Check DTC	SPN 51 FMI 4	If SPN 51 / FMI 3, check ETP signal for short to PWR
DMM - Measure volts VREF to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 514).
EST - Check DTC Short breakout harness across EGRTP and VREF	SPN 51 FMI 3	If SPN 51 / FMI 4, check ETCP signal for OPEN. Do Harness Resistance Check (page 514).
DMM - Measure resistance SR1 GND to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 514).
DMM - Measure voltage ETCL to GND	B+	If < B+, check ECTL for OPEN or short to GND. Do Harness Resistance Check (page 514).
DMM - Measure voltage ETCH to GND	B+	If < B+, check ECTH for OPEN or short to GND. Do Harness Resistance Check (page 514).

ETV - Standard Test and Output State Test

Connect Breakout Harness ZTSE4735A between ECM and ETV. Run KOEO test. Use Electronic Service Tool (EST) with ServiceMaxx™ software to monitor ETP duty cycle.

Test	Spec	Comment
Output State HIGH	100%	If < 90%, check for OPEN or short in ETC control circuits. Do Harness Resistance Check (page 514).
Output State LOW	0%	If > 10%, check for OPEN or short in ETC control circuits. Do Harness Resistance Check (page 514).

Connector Voltage Check

Connect Breakout Harness ZTSE4735A. Leave actuator disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
3 to B+	B+	If < B+, check for short to power, or open circuit.
1 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 514).
5 to GND	0 V	If > 0.25 V, check ETP for short to PWR. Do Harness Resistance Check (page 514).
2 to GND	B+	If < B+, check ETCL for OPEN or short to GND. Do Harness Resistance Check (page 514).
6 to GND	B+	If < B+, check ETCH for OPEN or short to GND. Do Harness Resistance Check (page 514).
If checks are within specification, do ETV - Standard Test and Output State Test (page 513).		

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4735A. Leave actuator disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4735A. Leave ECM and actuator disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
5 to E-49	< 5 Ω	If > 5 Ω, check ETP signal circuit for OPEN.
3 to E-07	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
2 to E-60	< 5 Ω	If > 5 Ω, check ETCL circuit for OPEN.
6 to E-59	< 5 Ω	If > 5 Ω, check ETCH circuit for OPEN.
1 to E-27	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.

SPN 51 FMI 7 ETP Does not agree with commanded position

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Throttle Position (ETP) Fault	Absolute value of throttle position error > 80%	Key ON ETP in close loop control	5 seconds

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the ETP is above a predetermined threshold when commanded.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

SPN 51 FMI 3, SPN 51 FMI4, SPN 3464 FMI 3, SPN 3464 FMI 4, and SPN 3464 FMI 5.

Drive Cycle to Determine Fault Status

N / A

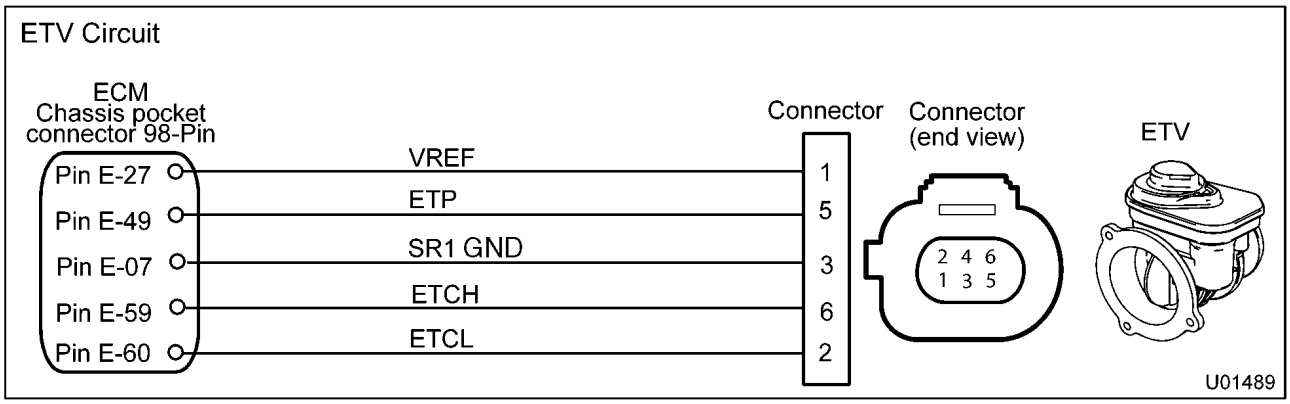


Figure 183 ETV Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 51 FMI 7 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 51 FMI 7. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Engine Throttle Valve (ETV). Key OFF, disconnect ETV connector. Check ETV and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are ETV valve connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 51 FMI 7.

Step	Action	Decision
4	Test ETP and ETC circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 514). Are ETP circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 51 FMI 7.

Step	Action	Decision
5	Compare ETP and ETC signal values. Using EST with ServiceMaxx™ software, do KOEO Output State Low Test and KOEO Output State High Test. Are ETP and ETC signal values within 30% for each test?	Yes: After doing all diagnostic steps, if SPN 51 FMI 7 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace ETV. After repairs are complete, retest for SPN 51 FMI 7.

NOTE: After doing all diagnostic steps, if SPN 51 FMI 7 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

EWPS (Engine Warning Protection System)

EWPS Diagnostics

SPN	FMI	Condition	Possible Causes	Actions
94	17	Fuel Delivery Pressure Below Warning	• Fuel Delivery Pressure Below Warning	Pin-Point Diagnostics (page 521)
94	31	Fuel Filter Minder Service Interval Now	• Fuel Filter Minder Service Interval Now	Pin-Point Diagnostics (page 521)
100	1	Engine Oil System below Critical Pressure	• Engine Oil System below Critical Pressure	Pin-Point Diagnostics (page 521)
100	18	Engine Oil System below Warning Pressure	• Engine Oil System below Warning Pressure	Pin-Point Diagnostics (page 521)
110	0	Engine Coolant System above Critical Temperature	• Engine Coolant System above Critical Temperature	Pin-Point Diagnostics (page 521)
110	15	Engine Coolant System above Warning Temperature	• Engine Coolant System above Warning Temperature	Pin-Point Diagnostics (page 521)
111	1	Low Engine Coolant Level	• Low Engine Coolant Level	Pin-Point Diagnostics (page 521)
174	0	Engine Fuel System above Critical Temperature	• Engine Fuel System above Critical Temperature	Pin-Point Diagnostics (page 521)
174	15	Engine Fuel System above Warning Temperature	• Engine Fuel System above Warning Temperature	Pin-Point Diagnostics (page 521)
175	0	Engine Oil System above Critical Temperature	• Engine Oil System above Critical Temperature	Pin-Point Diagnostics (page 521)
175	15	Engine Oil System above Warning Temperature	• Engine Oil System above Warning Temperature	Pin-Point Diagnostics (page 521)
188	0	Engine unable to achieve desired idle speed (too high)	• Contaminated fuel • Injector overfueling • Oil ingestion • External fuel source	Step-Based Diagnostics (page 525)

188	1	Engine unable to achieve desired idle speed (too low)	• Non-CAN PTO • Low fueling issues • Intake restriction • Exhaust restriction • Bad power cylinders	Step-Based Diagnostics (page 528)
190	0	Engine Overspeed – Most Severe Level	• Engine Overspeed – Most Severe Level	Pin-Point Diagnostics (page 521)
2629	15	High Compressor Outlet Temperature	• High Compressor Outlet Temperature	Pin-Point Diagnostics (page 521)
5395	0	Engine unable to achieve desired idle torque (too high)	• Contaminated fuel • Oil ingestion • External fuel source	Step-Based Diagnostics (page 530)
5395	1	Engine unable to achieve desired idle torque (too low)	• Non-CAN PTO • Intake restriction • Exhaust restriction • Base engine compression issue	Step-Based Diagnostics (page 532)

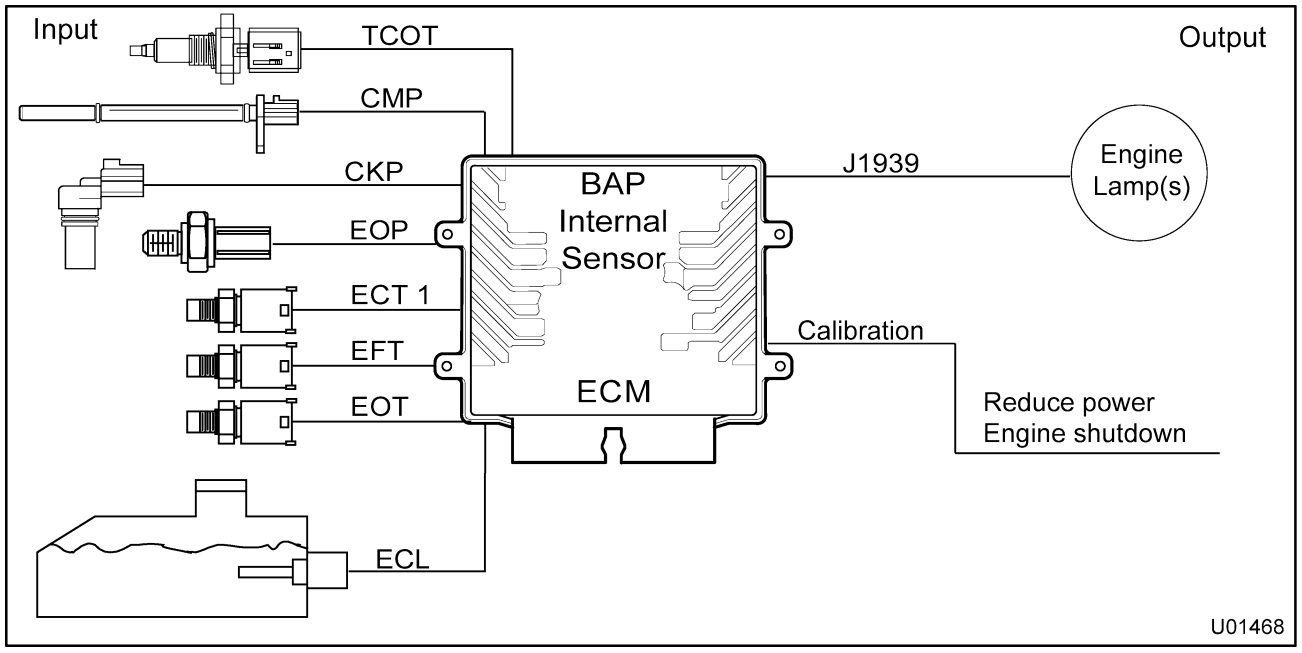


Figure 184 EWPS Function Diagram

Overview

The EWPS warns the operator of conditions that can damage the engine.

The Standard Warning System is the base system in which all engines are equipped. If one of these faults are detected, the ECM illuminates the Oil Warning Lamp (OWL) and sets a corresponding Diagnostic Trouble Code (DTC).

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

Pinpoint Diagnostics With ServiceMaxx™ Software

Standard Warning – No engine shutdown available.

- RPM - Engine overspeed warning
- ECT - Engine overheat warning

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

2-way Warning – No engine shutdown available.

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

3-way Warning – No engine shutdown available.

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

3-way Protection – Engine shutdown is available if critical condition is detected.

- ECT, EOP, ECL - Same as 3-way Warning
- ECT - Engine overheat critical protection
- EOP - Low engine oil pressure critical protection
- ECL - Low engine coolant level critical protection

Warning – Temperature above specific threshold will illuminate the OWL and set a fault.

Critical – Temperature above specific threshold shuts down the engine and sets a fault.

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

EWPS Programmable Parameters

Engine Warning and Protection System Mode

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

Engine Coolant Temperature (ECT) - WARNING

Specifies temperature threshold where the Oil Warning Lamp (OWL) and warning buzzer turns on.

Engine Coolant Temperature (ECT) - CRITICAL

Specifies temperature threshold where an engine shut-down is commanded.

Engine Oil Pressure Engine RPM Boundary 1

Specifies at what RPM a specified oil pressure (OIL-PRES-CRIT-SPD1) should be detected.

Engine Oil Pressure Engine RPM Boundary 2

Specifies at what RPM a specified oil pressure (OIL-PRES-CRIT-SPD2) should be detected.

Engine Oil Pressure Engine RPM Boundary 3

Specifies at what RPM a specified oil pressure (OIL-PRES-CRIT-SPD3) should be detected.

Engine Oil Warning Pressure for Region 1

Specifies the minimum oil pressure with engine speed greater than (PROT-ENG-SPD1). Failure to meet set-point turns on the OWL and warning buzzer.

Engine Oil Warning Pressure for Region 2

Specifies the minimum oil pressure with engine speed greater than (PROT-ENG-SPD1), but less than (PROT-ENG-SPD2). Failure to meet set-point turns on the OWL and warning buzzer.

Engine Oil Warning Pressure for Region 3

Specifies the minimum oil pressure with engine speed greater than (PROT-ENG-SPD2), but less than (PROT-ENG-SPD3). Failure to meet set-point turns on the OWL and warning buzzer.

Engine Oil Warning Pressure for Region 1

Specifies the minimum oil pressure with engine speed greater than (PROT-ENG-SPD1). Failure to meet set-point commands an engine shut down.

Engine Oil Warning Pressure for Region 2

Specifies the minimum oil pressure with engine speed greater than (PROT-ENG-SPD1), but less than (PROT-ENG-SPD2). Failure to meet set-point commands an engine shut down.

Engine Oil Warning Pressure for Region 3

Specifies the minimum oil pressure with engine speed greater then (PROT-ENG-SPD2), but less than (PROT-ENG-SPD3). Failure to meet set-point will command an engine shutdown.

SPN 94 / FMI 17
Fuel Filter Minder Service Interval Soon

- Replace primary and secondary fuel filters following procedures in the *Engine Operation and Maintenance Manual*.

SPN 94 / FMI 31
Fuel Filter Minder Service Interval Now

- Replace primary and secondary fuel filters immediately following procedures in the *Engine Operation and Maintenance Manual*.

SPN 100 / FMI 1
Engine Oil System below Critical Pressure

- SPN 100 / FMI 1 is set by the ECM, when the engine oil pressure drops below the critical level while the engine is running. The specifications are:
  - 14 kPa (2 psi) @ 700 rpm
  - 83 kPa (12 psi) @ 1400 rpm
  - 152 kPa (22 psi) @ 2000 rpm

- For diagnostics, see Low Oil Pressure Diagnostics (page 116) in the “Engine Symptoms Diagnostics” section of this manual.
- SPN 100 / FMI 1 can be set by an open, circuit short to voltage source in the EOP circuit, a loose or failed EOP sensor, or low oil pressure.
- When SPN 100 / FMI 1 is active, the red stop lamp (also known as oil warning lamp) flashes and sounds an audible signal.

SPN 100 / FMI 18
Engine Oil System below Warning Pressure

- SPN 100 / FMI 18 is set by the ECM when engine oil pressure is lower than expected, while the engine is running. The specifications for the warning are:
  - 34 kPa (5 psi) @ 700 rpm
  - 69 kPa (10 psi) @ 1400 rpm
  - 138 kPa (20 psi) @ 2000 rpm
- For diagnostics, see Low Oil Pressure (page 116) in the “Engine Symptoms Diagnostics” section of this manual.
- SPN 100 / FMI 18 can be set by an open, circuit short to voltage source in the EOP circuit, a loose or failed EOP sensor, or low oil pressure.
- When SPN 100 / FMI 18 is active, the amber warning lamp (also known as the warn engine lamp) is illuminated.

SPN 110 / FMI 0
Engine Coolant System above Critical Temperature

- SPN 110 / FMI 0 is set by the ECM when engine coolant temperature is above 112 °C (234 °F). The ECM illuminates the red stop lamp (also known as oil warning lamp). When temperature drops below 112 °C (234 °F) the fault becomes inactive. For diagnostics, see Coolant Over-Temperature (page 89) in the “Engine Symptoms Diagnostics” section of this manual.

SPN 110 / FMI 15
Engine Coolant System above Warning Temperature

- SPN 110 / FMI 15 is set by the ECM when engine coolant temperature is above 108 °C (226 °F). The ECM illuminates the amber warning lamp (also known as the warn engine lamp). When temperature drops below 108 °C (226 °F) the fault becomes inactive. For diagnostics, see Coolant Over-Temperature (page 89) in the “Engine Symptoms Diagnostics” section of this manual.

SPN 111 / FMI 1
Low Engine Coolant Level

- SPN 111 / FMI 1 is set by the ECM when coolant is low. When the EWPS mode is 3-way protection and SPN 111 / FMI 1 is active, the engine shuts down. The ECM logs engine hours and odometer reading at the time of occurrence. After the shutdown, the engine can be restarted for 30 seconds while the fault is active. When coolant has returned to correct levels, SPN 111 / FMI 1 becomes inactive

NOTE: If the coolant level is correct, do ECL sensor Connector Voltage Check (page 406). An ECL signal short to ground can cause SPN 111 / FMI 1.

SPN 174 / FMI 0
Engine Fuel System above Critical Temperature

- SPN 174 / FMI 0 is set by the ECM when the engine fuel temperature is above 80 °C (176 °F). The ECM illuminates the red stop lamp (also known as oil warning lamp). When temperature drops below 80 °C (176 °F) the fault becomes inactive. For diagnosis, see Fuel Over-Temperature Diagnostics in the “Engine Symptoms Diagnostics” section of this manual.

SPN 174 / FMI 15
Engine Fuel System above Warning Temperature

- SPN 174 / FMI 15 is set by the ECM when the engine fuel temperature is above 70 °C (158 °F). The ECM illuminates the amber warning lamp (also known as the warn engine lamp). When temperature drops below 70 °C (158 °F) the fault becomes inactive. For diagnosis, see Fuel Over-Temperature Diagnostics in the “Engine Symptoms Diagnostics” section of this manual.

SPN 175 / FMI 0
Engine Oil System above Critical Temperature

- SPN 175 / FMI 0 is set by the ECM when the engine oil pressure raises above 140 °C (284 °F) while the engine is running. The ECM illuminates the red stop lamp (also known as oil warning lamp). When temperature drops below 140 °C (284 °F) the fault becomes inactive. For diagnosis, see Oil Over-Temperature Diagnostics in the “Engine Symptoms Diagnostics” section of this manual.

SPN 175 / FMI 15
Engine Oil System above Warning Temperature

- SPN 175 / FMI 15 is set by the ECM when the engine oil temperature raises above 123 °C (254 °F) while the engine is running. The ECM illuminates the amber warning lamp (also known as the warn engine lamp). When temperature drops below 123 °C (254 °F), the fault becomes inactive. For diagnosis, see Oil Over-Temperature Diagnostics in the “Engine Symptoms Diagnostics” section of this manual.

SPN 190 / FMI 0
Engine Overspeed - Most Severe Level

- SPN 190 / FMI 0 is set by the ECM when the engine rpm has exceeded 3900 rpm.

- SPN 190 / FMI 0 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 SPN 190 / FMI 0 is active, the lamp is illuminated. The engine hours and miles of the last two over speed occurrences will be recorded in the engine event log.

SPN 2629 / FMI 15
High Compressor Outlet Temperature

- SPN 2629 / FMI 15 is set by the ECM when turbocharger compressor outlet temperature is above 249 °C (480 °F) and the engine torque is being limited by the derate. When the temperature drops below 235 °C (455 °F) or the engine torque is no longer limited by the derate, the fault will go inactive.

SPN 188 FMI 0 - Engine unable to achieve desired idle speed (too high)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine speed at idle very high	Engine low idle speed > 105% of desired idle speed	Engine Coolant Temperature (ECT) > 158°F (70°C) or < 248°F (120°C)	15 seconds
		Engine speed >/= 400 rpm	
		Vehicle Speed < 1 mph	
		Engine at idle state 700 rpm	
		Engine in running state	
		Not in active regen	
		The Following SPN / FMIs are NOT active: 110 / 3, 110 / 4, 191 / 3, 191 / 4, 636 / 2, 639 / 14, 191 / 1, 191 / 19, 636 / 7, and 637 / 10.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the engine speed is too high at idle.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 188 FMI 0 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 188 FMI 0. No: Go to Step 3.

Step	Action	Decision
3	Check for contaminated fuel. Perform Fuel Quality Check (page 131). Is fuel free of contaminants at this time?	Yes: Go to Step 4. No: Repair fuel contamination problem. After repairs are complete, retest for SPN 188 FMI 0.

Step	Action	Decision
4	Check engine for oil ingestion. Perform Charge Air Cooler (CAC) checks (page 160). Is the CAC system free of engine oil?	Yes: After doing all diagnostic steps, if SPN 188 FMI 0 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair fuel ingestion condition. After repairs are complete, retest for SPN 188 FMI 0.

NOTE: After doing all diagnostic steps, if SPN 188 FMI 0 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 188 FMI 1 - Engine unable to achieve desired idle speed (too low)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine speed at idle very low	Engine low idle speed < 95% of desired idle speed	Engine Coolant Temperature (ECT) > 158°F (70°C) or < 248°F (120°C)	15 seconds
		Engine speed >/= 400 rpm	
		Engine at idle state 700 rpm	
		Vehicle Speed < 1 mph	
		Engine in running state	
		Not in active regen	
		The Following SPN / FMIs are NOT active: 110 / 3, 110 / 4, 191 / 3, 191 / 4, 636 / 2, 639 / 14, 191 / 1, 191 / 19, 636 / 7, and 637 / 10.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the engine idle speed is too low.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Fault Fact

A correctly functioning non-CAN Power Take-Off (PTO) can cause engine to operate below desired idle and set this fault code.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 188 FMI 1 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 188 FMI 1. No: Go to Step 3.

Step	Action	Decision
3	Check for proper PTO operation. Does PTO operate properly?	Yes: Go to Step 4. No: Repair PTO. After repairs are complete, retest for SPN 188 FMI 1.

Step	Action	Decision
4	Inspect air intake system and air filter for restrictions. Is air intake system and air filter free of restrictions?	Yes: Go to Step 5. No: Repair restrictions. After repairs are complete, retest for SPN 188 FMI 1.

Step	Action	Decision
5	Inspect exhaust system for restrictions or physical damage. Are exhaust system free of leaks and physical damage?	Yes: Go to Step 6. No: Repair restrictions. After repairs are complete, retest for SPN 188 FMI 1.

Step	Action	Decision
6	Test engine for bad power cylinders. Perform Blow-by Test and all corresponding tests as necessary (page 160). Do power cylinders test within specifications at this time?	Yes: After doing all diagnostic steps, if SPN 188 FMI 1 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair fuel ingestion condition. After repairs are complete, retest for SPN 188 FMI 1.

NOTE: After doing all diagnostic steps, if SPN 188 FMI 1 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 5395 FMI 0 - Engine unable to achieve desired idle torque (too high)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Idle fuel quantity high	Engine fuel set-point at idle state > 71.4°F (21.9°C)	Engine Coolant Temperature (ECT) > 158°F (70°C)	12 seconds
		Engine speed >/= 400 rpm	
		Engine at idle state 700 rpm	
		Vehicle Speed < 1 mph	
		Engine in running state	
		The Following SPN / FMIs are NOT active: 110 / 3, 110 / 4, 191 / 3, 191 / 4, 636 / 2, 636 / 7, and 637 / 10.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the engine torque is too high at idle.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 5395 FMI 0 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 5395 FMI 0. No: Go to Step 3.

Step	Action	Decision
3	Check for contaminated fuel. Perform Fuel Quality Check (page 131). Is fuel free of contaminants at this time?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5395 FMI 0.

Step	Action	Decision
4	Check engine for oil ingestion. Perform Charge Air Cooler (CAC) checks (page 160). Is the CAC system free of engine oil?	Yes: After doing all diagnostic steps, if SPN 5395 FMI 0 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair oil ingestion condition. After repairs are complete, retest for SPN 5395 FMI 0.

NOTE: After doing all diagnostic steps, if SPN 5395 FMI 0 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 5395 FMI 1 - Engine unable to achieve desired idle torque (too low)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Idle fuel quantity low	Engine fuel setpoint at idle state < 2.35 mg/stk	Engine Coolant Temperature (ECT) > 158°F (70°C)	12 seconds
		Engine speed >/= 400 rpm	
		Engine at idle state 700 rpm	
		Vehicle Speed < 1 mph	
		Engine in running state	
		Not in active regen	
		The Following SPN/FMIs are NOT active: 110/3, 110/4, 191/3, 191/4, 636/2, 636/7, and 637/10.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the engine torque is too low at idle.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Fault Fact

Correctly functioning non-CAN controlled Power Take-Off (PTO) can cause this fault to set.

Associated Faults

SPN 3055 FMI 2, SPN 3055 FMI 15, SPN 3055 FMI 16, SPN 3055 FMI 31.

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 5395 FMI 1 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 5395 FMI 1. No: Go to Step 3.

Step	Action	Decision
3	Inspect air intake system for restrictions. Is air intake system free of restrictions?	Yes: Go to Step 4. No: Repair restriction in air intake system. After repairs are complete, retest for SPN 5395 FMI 1.

Step	Action	Decision
4	Inspect exhaust system for restrictions. Is exhaust system free of restrictions?	Yes: Go to Step 5. No: Repair restriction in exhaust system. After repairs are complete, retest for SPN 5395 FMI 1.

Step	Action	Decision
5	Test engine for bad power cylinders. Perform Blow-by Test and all corresponding tests as necessary (page 160). Do power cylinders test within specifications at this time?	Yes: After doing all diagnostic steps, if SPN 5395 FMI 1 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair fuel ingestion condition. After repairs are complete, retest for SPN 5395 FMI 1.

NOTE: After doing all diagnostic steps, if SPN 5395 FMI 1 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

FCC (Fuel Cooler Control) Valve

SPN	FMI	Condition
522283	3	FCC short to PWR
522283	4	FCC short to GND
522283	5	FCC open load / circuit

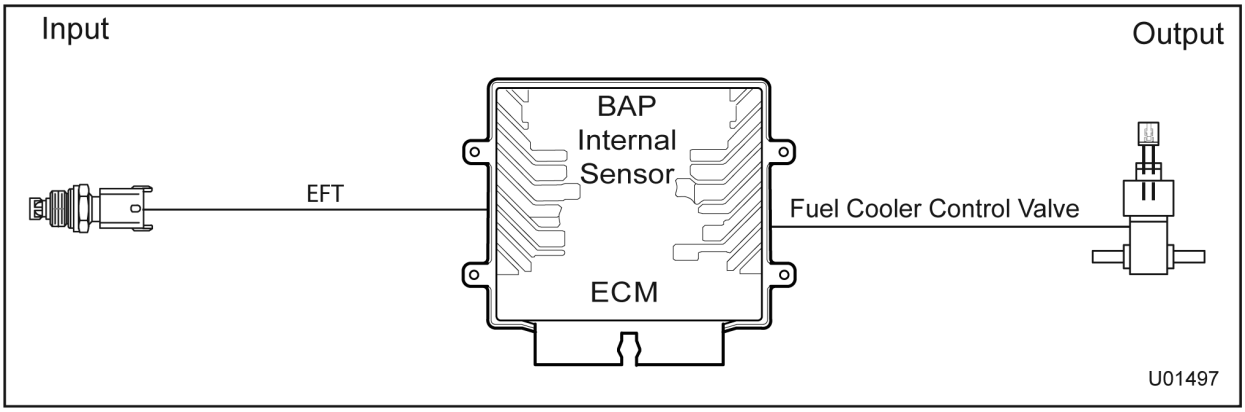


Figure 185 Function diagram for the Fuel Cooler Control Valve

The Fuel Cooler Control Valve function diagram includes the following:

- Fuel Cooler Control Valve
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Engine Fuel Temperature (EFT) sensor

Function

The Fuel Cooler Control Valve is used to redirect coolant through the fuel cooler. The ECM uses the EFT sensor to monitor fuel temperature and controls the Fuel Cooler Control Valve to maintain desired fuel temperature.

Sensor Location

The Fuel Cooler Control Valve is located on the left side radiator core support.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

Fuel Cooler Control Valve Circuit Diagnostics

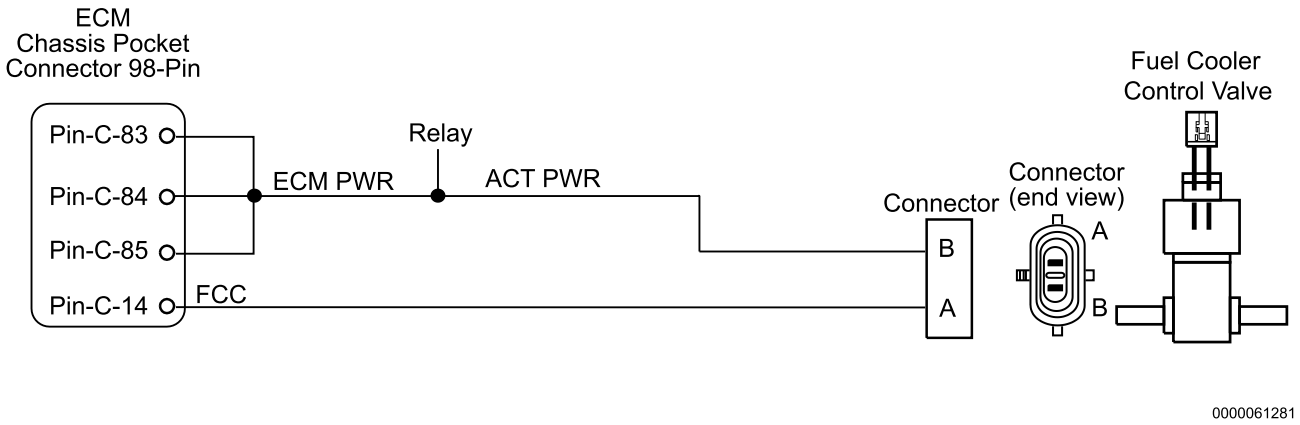


Figure 186 Fuel Cooler Control Valve circuit diagram

Voltage Check at Fuel Cooler Control Valve Connector – Output State Test

Disconnect Fuel Cooler Control Valve solenoid 2-pin connector. Turn the ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comments
A to B+	0 V to B+	If < B+, check for short to power or open circuit. Do Harness Resistance Check (page 535).
B to GND	B+	If < B+, check ACT PWR circuit for OPEN or blown fuse.
Run Output State Test HIGH.		
A to B+	0 V to 0.25 V	If > 0.25 V, check FCC circuit for short to GND.
Run Output State Test LOW.		
A to B+	B+	If < B+, check FCC circuit for OPEN or short to PWR. Do Harness Resistance Check.
B to A	B+	If < B+, check ACT PWR circuit for OPEN. Do Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box. Leave ECM and Fuel Cooler Control Valve disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
C-14 to A	< 5 Ω	If > 5 Ω, check FCC circuit for OPEN.
C-14 to GND	> 1kΩ	If < 1kΩ, check FCC circuit for short to GND.
B to C-83, 84, and 85	< 5 Ω	If > 5 Ω, check ACT PWR for OPEN in circuit.
B to GND	> 1kΩ	If < 1 kΩ, check ACT PWR for short to GND.

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

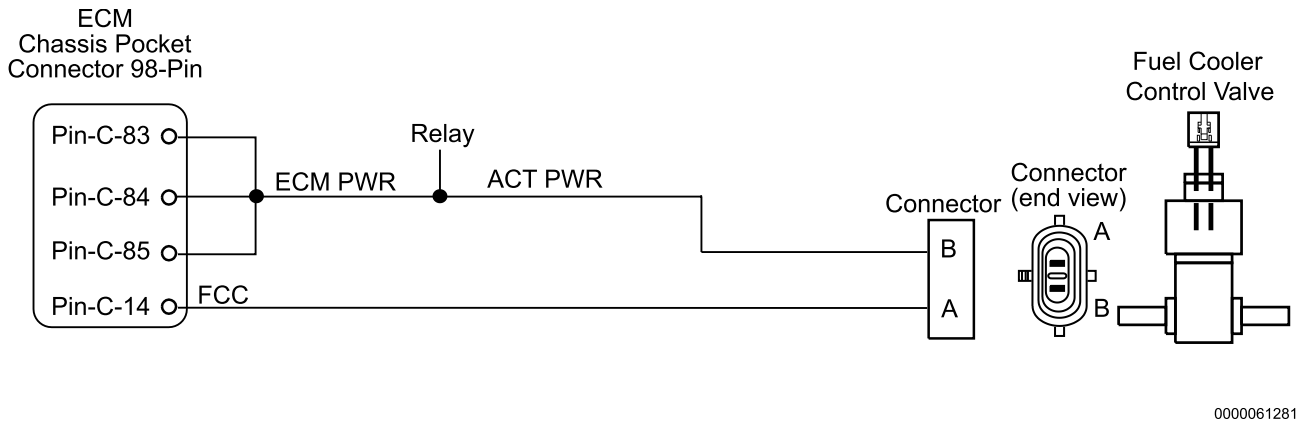


Figure 187 Fuel Cooler Control Valve circuit diagram

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

Fuel Cooler Control Valve Circuit Operation

The Fuel Cooler Control Valve solenoid is supplied ACT PWR at Pin B. The ECM Pin C-14 controls the solenoid by grounding Pin A.

FDP (Fuel Delivery Pressure) Sensor

SPN	FMI	Condition
94	0	Fuel Delivery Pressure above Critical
94	3	FDP signal Out of Range HIGH
94	4	FDP signal Out of Range LOW
94	10	FDP signal abnormal rate of change

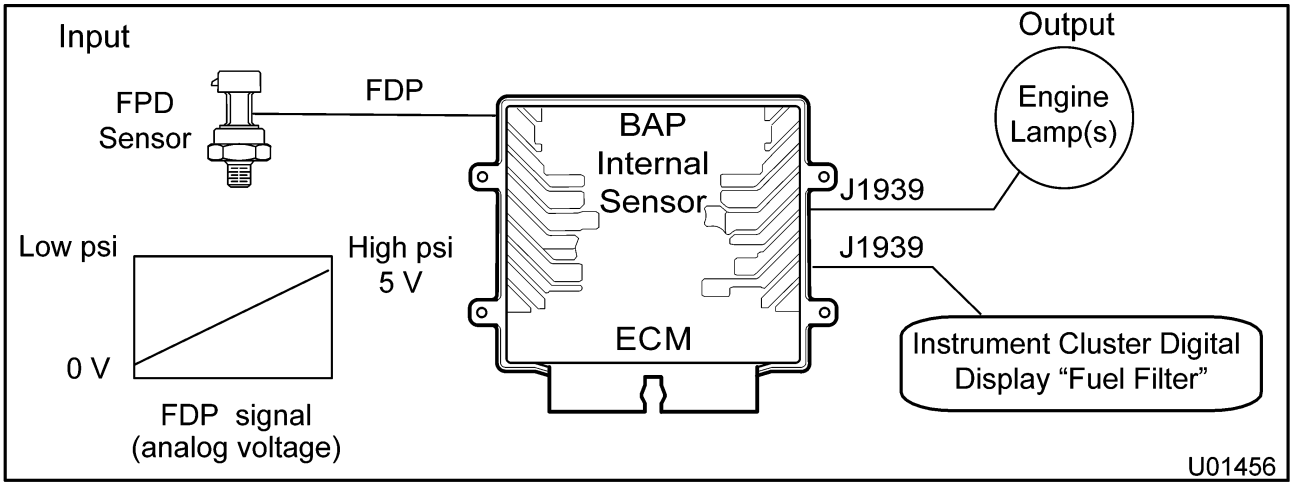


Figure 188 Function diagram for the FDP sensor

The FDP sensor function diagram includes the following:

- Fuel Delivery Pressure (FDP) Sensor
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Engine Lamp(s)
- Fuel filter display message

Function

The FDP sensor provides a feedback signal to the ECM indicating engine fuel supply pressure. During engine operation, if pressure is low, the ECM turns on the "Fuel Filter" display message to alert the operator when the fuel filter needs servicing.

Sensor Location

The FDP sensor is installed in the secondary fuel filter housing on the driver's side of the engine.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit
- Digital Multimeter (DMM)

- 3-Banana Plug Harness ZTSE4498
- 1180–N4–0X0 – 180-Pin Breakout Box
- Breakout Harness ZTSE6038 (FDP)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

FDP Sensor End Diagnostics

SPN	FMI	Condition	Possible Causes
94	0	Fuel Delivery Pressure above Critical	• Failed or restricted fuel regulator valve • Restricted fuel return line • High suction pressure at low-pressure fuel pump inlet • Low-pressure fuel pump electrical problem
94	3	FDP signal Out of Range HIGH	• FDP signal circuit short to PWR • Failed sensor
94	4	FDP signal Out of Range LOW	• FDP signal circuit OPEN or short to GND • VREF circuit OPEN or short to GND • Failed sensor
94	10	FDP signal abnormal rate of change	• Biased circuit or sensor

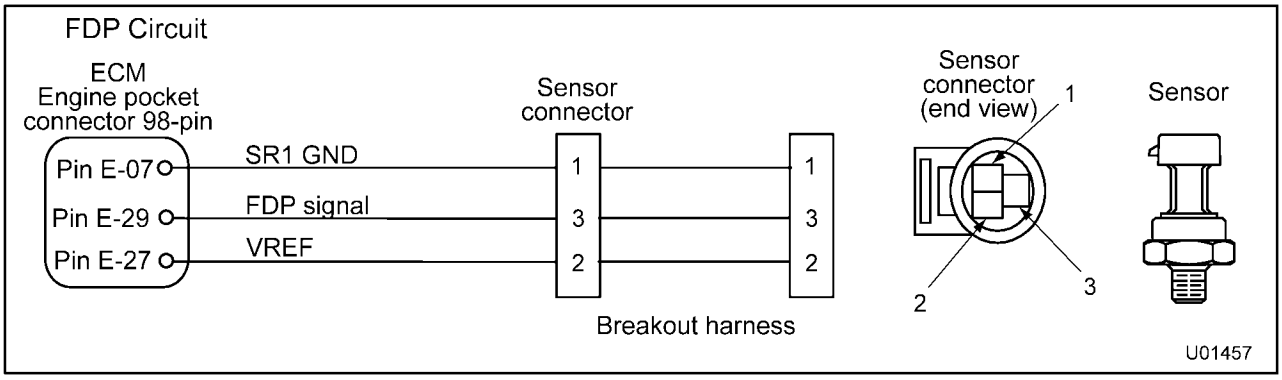


Figure 189 FDP circuit diagram

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

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, open the Continuous Monitor session
2. Verify sensor voltage is within KOEO specification. See “Appendix A: Performance Specifications” (page 813).

3. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If code is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
4. Disconnect engine harness from sensor.

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

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

SPN 94 FMI 0 – Fuel Delivery Pressure Above Critical

Fuel pressure, restriction, and pump voltage test

1. Go to Fuel System in “PERFORMANCE DIAGNOSTICS” section of this manual to diagnose a restriction, failed regulator valve, and suction problem.
   - If no problems are found, continue to next step.
2. Check voltage / current to low-pressure fuel pump. High voltage will result in higher pressures. Go to Fuel Pump (page 548) in this section.

Sensor Circuit Check

Connect Breakout Harness ZTSE6038. Leave sensor disconnected. Turn the ignition switch to ON. Use Electronic Service Tool (EST) with ServiceMaxx™ software to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	SPN 94 FMI 4	If SPN 94 / FMI 3 is active, check FDP signal for short to PWR.
DMM – Measure volts 2 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 535).
EST - Check DTC Short breakout harness across 2 and 3	SPN 94 FMI 3	If SPN 94 / FMI 4 is active, check FDP signal for OPEN. Do Harness Resistance Check (page 535).
DMM – Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 535).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

FDP Pin-point Diagnostics

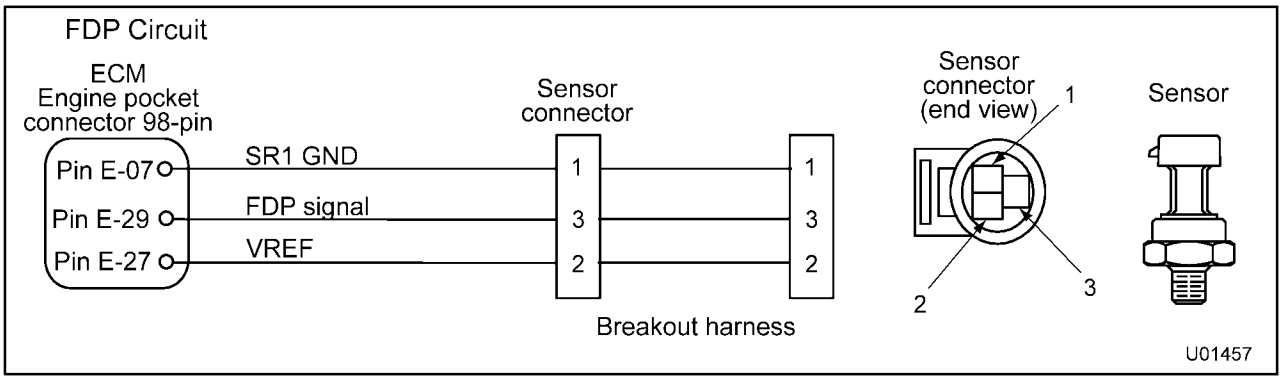


Figure 190 FDP circuit diagram

Connector Voltage Check

Connect Breakout Harness ZTSE6038. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	0 V	If > 0.25 V, check for short to PWR.
2 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 535).
3 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 535).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE6038. Leave sensor disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE6038. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-7	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
2 to E-27	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
3 to E-29	< 5 Ω	If > 5 Ω, check FDP signal circuit for OPEN.

FDP Circuit Operation

The FDP sensor is a variable capacitance sensor supplied with a 5-volt reference voltage at Pin 2 from ECM Pin E-27. The sensor is grounded at Pin 1 from ECM Pin E-7. The sensor returns a variable voltage signal from Pin 3 to ECM Pin E-29.

Fault Detection / Management

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

FPCV (Fuel Pressure Control Valve)

SPN	FMI	Condition
633	3	FPCV short to PWR
633	4	FPCV short to GND
633	5	FPCV open load / circuit
633	6	FPCV Current max limit exceeded

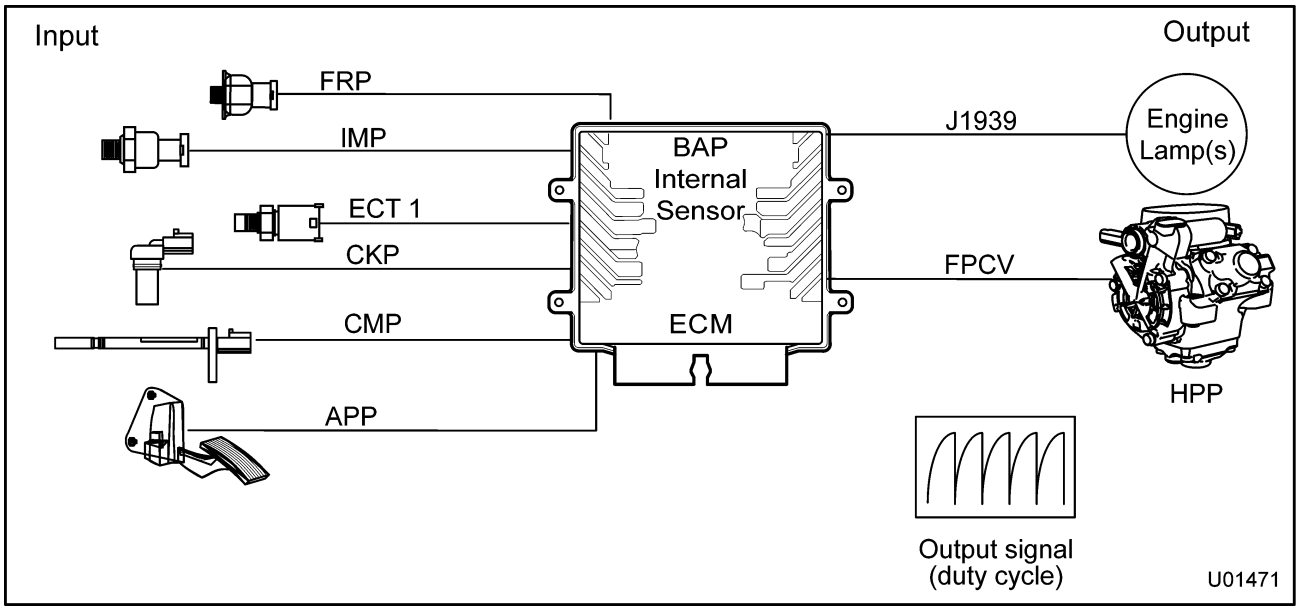


Figure 191 Function diagram for the FPCV

The FPCV function diagram includes the following:

- High-Pressure Pump (HPP) with integrated Fuel Pressure Control Valve (FPCV)
- Engine Coolant Temperature 1 (ECT1) sensor
- Fuel Rail Pressure (FRP) sensor
- Intake Manifold Pressure (IMP) sensor
- Camshaft Position (CMP) sensor
- Crankshaft Position (CKP) sensor
- Accelerator Pedal Position (APP) sensor
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Engine Lamp(s)

Function

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

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

FPCV Location

The FPCV is a nonserviceable part in the HPP. If the FPCV fails, replace the HPP.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 00-00956-08 – 180-Pin Breakout Box
- International® Electronic Engine Terminal Test Kit ZTSE4435C

FPCV Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
633	3	FPCV short to PWR	• FPCV circuit short to PWR • Failed valve
633	4	FPCV short to GND	• FPCV circuit short to GND • Failed valve
633	5	FPCV open load / circuit	• FPCV circuit OPEN • Failed valve
633	6	FPCV current max limit exceeded	• Failed valve

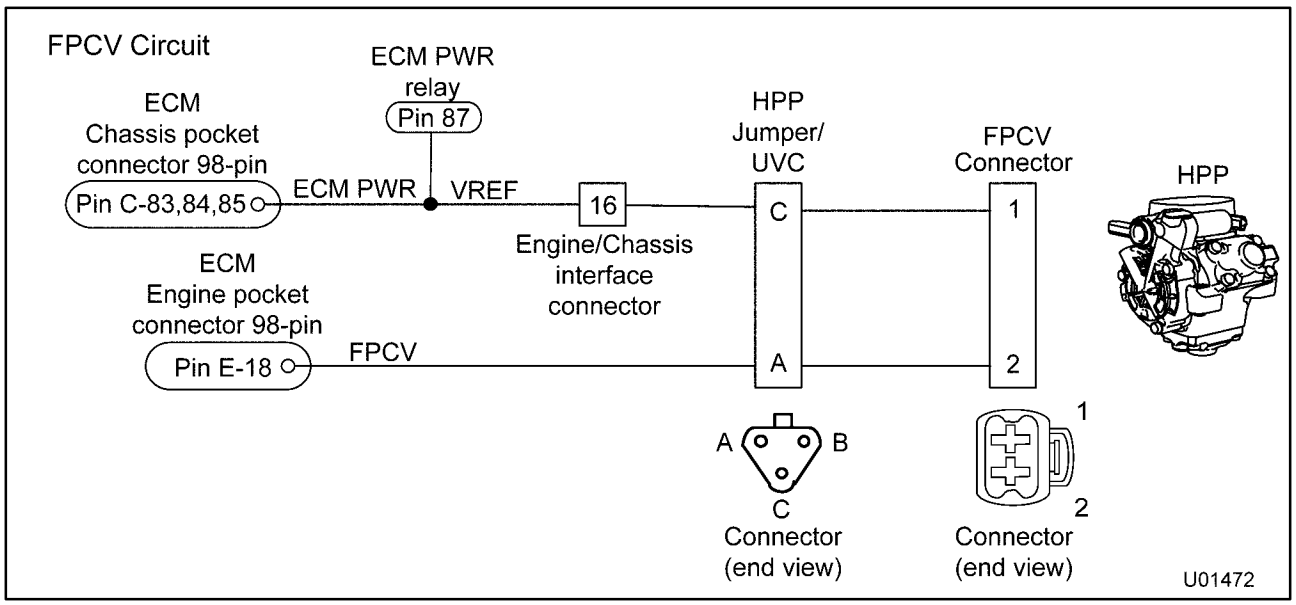


Figure 192 FPCV circuit diagram

Actuator / Harness Resistance Check

Connect 180-Pin Breakout Box to Engine and Chassis harness. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
2 to 1	3.5 +/- 1.5 Ω	If not within specification, check for failed FPCV valve.
E-18 to GND	> 1 k Ω	If < 1 k Ω, check for short to GND or failed FPCV valve.
E-18 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C-83 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.

Operational Voltage Check - Output Circuit Check

Connect 180-Pin Breakout Box between Engine and Chassis harness to ECM. Run KOEO test and Output Circuit Test HIGH and LOW. Use DMM to measure voltage. If unable to run KOEO test, see ECM PWR Relay (page 408) in this section.

Test Point	Test	Spec	Comment
E-18 to GND	Output State LOW	B+	If < B+, check FPCV circuit for short to GRD or internal shorted FPCV valve.
E-18 to GND	Output State HIGH	5.5 V	If < 2.5 V, check FPCV circuit for OPEN or internal OPEN FPCV valve.

FPCV Circuit Operation

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

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

The FVCV governs the amount of fuel supplied to the HPP. The FPCV regulates fuel pressure supplied to the injectors. The HPP delivers fuel to the rail at about 165 MPa (1650 Bar) (23,900 psi).

The FPCV is supplied with VPWR at Pin 1. ECM Pin E-18 controls the valve by duty cycling a ground path to FPCV Pin 2. High duty cycle indicates high pressure and low duty cycle indicates low pressure.

Fault Detection / Management

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

Fuel Pump

SPN	FMI	Condition
4082	2	FPC Relay Circuit Fault
4082	3	FPC short to PWR
4082	4	FPC short to GND
4082	5	FPC open load / circuit

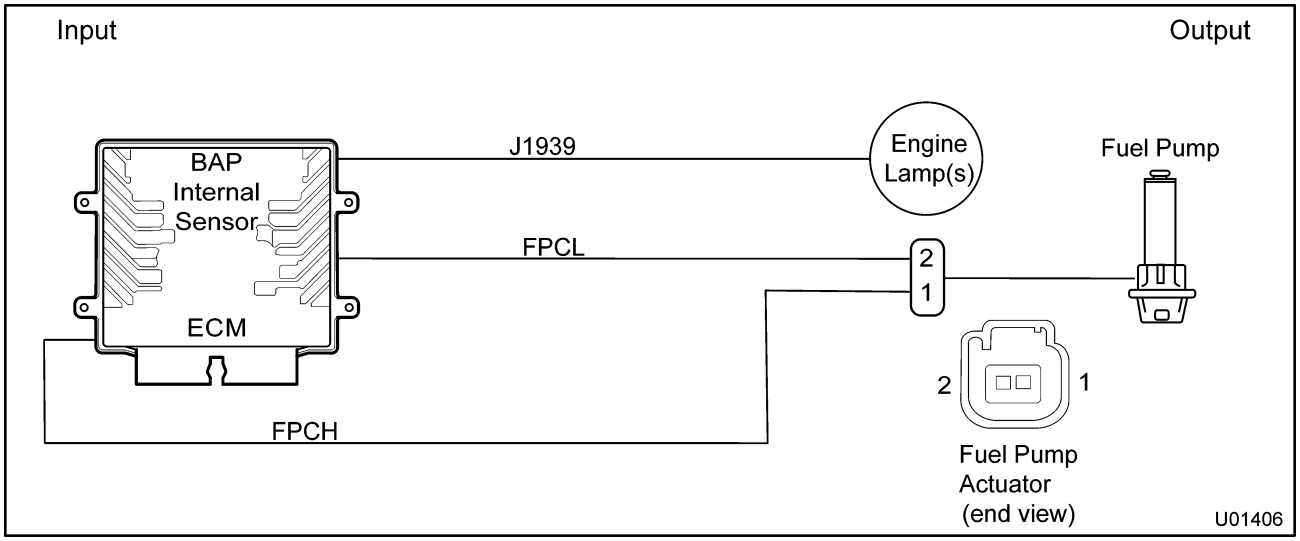


Figure 193 Function diagram for the Fuel Pump

The Fuel Pump function diagram includes the following:

- Fuel pump
- Fuel Pump Control High (FPCH) circuit
- Fuel Pump Control Low (FPCL) circuit
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Engine Lamp(s)

Function

The fuel pump supplies fuel to the engine at approximately 5 psi (34 kPa). The ECM drives the fuel pump directly using H-Bridge driver.

FPC Location

The fuel pump is located in the fuel filter module.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

- Digital Multimeter (DMM)
- 00-00956-08 – 180-Pin Breakout Box
- Breakout Harness ZTSE6001 (FPC)

Fuel Pump Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
4082	2	FPC Relay Circuit Fault	• Failed relay • FPCH circuit OPEN • FPCL circuit OPEN
4082	3	FPC short to PWR	• FPCH circuit shorted to PWR • FPCL circuit shorted to PWR
4082	4	FPC short to GND	• FPCH circuit shorted to GND • FPCL circuit shorted to GND
4082	5	FPC open load / circuit	• FPCH circuit OPEN • FPCL circuit OPEN • Failed fuel pump

Figure 194 Fuel Pump circuit diagram

Connector Voltage Check

Connect Breakout Harness ZTSE6001. Leave actuator disconnected. Turn ignition switch to ON. Use DMM to measure voltage and Run Output State Test High and Low.

Run Output State Test – Low		
Test Point	**Spec**	**Comment**
1 to B+	B+	If < B+, check FPCH for OPEN or short to GND. Do harness resistance check.
2 to B+	B+	If > 0.25 V, check FPCL for short to B+. Do harness resistance check.
Run Output State Test – Low		
1 to GND	B+	If < B+, check FPCH for OPEN or short to GND. Do harness resistance check.
2 to GND	0 V	If > 0.25 V, check FPCL for short to B+. Do harness resistance check.

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE6001. Leave actuator disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE6001. Leave ECM and actuator disconnected. Use DMM to measure resistance.

Test	Spec	Comment
1 to E-80	< 5 Ω	If > 5 Ω, check FPCH circuit for OPEN.
2 to E-79	< 5 Ω	If > 5 Ω, check FPCH circuit for OPEN.

Fuel Pump Actuator

The ECM controls the fuel pump with a Pulse Width Modulation (PWM) signal through H-Bridge circuitry. PWM voltage is supplied by a series of pulses. To control motor speed, it varies (modulates) the width of the pulses. The ECM controls the fuel pump by driving the FPCH circuit high and low.

Fault Detection / Management

An OPEN or short FPCH or FPCL circuit will be detected while fuel pump command is ON or during the on-demand output circuit check during the KOEO standard test. If there is a circuit fault, a DTC is set.

FRP (Fuel Rail Pressure) Sensor

SPN	FMI	Condition	Possible Causes	Actions
157	3	FRP signal Out of Range HIGH	• FRP signal circuit short to PWR • SIG GND circuit OPEN • Failed sensor	Pin-Point Diagnostics (page 554)
157	4	FRP signal Out of Range LOW	• FRP signal circuit short to GND • Failed sensor	Pin-Point Diagnostics (page 554)
157	9	Fuel Rail Pressure (FRP) Abnormal Rate of Change	• Biased FRP sensor • FRP circuit fault	Step-Based Diagnostics (page 558)
157	10	Fuel Rail Pressure (FRP) Abnormal Rate of Change	• Biased FRP sensor • FRP circuit fault	Step-Based Diagnostics (page 561)
157	13	FRP Above KOEO Spec	• Biased FRP sensor • Fuel return restrictions • Fuel Pressure Control Valve (FPCV)	Step-Based Diagnostics (page 564)

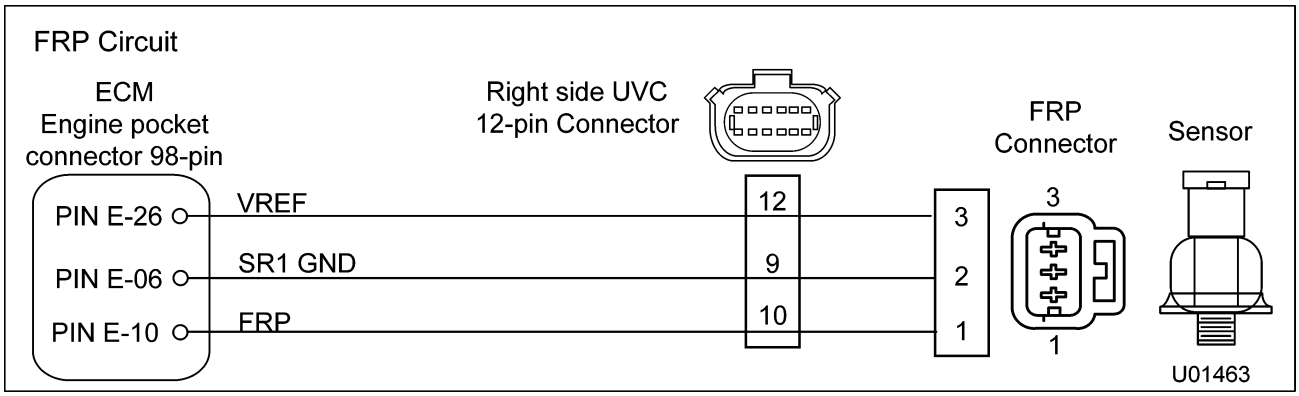


Figure 195 FRP circuit diagram

Overview

The FRP sensor is a micro strain gauge sensor supplied with a 5-volt reference voltage at Pin 3 from ECM Pin E-26. The sensor is grounded at Pin 2 from ECM Pin E-06. The sensor returns a variable voltage signal from Pin 1 to ECM Pin E-10. The FRP sensor provides a feedback signal to the ECM indicating fuel rail pressure. The ECM monitors FRP as the engine is operating to control the FPCV and FVCV. This is a closed loop function in which the ECM continuously monitors and adjusts for ideal FRP determined by conditions such as load, speed, and temperature.

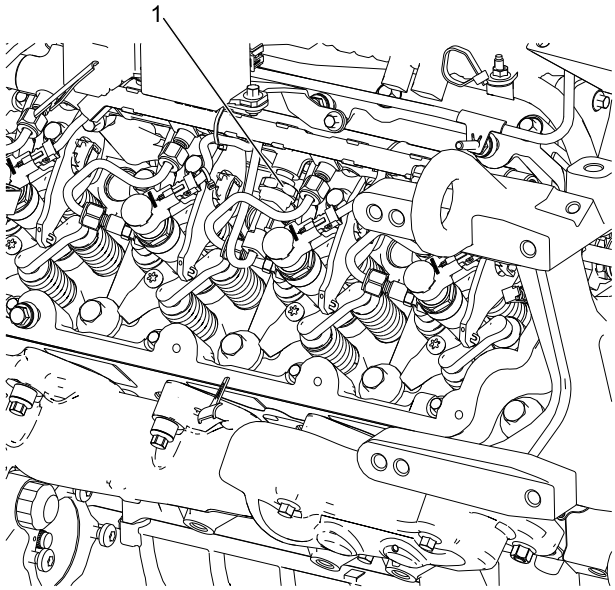


Figure 196 FRP Sensor Location

1. FRP Sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- Breakout Harness ZTSE6038 (FRP)
- 00–00956–08 - 180-Pin Breakout Box
- International® Electronic Engine Terminal Test Kit ZTSE4435C

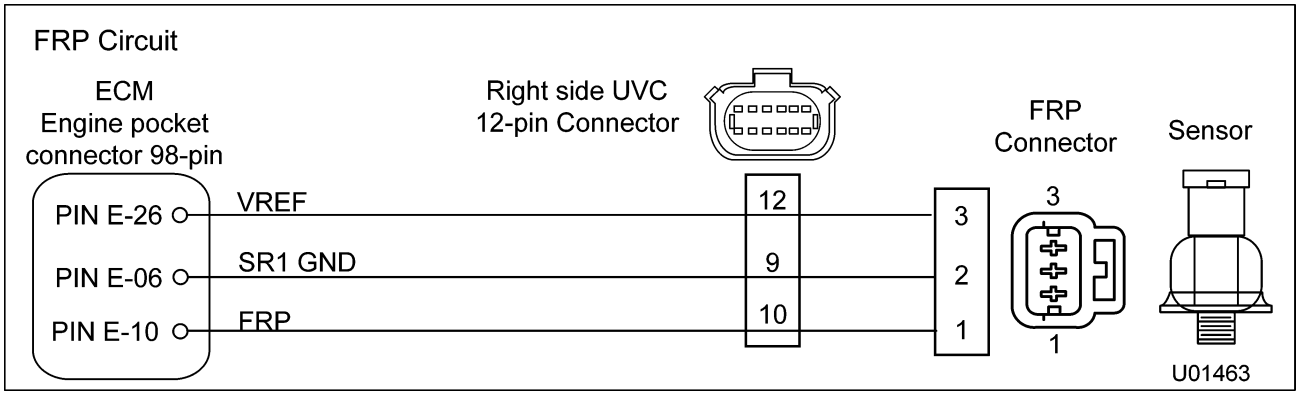


Figure 197 FRP circuit diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

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

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, open the Continuous Monitor session.
2. Verify sensor voltage is within KOEO specifications. See “Appendix B: Signal Values” (page 819).
3. Monitor sensor voltage. Verify active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the fault goes active.
   - If DTC is active, proceed to the next step.
4. Disconnect engine harness from sensor.

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

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

Sensor Circuit Check

Disconnect 12-pin UVC connector from right cylinder head. Turn the ignition switch to ON. Use Electronic Service Tool (EST) with ServiceMaxx™ software to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC Short breakout harness across 10 and 12	SPN 157 FMI 3	If SPN 157 / FMI 4 is active, check FRP signal for short to GND.
DMM - Measure resistance 9 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 557).
EST - Check DTC Short breakout harness across 10 and 9	SPN 157 FMI 4	If SPN 157 / FMI 3 is active, check FRP signal for OPEN. Do Harness Resistance Check (page 557).
DMM - Measure volts 12 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 557).
If checks are within specification, connect 12-pin UVC connector and clear DTCs. If active DTC remains, check under valve cover harness for OPEN or shorts. If okay, replace sensor.		

Connector Voltage Check

WARNING: To prevent personal injury or death, engine must not be running when performing voltage checks on injector circuits. With engine running, injector circuits have high voltage and amperage.

Connect Breakout Harness ZTSE6038 to 12-pin UVC connector from right cylinder head. Leave UVC harness disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
9 to B+	B+	If < B+, check for short to power, or open circuit.
10 to GND	5 V ± 0.5 V	If > 5.5 V, check FRP for short to PWR. If < 4.5 V, check FRP for OPEN or short to GND. Do Harness Resistance Check (page 557).
12 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 557).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect 12-pin UVC harness to right cylinder head. Leave UVC harness disconnected. Use DMM to measure resistance.

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

Under Valve Cover Resistance Check to Engine GND

Connect Breakout Harness ZTSE6038 to UVC 12-pin connector (right side). Leave engine harness disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Remove right valve cover. Connect 180-Pin Breakout Box and Breakout Harness ZTSE6038 to engine. Leave ECM and FRP sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-06 to 2	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
E-06 to GND	> 1 k Ω	If < 1 k Ω, check for short to GND.
E-10 to 1	< 5 Ω	If > 5 Ω, check FRP signal circuit for OPEN.
E-10 to GND	> 1 k Ω	If < 1 k Ω, check for short to GND.
E-26 to 3	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
E-26 to GND	> 1 k Ω	If < 1 k Ω, check for short to GND.

SPN 157 FMI 9 - Fuel Rail Pressure (FRP) Abnormal Rate of Change

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel Rail Pressure (FRP) Abnormal Rate of Change	Instantaneous difference of any two consecutive Engine Injector Metering Rail 1 Pressure sensor values * (1/0.01 seconds) > 40 MPa	Key ON The following SPN / FMIs are not active: SPN FMI's 3509/3, 3509/4, 3510/3, 3510/4, 3511/3, 3511/4.	0.03 second

Fault Overview

Fault sets when the FRP changes more than 5800 psi (40 MPa) within 0.03 seconds.

Amber Warning Lamp (AWL) Reaction

When fault is active, the Amber Warning Lamp (AWL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

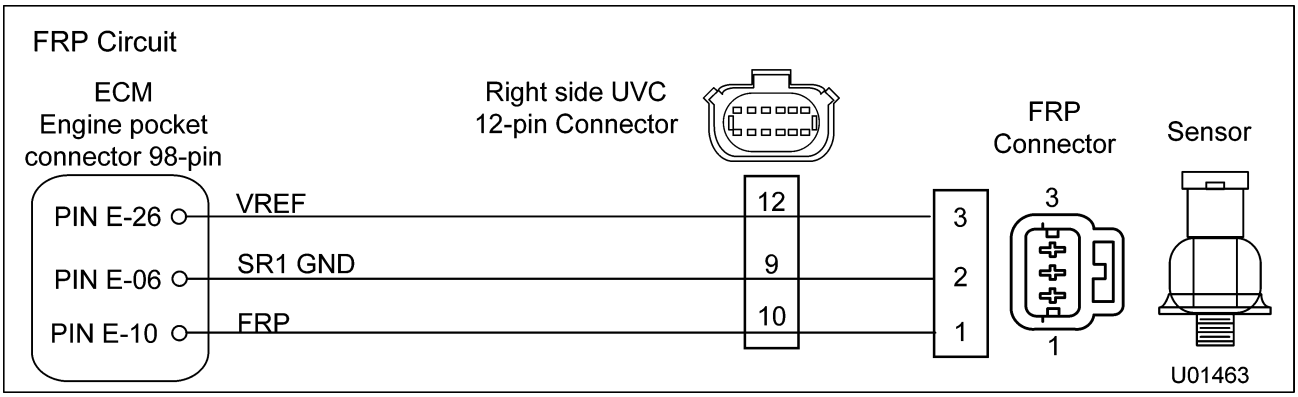


Figure 198 FRP circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 157 FMI 9 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 157 FMI 9. No: Go to Step 3.

Step	Action	Decision
3	Inspect connection at Under Valve Cover (UVC) connector. Key OFF, disconnect UVC connector. Check UVC connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the UVC connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 157 FMI 9.

Step	Action	Decision
4	Test FRP circuits from ECM to UVC for open, short, or high resistance conditions. Do connector voltage checks and resistance checks. Are FRP circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 157 FMI 9.

Step	Action	Decision
5	Inspect connection at FRP connector. Key OFF, disconnect FRP connector. Check FRP connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are FRP connector, harness, and terminals clean and undamaged?	Yes: Go to Step 6. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 157 FMI 9.

Step	Action	Decision
6	Test FRP circuits between UVC and FRP for open, short, or high resistance conditions. Do harness resistance check Do connector voltage checks and resistance checks (page 556). Are FRP sensor circuits within specifications?	Yes: Go to Step 7. No: Repair circuits as required. After repairs are complete, retest for SPN 157 FMI 9.

Step	Action	Decision
7	Connect FRP and UVC connectors without installing valve cover. Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test. Does circuit operate properly?	Yes: Go to Step 8. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuits as required. After repairs are complete, retest for SPN 157 FMI 9.

Step	Action	Decision
8	Test FRP sensor. Connect breakout harness 6038 between FRP sensor and FRP sensor connector. Perform KOEO voltage check of FRP sensor between FRP signal and ground. Is voltage within specifications?	Yes: After doing all diagnostic steps, if SPN 157 FMI 9 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace FRP sensor. After repairs are complete, retest for SPN 157 FMI 9.

NOTE: After doing all diagnostic steps, if SPN 157 FMI 9 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 157 FMI 10 - Fuel Rail Pressure (FRP) Abnormal Rate of Change

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel Rail Pressure (FRP) Abnormal Rate of Change	Instantaneous difference of any two consecutive Engine Injector Metering Rail 1 Pressure sensor values * (1/0.01 seconds) > 40 MPa	Key ON The following SPN / FMIs are not active: SPN FMI's 3509/3, 3509/4, 3510/3, 3510/4, 3511/3, 3511/4.	0.03 second

Fault Overview

Fault sets when the FRP changes more than 5800 psi (40 MPa) within 0.03 seconds.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

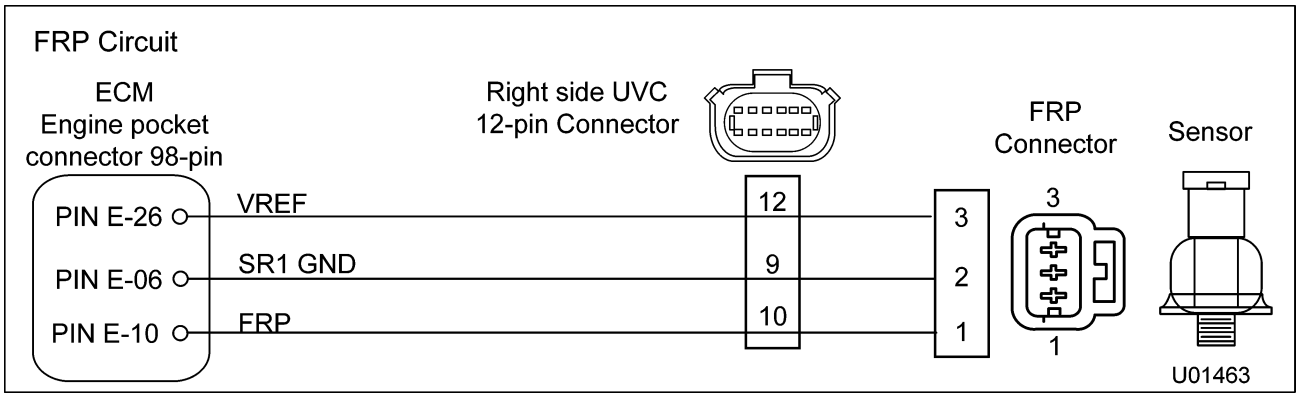


Figure 199 FRP circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 157 FMI 10 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 157 FMI 10. No: Go to Step 3.

Step	Action	Decision
3	Inspect connection at Under Valve Cover (UVC) connector. Key OFF, disconnect UVC connector. Check UVC connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the UVC connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 157 FMI 10.

Step	Action	Decision
4	Test FRP circuits from ECM to UVC for open, short, or high resistance conditions. Do connector voltage checks and resistance checks. Are FRP circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 157 FMI 10.

Step	Action	Decision
5	Inspect connection at FRP connector. Key OFF, disconnect FRP connector. Check FRP connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are FRP connector, harness, and terminals clean and undamaged?	Yes: Go to Step 6. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 157 FMI 10.

Step	Action	Decision
6	Test FRP circuits between UVC and FRP for open, short, or high resistance conditions. Do harness resistance check Do connector voltage checks and resistance checks (page 556). Are FRP sensor circuits within specifications?	Yes: Go to Step 7. No: Repair circuits as required. After repairs are complete, retest for SPN 157 FMI 10.

Step	Action	Decision
7	Connect FRP and UVC connectors without installing valve cover. Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test. Does circuit operate properly?	Yes: Go to Step 8. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuits as required. After repairs are complete, retest for SPN 157 FMI 10.

Step	Action	Decision
8	Test FRP sensor. Connect breakout harness 6038 between FRP sensor and FRP sensor connector. Perform KOEO voltage check of FRP sensor between FRP signal and ground. Is voltage within specifications?	Yes: After doing all diagnostic steps, if SPN 157 FMI 10 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace FRP sensor. After repairs are complete, retest for SPN 157 FMI 10.

NOTE: After doing all diagnostic steps, if SPN 157 FMI 10 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 157 FMI 13 - FRP Above KOEO Spec

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel pressure offset check	Engine injector metering rail 1 pressure sensor reading > 1740 psi (12 MPa).	Time after key OFF > 2.55 seconds	0.1 second
		The following SPN / FMIs are not active: SPN FMIs 3509/3, 3509/4, 3510/3, 3510/4, 3511/3, 3511/4, 157/3, and 157/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the Fuel Rail Pressure (FRP) sensor value is above the Key On Engine OFF (KOEO) specification of 12 MPa.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

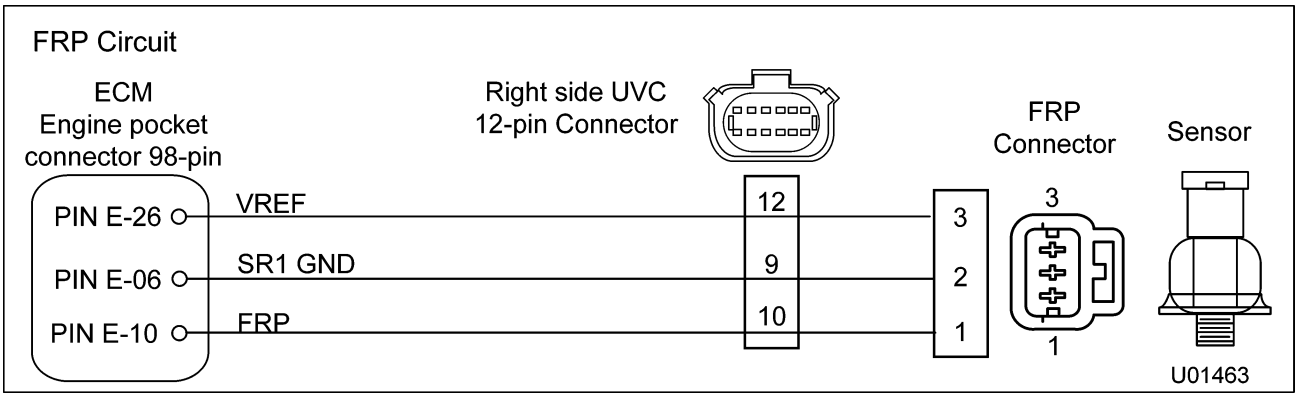


Figure 200 FRP circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 157 FMI 13 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 157 FMI 13. No: Go to Step 3.

Step	Action	Decision
3	Test fuel return system for restrictions. Do Fuel Return Restriction Test(page 148). Is fuel return system operating properly?	Yes: Go to Step 4. No: Repair restriction in fuel return system. After repairs are complete, retest for SPN 157 FMI 13.

Step	Action	Decision
4	Inspect connections at Fuel Rail Pressure (FRP) sensor. Key OFF, disconnect FRP sensor connector. Check FRP sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are FRP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 157 FMI 13.

Step	Action	Decision
5	Inspect connections at Fuel Pressure Control Valve (FPCV). Key OFF, disconnect FPCV connector. Check FPCV and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are FPCV connector, harness, and terminals clean and undamaged?	Yes: Go to Step 6. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 157 FMI 13.

Step	Action	Decision
6	Test FRP sensor circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 556). Are FRP sensor circuits within specifications?	Yes: Go to Step 7. No: Repair circuits as required. After repairs are complete, retest for SPN 157 FMI 13.

Step	Action	Decision
7	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform theKey On Engine Off (KOEO) Continuous Monitor Test(page 71). Does circuit operate properly?	Yes: Go to Step 8. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuits as required. After repairs are complete, retest for SPN 157 FMI 13.

Step	Action	Decision
8	Test FRP sensor. Connect breakout harness 6038 between FRP sensor and FRP sensor connector. Perform KOEO voltage check of FRP sensor between FRP signal and ground. Is voltage within specifications?	Yes: Go to Step 9. No: Replace FRP sensor. After repairs are complete, retest for SPN 157 FMI 13.

Step	Action	Decision
9	Test FPCV circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 556). Are FPCV circuits within specifications?	Yes: Go to Step 10. No: Repair circuits as required. After repairs are complete, retest for SPN 157 FMI 13.

Step	Action	Decision
10	Test FPCV for proper operation. Do FPCV and Fuel Volume Control Valve (FVCV) (page 151) checks. Is FPCV operating properly?	Yes: After doing all diagnostic steps, if SPN 157 FMI 13 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace FPCV. After repairs are complete, retest for SPN 157 FMI 13.

NOTE: After doing all diagnostic steps, if SPN 157 FMI 13 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

FRP System Diagnostics

SPN	FMI	Condition	Possible Causes	Actions
3055	0	FRP exceeded maximum	• Fuel Pressure Control Valve (FPCV) / Fuel Volume Control Valve (FVCV) not responding appropriately • FRP sensor not working properly	Pin-Point Diagnostics (page 572)
3055	1	Low fuel pressure at start	• Fuel line leakage • Fuel pump not able to prime up • Transfer case unable to draw fuel from one of the tanks when other tank is almost empty • Previous adaptive values inhibiting FUP control strategy	Pin-Point Diagnostics (page 572)
3055	2	FPCV adaptation in-range fault	• Biased FRP sensor • Fuel line leakage • High-pressure pump failure • FPCV or FVCV sticking / electrical / failed	Step-Based Diagnostics (page 573)
3055	13	Fuel pressure offset check	• The fuel line pressure is unable to fall to desired level after key OFF and before the next key ON • Fuel filter is choked • Ignition switch cycled too fast • Fuel pump does not shut off at key OFF and valves remain open • High hydraulic resistance in low pressure return line	Pin-Point Diagnostics (page 572)

3055	15	FRP below minimum with maximum command	• Low Fuel Delivery Pressure (FDP) • Aerated fuel delivery • Restricted fuel supply lin • Stuck or sticking FPCV • High-pressure fuel system leak	Step-Based Diagnostics (page 574)
3055	16	FRP below minimum with maximum command	• Low FDP • Aerated fuel delivery • Restricted fuel supply line • Stuck or sticking FPCV • High-pressure fuel system leak	Step-Based Diagnostics (page 577)
3055	17	FRP above maximum with minimum command	• Biased FRP sensor or circuit • Stuck or sticking FPCV	Step-Based Diagnostics (page 579)
3055	18	FRP above maximum with minimum command	• Biased FRP sensor or circuit • Stuck or sticking FPCV	Step-Based Diagnostics (page 581)
3055	31	FPCV adaptation in-range fault	• Biased FRP sensor • Fuel line leakage • High-pressure pump failure • FPCV or FVCV sticking / electrical / failed	Step-Based Diagnostics (page 584)

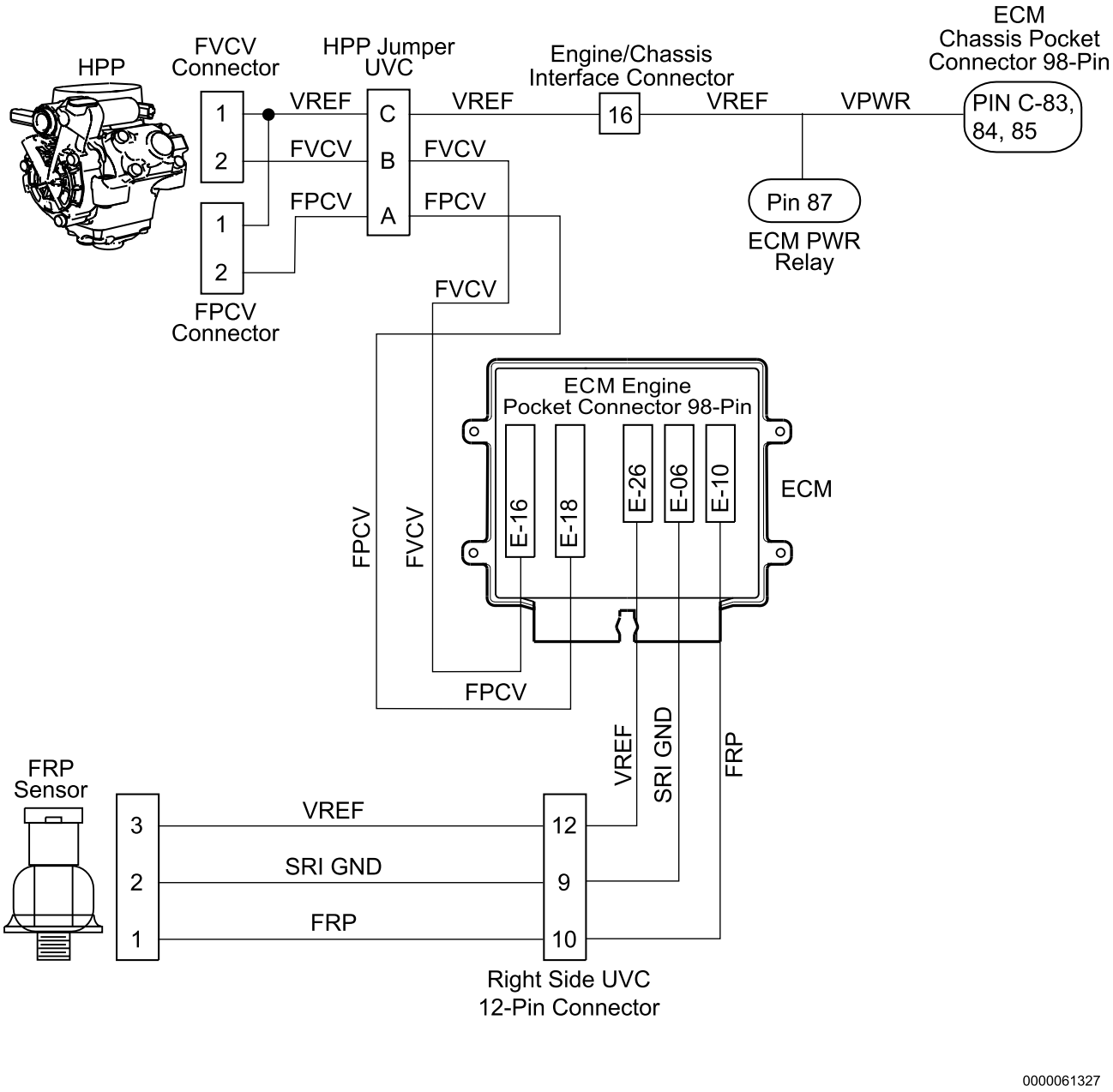


Figure 201 Fuel Rail Pressure System Circuit Diagram

Overview

Filtered fuel is supplied to the High-Pressure Pump (HPP) from the fuel pump and fuel filter. The HPP pressurizes fuel and routes it to separate fuel rails for each engine bank. The fuel rails then supply fuel to each injector through individual supply tubes. The FRP sensor, located in the right side fuel rail, provides a feedback signal to the ECM indicating FRP. The ECM continuously monitors and adjusts for ideal FRP based on load, speed, and temperature conditions.

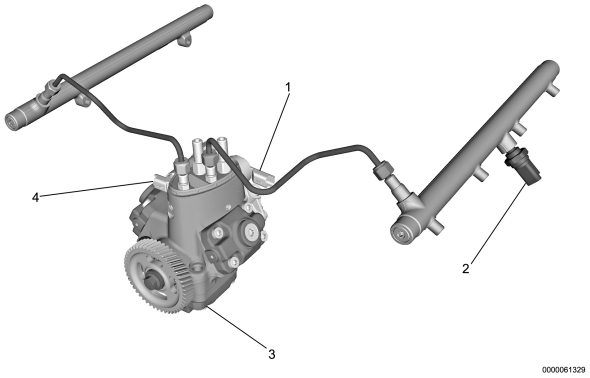


Figure 202 Fuel Rail Pressure System Components

1. Fuel Pressure Control Valve (FPCV)
2. Fuel Rail Pressure (FRP) sensor
3. High Pressure Pump (HPP)
4. Fuel Volume Control Valve (FVCV)

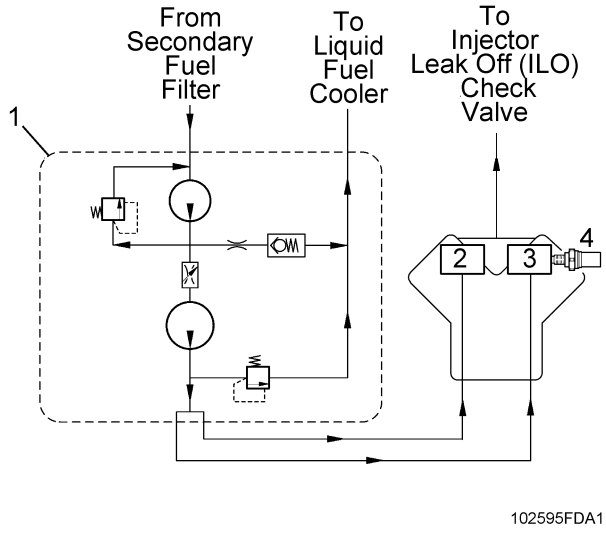


Figure 203 High Pressure Fuel Flow

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

Pin-point FRP System Fault

1. At KOEO, verify FRP sensor is within specification. See “Appendix A: Performance Specifications” (page 813).
2. Check for intermittent circuit faults. Open Continuous Monitor session and wiggle the engine harness while monitoring signals for spikes.
3. Check fuel system for faults. See Fuel System (page 172) in the “Performance Diagnostics” section of this manual.
4. Run KOEO Output State Test to verify FPCV and FVCV are working without an electrical fault. See FPCV (page 543) and FVCV (page 587) subsections in this section of the manual to test these valves.
5. Check the FRP system for leaks. See “Hard Start and No Start Diagnostics” (page 122) section in this manual.

NOTE: After repairing a leak in high-pressure fuel system, fuel pressure adaptation values must be reset. See Fuel System Adaptation Reset (page 75) in the “Diagnostic Software Operation” section of this manual.

SPN 3055 FMI 2 - FPCV adaptation in-range fault

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
FPCV adaptation value lower than expected.	FPCV adaptation value < -3.296 % or > 3.456 %	Fuel gradient threshold < 0.5 mg/stk	0.1 second
		Engine speed gradient < 200 rpm/sec	
		Engine speed > 600 rpm	
		Time after engine start > 30 seconds	
		Engine Coolant Temperature (ECT) > -58°F (-50°C)	
		Rail pressure set-point deviation from FPCV adaptation breakpoint < 363 psi (2500 kPa)	
		Time since last successful adaptation > 2 minutes	
		FPCV mode enabled	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines FPCV adaptation value is lower than expected while being measured over a predetermined amount of time.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3055 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3055 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Test High-pressure fuel system. Refer to High-pressure Fuel System Tests (page 151)in Hard Start-No Start section. Is High-pressure fuel system operating properly at this time?	Yes: After doing all diagnostic steps, if SPN 3055 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair High-pressure fuel system. After repairs are complete, retest for SPN 3055 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 3055 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3055 FMI 15 - Fuel Rail Pressure (FRP) Below Minimum with Maxiumum Command

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel Rail Pressure (FRP) system monitor - negative governor deviation	Rail pressure setpoint minus fuel rail pressure sensor value 100/rail pressure setpoint > 11.9%	1.Engine speed defines OMS Mode = 2 > Threshold speed value as defined in a ECT based table A053	1.65 second
	AND fuel Volume Control Valve (VCV) close loop control command Defines VCV max saturation condition > 4999	2. Monitor inhibit time during engine fuel control state transition fuel control change from PCV state to VCV state = 0.5 Seconds	
	Or fuel Pressure Control Valve (PCV) close loop control command saturated defines PCV max saturation condition > 20	3. Monitor inhibit time during engine fuel control state transition fuel control change from VCV state to PCV state = 0.5 Seconds	

SPN 3055 FMI 15 - Fuel Rail Pressure (FRP) Below Minimum with Maxiumum Command (cont.)

		4. SPN / FMI's 633/3,633/4,633/5,633/6,157/3,157/4,157/10,3509/3, 3509/4,1244/3,1244/4 and 1244/5 are not active.	
		Wait time after entry conditions listed above (1 through 4) are met = 2 Seconds	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines FRP value is lower than expected at minimum command.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3055 FMI 15 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3055 FMI 15. No: Go to Step 3.

Step	Action	Decision
3	Inspect fuel system components for signs of visible leaks. Is the fuel system free of leaks?	Yes: Go to step 4. No: Repair fuel leaks as necessary. After repairs are complete, retest for SPN 3055 FMI 15.

Step	Action	Decision
5	Test Low-pressure fuel system. Refer to Low-pressure Fuel System Tests (page 141) in Hard Start-No Start section. Is Low-pressure fuel system operating properly at this time?	Yes: Go to step 5 No: Repair fuel system as directed by test. After repairs are complete, retest for SPN 3055 FMI 15.

Step	Action	Decision
5	Test High-pressure fuel system. Refer to High-pressure Fuel System Tests (page 151) in Hard Start-No Start section. Is High-pressure fuel system operating properly at this time?	Yes: After doing all diagnostic steps, if SPN 3055 FMI 15 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair fuel system as directed by test. After repairs are complete, retest for SPN 3055 FMI 15.

NOTE: After doing all diagnostic steps, if SPN 3055 FMI 15 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3055 FMI 16 - Fuel Rail Pressure (FRP) Below Minimum with Maxiumum Command

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel Rail Pressure (FRP) system monitor - negative governor deviation	Rail pressure setpoint minus fuel rail pressure sensor value 100/rail pressure setpoint > 11.9%	1.Engine speed defines OMS Mode = 2 > Threshold speed value as defined in a ECT based table A053	1.65 second
	AND fuel Volume Control Valve (VCV) close loop control command Defines VCV max saturation condition > 4999	2. Monitor inhibit time during engine fuel control state transition fuel control change from PCV state to VCV state = 0.5 Seconds	
	Or fuel Pressure Control Valve (PCV) close loop control command saturated defines PCV max saturation condition > 20	3. Monitor inhibit time during engine fuel control state transition fuel control change from VCV state to PCV state = 0.5 Seconds	
		4. SPN / FMI's 633/3,633/4,633/5,633/6,157/3,157/4,157/10,3509/3, 3509/4,1244/3,1244/4 and 1244/5 are not active.	
		Wait time after entry conditions listed above (1 through 4) are met = 2 Seconds	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines FRP value is lower than expected at minimum command.

Amber Warning Lamp (AWL) Reaction

When fault is active, the Amber Warning Lamp (AWL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3055 FMI 16 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3055 FMI 16. No: Go to Step 3.

Step	Action	Decision
3	Inspect fuel system components for signs of visible leaks. Is the fuel system free of leaks?	Yes: Go to step 4. No: Repair fuel leaks as necessary. After repairs are complete, retest for SPN 3055 FMI 16.

Step	Action	Decision
5	Test Low-pressure fuel system. Refer to Low-pressure Fuel System Tests (page 141) in Hard Start-No Start section. Is Low-pressure fuel system operating properly at this time?	Yes: Go to step 5 No: Repair fuel system as directed by test. After repairs are complete, retest for SPN 3055 FMI 16.

Step	Action	Decision
5	Test High-pressure fuel system. Refer to High-pressure Fuel System Tests (page 151) in Hard Start-No Start section. Is High-pressure fuel system operating properly at this time?	Yes: After doing all diagnostic steps, if SPN 3055 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair fuel system as directed by test. After repairs are complete, retest for SPN 3055 FMI 16.

NOTE: After doing all diagnostic steps, if SPN 3055 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3055 FMI 17 - Fuel Rail Pressure (FRP) Above Maximum with Minimum Command

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel Rail Pressure (FRP) system monitor - positive governor deviation	Rail pressure setpoint minus fuel rail pressure sensor value 100 / rail pressure setpoint < -8%	1.Engine speed defines OMS mode = 2 > Threshold speed value as defined in a ECT based table A053	1.1 second
	AND fuel Volume Control Valve (VCV) close loop control command Defines VCV max saturation condition > -2000	2. Monitor inhibit time during engine fuel control state transition fuel control change from PCV state to VCV state = 0.5 Seconds	
	Or fuel Pressure Control Valve (PCV) close loop control command saturated defines PCV min saturation condition	3. Monitor inhibit time during engine fuel control state transition fuel control change from VCV state to PCV state = 0.5 Seconds	
		Wait time after entry conditions listed above (1 through 3) are met = 2 Seconds	
		SPN / FMIs: 633/3,633/4,633/5,633/6,157/3,157/4,157/10,3509/3, 3509/4,1244/3,1244/4 and 1244/5 are not active.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines FRP value is higher than expected at minimum command.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3055 FMI 17 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3055 FMI 17. No: Go to Step 3.

Step	Action	Decision
3	Inspect connection at Under Valve Cover (UVC) connector. Key OFF, disconnect UVC connector. Check UVC connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are FRP circuits within specifications?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3055 FMI 17.

Step	Action	Decision
4	Test FRP circuits from ECM to UVC for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 572). Are FRP circuits within specifications?	Yes: Go to step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 3055 FMI 17.

Step	Action	Decision
5	Inspect connection at Fuel Rail Pressure (FRP) connector. Key OFF, disconnect FRP connector. Check FRP connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the FRP connector, harness, and terminals clean and undamaged?	Yes: Go to step 6. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3055 FMI 17.

Step	Action	Decision
6	Test FRP circuits between UVC and FRP for open, short, or high resistance conditions. Do harness resistance check (page 572). Are FRP circuits within specifications?	Yes: Go to step 7. No: Repair circuits as required. After repairs are complete, retest for SPN 3055 FMI 17.

Step	Action	Decision
7	Test FRP sensor. Connect UVC connector without installing valve cover. Connect breakout harness 6038 between FRP sensor and FRP sensor connector. Perform KOEO voltage check of FRP sensor between FRP signal and ground. Is voltage within specification?	Yes: Go to step 8. No: Replace FRP sensor. After repairs are complete, retest for SPN 3055 FMI 17.

Step	Action	Decision
8	Check for FPCV and FVCV function. Perform High-pressure Fuel System tests. Refer to High-pressure Fuel System Tests (page 151) in Hard Start-No Start section. Are voltage and resistance checks within specification?	Yes: After doing all diagnostic steps, if SPN 3055 FMI 17 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: If not in specification, see FPCV(page 543) or FVCV(page 587) in the Electronic Control Systems Diagnostics section of this manual.

NOTE: After doing all diagnostic steps, if SPN 3055 FMI 17 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3055 FMI 18 - Fuel Rail Pressure (FRP) Above Maximum with Minimum Command

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel Rail Pressure (FRP) system monitor - positive governor deviation	Rail pressure setpoint minus fuel rail pressure sensor value 100/rail pressure setpoint > 11.9%	1.Engine speed defines OMS mode = 2 > Threshold speed value as defined in a ECT based table A053	1.1 second
	AND fuel Volume Control Valve (VCV) close loop control command Defines VCV max saturation condition > -2000	2. Monitor inhibit time during engine fuel control state transition fuel control change from PCV state to VCV state = 0.5 Seconds	
	Or fuel Pressure Control Valve (PCV) close loop control command saturated defines PCV min saturation condition > 20	3. Monitor inhibit time during engine fuel control state transition fuel control change from VCV state to PCV state = 0.5 Seconds	
		Wait time after entry conditions listed above (1 through 3) are met = 2 Seconds	

SPN 3055 FMI 18 - Fuel Rail Pressure (FRP) Above Maximum with Minimum Command (cont.)

		SPN / FMIs: 633/3,633/4,633/5,633/6,157/3,157/4,157/10,3509/3, 3509/4,1244/3,1244/4 and 1244/5 are not active.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines FRP value is higher than expected at minimum command.

Amber Warning Lamp (AWL) Reaction

When fault is active, the Amber Warning Lamp (AWL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3055 FMI 18 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3055 FMI 18. No: Go to Step 3.

Step	Action	Decision
3	Inspect connection at Under Valve Cover (UVC) connector. Key OFF, disconnect UVC connector. Check UVC connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are FRP circuits within specifications?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3055 FMI 18.

Step	Action	Decision
4	Test FRP circuits from ECM to UVC for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 572). Are FRP circuits within specifications?	Yes: Go to step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 3055 FMI 18.

Step	Action	Decision
5	Inspect connection at Fuel Rail Pressure (FRP) connector. Key OFF, disconnect FRP connector. Check FRP connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the FRP connector, harness, and terminals clean and undamaged?	Yes: Go to step 6. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3055 FMI 18.

Step	Action	Decision
6	Test FRP circuits between UVC and FRP for open, short, or high resistance conditions. Do harness resistance check (page 572). Are FRP circuits within specifications?	Yes: Go to step 7. No: Repair circuits as required. After repairs are complete, retest for SPN 3055 FMI 18.

Step	Action	Decision
7	Test FRP sensor. Connect UVC connector without installing valve cover. Connect breakout harness 6038 between FRP sensor and FRP sensor connector. Perform KOEO voltage check of FRP sensor between FRP signal and ground. Is voltage within specification?	Yes: Go to step 8. No: Replace FRP sensor. After repairs are complete, retest for SPN 3055 FMI 18.

Step	Action	Decision
8	Check for FPCV and FVCV function. Perform High-pressure Fuel System tests. Refer to High-pressure Fuel System Tests (page 151) in Hard Start-No Start section. Are voltage and resistance checks within specification?	Yes: After doing all diagnostic steps, if SPN 3055 FMI 18 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: If not in specification, see FPCV(page 543) or FVCV(page 587) in the Electronic Control Systems Diagnostics section of this manual.

NOTE: After doing all diagnostic steps, if SPN 3055 FMI 18 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3055 FMI 31 - FPCV adaptation in-range fault

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
FPCV adaptation value lower than expected.	FPCV adaptation value < -3.296 % or > 3.456 %	Fuel gradient threshold < 0.5 mg/stk	0.1 second
		Engine speed gradient < 200 rpm/sec	
		Engine speed > 600 rpm	
		Time after engine start > 30 seconds	
		Engine Coolant Temperature (ECT) > -58°F (-50°C)	
		Adaptation breakpoints as defined by (Table A087)	
		Rail pressure set-point deviation from FPCV adaptation breakpoint < 363 psi (2500 kPa)	
		Time since last successful adaptation > 120 seconds	
		FPCV mode enabled	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines FPCV adaptation value is lower than expected while being measured over a predetermined amount of time.

Amber Warning Lamp (AWL) Reaction

When fault is active, the Amber Warning Lamp (AWL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3055 FMI 31 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3055 FMI 31. No: Go to Step 3.

Step	Action	Decision
3	Test High-pressure fuel system. Refer to High-pressure Fuel System Tests (page 151) in Hard Start-No Start section. Is High-pressure fuel system operating properly at this time?	Yes: After doing all diagnostic steps, if SPN 3055 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair High-pressure fuel system. After repairs are complete, retest for SPN 3055 FMI 31.

NOTE: After doing all diagnostic steps, if SPN 3055 FMI 31 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

FVCV (Fuel Volume Control Valve)

SPN	FMI	Condition
1244	3	FVCV short to PWR
1244	4	FVCV short to GND
1244	5	FVCV open load / circuit
1244	6	FVCV Current max limit exceeded

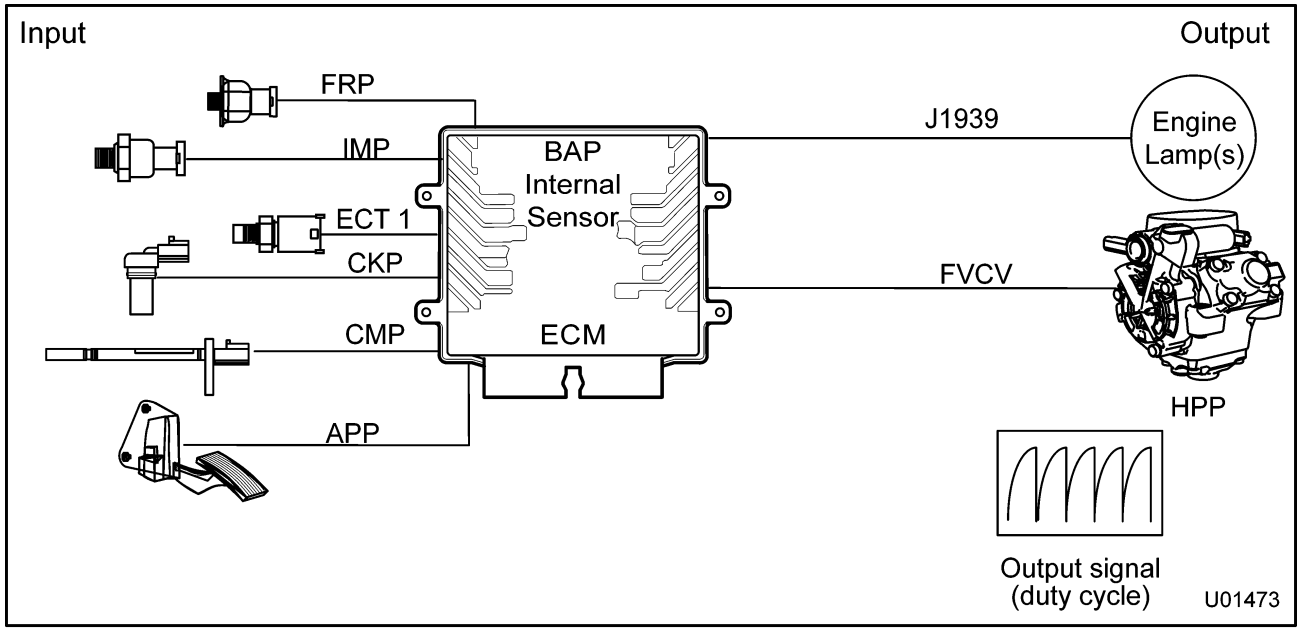


Figure 204 Function diagram for the FVCV

The FVCV function diagram includes the following:

- High-Pressure Pump (HPP) with integrated Fuel Volume Control Valve (FVCV)
- Engine Coolant Temperature 1 (ECT1) sensor
- Fuel Rail Pressure (FRP) sensor
- Intake Manifold Pressure (IMP) sensor
- Camshaft Position (CMP) sensor
- Crankshaft Position (CKP) sensor
- Accelerator Pedal Position (APP)
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Engine Lamp(s)

Function

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

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

FVCV Location

The FVCV is a nonserviceable part in the HPP. If the FVCV fails, replace the HPP.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 00-00956-08 – 180-Pin Breakout Box
- International® Electronic Engine Terminal Test Kit ZTSE4435C

FVCV Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
1244	3	FVCV short to PWR	• FVCV circuit short to PWR • Failed valve
1244	4	FVCV short to GND	• FVCV circuit short to GND • Failed valve
1244	5	FVCV open load / circuit	• FVCV circuit OPEN • Failed valve
1244	6	FVCV Current max limit exceeded	• Failed valve

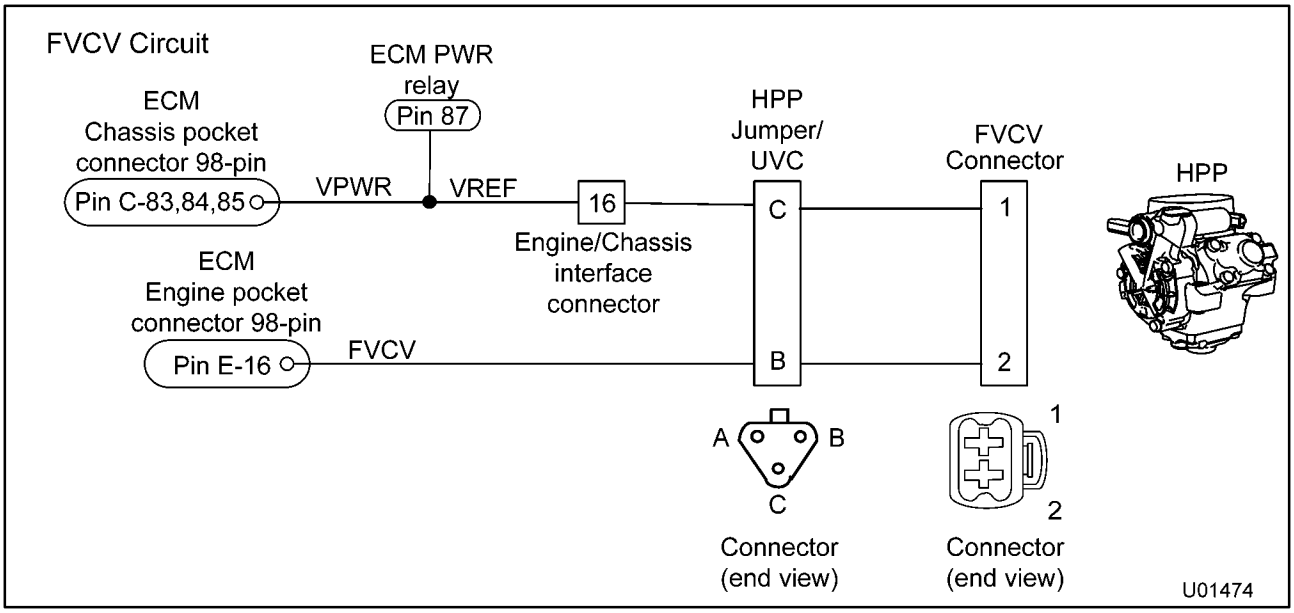


Figure 205 FVCV circuit diagram

Actuator / Harness Resistance Check

Connect 180-Pin Breakout Box to engine and chassis harness. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
2 to 1	3.5 +/- 1.5 Ω	If not within specification, check for failed FVCV valve.
E-16 to GND	> 1 k Ω	If < 1 k Ω, check for short to GND or failed FVCV valve.
E-16 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C-83 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.

Operational Voltage Check - Output Circuit Check

Connect 180-Pin Breakout Box between engine and chassis harness to ECM. Run KOEO test and Output Circuit Test HIGH and LOW. Use DMM to measure voltage. If unable to run KOEO test, see ECM PWR Relay (page 408) in this section.

Test Point	Test	Spec	Comment
E-16 to GND	Output State LOW	B+	If < B+, check FVCV circuit for short to GRD or internal shorted FVCV valve.
E-16 to GND	Output State HIGH	5.5 V	If < 2.5 V, check FVCV circuit for OPEN or internal OPEN FVCV valve.

FVCV Circuit Operation

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

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

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

The FVCV is supplied with VPWR at Pin 1. The ECM Pin E-16 controls the valve by duty cycling a ground path to FVCV Pin 1. High duty cycle indicates high pressure and low duty cycle indicates low pressure.

Fault Detection / Management

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

IAH (Inlet Air Heater)

SPN	FMI	Condition	Possible Causes	Actions
729	2	IAHC Relay Circuit Fault	• IAH diagnostic circuit OPEN • IAH diagnostic circuit shorted to PWR • IAH diagnostic circuit shorted to GND • B+ supply circuit to relay switch OPEN • B+ supply circuit to relay switch shorted to GND • Blown fuse • IAH relay output side circuit OPEN • IAH relay output side circuit shorted to GND • IAH relay output side circuit shorted to PWR • IAH relay control circuit faults • IAH relay failed	Pin-Point Diagnostics (page 594)
729	3	IAHC short to PWR	• IAH relay control circuit shorted to PWR	Pin-Point Diagnostics (page 594)
729	4	IAHC short to GND	• IAH relay control circuit shorted to GND	Pin-Point Diagnostics (page 594)

729	5	IAHC open load / circuit	• IAH relay control circuit OPEN • IAH relay coil GND circuit OPEN • Failed relay coil	Pin-Point Diagnostics (page 594)
729	18	IAH Monitor: lack of heat in the intake manifold	• Heater element failure • Failed CACOT sensor or circuit	Step-Based Diagnostics (page 597)

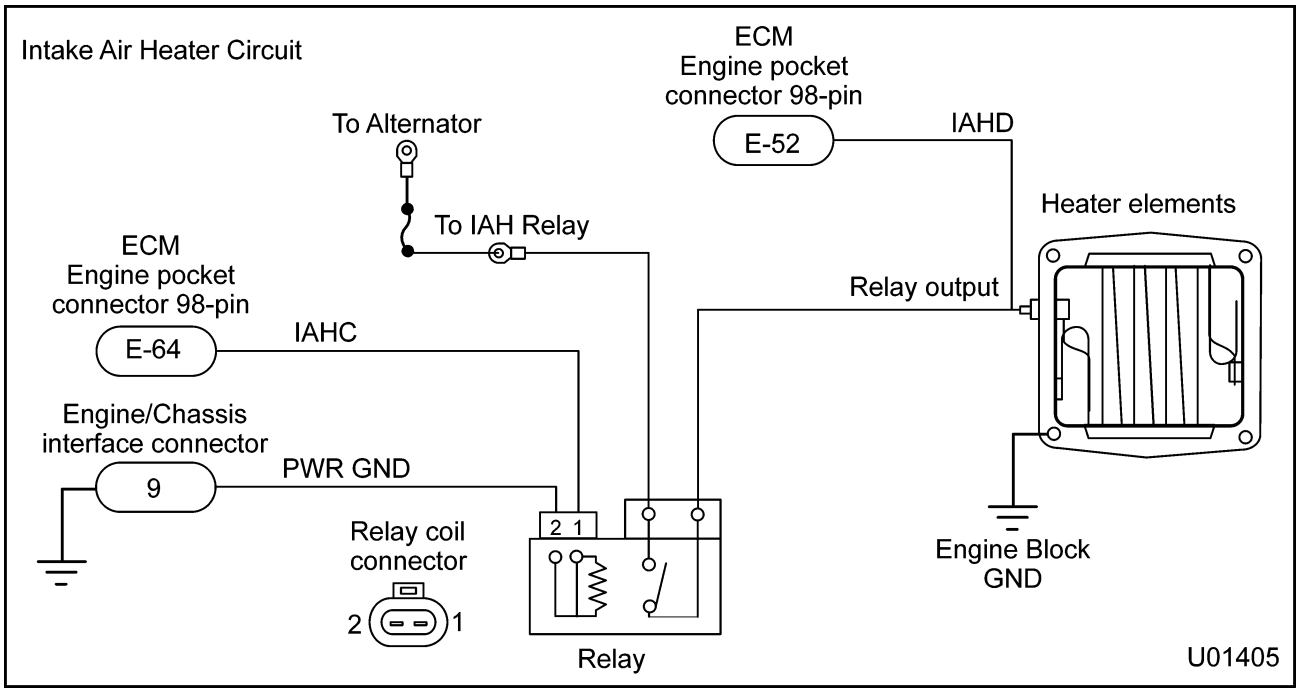


Figure 206 IAH Circuit Diagram

Overview

The IAH system warms the incoming air supply prior to cranking to aid cold engine starting during warmup. The IAH system also assists in reducing white smoke emissions during cold weather conditions.

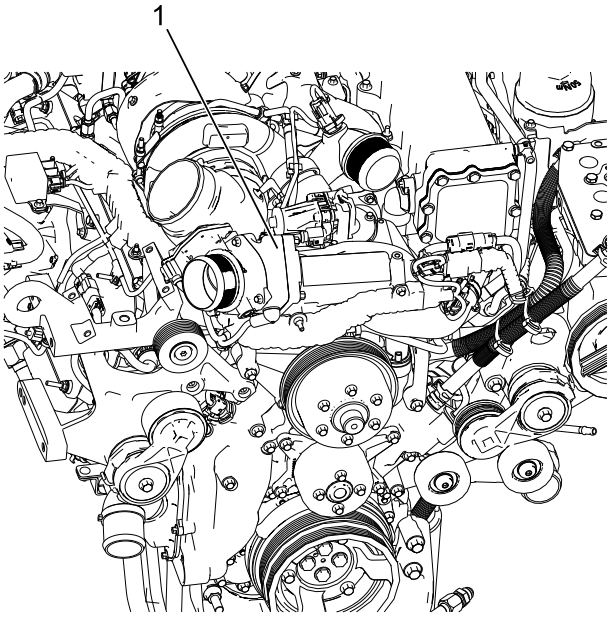


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Figure 207 IAH Location

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- Breakout Harness ZTSE4602 (CACOT)
- Breakout Harness ZTSE6025 (IAH)
- 00–00956–08 - 180-Pin Breakout Box
- International® Electronic Engine Terminal Test Kit

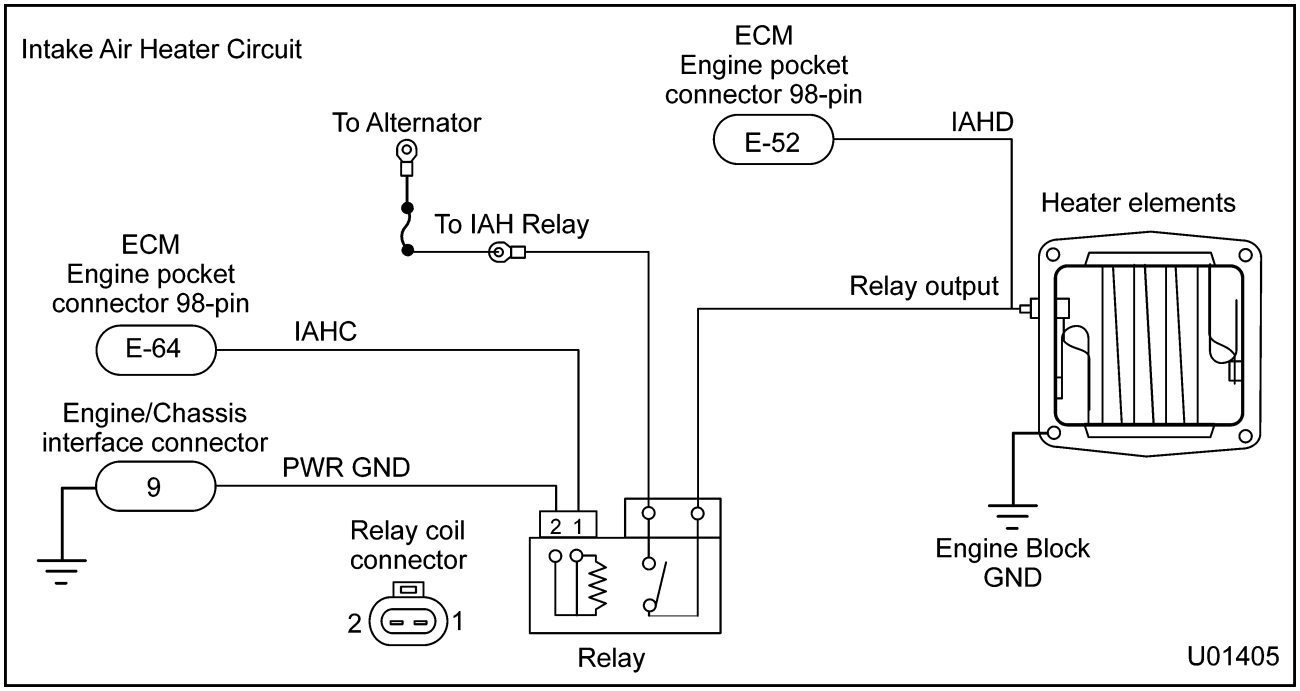

Figure 208 IAH Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

NOTE: For this procedure, run the KOEO Standard Test prior to KOEO Output State Test IAH.

The KOEO Output State Test IAH only enables the relay twice for 45 seconds each to prevent element overheating.

Voltage Check on Relay Switch – Output State Test IAH

Turn ignition switch to OFF. Use DMM to measure voltage on relay B+ side.

Test Point	Spec	Comments
Relay B+ side to GND	B+	If < B+, check large power circuit to relay for OPEN, corroded terminal, or blown fuse link.
Turn ignition switch to ON. KOEO Output State Test IAH. Use DMM to measure voltage when relay is commanded ON.		
Relay Output side to GND	B+	If 0 V, go to Voltage Check on Relay Coil – Output State Test.
Element to GND	B+	If < B+, check for corroded terminals on relay and element. Go to Amperage Check.

Voltage Check on Relay Coil – Output State Test

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

Test Point	Spec	Comment
IAH Relay	0 V	If > 0 V, check for OPEN or short to PWR.
Pin 1 to GND	2.74 V	If < 2 V, check for OPEN or short to GND. Go to Harness Resistance Check – Relay Coil.
Run KOEO Output State Test IAH. Use DMM to measure voltage when relay is commanded on.		
Pin 1 to GND	B+	If < B+, check IAH control circuit for OPEN. Go to Harness Resistance Check – Relay Coil.
Pin 1 to 2	B+	If < B+ check GND circuit for OPEN. Go to harness Resistance Check
If voltage checks at relay coil are okay, but voltage checks at relay switch failed, replace the relay.		

Amperage Draw Check

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

Measure the amperage going to element. Run KOEO Output State Test IAH. Use a DMM with an amp probe. Set DMM to DCmV and zero amp clamp.

Test Point	Spec	Comment
Element	125 A ± 30 A (within 2 seconds)	If 0 A, go to Voltage Check on Relay Switch – Output State Test.
		If > 0 A, but below specification, check for corroded terminals on relay, element, and power source. Go to Element Resistance Check.
If > 0 A, but below specification, and element and wiring check out okay, replace the relay.		

Element Resistance Check

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

Test Point	Spec	Comment
Element to GND	< 0.5 Ω	If > 0.5 Ω, replace failed heater element.

Harness Resistance Check – Relay Coil Circuits

Turn ignition switch to OFF. Connect 180-Pin Breakout Box. Leave ECM and relay disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
IAH Relay	< 5 Ω	If > 5 Ω, check IAH control for OPEN circuit.
Pin 1 to E-64	< 5 Ω	If > 5 Ω, check VREF GND for OPEN circuit.
Pin 2 to GND	< 5 Ω	If > 5 Ω, check pin 2 for OPEN circuit.
E-64 to GND	> 38 Ω ± 5 Ω	If < 33 Ω, check IAH control for short to GND.
		If > 43 Ω, check IAH control circuit for OPEN.

Harness Resistance Check – Relay Switch Circuits

Turn ignition switch to OFF. Use DMM to measure resistance.

Test Point	Spec	Comment
IAH Relay	< 0.5 Ω	Disconnect both battery GND cables. Use DMM to measure resistance.
Output side to element		If > 0.5 Ω, check for OPEN circuit or corroded terminals.

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

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

If circuits and element are within specifications, but failed amperage test, replace the relay.

SPN 729 FMI 18 - IAH Monitor: lack of heat in the intake manifold

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Inlet Air Heater (IAH) rationality check: Check for minimum temperature rise on Charge Air Cooler Outlet Temperature (CACOT) sensor.	Highest CACOT measured within the monitoring window minus CACOT at IAH activation > 9°F (5°C)	Key ON	0.001 seconds
		Engine Throttle Position (ETP) >= 0%	
		Exhaust Gas Recirculation (EGR) Valve Position Command <= 90%	
		Engine speed > 100 rpm and < 3000 rpm and percentage time in monitoring window >=50%	
		Minimum time IAH has been on > 10 seconds	
	Starts when IAH ON rising edge is detected or engine speed > 0 rpm and engine is running for < 0.2 seconds and ends after >= 20 seconds	Air Inlet Temperature (AIT) < 212°F (100°C) and engine OFF timer > 0 seconds Engine Coolant Temperature (ECT) minus AIT > 9°F (5°C) Enable Conditions are met if the following combinations are true: - None of the values are true - One of the vales are true - Two of the values are true If all three of the values are true, enable conditions are not met.	
		The following SPN / FMIs are NOT active: 105/3, 105/4, 2630/3, 2630/4, 110/3, 110/4, 172/3, 172/4, 729/3, 729/4, and 729/5.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the IAH is not heating the intake air at the appropriate rate.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

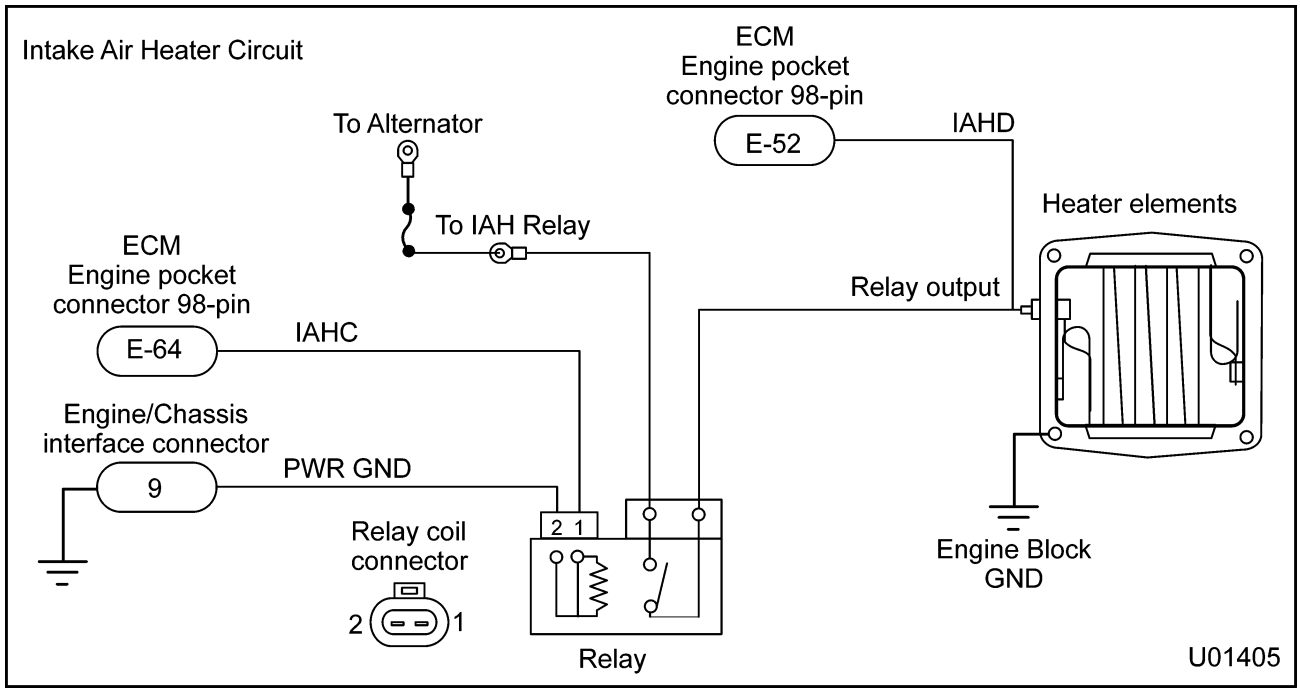

Figure 209 IAH Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 729 FMI 18 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 729 FMI 18. No: Go to Step 3.

Step	Action	Decision
3	Test Inlet Air Heater (IAH) element for proper operation. Perform Element Resistance Check (page 595). Is IAH element within specifications?	Yes: Go to Step 4. No: Replace IAH heater element. After repairs are complete, retest for SPN 729 FMI 18.

Step	Action	Decision
4	Inspect connections at Charge Air Cooler Outlet Temperature (CACOT) sensor. With Key OFF, disconnect CACOT sensor. Check CACOT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the CACOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 729 FMI 18.

Step	Action	Decision
5	Test CACOT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 292). Are CACOT circuits within specifications?	Yes: Go to Step 6. No: Repair circuits as required. After repairs are complete, retest for SPN 729 FMI 18.

Step	Action	Decision
6	Connect breakout harness 4602 between CACOT sensor and CACOT sensor connector. Do KOEO voltage check of CACOT sensor between sensor signal and ground(page 71). Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 729 FMI 18 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair circuits as required. After repairs are complete, retest for SPN 729 FMI 18.

NOTE: After doing all diagnostic steps, if SPN 729 FMI 18 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

IMP (Intake Manifold Pressure) Sensor

SPN	FMI	Condition	Possible Causes	Actions
102	2	IMP signal erratic, intermittent, or incorrect	• IMP biased circuit or sensor • Barometric pressure sensor biased sensor or circuit	Step-Based Diagnostics (page 607)
102	3	IMP signal Out of Range HIGH	• IMP signal circuit short to PWR • Failed sensor	Pin-Point Diagnostics (page 604)
102	4	IMP signal Out of Range LOW	• IMP signal circuit OPEN or short to GND • VREF circuit OPEN • Failed sensor	Pin-Point Diagnostics (page 604)
102	10	Boost slow response fault	• IMP biased circuit or sensor	Pin-Point Diagnostics (page 604)
102	15	Overboost	• Failed IMP sensor or circuit • Turbocharger 2 wastegate stuck closed • Wastegate air supply control solenoid stuck closed • Loss of wastegate air supply	Step-Based Diagnostics (page 610)
102	16	Overboost	• Failed IMP sensor or circuit • Turbocharger 2 wastegate stuck closed • Wastegate air supply control solenoid stuck closed • Loss of wastegate air supply	Step-Based Diagnostics (page 613)
102	18	Underboost	• Restricted air filter • IMP blockage	Step-Based Diagnostics (page 616)

- Charge Air Cooler (CAC) leaks or restrictions
- Exhaust or intake air leaks
- Restricted exhaust
- Turbocharger 2 wastegate stuck open
- Failed turbocharger

IMP Circuit

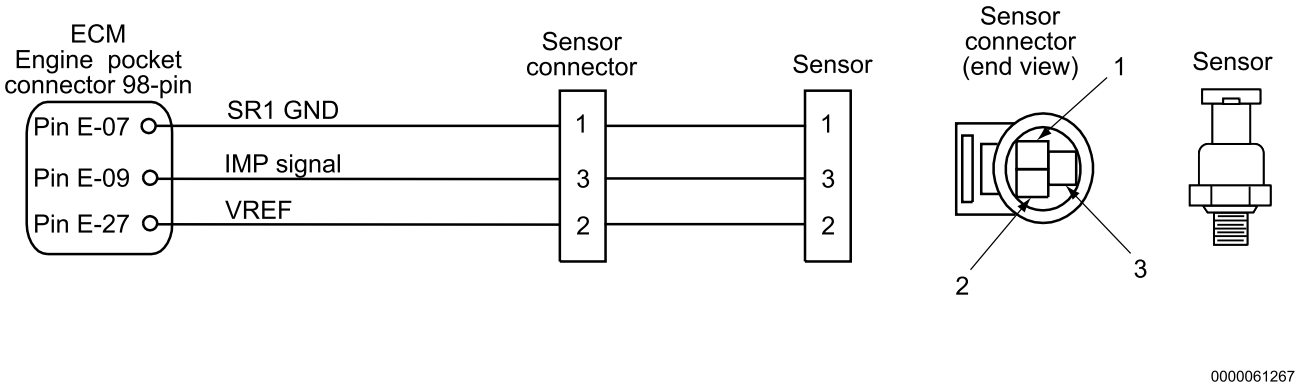

Figure 210 IMP Circuit Diagram

Overview

The Engine Control Module (ECM) uses the IMP sensor signal to assist in the calculation of the Exhaust Gas Recirculation (EGR) and Turbocharger Wastegate Control (TCWC) duty percentage. The ECM monitors the IMP 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.

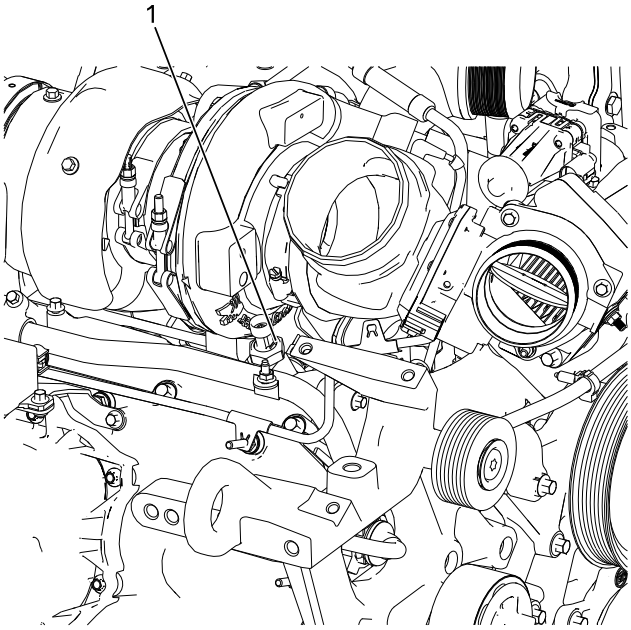

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Figure 211 IMP Sensor Location

1. IMP Sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 00–00956–08 – 180-Pin Breakout Box
- Breakout Harness ZTSE4850 (IMP)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

IMP Circuit

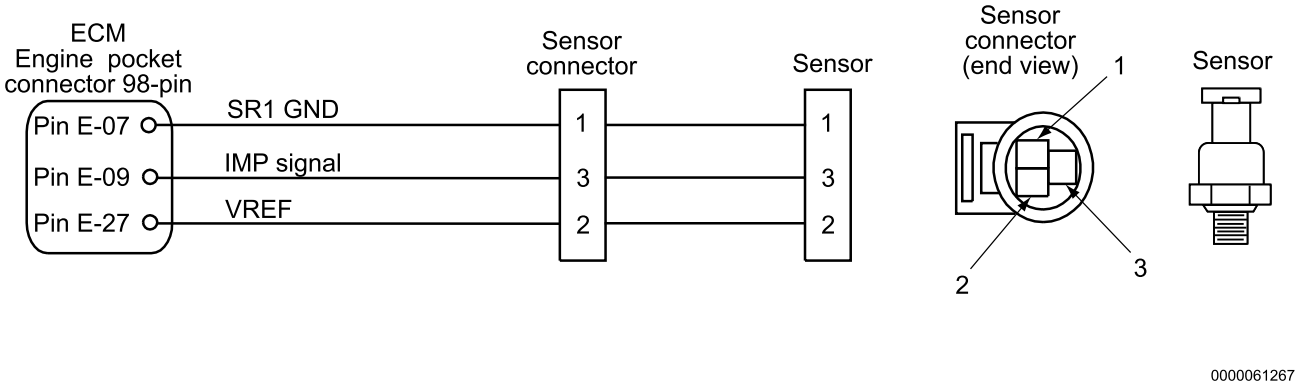


Figure 212 IMP Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

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

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, open the Continuous Monitor session.
2. Verify IMP and BAP are within specification. See “Appendix A: Performance Specifications” (page 813).
3. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
4. Disconnect engine harness from sensor.

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

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

Sensor Circuit Check

Connect sensor Breakout Harness ZTSE4850. Leave sensor disconnected. Turn ignition switch to ON. Use Electronic Service Tool (EST) with ServiceMaxx™ software to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	SPN 102 FMI 4	If SPN 102 / FMI 3 is active, check IMP signal for short to PWR.
DMM – Measure volts 2 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 606).
EST - Check DTC Short breakout harness across 2 and 3	SPN 102 FMI 3	If SPN 102 / FMI 4 is active, check IMP signal for OPEN. Do Harness Resistance Check (page 606).
DMM – Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 606).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

IMP Pin-point Diagnostics

Connector Voltage Check

Connect Breakout Harness ZTSE4850. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to B+	B+	If < B+, check for short to power, or open circuit. Do Harness Resistance Check (page 606).
2 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. If < B+, check for short to power, or open circuit.
3 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 606).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4850. Leave sensor disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4850. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-07	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
2 to E-27	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
3 to E-09	< 5 Ω	If > 5 Ω, check IMP signal circuit for OPEN.

SPN 102 FMI 2 - IMP signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of Intake Manifold Pressure (IMP) with Barometric Pressure (BARO) sensor	Absolute value of {BARO value minus IMP Value} > 2.17 psi (15kPa)	Battery voltage > 8 volts and < 14 volts	0.5 second
		Engine speed = 0 rpm (Defines OMS_Mode =0).	
		The following SPN / FMIs are not active: 108/3, 108/4, 102/3, and 102/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the IMP signal value is incorrect when compared to other sensor values.

Amber Warning Lamp (AWL) Reaction

When fault is active, the Amber Warning Lamp (AWL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

IMP Circuit

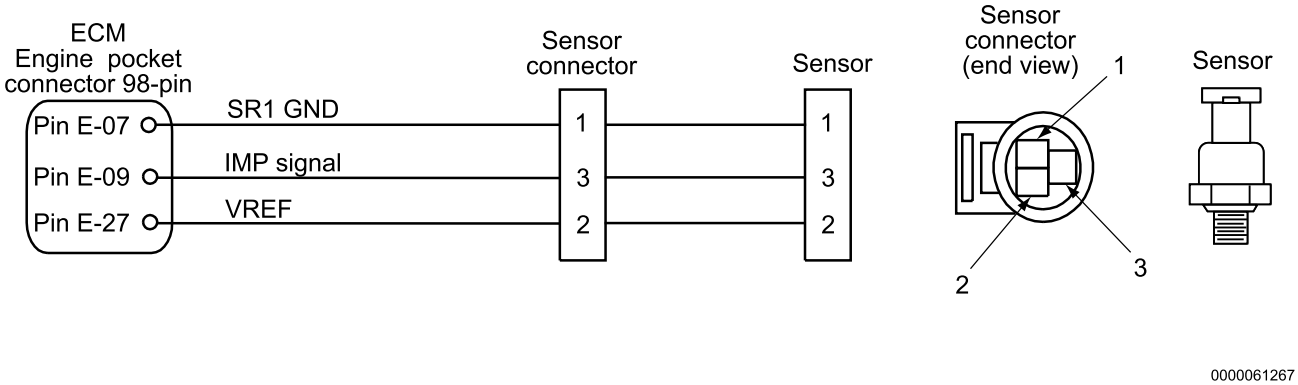


Figure 213 IMP Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 102 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 102 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Intake Manifold Pressure sensor (IMP). With key OFF, disconnect IMP connector. Check IMP and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are IMP connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 102 FMI 2.

Step	Action	Decision
4	Test IMP circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 605). Are IMP circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 102 FMI 2.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test(page 71). Does circuit operate properly?	Yes: Go to Step 6.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 102 FMI 2.

Step	Action	Decision
6	Test IMP sensor. Connect breakout harness 4850 between IMP sensor and IMP sensor connector. Perform KOEO voltage check of IMP sensor between IMP signal and ground(page 71). Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 102 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace IMP sensor. After repairs are complete, retest for SPN 102 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 102 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 102 FMI 15 - Overboost

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of sensor reading to modeled value (Overboost monitor)	Actual boost as indicated by Intake Manifold Pressure (IMP) sensor minus modeled boost value > threshold defined as a function of speed based table (Table A024)	Ambient pressure > 11psi (76 kPa)	1.0 second
		Air Inlet Temperature (AIT) > 19°F (-7°C) and < 122°F (50°C)	
		Engine cooolant temperature > 104°F (40°C) and < 239°F(115°C)	
		Exhaust Backpressure Control Valve (EBPV) <10%	
		Not in regeneration mode	
		Monitor operation range defined as function of speed / load (Table A007) and output of speed / load based enablement table > 0.95	
		Engine speed gradient < 75 rpm/second	
		Engine torque command gradient < 75 N•m/second	
		The following SPN / FMIs are not active: 173/3, 173/4, 102/2, 102/3, 102/4, 102/18, 102/10, 108/3, 108/4, 51/3, 110/3, 110/4, 132/3, 132/4, 172/3, 172/4, 51/7, 1189/3, 2630/16, 1189/4, and 1189/5.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the difference between the IMP sensor signal value and modeled boost value is too high.

Amber Warning Lamp (AWL) Reaction

When fault is active, the Amber Warning Lamp (AWL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

IMP Circuit

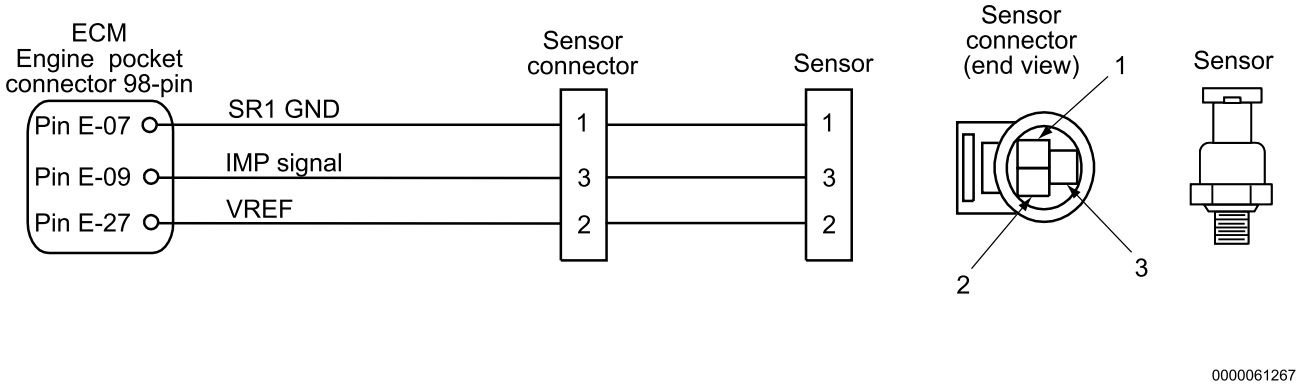


Figure 214 IMP Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 102 FMI 15 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 102 FMI 15. No: Go to Step 3.

Step	Action	Decision
3	Inspect air intake system and air filter for restrictions, air leaks, or physical damage. Is air intake system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to Step 4. No: Repair air intake system or replace air filter. After repairs are complete, retest for SPN 102 FMI 15.

Step	Action	Decision
4	Inspect connections at the Intake Manifold Pressure (IMP) sensor. With key OFF, disconnect IMP sensor connector. Check IMP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the IMP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 102 FMI 15.

Step	Action	Decision
5	Test IMP circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 605). Are IMP circuits within specifications?	Yes: Go to Step 6. No: Repair circuits as required. After repairs are complete, retest for SPN 102 FMI 15.

Step	Action	Decision
6	Test IMP sensor. Connect breakout harness 4850 between IMP sensor and IMP sensor connector. Perform Key On Engine Off (KOEO) voltage check of IMP sensor between IMP signal and ground (page 71). Is voltage within specification?	Yes: Go to Step 7. No: Replace IMP sensor. After repairs are complete, retest for SPN 102 FMI 15.

Step	Action	Decision
7	Verify proper turbocharger 2 wastegate operation. Perform Wastegate Checks (Overboost) (page 177). Do wastegate air supply solenoid and wastegate perform as expected?	Yes: After doing all diagnostic steps, if SPN 102 FMI 16 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace turbocharger wastegate actuator and / or wastegate control solenoid. After repairs are complete, retest for SPN 102 FMI 15.

NOTE: After doing all diagnostic steps, if SPN 102 FMI 15 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 102 FMI 16 - Overboost

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of sensor reading to modeled value (Overboost monitor)	Actual boost as indicated by Intake Manifold Pressure (IMP) sensor minus modeled boost value > 0.29 psi (2 kPa)	Ambient pressure > 11psi (76 kPa)	1.0 second
		Air Inlet Temperature (AIT) > 19°F (-7°C) and < 122°F (50°C)	
		Engine cooolant temperature > 104°F (40°C) and < 239°F(115°C)	
		Exhaust Backpressure Control Valve (EBPV) <10%	
		Not in regeneration mode	
		>1200 rpm	
		Engine speed gradient < 75 rpm/second	
		Engine torque command gradient < 75 N•m/second	
		The following SPN / FMIs are not active: 173/3, 173/4, 102/2, 102/3, 102/4, 102/18, 102/10, 108/3, 108/4, 51/3, 110/3, 110/4, 132/3, 132/4, 172/3, 172/4, 51/7, 1189/3, 2630/16, 1189/4, and 1189/5.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the difference between the IMP sensor signal value and modeled boost value is too high.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

IMP Circuit

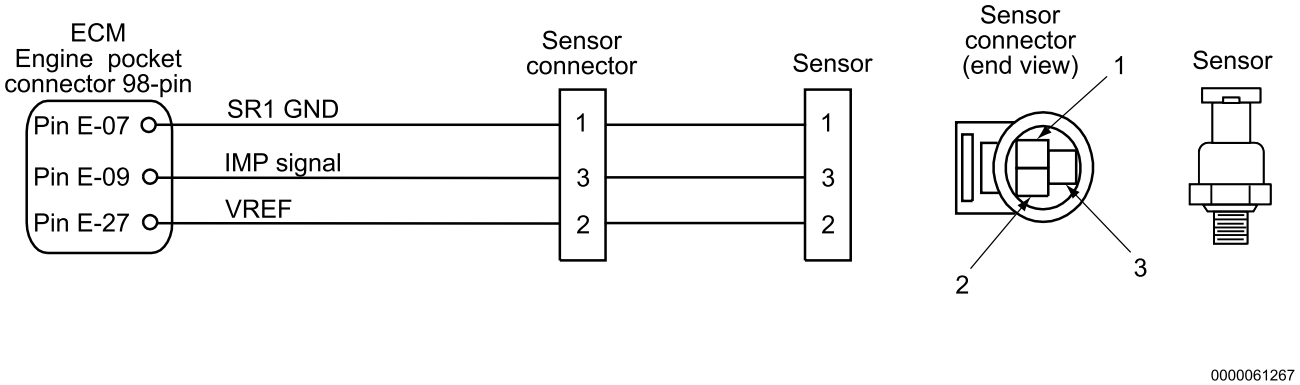


Figure 215 IMP Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 102 FMI 16 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 102 FMI 16. No: Go to Step 3.

Step	Action	Decision
3	Inspect air intake system and air filter for restrictions, air leaks, or physical damage. Is air intake system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to Step 4. No: Repair air intake system or replace air filter. After repairs are complete, retest for SPN 102 FMI 16.

Step	Action	Decision
4	Inspect connections at the Intake Manifold Pressure (IMP) sensor. With key OFF, disconnect IMP sensor connector. Check IMP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the IMP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 102 FMI 16.

Step	Action	Decision
5	Test IMP circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 605). Are IMP circuits within specifications?	Yes: Go to Step 6. No: Repair circuits as required. After repairs are complete, retest for SPN 102 FMI 16.

Step	Action	Decision
6	Test IMP sensor. Connect breakout harness 4850 between IMP sensor and IMP sensor connector. Perform Key On Engine Off (KOEO) voltage check of IMP sensor between IMP signal and ground (page 71). Is voltage within specification?	Yes: Go to Step 7. No: Replace IMP sensor. After repairs are complete, retest for SPN 102 FMI 16.

Step	Action	Decision
7	Verify proper turbocharger 2 wastegate operation. Perform Wastegate Checks (Overboost) (page 177). Do wastegate air supply solenoid and wastegate perform as expected?	Yes: After doing all diagnostic steps, if SPN 102 FMI 16 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace turbocharger wastegate actuator and / or wastegate control solenoid. After repairs are complete, retest for SPN 102 FMI 16.

NOTE: After doing all diagnostic steps, if SPN 102 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 102 FMI 18 - Underboost

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of sensor reading to modeled value	Actual boost as indicated by Intake Manifold Pressure (IMP) sensor minus IMP setpoint < 120 kPa (17.42 psi)	Ambient pressure > 11psi (76 kPa)	20 seconds
		Air Inlet Temperature (AIT) > 19°F (-7°C) and < 122°F (50°C)	
		Engine Coolant Temperature (ECT) > 104°F (40°C) and < 239°F (115°C)	
		Engine Throttle Position (ETP) < 20%	
		Exhaust Backpressure Control Valve (EBPV) < 10%	
		Not in regeneration mode	
		1400-2200 rpm and >700 N•m	
		Engine speed gradient < 75 rpm/second	
		Engine torque command gradient < 75 N•m/second	
		The following SPN / FMIs are not active: 173/3, 173/4, 102/2, 102/3, 102/4, 102/10, 102/16, 108/3, 108/4, 51/3, 110/3, 110/4, 132/3, 132/4, 172/3, 172/4, 51/7, 1189/3, 2630/16, 1189/4, and 1189/5.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the difference between the IMP sensor signal value and modeled boost value is too low.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

IMP Circuit

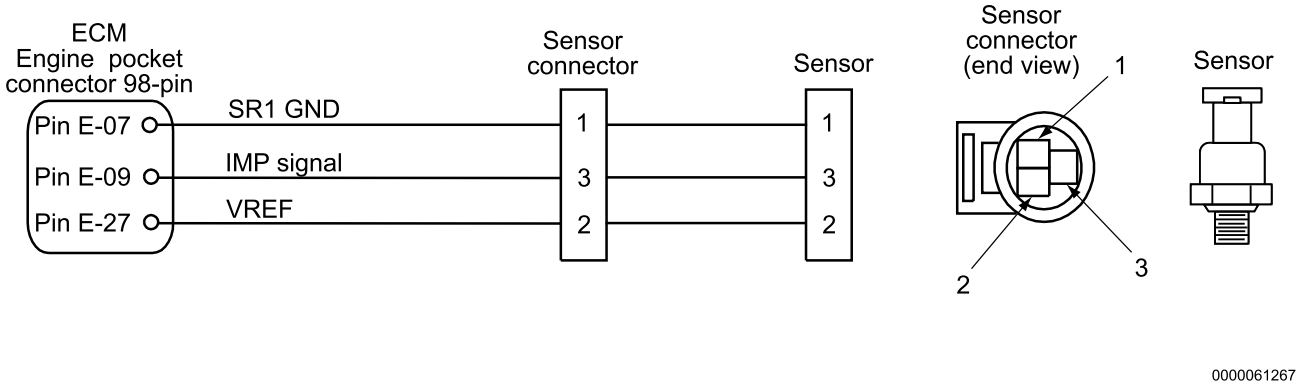


Figure 216 IMP Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 102 FMI 18 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 102 FMI 18. No: Go to Step 3.

Step	Action	Decision
3	Visually inspect air intake system, Charge Air Cooler (CAC), and air filter for restrictions, air leaks, or physical damage. Are air intake system, CAC, and air filter free of restrictions, air leaks, and physical damage?	Yes: Go to Step 4. No: Repair restriction, air leak, and / or physical damage. After repairs are complete, retest for SPN 102 FMI 18.

Step	Action	Decision
4	Visually inspect exhaust system for restrictions, air leaks, or physical damage. Is exhaust system free of restrictions, air leaks, and physical damage?	Yes: Go to Step 5. No: Repair restriction, air leak, and / or physical damage. After repairs are complete, retest for SPN 102 FMI 18.

Step	Action	Decision
5	Test air intake system, CAC, and exhaust system for leaks or restrictions. Perform Intake Air Restriction Test (page 183). Are air intake system, CAC, and exhaust system free of leaks and restrictions?	Yes: Go to Step 6. No: Repair restriction and / or air leak. After repairs are complete, retest for SPN 102 FMI 18.

Step	Action	Decision
6	Verify proper turbocharger 2 wastegate operation. Perform Wastegate Checks (Over Boost) (page 177). Do wastegate air supply solenoid and wastegate perform as expected?	Yes: Go to Step 7. No: Replace turbocharger assembly. After repairs are complete, retest for SPN 102 FMI 18.

Step	Action	Decision
7	Test turbocharger for proper operation. Perform Turbocharger Checks (Underboost) (page 177). Does turbocharger operate as expected?	Yes: After doing all diagnostic steps, if SPN 102 FMI 18 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace turbocharger assembly. After repairs are complete, retest for SPN 102 FMI 18.

NOTE: After doing all diagnostic steps, if SPN 102 FMI 18 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

IMT (Intake Manifold Temperature) Sensor

SPN	FMI	Condition	Possible Causes	Actions
105	2	IMT signal erratic, intermittent, or incorrect	• IMT biased circuit or sensor	Step-Based Diagnostics (page 623)
105	3	IMT signal Out of Range HIGH	• IMT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor	Pin-Point Diagnostics (page 621)
105	4	IMT signal Out of Range LOW	• IMT signal circuit short to GND • Failed sensor	Pin-Point Diagnostics (page 621)
105	10	IMT signal abnormal rate of change	• IMT biased sensor or circuit	Pin-Point Diagnostics (page 621)
105	21	IMT signal drifted LOW	• IMT biased circuit or sensor	Step-Based Diagnostics (page 627)

IMT Circuit

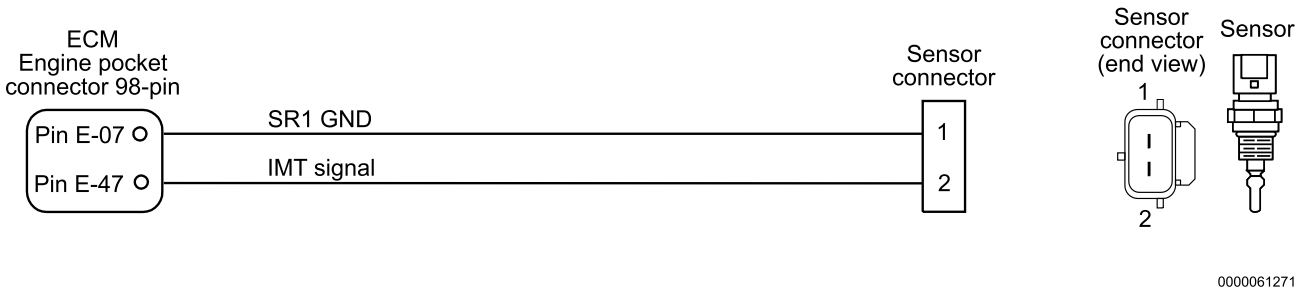
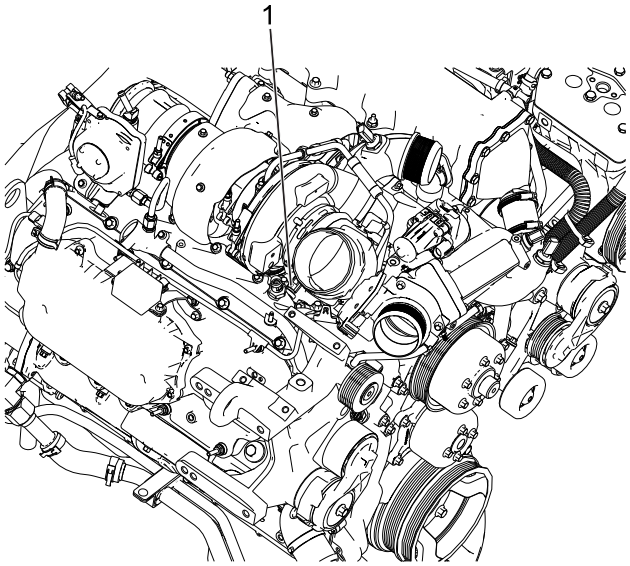


Figure 217 IMT Circuit Diagram

Overview

The Intake Manifold Temperature (IMT) sensor provides a feedback signal to the Engine Control Module (ECM) indicating intake manifold air temperature. The ECM controls the Exhaust Gas Recirculation (EGR) system based on the air temperature in the intake manifold. This aids in cold engine starting and warm-ups and also reduces exhaust emissions.



0000061273

Figure 218 IMT Sensor Location

1. IMT Sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 00–00956–08 – 180-Pin Breakout Box
- Breakout Harness ZTSE4602 (IMT)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

IMT Circuit

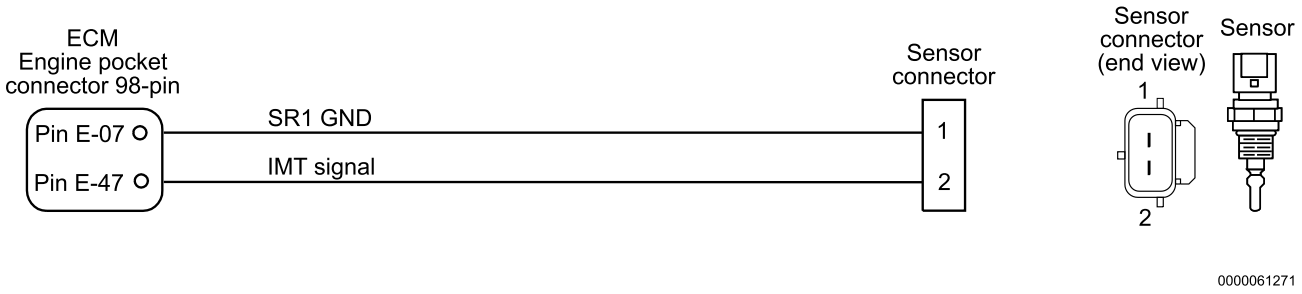


Figure 219 IMT Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

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

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, open the Continuous Monitor session.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor.

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

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

Sensor Circuit Check

Connect Breakout Harness ZTSE4602. Leave sensor disconnected. Turn ignition switch to ON. Use Electronic Service Tool (EST) with ServiceMaxx™ software to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	SPN 105 FMI 3	If SPN 105 and FMI 4 is active, check IMTsignal for short to GND. Do Harness Resistance Check (page 622).
EST - Check DTC Short a 3-banana plug harness across 2 and GND	SPN 105 FMI 4	If SPN 105 and FMI 3 is active, check IMT signal for OPEN. Do Harness Resistance Check (page 622).
EST - Check DTC Short 3-banana plug harness across 1 and 2	SPN 105 FMI 4	If SPN 105 and FMI 3 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 622).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

IMT Pin-point Diagnostics

Connector Voltage Check

Connect Breakout Harness ZTSE4602. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to B+	B+	If < B+, check for short to power, or open circuit. Do Harness Resistance Check (page 622).
2 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 622).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4602. Leave sensor disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4602. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-07	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to E-47	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 105 FMI 2 - IMT signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of sensor reading to other sensor readings after a calibratable cold soak period	Sum of failed temperature sensor comparisons as listed below: Intake Manifold Temperature (IMT) vs. Air Inlet Temperature (AIT), Turbocharger 1 Compressor Outlet Temperature (TC1COT), Charge Air Cooler Outlet Temperature (CACOT), Exhaust Gas Recirculation Temperature (EGRT) using calibrations listed below >=4	Engine Off soak time > 8 hours	0.5 second
		Time in key ON engine OFF state < 3 seconds	
	Comparison between IMT and AIT > 36°F (20°C)	Engine NOT in running state	
		{[Comparison of AIT with IMT > 27°F (15°C). Comparison of AIT with CACOT > 27°F (15°C). Comparison of AIT with TC1COT > 27°F (15°C). Comparison of AIT with EGRT > 27°F (15°C). Comparison of IMT with CACOT > 27°F (15°C). Comparison of IMT with TC1COT > 27°F (15°C). Comparison of IMT with EGRT > 27°F (15°C). Comparison of CACOT with TC1COT > 27°F (15°C). Comparison of CACOT with EGRT > 27°F(15°C). Comparison of TC1COT with EGRT > 27°F (15°C).] and sum of true conditions from comparisons listed above} > 5	
	Comparison between IMT and CACOT > 36°F (20°C)	The following SPN / FMIs are not active: 172/3, 172/4, 2629/3, 2629/4, 2630/3, 2630/4, 105/3, 105/4, 412/3, and 412/4.	
	Comparison between IMT and EGRT > 36°F (20°C)		
	Comparison between IMT and TC1COT > 36°F (200°C)		

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the IMT signal value is incorrect when compared to other sensor values.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

IMT Circuit

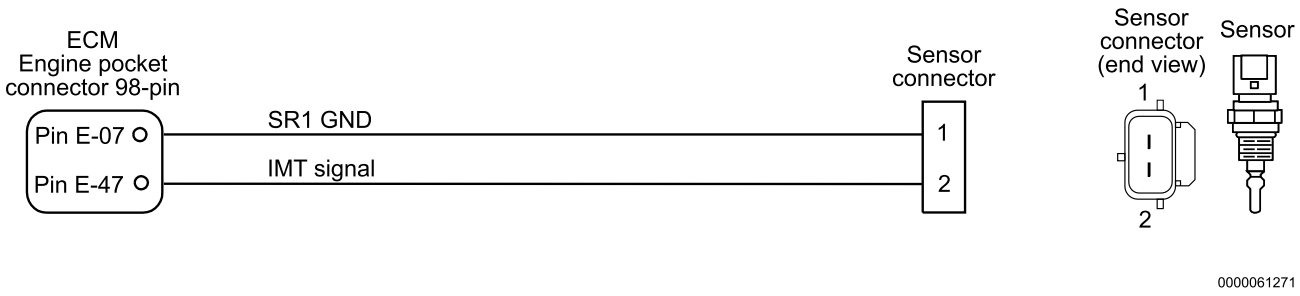


Figure 220 IMT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 105 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 105 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Intake Manifold Temperature (IMT) sensor. With key OFF, disconnect IMT sensor connector. Check IMT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are IMT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 105 FMI 2.

Step	Action	Decision
4	Test IMT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 622). Are IMT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 105 FMI 2.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test (page 71). Does circuit operate properly?	Yes: Go to Step 6.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 105 FMI 2.

Step	Action	Decision
6	Test IMT sensor. Connect breakout harness 4602 between IMT sensor and IMT sensor connector. Perform KOEO voltage check of IMT sensor between IMT signal and ground (page 71). Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 105 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace IMT sensor. After repairs are complete, retest for SPN 105 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 105 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 105 FMI 21 - IMT signal drifted LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Intake Manifold Temperature (IMT) stuck in range fault	IMT < -40°F (-40°C)	Minimum engine speed value for incrementing accumulator > 800 rpm	1 second
		Minimum engine torque command for incrementing accumulator > 300 N•m	
		Accumulated threshold for enabling monitor > 6 minutes and 40 seconds	
		The following SPN / FMIs are not active: 172/2, 172/3, 105/2, 105/3, 105/4, 108/3, and 108/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the IMT signal value is lower than expected at a given time.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

IMT Circuit

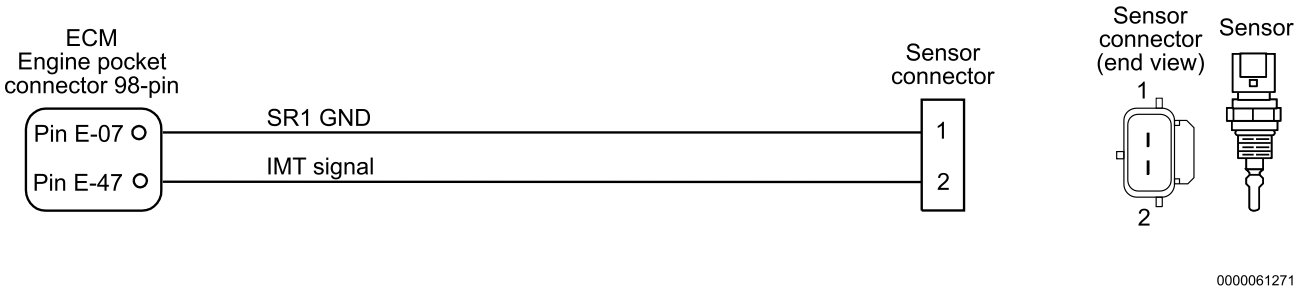


Figure 221 IMT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 105 FMI 21 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 105 FMI 21. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Intake Manifold Temperature (IMT) sensor. With key OFF, disconnect IMT sensor connector. Check IMT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are IMT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 105 FMI 21.

Step	Action	Decision
4	Test IMT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 622). Are IMT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 105 FMI 21.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test (page 71). Does circuit operate properly?	Yes: Go to Step 6.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 105 FMI 21.

Step	Action	Decision
6	Test IMT sensor. Connect breakout harness 4602 between IMT sensor and IMT sensor connector. Perform KOEO voltage check of IMT sensor between IMT signal and ground (page 71). Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 105 FMI 21 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace IMT sensor. After repairs are complete, retest for SPN 105 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 105 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

INJ (Injector Circuits)

INJ Diagnostics

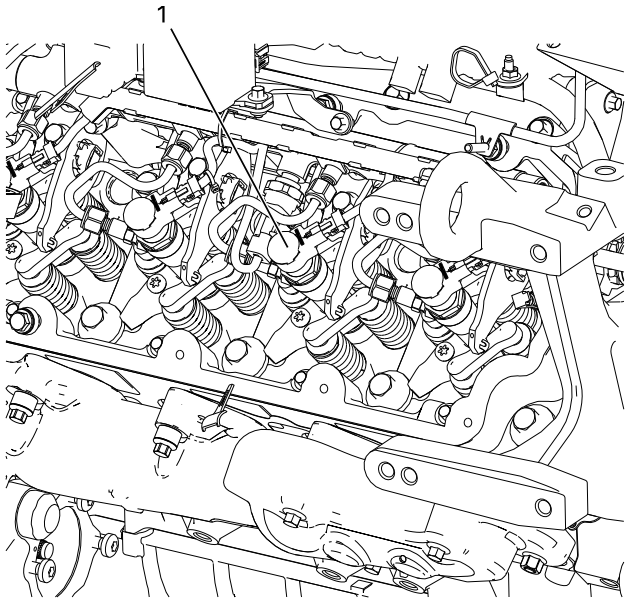
SPN	FMI	Condition	Possible Causes	Actions
651–658	4	Injector # short circuit	• Electrical harness issue • Failed injector(s)	Pin-Point Diagnostics (page 632)
651–658	5	Injector # open circuit	• Electrical harness issue • Failed injector(s)	Pin-Point Diagnostics (page 632)
2797	2	Injector Control Group 1 Open Circuit (INJ 1, 3, 5, 7)	• Electrical harness issue • Failed injector(s)	Step-Based Diagnostics (page 641)
2797	3	Injector Control Group 1 Open Circuit (INJ 1, 3, 5, 7)	• Electrical harness issue • Failed injector(s)	Step-Based Diagnostics (page 644)
2797	4	Initialization of fuel injector driver circuit failed group 1 (INJ 1, 3, 5, 7)	• Electrical harness issue • Failed injector(s)	Pin-Point Diagnostics (page 632)
2797	11	Injector Control Group 1 short circuit (INJ 1, 3, 5, 7)	• Electrical harness issue • Failed injector(s)	Pin-Point Diagnostics (page 632)
2798	2	Injector Control Group 2 Open Circuit (INJ 2, 4, 6, 8)	• Electrical harness issue • Failed injector(s)	Step-Based Diagnostics (page 647)
2798	3	Injector Control Group 2 Open Circuit (INJ 2, 4, 6, 8)	• Electrical harness issue • Failed injector(s)	Step-Based Diagnostics (page 650)
2798	4	Initialization of fuel injector driver circuit failed group 2 (INJ 2, 4, 6, 8)	• Electrical harness issue • Failed injector(s)	Pin-Point Diagnostics (page 632)
2798	11	Injector Control Group 2 short circuit (INJ 2, 4, 6, 8)	• Electrical harness issue • Failed injector(s)	Pin-Point Diagnostics (page 632)

Overview

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

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

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



0000061365

Figure 222 Injector Location

1. Injector (shown under right side valve cover)

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- International® Electronic Engine Terminal Test Kit ZTSE4435C
- 00–00956–08 – 180-Pin Breakout Box
- Breakout Harness ZTSE6000 (INJ)

Pinpoint Diagnostics With ServiceMaxx™ Software

Injector 1 Check

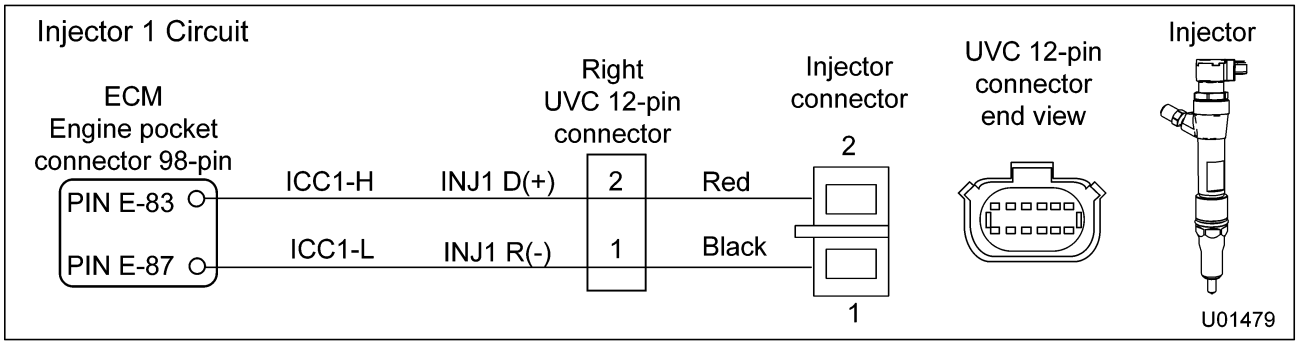


Figure 223 Injector 1 Circuit Diagram

Injector 1 - Resistance Checks Through Harness and Injector

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

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

Turn ignition switch to OFF. Connect 180-Pin Breakout Box to the ECM 98-pin connector. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-83 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
E-87 to GND	> 1 kΩ	

Injector 1 - Resistance UVC Checks

Turn ignition switch to OFF. Connect Breakout Harness ZTSE6000 to right UVC 12-pin harness. Use DMM to measure resistance.

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

Injector 1 - Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box to the ECM 98-pin connector. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-83 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-83 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E-87 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-87 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 2 Check

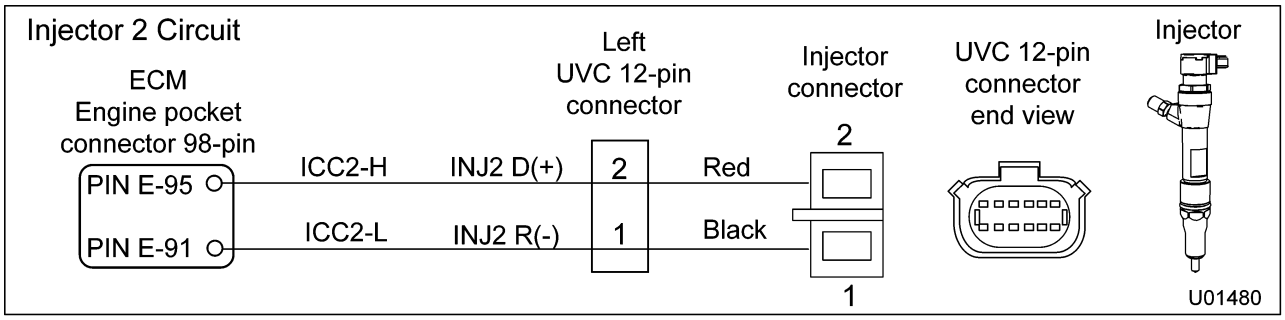


Figure 224 Injector 2 Circuit Diagram

Injector 2 - Resistance Through Valve Cover to Engine GND Check

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

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

Turn ignition switch to OFF. Connect Breakout Harness ZTSE6000 to the left UVC 12-pin harness. Use DMM to measure resistance.

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

Injector 2 - Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box to engine harness. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-95 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-95 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E-91 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-91 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 3 Check

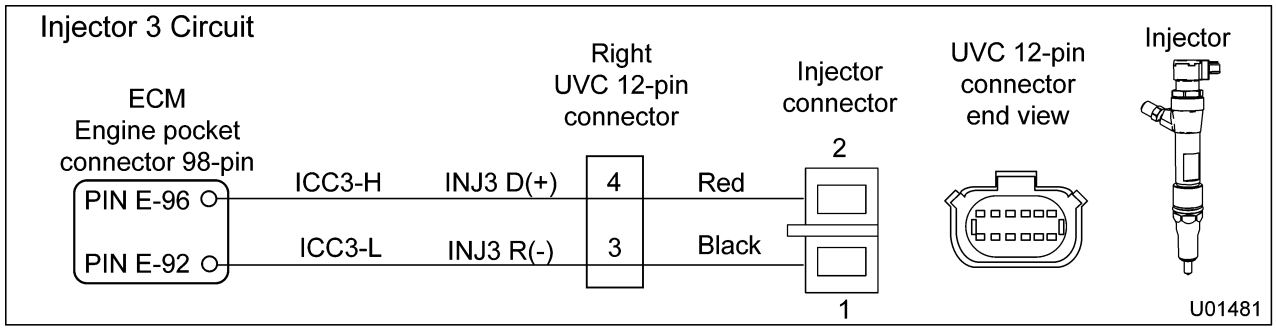


Figure 225 Injector 3 Circuit Diagram

Injector 3 - Resistance Through Valve Cover to Engine GND Check

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

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

Turn ignition switch to OFF. Connect Breakout Harness ZTSE6000 to the right UVC 12-pin connector. Use DMM to measure resistance.

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

Injector 3 - Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box to engine harness. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-96 to 4	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-96 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E-92 to 3	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-92 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 4 Check

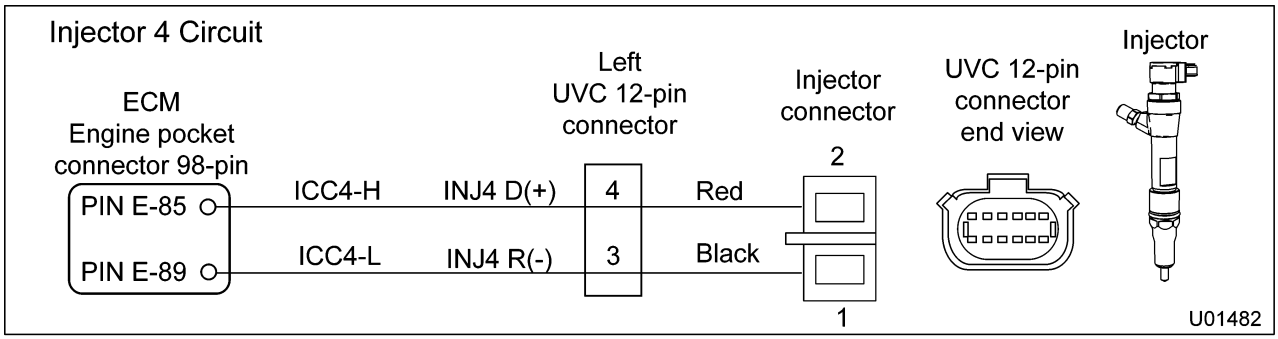


Figure 226 Injector 4 Circuit Diagram

injector 4 - Resistance Through Valve Cover to Engine GND Check

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

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

Turn ignition switch to OFF. Connect Breakout Harness ZTSE6000 to the left UVC 12-pin connector. Use DMM to measure resistance.

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

Injector 4 - Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box to engine harness. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-85 to 4	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-85 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E-89 to 3	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-89 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 5 Check

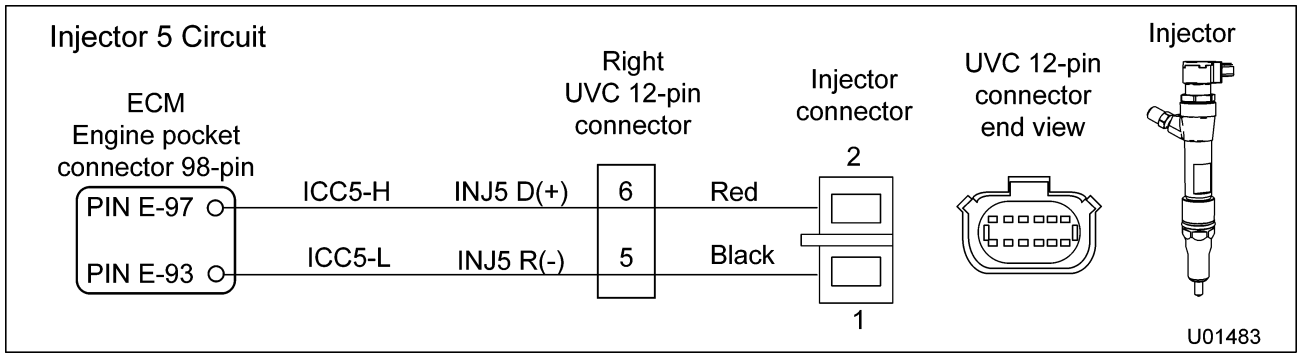


Figure 227 Injector 5 Circuit Diagram

Injector 5 - Resistance Through Valve Cover to Engine GND Check

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

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

Turn ignition switch to OFF. Connect Breakout Harness ZTSE6000 to the right UVC 12-pin connector. Use DMM to measure resistance.

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

Injector 5 - Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box to engine harness. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-97 to 6	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-97 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E-93 to 5	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-93 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 6 Check

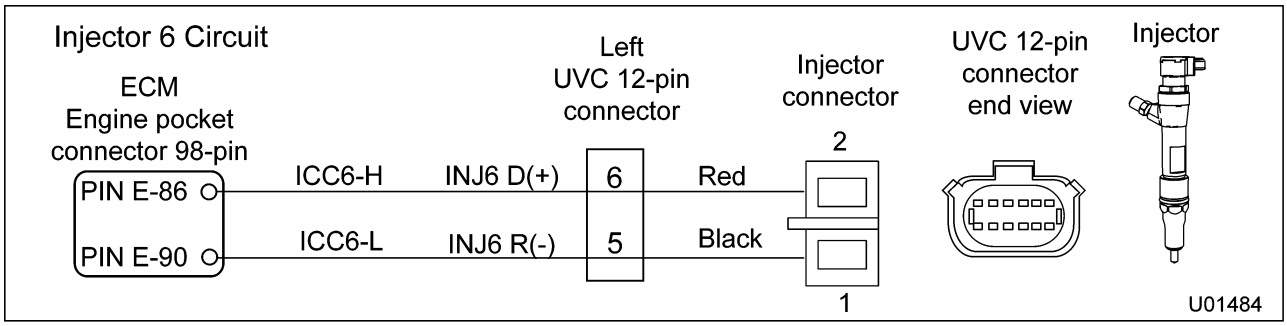


Figure 228 Injector 6 Circuit Diagram

Injector 6 - Resistance Through Valve Cover to Engine GND Check

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

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

Turn ignition switch to OFF. Connect Breakout Harness ZTSE6000 to the left UVC 12-pin connector. Use DMM to measure resistance.

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

Injector 6 - Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box to engine harness. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-86 to 6	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-86 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E-90 to 5	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-90 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 7 Check

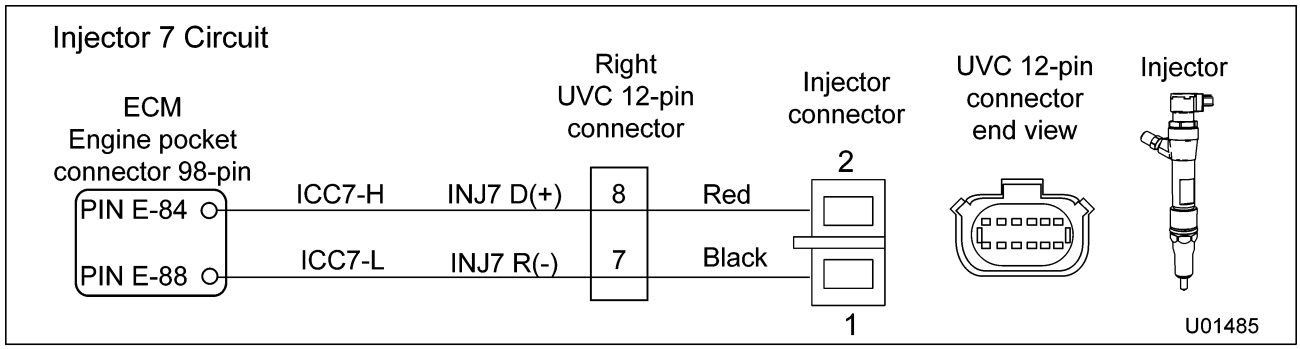


Figure 229 Injector 7 Circuit Diagram

Injector 7 - Resistance Through Valve Cover to Engine GND Check

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

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

Turn ignition switch to OFF. Connect Breakout Harness ZTSE6000 to the right UVC 12-pin connector. Use DMM to measure resistance.

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

Injector 7 - Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box to engine harness. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-84 to 8	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-84 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E-88 to 7	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-88 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 8 Check

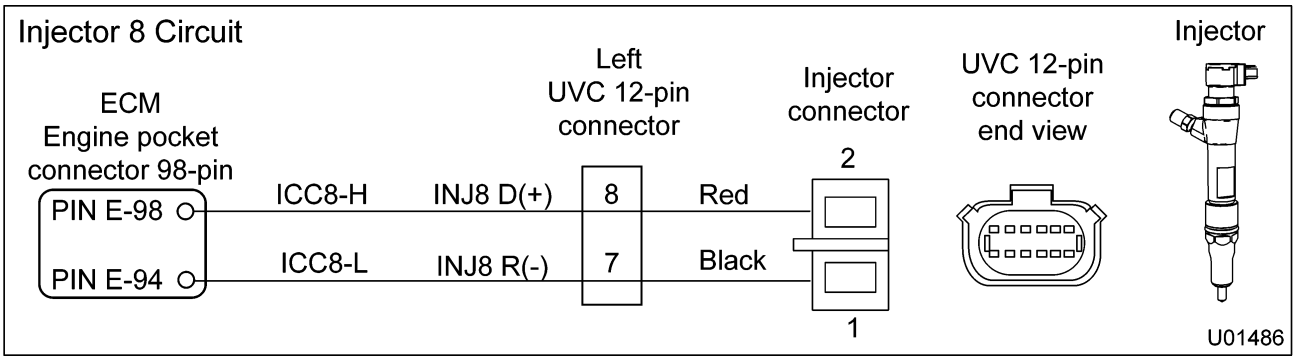


Figure 230 Injector 8 Circuit Diagram

Injector 8 - Resistance Through Valve Cover to Engine GND Check

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

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

Turn ignition switch to OFF. Connect Breakout Harness ZTSE6000 to the left UVC 12-pin connector. Use DMM to measure resistance.

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

Injector 8 - Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box to engine harness. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-98 to 8	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-98 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E-94 to 7	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-94 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

SPN 2797 FMI 2 - Injector Control Group 1 Open Circuit (INJ 1, 3, 5, 7)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Injector Control Group 1 Open Circuit (INJ 1, 3, 5, 7)	DC / DC converter output voltage > 300 volts	Key ON	4 seconds
		Battery voltage > 7 volts	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the Injector Control Group 1 circuit is open.

Amber Warning Lamp (AWL) Reaction

When fault is active, the Amber Warning Lamp (AWL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

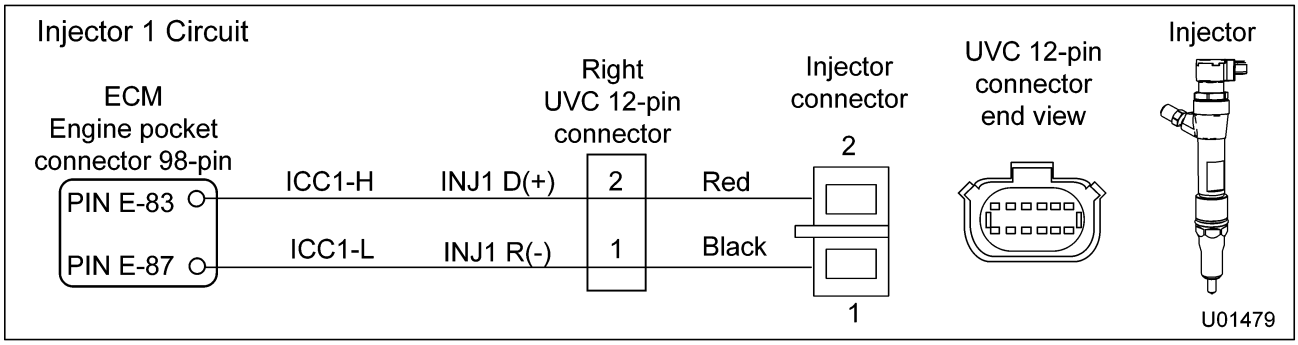


Figure 231 Injector 1 Circuit Diagram

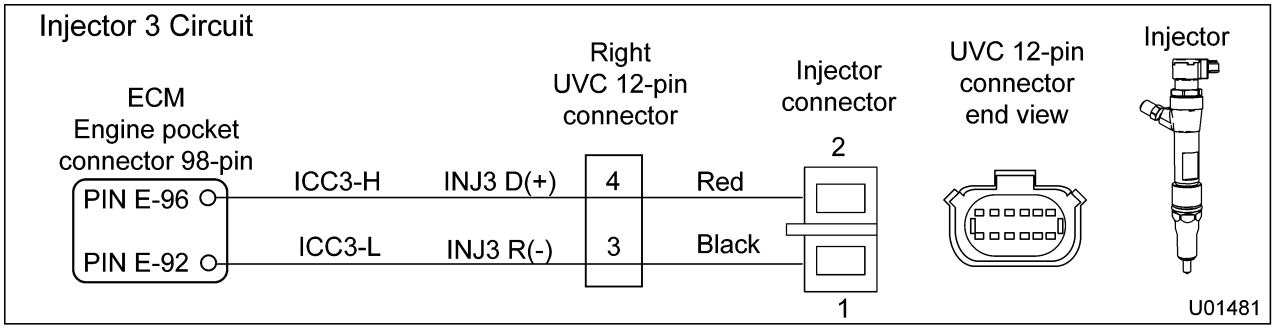


Figure 232 Injector 3 Circuit Diagram

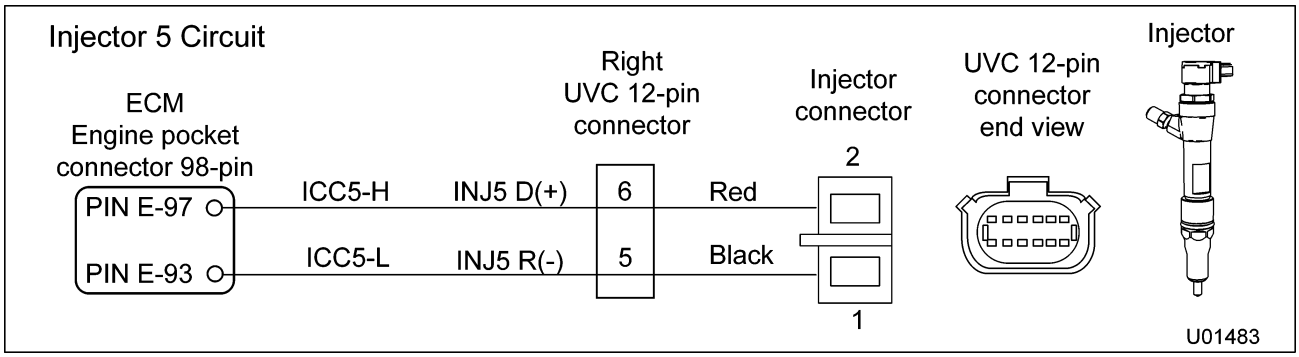


Figure 233 Injector 5 Circuit Diagram

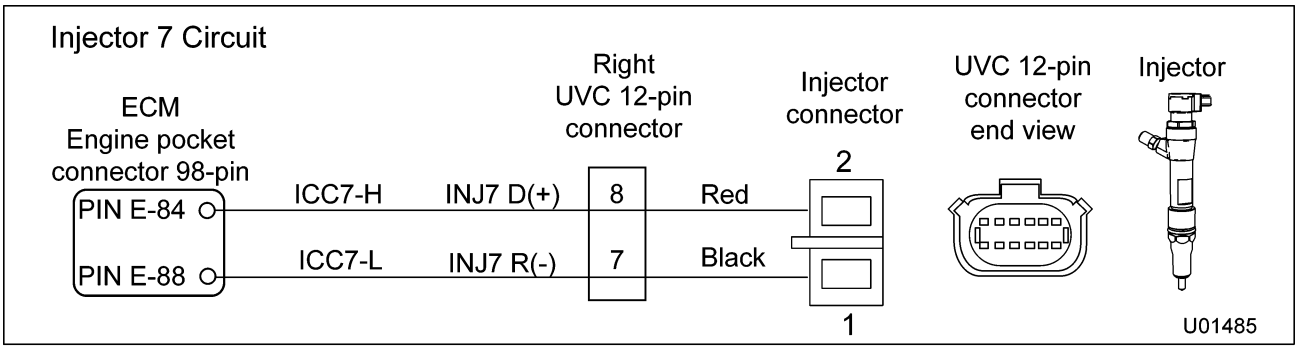


Figure 234 Injector 7 Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2797 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2797 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Check for failed injectors or electrical harness issues. Perform Cylinder Cutout Test (Cylinder Cutout Test, page 184). Do one or more cylinders have Rotations Per Minute (RPM) readings significantly different than the rest?	Yes: Go to Step 4. No: After doing all diagnostic steps, if SPN 2797 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Step	Action	Decision
4	Isolate electrical failure to injector or harness. Remove valve cover, disconnect harness from injector, and perform harness resistance checks (page 632) on the suspect injector harness. Are injector circuits within specification?	Yes: Replace injector(s) of cylinders identified in Cylinder Cutout Test. No: Repair injector wiring harness as indicated. After repairs are complete, retest for SPN 2797 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 2797 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2797 FMI 3 - Injector Control Group 1 Open Circuit (INJ 1, 3, 5, 7)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Injector Control Group 1 Open Circuit (INJ 1, 3, 5, 7)	DC / DC converter output voltage > 300 volts	Key ON	4 seconds
		Battery voltage > 7 volts	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the Injector Control Group 1 circuit is open.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

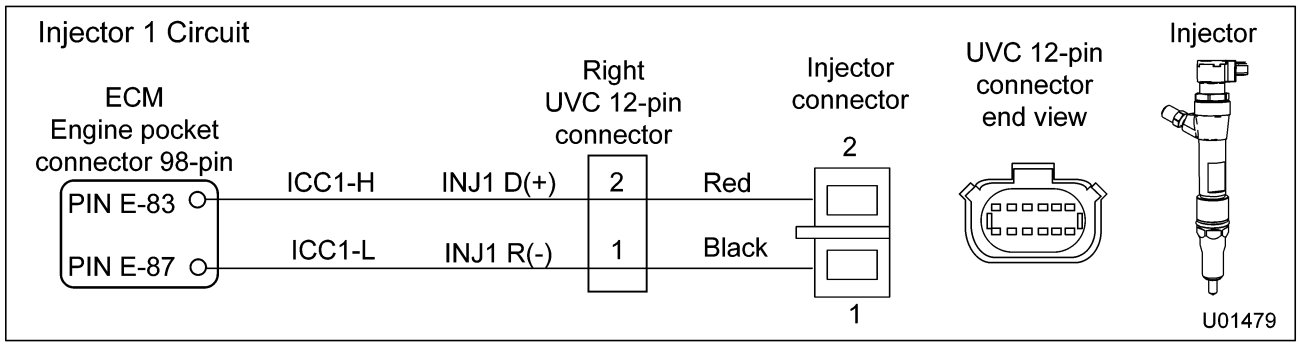


Figure 235 Injector 1 Circuit Diagram

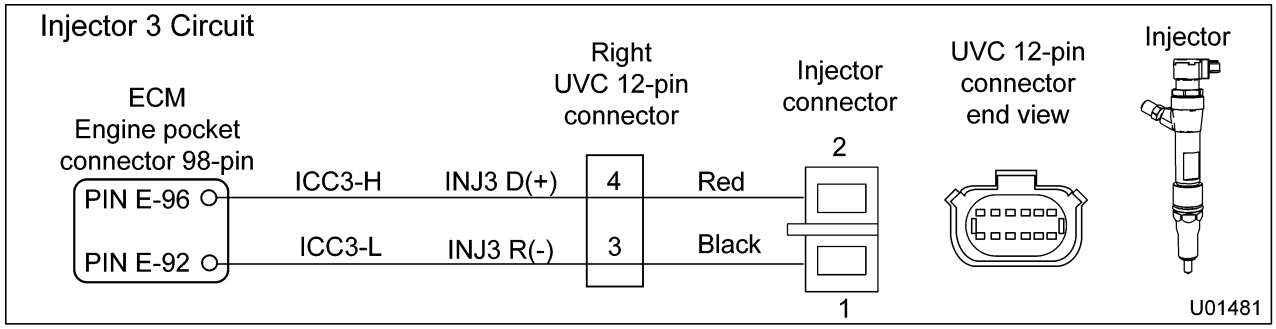


Figure 236 Injector 3 Circuit Diagram

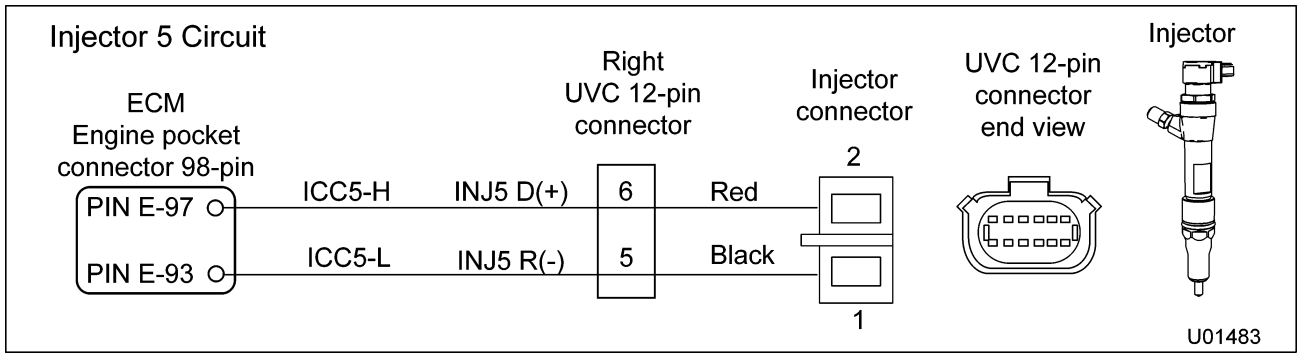


Figure 237 Injector 5 Circuit Diagram

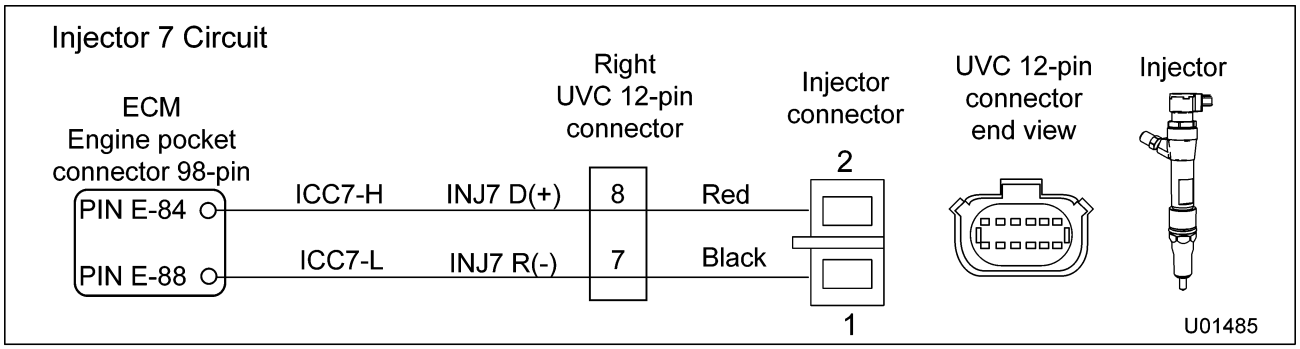


Figure 238 Injector 7 Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2797 FMI 3 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2797 FMI 3. No: Go to Step 3.

Step	Action	Decision
3	Check for failed injectors or electrical harness issues. Perform Cylinder Cutout Test (Cylinder Cutout Test, page 184). Do one or more cylinders have Rotations Per Minute (RPM) readings significantly different than the rest?	Yes: Go to Step 4. No: After doing all diagnostic steps, if SPN 2797 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Step	Action	Decision
4	Isolate electrical failure to injector or harness. Remove valve cover, disconnect harness from injector, and perform harness resistance checks (page 632) on the suspect injector harness. Are injector circuits within specification?	Yes: Replace injector(s) of cylinders identified in Cylinder Cutout Test. No: Repair injector wiring harness as indicated. After repairs are complete, retest for SPN 2797 FMI 3.

NOTE: After doing all diagnostic steps, if SPN 2797 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2798 FMI 2 - Injector Control Group 2 Open Circuit (INJ 2, 4, 6, 8)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Injector Control Group 2 Open Circuit (INJ 2, 4, 6, 8)	DC / DC converter output voltage > 300 volts	Key ON	4 seconds
		Battery voltage > 7 volts	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the Injector Control Group 2 circuit is open.

Amber Warning Lamp (AWL) Reaction

When fault is active, the Amber Warning Lamp (AWL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

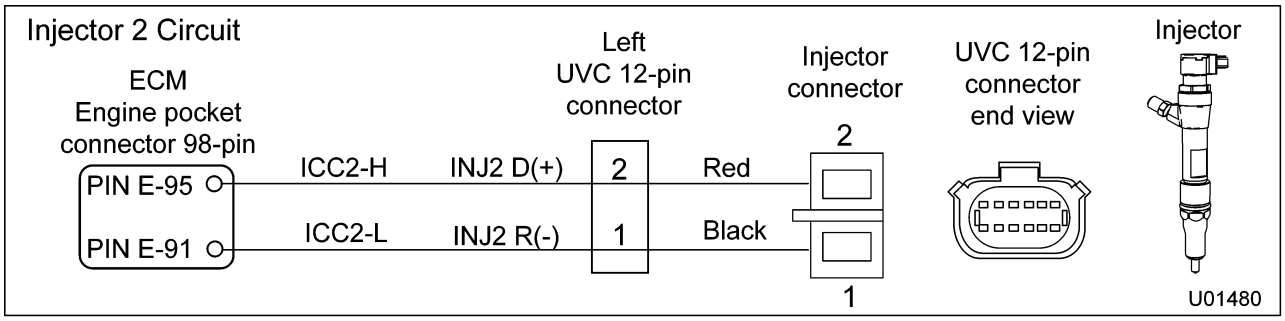


Figure 239 Injector 2 Circuit Diagram

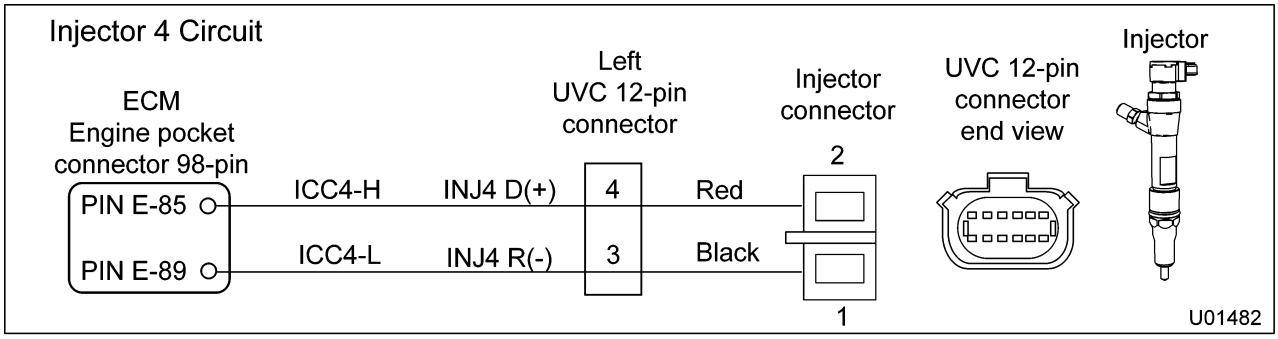


Figure 240 Injector 4 Circuit Diagram

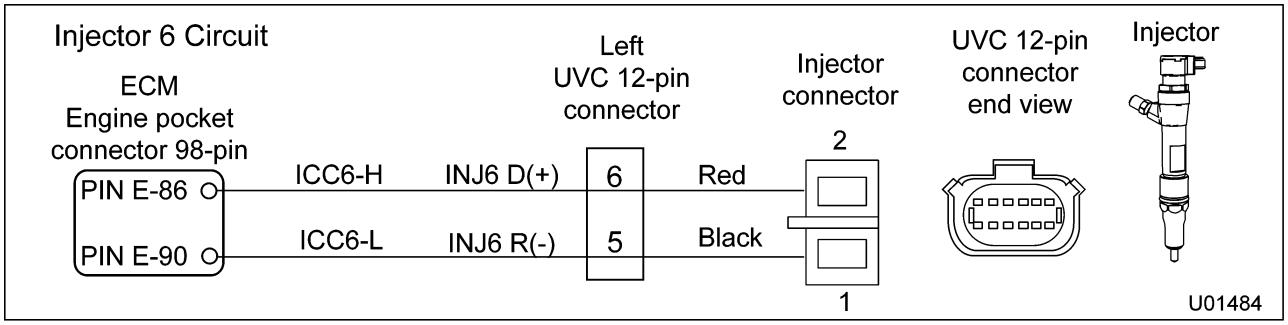


Figure 241 Injector 6 Circuit Diagram

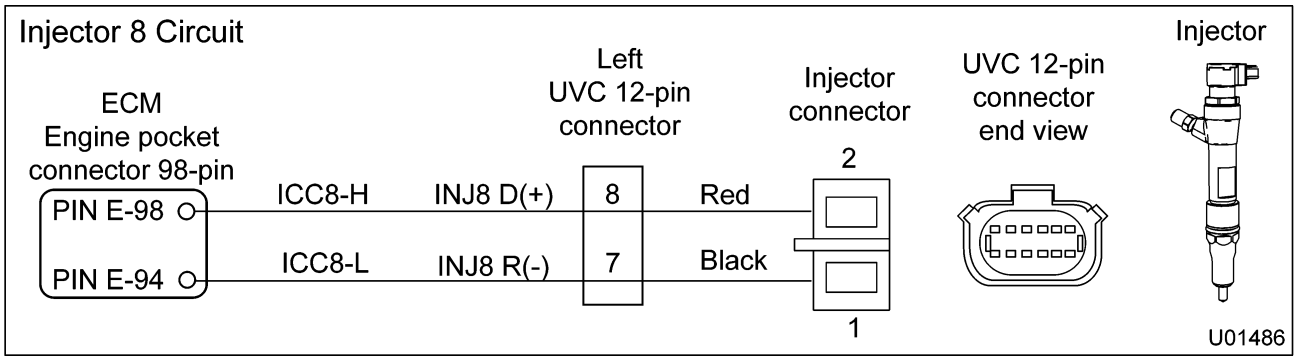


Figure 242 Injector 8 Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2798 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2798 FMI 3. No: Go to Step 3.

Step	Action	Decision
3	Check for failed injectors or electrical harness issues. Perform Cylinder Cutout Test (Cylinder Cutout Test, page 184). Do one or more cylinders have Rotations Per Minute (RPM) readings significantly different than the rest?	Yes: Go to Step 4. No: After doing all diagnostic steps, if SPN 2798 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Step	Action	Decision
4	Isolate electrical failure to injector or harness. Remove valve cover, disconnect harness from injector, and perform harness resistance checks (page 632) on the suspect injector harness. Are injector circuits within specification?	Yes: Replace injector(s) of cylinders identified in Cylinder Cutout Test. No: Repair injector wiring harness as indicated. After repairs are complete, retest for SPN 2798 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 2798 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2798 FMI 3 - Injector Control Group 2 Open Circuit (INJ 2, 4, 6, 8)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Injector Control Group 2 Open Circuit (INJ 2, 4, 6, 8)	DC / DC converter output voltage > 300 volts	Key ON	4 seconds
		Battery voltage > 7 volts	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the Injector Control Group 2 circuit is open.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

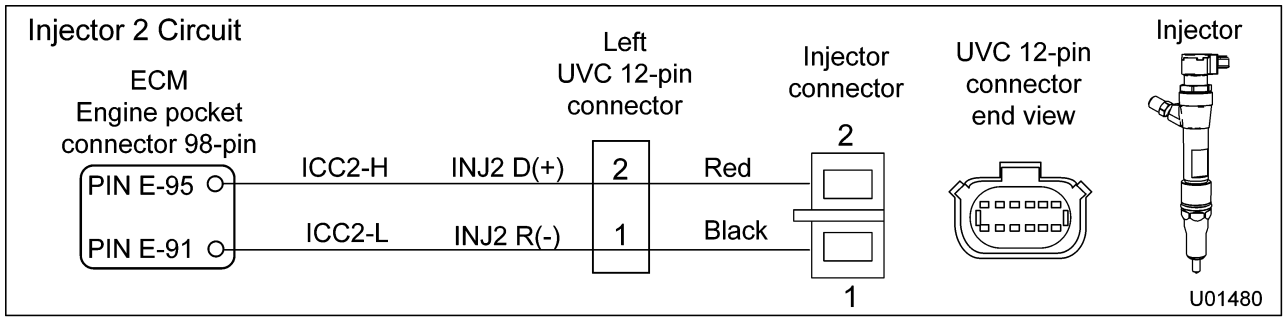


Figure 243 Injector 2 Circuit Diagram

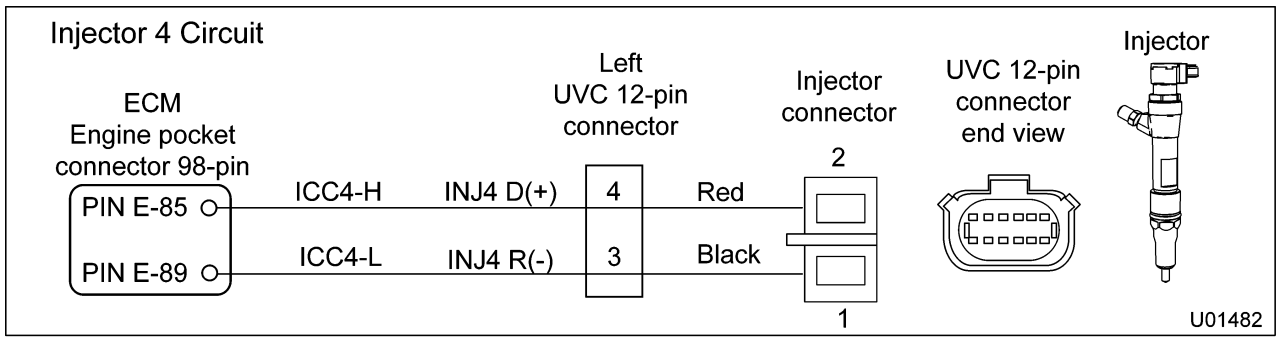


Figure 244 Injector 4 Circuit Diagram

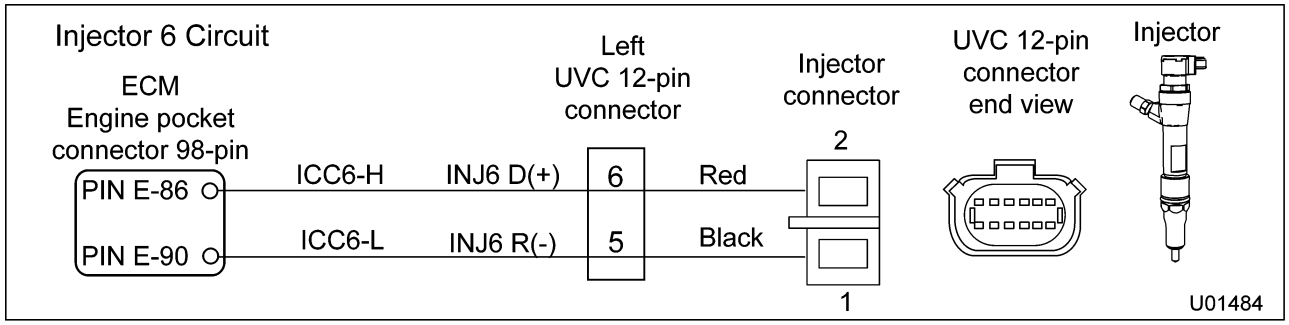


Figure 245 Injector 6 Circuit Diagram

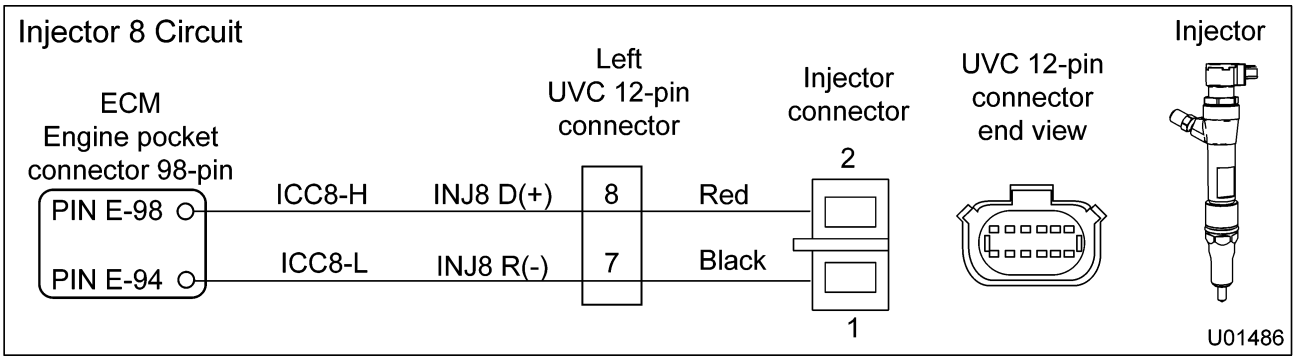


Figure 246 Injector 8 Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2798 FMI 3 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2798 FMI 3. No: Go to Step 3.

Step	Action	Decision
3	Check for failed injectors or electrical harness issues. Perform Cylinder Cutout Test (Cylinder Cutout Test, page 184). Do one or more cylinders have Rotations Per Minute (RPM) readings significantly different than the rest?	Yes: Go to Step 4. No: After doing all diagnostic steps, if SPN 2798 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Step	Action	Decision
4	Isolate electrical failure to injector or harness. Remove valve cover, disconnect harness from injector, and perform harness resistance checks (page 632) on the suspect injector harness. Are injector circuits within specification?	Yes: Replace injector(s) of cylinders identified in Cylinder Cutout Test. No: Repair injector wiring harness as indicated. After repairs are complete, retest for SPN 2798 FMI 3.

NOTE: After doing all diagnostic steps, if SPN 2798 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

IST (Idle Shutdown Timer) System

SPN	FMI	Condition
593	31	Engine stopped by IST

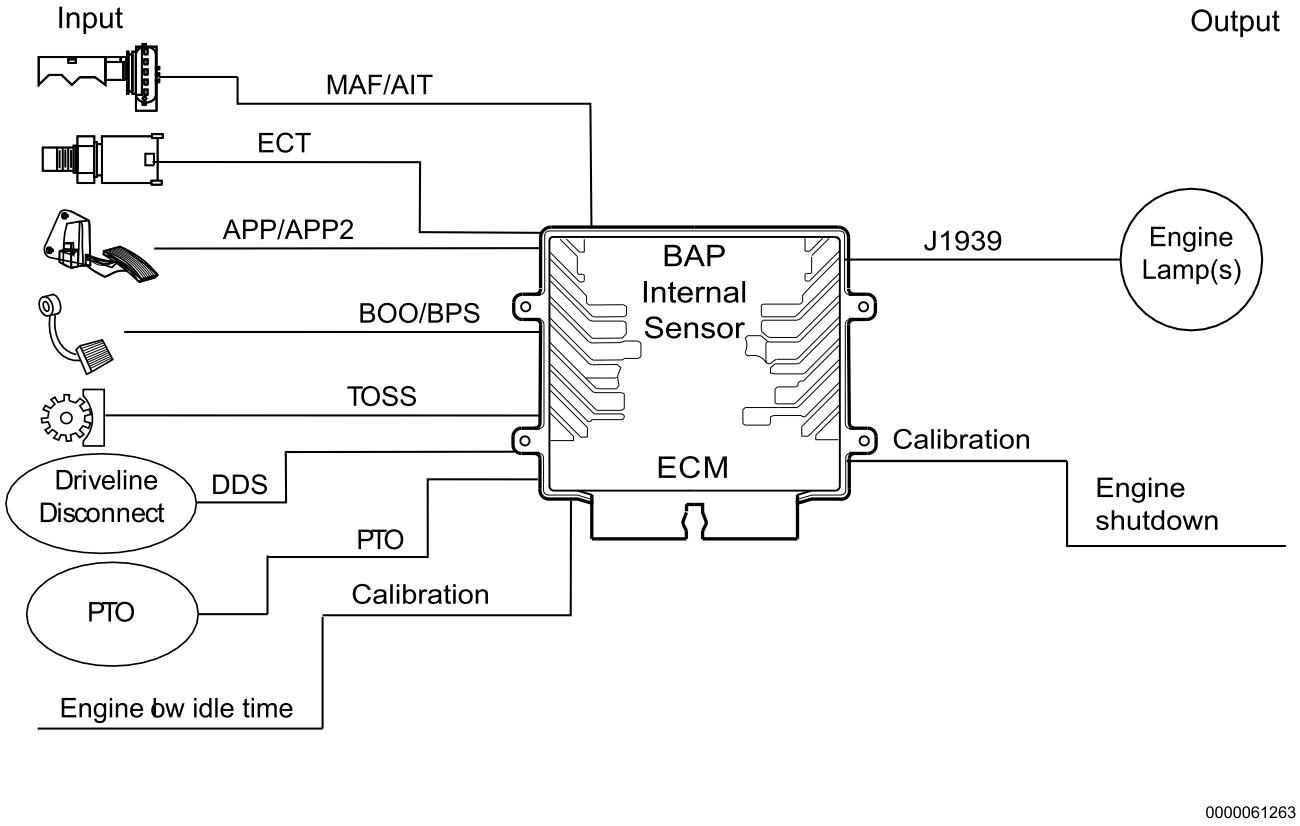


Figure 247 Function diagram for IST system

The IST system function diagram includes the following:

- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Mass Air Flow (MAF) / Air Inlet Temperature (AIT) sensor
- Engine Coolant Temperature 1 (ECT1) sensor
- Accelerator Pedal Position (APP) sensor
- Brake On / Off switch (BOO) and Brake Pressure Switch (BPS)
- Transmission Output Speed Sensor (TOSS)
- Driveline Disengagement Switch (DDS)
- Power Takeoff (PTO)
- Engine lamp(s)

Function

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

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

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

IST Operation

Idle Shutdown Warning

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

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

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

Engine Idle Shutdown Timer for California ESS-Compliant Engines

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

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

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

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

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

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

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

CARB IST Conditions

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

- Manual Diesel Particulate Filter (DPF) regeneration is inactive (not enabled).
- Steady driveline state (no transition detected). No change in the state of the clutch switch (manual transmission) or transmission shifter between the in-gear position and neutral or park (automatic transmission).
- Power Takeoff (PTO) Remote mode disabled.
- Engine coolant temperature greater than 15.6 ºC (60 ºF).
- Engine is operating in run mode or in active EST mode.
- Vehicle speed is less than 1.25 miles / hr.
- No active vehicle speed diagnostic faults.
- PTO control is in off or standby mode.
- Engine speed is less than 750 RPM.
- Steady accelerator pedal position (no transition detected from any preset position).
- Steady brake pedal state (no transition detected from any preset state).
- Steady parking brake state (CAN (J1939) message) (no transition detected from any preset state).

Engine Idle Shutdown Timer (Federal-Optional)

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

Federal IST Conditions

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

Common Enable Conditions for All Federal IST Options

- Manual Diesel Particulate Filter (DPF) regeneration is inactive (not enabled).
- Steady driveline state (no transition detected). No change in the state of the clutch switch (manual transmission) or transmission shifter between the in-gear position and neutral or park (automatic transmission).
- PTO Remote mode disabled.
- Air inlet temperature greater than 15.6 ºC (60 ºF) (manufacturer's default, customer adjustable parameter).
- Air inlet temperature lower than 44 ºC (111 ºF) (manufacturer's default, customer adjustable parameter).
- Engine coolant temperature greater than 60º C (140 ºF).
- Engine is operating in run mode or in active EST mode.
- Vehicle speed is less than 1.25 miles / hr.
- No active vehicle speed diagnostic faults.

- Steady parking brake state (CAN (J1939) message). No transition detected from any preset state.

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

Federal IST Mode 1: PTO Operation Option Enable Conditions

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

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

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

Federal IST Mode 3: Tamper Proof Option Enable Conditions

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

Fault Detection / Management

The IST Diagnostic Trouble Code (DTC) does not indicate a system fault. SPN 595 FMI 31 sets by the ECM when the engine has been shut down due to exceeding the programmed idle time. The IST feature must be enabled for SPN 595 FMI 31 to be displayed.

MAF / AIT (Mass Air Flow / Air Inlet Temperature) Sensor

SPN	FMI	Condition	Possible Causes	Actions
132	2	MAF signal erratic, intermittent or incorrect	• MAF sensor circuit failure • Failed MAF / AIT sensor • Intake air contaminants	Step-Based Diagnostics (page 665)
132	3	MAF signal Out of Range HIGH	• MAF signal circuit OPEN or short to PWR • Failed MAF / AIT sensor	Pin-point Diagnostics (page 663)
132	4	MAF signal Out of Range LOW	• MAF signal circuit short to GND • Failed MAF / AIT sensor	Pin-point Diagnostics (page 663)
132	10	MAF signal abnormal rate of change	• Biased MAF sensor or circuit	Pin-point Diagnostics (page 663)
132	11	MAF sensor Calibration – Insufficient number of data points	• Engine condition not stable to accept MAF calibration • See MAF Calibration Pre-Checks	Pin-point Diagnostics (page 663)
132	13	MAF sensor Calibration Needed	• ECM was replaced • ECM was reprogrammed	Pin-point Diagnostics (page 663)
132	14	MAF sensor Calibration Failed	• Leak in intake air system • Leak in exhaust system • Failed MAF / AIT sensor	Pin-point Diagnostics (page 663)
172	2	AIT Signal Erratic, Intermittent or Incorrect	• AIT sensor circuit failure • Failed MAF / AIT sensor	Step-Based Diagnostics (page 668)

172	3	AIT signal Out of Range HIGH	• AIT signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed MAF / AIT sensor	Pin-point Diagnostics (page 663)
172	4	AIT signal Out of Range LOW	• AIT signal circuit short to GND • Failed MAF / AIT sensor	Pin-point Diagnostics (page 663)
172	10	AIT signal abnormal rate of change	• AIT signal circuit short to GND • Failed MAF / AIT sensor	Pin-point Diagnostics (page 663)

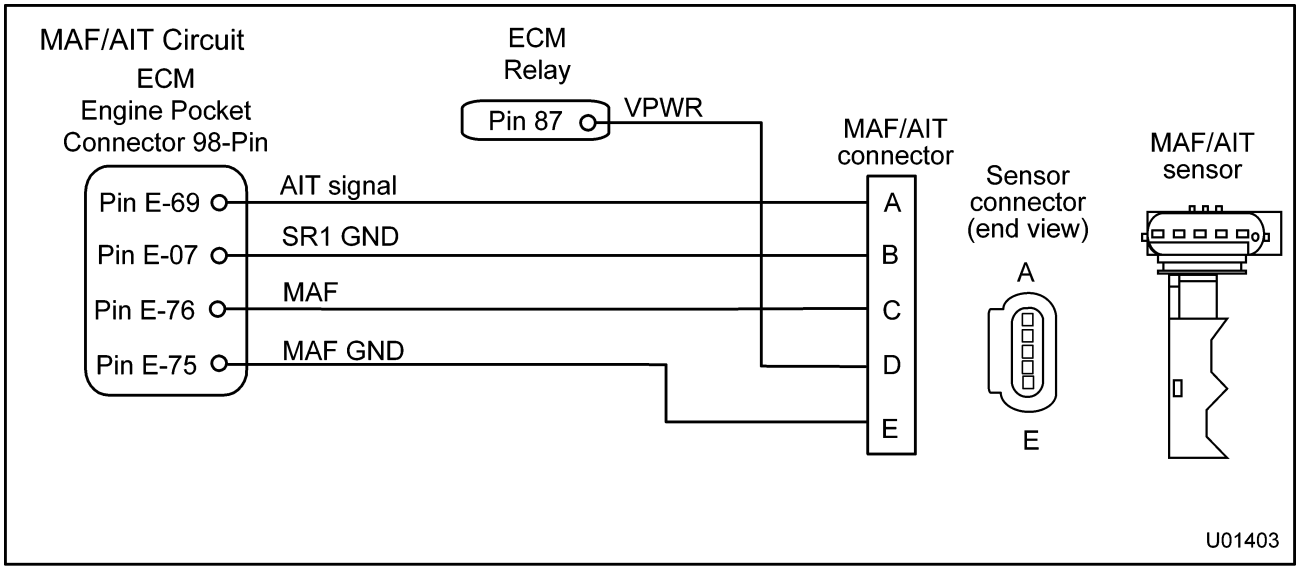


Figure 248 MAF / AIT Circuit Diagram

Overview

The MAF sensor is used to measure the volume and density of air entering the engine at any given time. The ECM uses this information to calculate the correct amount of EGR during engine operation. The AIT monitors the temperature of the air entering the intake system.

Sensor Location

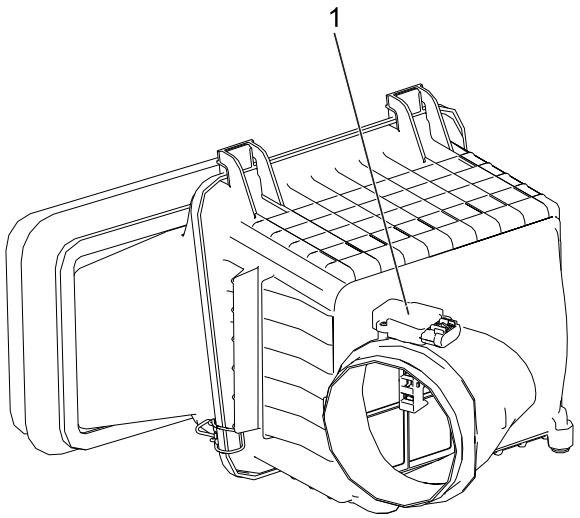


Figure 249 MAF / AIT Sensor Location

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 00–00956–08 - 180-Pin Breakout Box
- Breakout Harness ZTSE4960 (MAF / AIT)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

MAF Calibration Requirements

NOTE: Only run the MAF Calibration Procedure if one of the following conditions have occurred:

- SPN 132 FMI 13 is set
- ECM replacement
- Repair or replacement of MAF sensor or circuit
- Repair or replacement of Intake Manifold Pressure (IMP) sensor or circuit
- Repair or replacement of Intake Manifold Temperature (IMT) sensor or circuit
- Repair or replacement of intake air system
- Repair or replacement of CAC system
- Repair or replacement of turbocharger
- Repair or replacement of Engine Throttle Valve (ETV)
- Repair or replacement of EGR valve
- Repair base engine (cylinder head, pistons, camshaft)
- Engine replacement or rebuild

Continue to MAF Calibration Pre-Checks

MAF Calibration Pre-Checks

NOTE: Verify the following before running the MAF Calibration Procedure:

- No active fault codes, other than SPN 132 FMI 13
- Ambient Air Temperature (AAT) at or above 14°C (58°F)
- KOER Standard Test run and successfully completed
- Engine Coolant Temperature (ECT) at or above 70°C (158°F)
- DPF Status = Regen Not Needed
- No leaks in intake air system
- No leaks in exhaust system
- No shop exhaust hose attached
- No engine performance issues
- No engine misfire issues
- Engine hood is closed
- Transmission in Park or Neutral
- Clutch disengaged
- Engine Fan OFF
- Parking brake ON
- Power Takeoff (PTO) disabled
- Air conditioning OFF
- Accelerator pedal not depressed
- MAF sensor within KOEO specification
- IMP sensor within KOEO specification
- IMT sensor within -30°C (-22°F) and 125°C (257°F)

Continue to MAF Calibration Procedure

MAF Calibration Procedure – Using ServiceMaxx™ Software

NOTE: Ensure MAF Calibration Requirements are met and MAF Calibration Pre-Checks are done, prior to doing this procedure.

1. Turn ignition switch to ON, engine OFF.
2. Start ServiceMaxx™ software.
3. Start engine. Ensure engine operating temperature is at or above 80°C (176°F).
4. Run KOER Standard Test.
5. Run KOER MAF Sensor Calibrate Procedure (page 76).
   - If calibration fails, verify all MAF Calibration Requirements (page 660) are met and MAF Calibration Pre-Checks (page 661) are done.
   - If calibration is successful, clear previously active DTC (SPN 132 FMI 13), if present. Turn ignition switch to OFF and wait for 3 seconds. Turn ignition switch ON and review results (programmable parameters 99391 and 99401) in the Parameters tab.

NOTE: If results do not update during the ignition switch cycle, cycle ignition switch again and manually select the engine from the File drop-down menu.

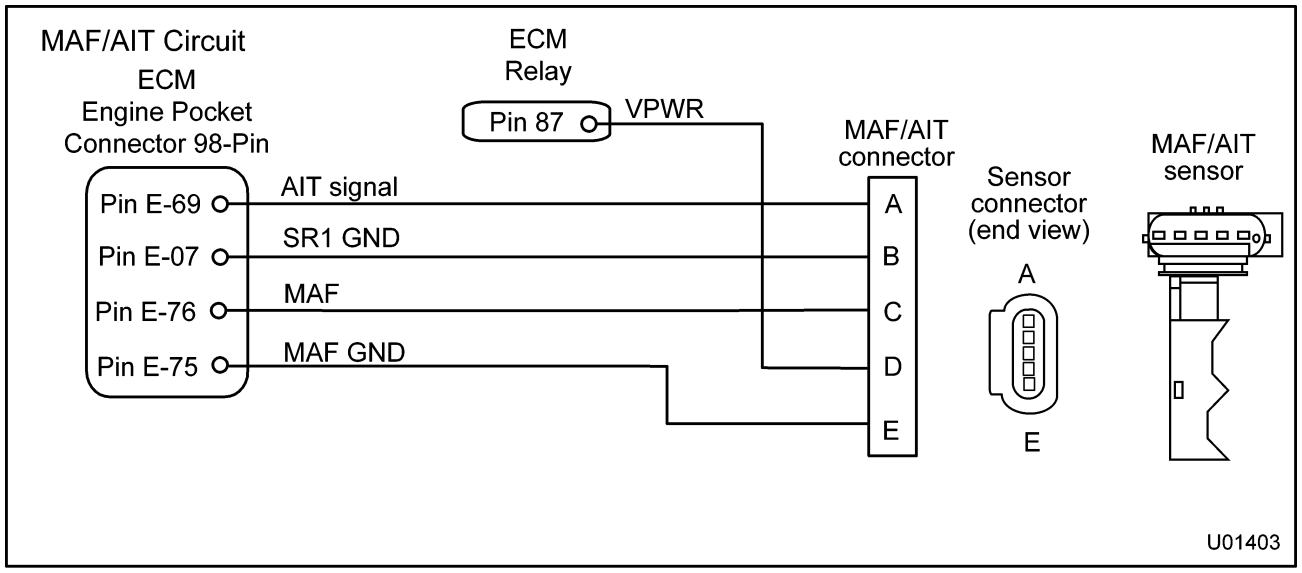


Figure 250 MAF / AIT Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

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

1. Using ServiceMaxx™, monitor sensor voltage. Verify an active DTC for the sensor.
   - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the Diagnostic Trouble Code (DTC) goes active.
   - If DTC is active, proceed to the next step.
2. Disconnect engine harness from sensor.

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

3. Connect to engine harness. Leave sensor disconnected.

Connector Voltage Check

Connect Breakout Harness ZTSE4960. Leave sensor disconnected. Turn ignition switch to ON, engine OFF. Use DMM to measure voltage. Use DMM to measure voltage.

Test Point	Spec	Comment
A to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN AIT circuit or short to GND
B to B+	B+	If below B+ check for OPEN SR1 GND circuit.
C to GND	4.6 V to 5 V	If < 5 V, Check for OPEN MAF circuit or short to GND.
D to GND	B+	If < B+, Check for OPEN VPWR circuit.
E to B+	B+	If < B+, Check for OPEN MAF GND circuit.

If checks are within specifications, connect sensor and clear DTCs. If active DTCs remain, replace sensor.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4960. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
A to E-69	< 5 Ω	If > 5 Ω, check for OPEN AIT circuit.
B to E-07	< 5 Ω	If > 5 Ω, check for OPEN SR1 GND circuit.
C to E-76	< 5 Ω	If > 5 Ω, check for OPEN MAF circuit.
E to E-75	< 5 Ω	If > 5 Ω, check for OPEN MAF GND circuit.

Extended Diagnostic Information

1. At KOEO, the MAF / AIT sensor produces a frequency of 750–10,000 Hz. Monitor the MAF Hz. Record your MAF / AIT sensor readings at KOEO and at idle and again at various RPM ranges. Compare the values against specifications.
2. Start from idle and increase the RPM while watching MAF / AIT reading. Increase should be steadily proportional to RPM change.
3. Perform the same checks while lightly tapping on the sensor or heating the sensor with a blow dryer. Any fluctuation or out-of-specification reading indicates a MAF / AIT sensor or related wiring concern. Repair and retest.

SPN 132 FMI 2 - MAF Signal Erratic, Intermittent, or Incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of sensor reading to other sensor readings after a calibrate cold soak period.	Absolute relative deviation between modeled Mass Air Flow (MAF) rate and measured MAF rate > 40%	Ambient Pressure > 11 psi (76 kPa)	20 seconds
		Air Inlet Temperature (AIT) > 19°F (-7°C) and < 122°F (50°C)	
		Engine Throttle Position (ETP) < 100%	
		Engine Coolant Temperature (ECT) > 104°F (40°C) and < 239°F (115°C)	
		> 1400 rpm and > 700 N•m	
		Not in active regeneration	
		Absolute value of engine speed gradient is < 10 rpm/second for 100 seconds	
		Absolute value of engine torque command gradient is < 10 N•m/second for 100 seconds	
		Exhaust Gas Recirculation Position (EGRP) > 30%	
		The following SPN / FMIs are not active: SPN FMIs 105/3, 105/4, 110/3, 110/4, 132/3, 132/4, 172/3, 172/4, 108/3, 108/4, 412/3, 412/4, 2630/3, 2630/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the deviation between MAF rate and measured MAF rate is above threshold.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

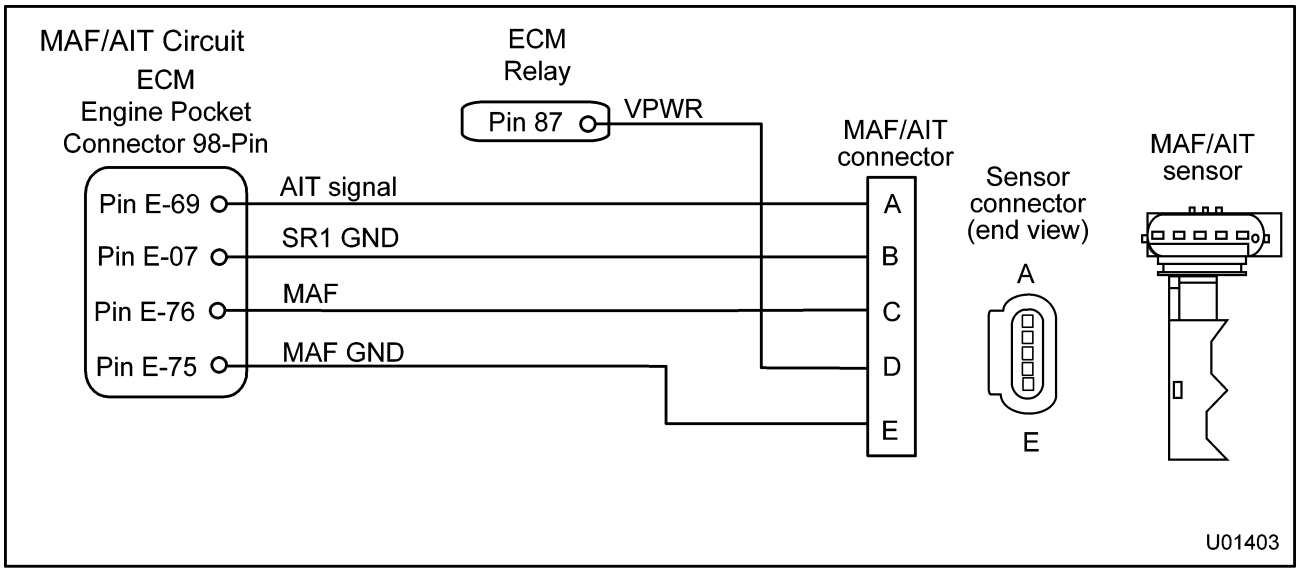


Figure 251 MAF / AIT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx software, check for other fault codes. Is SPN 132 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 132 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Inspect air intake system and air filter for restrictions, air leaks, or physical damage. PerformIntake Air Restriction (page 183) and Charge Air Cooler tests. Is air intake system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to Step 4. No: Repair intake air system or replace air filter.

Step	Action	Decision
4	Inspect connections at Mass Air Flow / Air Inlet Temperature (MAF / AIT) sensor. Key OFF, disconnect MAF / AIT connector. Check MAF / AIT and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are MAF / AIT connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 132 FMI 2.

Step	Action	Decision
5	Test MAF circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 664). Are MAF circuits within specifications?	Yes: Go to Step 6. No: Repair circuits as required, After repairs are complete, retest for SPN 132 FMI 2.

Step	Action	Decision
6	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test (Key On, Engine Off (KOEO) Tests, page 68). Does circuit operate properly?	Yes: Go to Step 7. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 132 FMI 2.

Step	Action	Decision
7	Test MAF / AIT sensor. Connect breakout harness 4960 between MAF / AIT sensor and MAF / AIT sensor connector. Perform KOEO voltage check of MAF / AIT sensor between MAF signal and ground (Key On, Engine Off (KOEO) Tests, page 68). Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 132 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace MAF / AIT sensor. After repairs are complete, retest for SPN 132 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 132 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 172 FMI 2 - AIT Signal Erratic, Intermittent, or Incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of sensor reading to other sensor readings after a calibrate cold soak period.	Sum of FAILED temperature sensor comparisons as listed below: Air Inlet Temperature (AIT) vs Turbocharger 1 Compressor Outlet Temperature (TCOT), Charge Air Cooler Outlet Temperature (CACOT), Intake Manifold Temperature (IMT), Exhaust Gas Recirculation Temperature (EGRT) >= 4	Engine OFF soak time > 8 hours	0.5 seconds
	Comparison between AIT and IMT sensor value > 36°F (20°C)	Time in Key ON engine OFF state < 3 seconds	
	Comparison between AIT and CACOT sensor value > 36°F (20°C)	Engine not in running state	
		{[Comparison of Air Inlet Temperature (AIT) with Intake Manifold Temperature (IMT) > 27°F (15°C), Comparison of AIT with Engine Charge Air Cooler Outlet temperature > 27°F (15°C), Comparison of AIT with Engine Turbocharger 1 Compressor Outlet temperature > 27°F (15°C), Comparison of AIT with Engine Exhaust Gas Recirculation temperature > 27°F (15°C), Comparison of Intake Manifold Temperature (IMT) with Charge Air Cooler Outlet Temperature (CACOT) > 27°F (15°C), Comparison of IMT with Turbocharger Outlet Temperature (TCOT) > 27°F (15°C), Comparison of IMT with Engine Exhaust Gas Recirculation Temperature (EGRT) > 27°F (15°C), Comparison of CACOT with TCOT > 27°F (15°C),

SPN 172 FMI 2 - AIT Signal Erratic, Intermittent, or Incorrect (cont.)

<table>
<tr><td rowspan="2"></td><td>Comparison between AIT and EGRT sensor value > 36°F (20°C)</td><td>Comparison of CACOT with EGRT > 27°F (15°C), Comparison of TC1COT with EGRT > 27°F (15°C),], and sum of True Conditions from comparisons listed above} >5 TBD</td><td rowspan="2"></td></tr>
<tr><td>Comparison between AIT and TCOT sensor value > 36°F (20°C)</td><td>The following SPN / FMIs are not active: 172/3, 172/4, 2629/3, 2629/4, 2630/3, 2630/4, 105/3, 105/4, 412/3, and 412/4.</td></tr>
</table>

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the AIT sensor value is incorrect when compared to other sensor values.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

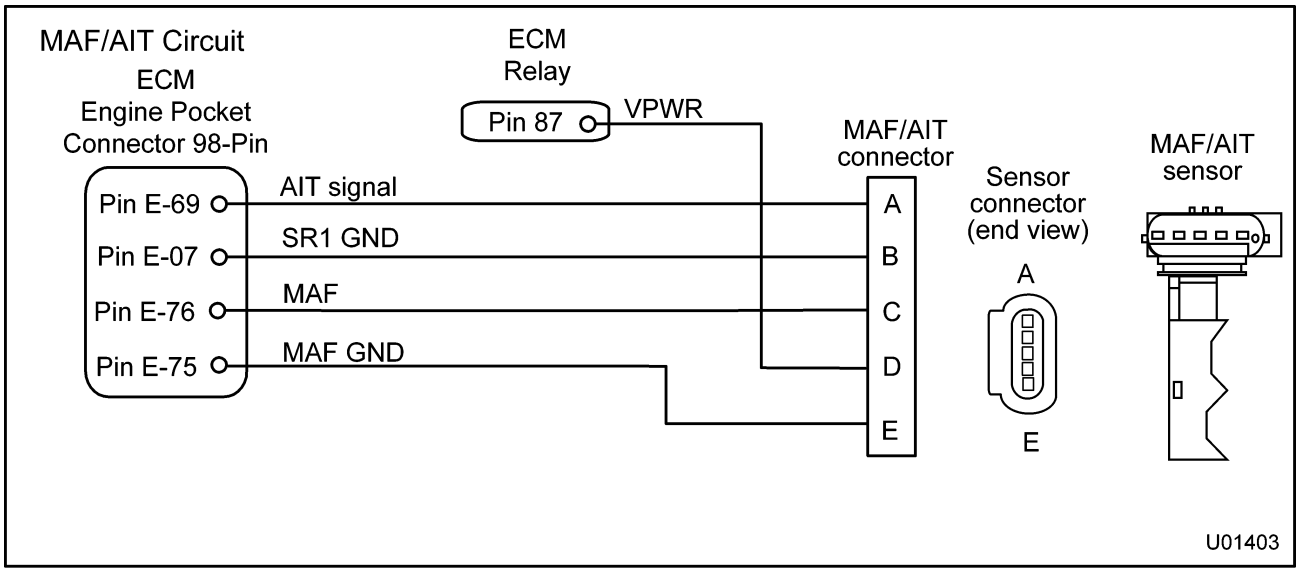


Figure 252 MAF / AIT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. SPN 172 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 172 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Mass Air Flow / Air Inlet Temperature (MAF / AIT) sensor. Key OFF, disconnect MAF / AIT connector. Check MAF / AIT and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are MAF / AIT connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 172 FMI 2.

Step	Action	Decision
4	Test AIT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 664). Are AIT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 172 FMI 2.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test (Key On, Engine Off (KOEO) Tests, page 68). Does circuit operate properly?	Yes: Go to Step 6. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required. After repairs are complete, retest for SPN 172 FMI 2.

Step	Action	Decision
6	Test MAF / AIT sensor. Connect breakout harness 4960 between MAF / AIT sensor and MAF / AIT sensor connector. Perform KOEO voltage check of MAF / AIT sensor between MAF signal and ground (Key On, Engine Off (KOEO) Tests, page 68). Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 172 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace MAF / AIT sensor. After repairs are complete, retest for SPN 172 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 172 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

TOSS / VSS (Transmission Output Shaft Speed / Vehicle Speed Sensor) Sensor

SPN	FMI	Condition	Possible Causes	
191	1	TOSS / VSS not detected with vehicle moving	• Biased, damaged, or disconnected sensor or circuit • Non-CAN PTO • Loss of CAN signal from transmission	Step-Based Diagnostics (page 677)
191	3	TOSS / VSS signal Out of Range HIGH	• TOSS / VSS circuits OPEN or short to PWR • TOSS / VSS frequency below 0.25 Hz • Failed TOSS / VSS • Incorrect PP setting	Pin-Point Diagnostics (page 676)
191	4	TOSS / VSS signal Out of Range LOW	• TOSS / VSS circuits short to GND • TOSS / VSS frequency below 0.25 Hz • Incorrect PP setting	Pin-Point Diagnostics (page 676)
191	19	TOSS / VSS signal not detected on J1939	• See *Electrical System Troubleshooting Guide*.	Pinpoint Diagnostics (page 676)

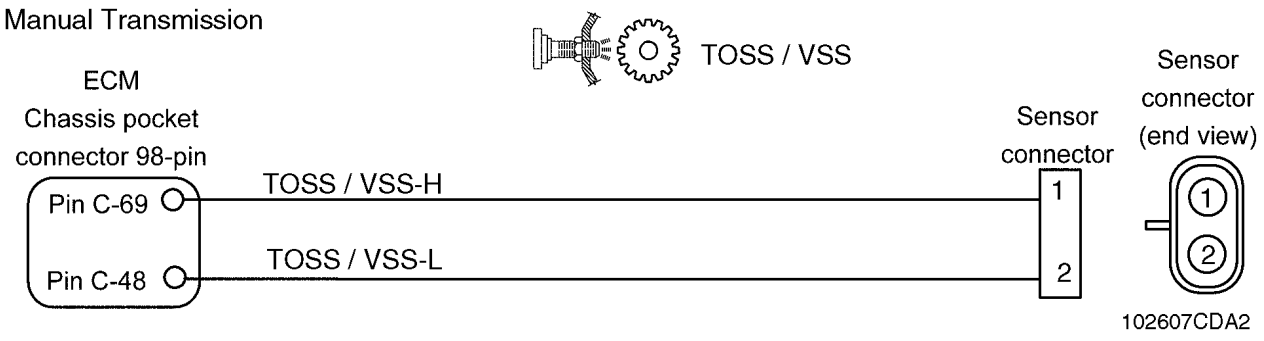


Figure 253 TOSS / VSS Circuit Diagram (Manual Transmissions)

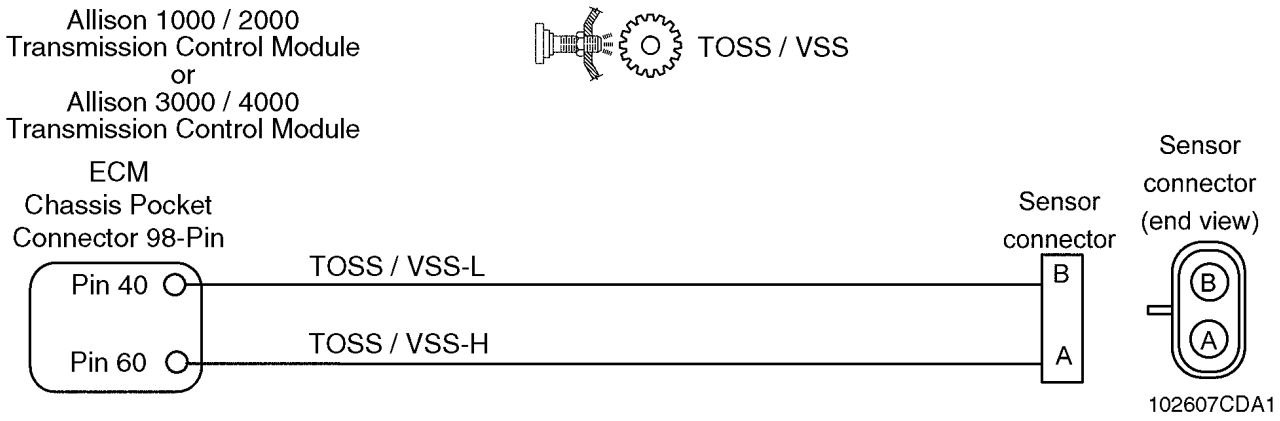
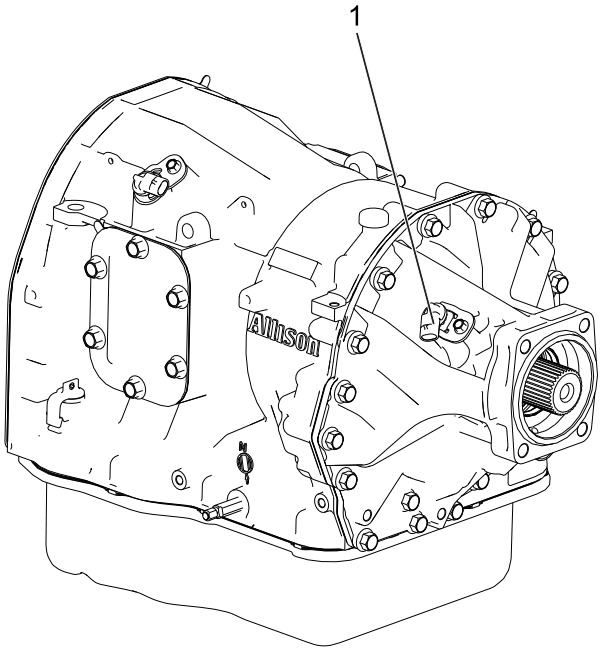


Figure 254 TOSS / VSS Circuit Diagram (Automatic Transmissions)

Overview

The Transmission Output Shaft Speed / Vehicle Speed Sensor (TOSS / VSS) Sensor is used by the Engine Control Module (ECM) to monitor the vehicle's speed. The ECM uses this signal to control Power Takeoff (PTO), road speed limiting, and cruise control. Automatic transmissions use this signal for shift scheduling.



0000061341

Figure 255 TOSS / VSS Sensor Location

1. TOSS / VSS Sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- *Electrical System Troubleshooting Guide* (truck manual)
- *Chassis Electrical Circuit Diagram Manual* (truck manual)
- Digital Multimeter (DMM)
- 00–00956–08 - 180-Pin Breakout Box

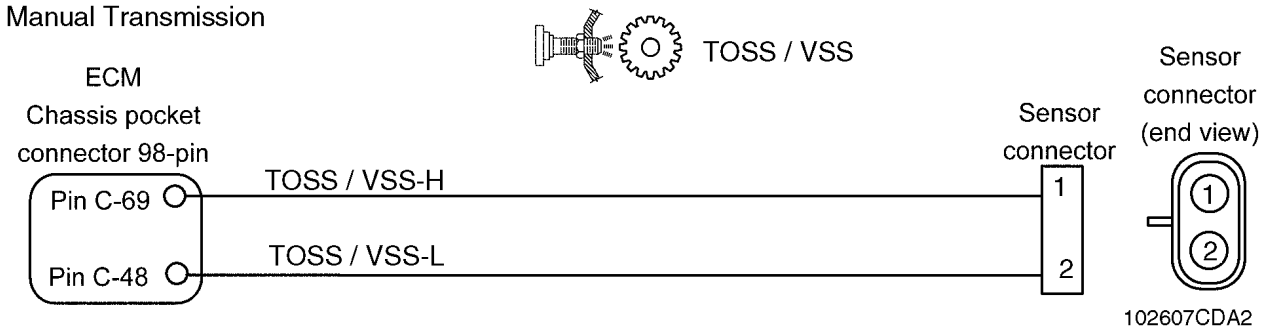


Figure 256 TOSS / VSS Circuit Diagram (Manual Transmissions)

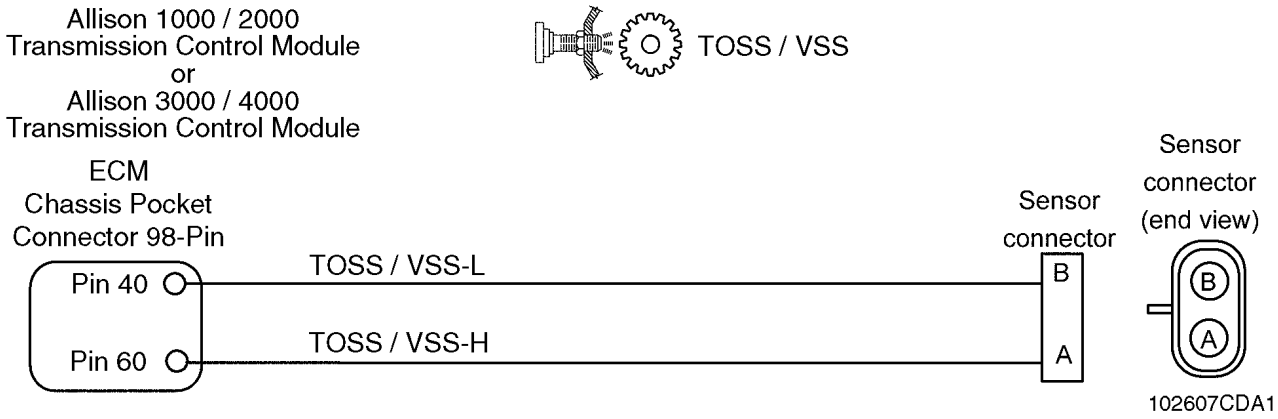


Figure 257 TOSS / VSS Circuit Diagram (Automatic Transmissions)

Pinpoint Diagnostics With ServiceMaxx™ Software

TOSS / VSS circuit diagnostics require the use of vehicle circuit diagrams. See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for circuit numbers, connectors, and fuse locations.

1. Connect EST to Diagnostic Connector.
2. Turn ignition switch to ON.
   - If SPN 191 FMI 19 is displayed, see *Electrical System Troubleshooting Guide*.
   - If SPN 191 FMI 3 or 4 is displayed, continue to next check.

Connector Voltage Checks

Disconnect TOSS / VSS. Turn ignition switch to ON. Use a DMM to measure voltage.

Test Point	Spec	Comment
B to GND	2.5 V ± 0.5 V	If < 2 V, check for OPEN or short to GND.
A to GND	2.5 V ± 0.5 V	If > 3 V, check for OPEN or short to PWR.

Sensor Resistance Check

Disconnect TOSS / VSS. Use a DMM to measure resistance through sensor.

Test Point	Spec	Comment
A to B	700 Ω ± 100 Ω	If not within specification, replace TOSS / VSS.

Harness Resistance Check

Connect breakout box. Leave TOSS / VSS and ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
C-48 to A	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C-69 to B	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 191 FMI 1- TOSS / VSS not detected with vehicle moving

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Transmission Output Shaft Speed / Vehicle Speed Sensor (TOSS / VSS) sensor impossible reading	Vehicle speed < 1 mph	PTO mode not active	60 seconds
		Engine speed > 1500 rpm and Engine torque > 1000 N•m	
		RSC_VS_FLT not active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the TOSS / VSS sensor signal value is not possible when compared to other related signal values.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Fault Fact

Code can be set if a non- Controller Area Network (CAN) Power Takeoff (PTO) is installed on vehicle.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

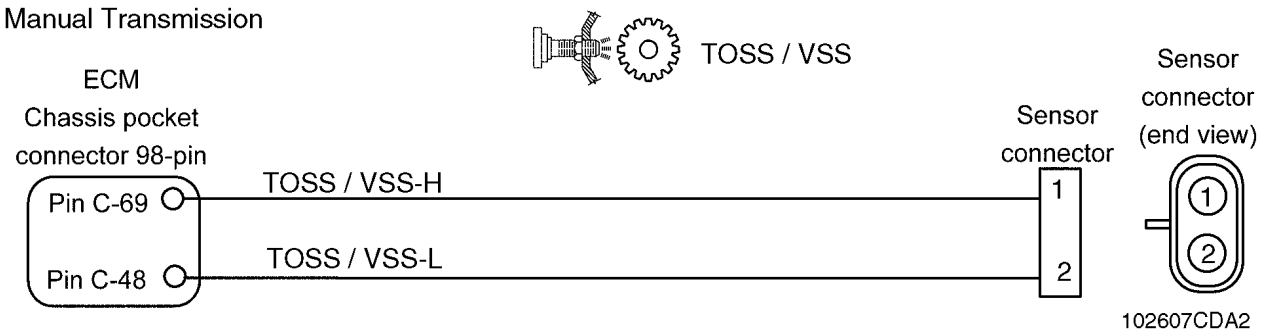


Figure 258 TOSS / VSS Circuit Diagram (Manual Transmissions)

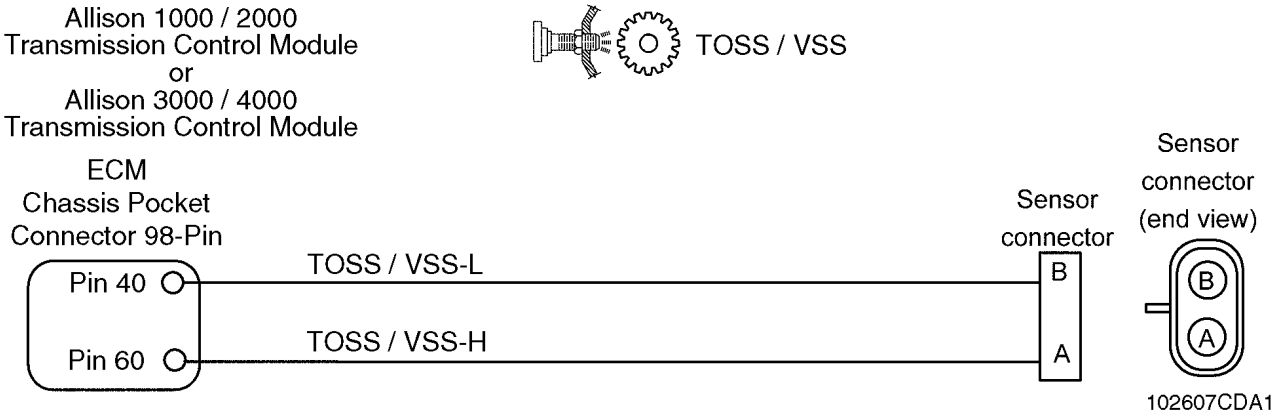


Figure 259 TOSS / VSS Circuit Diagram (Automatic Transmissions)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 191 FMI 1 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 191 FMI 1. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at TOSS / VSS sensor. With Key OFF, disconnect TOSS / VSS connector. Check TOSS / VSS and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are TOSS / VSS connector, harness, and terminals clean and undamaged?	Yes: For manual transmission, go to Step 4. For automatic transmission, go to Step 6 (page 679) . No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 191 FMI 1.

Step	Action	Decision
4	Using EST with Servicemaxx ™, verify programmable parameters are set for manual transmission. Are programmable parameters set for manual transmission?	Yes: Go to Step 5. No: Correct programmable parameters. After repairs are complete, retest for SPN 191 FMI 1.

Step	Action	Decision
5	Install 180 pin Breakout Box and check resistance on TOSS / VSS sensor circuits (TOSS / VSS-H and TOSS / VSS-L) between sensor and ECM. Is resistance within specifications?	Yes: Replace TOSS / VSS. After repairs are complete, retest for SPN 191 FMI 1. No: Repair circuits as needed. After repairs are complete, retest for SPN 191 FMI 1.

Step	Action	Decision
6	Using EST with Servicemaxx ™, verify programmable parameters are set for automatic transmission. Are programmable parameters set for automatic transmission?	Yes: Go to Step 7. No: Correct programmable parameters. After repairs are complete, retest for SPN 191 FMI 1.

Step	Action	Decision
7	Using EST with ServiceMaxx™, refer to Sniffer window in lower right corner of screen. With Key ON Engine OFF (KOEO), are modules present in the Module Name column?	Yes: Go to Step 8. No: Repair CAN wiring for open, short, high resistance, or tampering.

Step	Action	Decision
8	Using EST with ServiceMaxx™, refer to Sniffer window in lower right corner of screen. With KOEO, does Transmission appear in the Module Name column?	Yes: Refer vehicle to transmission repair facility.
		No: Check CAN wiring and power and ground circuits to Transmission Control Module (TCM). If wiring is okay, refer vehicle to transmission repair facility.

NOTE: After doing all diagnostic steps, if SPN 191 FMI 1 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

RSE (Radiator Shutter Enable)

SPN	FMI	Condition
None	None	

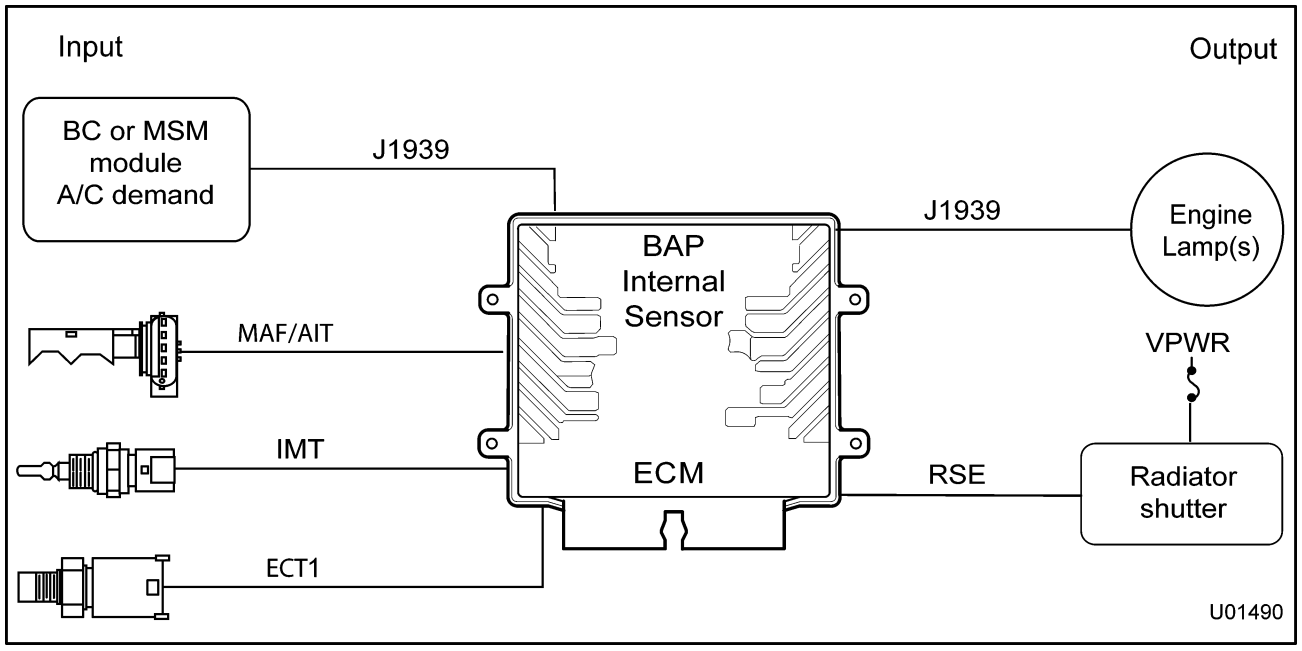


Figure 260 Function diagram for RSE

The RSE function diagram includes the following:

- Radiator Shutter Enable (RSE)
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Air Inlet Temperature (AIT) signal from the Mass Air Flow (MAF) sensor
- Intake Manifold Temperature (IMT)
- Engine Coolant Temperature 1 (ECT1) sensor
- Engine Lamp(s)
- Body Controller (BC) or Multiplex System Module (MSM)

Function

RSE feature provides signals to open or close radiator shutters (energize or de-energize the solenoid). Closing the shutters keeps the engine warm during cold weather operation. This provides faster warmup of the passenger cab and enables faster windshield defrosting.

Component Location

The radiator shutter solenoid is installed in the pressure line that feeds the shutters.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

RSE Circuit Diagnostics

SPN	FMI	Condition	Possible Causes
None	None	Inactive radiator shutter	• RSE circuit OPEN or short to GND • VPWR circuit OPEN or short to GND, blown fuse • Failed relay • Failed RSE solenoid

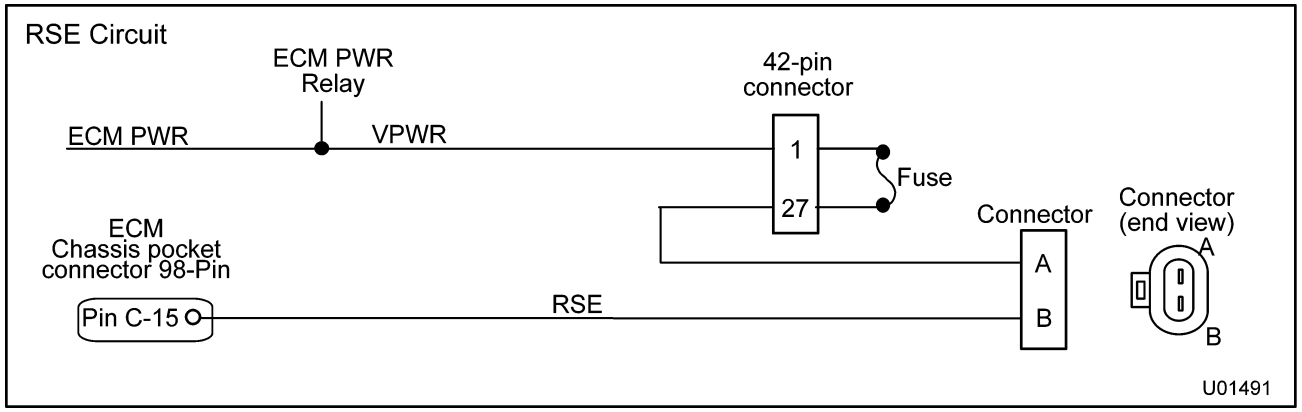


Figure 261 RSE circuit diagram

Voltage Check at RSE Connector - Output State Test

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

Test Point	Spec	Comment
A to GND	B+	If < B+, check VPWR circuit for OPEN, blown fuse, or failed relay.
B to GND	0 V to 0.25 V	If > 0.25 V, check RSE circuit for short to PWR.
Run Output State Test HIGH.		
B to B+	0 V to 0.25 V	If > 0.25 V, check RSE circuit for short to GND.
Run Output State Test LOW.		
B to B+	B+	If < B+, check RSE circuit for OPEN or short to PWR. Do Harness Resistance Check (page 684).
A to B+	B+	If < B+, check VPWR circuit for OPEN. Do Harness Resistance Check (page 684).

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box. Leave ECM and radiator shutter solenoid disconnected.

Test Point	Spec	Comment
C-15 to B	< 5 Ω	If > 5 Ω, check RSE for OPEN circuit.
C-15 to GND	> 1 kΩ	If < 1 kΩ, check RSE circuit for short to GND.
A to C-83, C-84 and C-85	< 5 Ω	If > 5 Ω, check VPWR for OPEN in circuit.
A to GND	> 1 kΩ	If < 1 kΩ, check VPWR for short to GND.

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

RSE Circuit Operation

The control cylinder responds to air or hydraulic pressure from the shutter control valve and actuates to hold the spring-loaded vanes closed. When pressure is relieved, the vanes open. The vanes open automatically when the vehicle is shut down.

The RSE solenoid is supplied VPWR at Pin A. The ECM Pin C-15 controls the solenoid by grounding Pin B.

The shutters close when all of the following conditions exist:

- IMT is less than 37 °C (99 °F)
- AIT 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:

- IMT is greater than 60 °C (140 °F)
- AIT is greater than 12 °C (54 °F)
- Transmission retarder request is present
- Engine fan request is present
- ECT is greater than 87° C (189 °F)

NOTE: ECT is customer programmable

The shutters will not close again until all closed conditions exist.

Fault Detection / Management

An open or short to ground in the RSE can be detected by the ECM during an on-demand engine standard test. The AIT, IMT, and ECT are continuously monitored. If a fault is detected in the AIT, IMT, or ECT circuit, the RSE control is disabled and the radiator shutters remain open.

Service Interval Messages

SPN	FMI	Condition	Possible Causes	Actions
1378	14	Change Engine Oil Service Interval (COSI) reset ahead of schedule	• Manual reset of interval with cruise buttons before full interval for COSI	Step-Based Diagnostics (page 686)

Service Interval Messages Operation

The service interval messages are displayed on the instrument cluster message center and include engine oil and fuel filter change reminders.

The change oil reminder can be programmed for kilometers, miles, hours, or calculated fuel consumption. These service interval limits may be adjusted at the owner's discretion. The change engine oil message below the odometer illuminates after a preselected parameter is reached.

The fuel filter change message displays when the fuel filter needs replacement due to high filter restriction.

SPN 1378 FMI 14 - Change engine oil service interval reset ahead of schedule

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Change engine oil service interval reset ahead of schedule	TBD	TBD	TBD

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the oil service interval light has been reset ahead of schedule.

Malfunction Indicator Lamp (MIL) Reaction

TBD

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 1378 FMI 14 the only fault code active?	Yes: Go to Step 2.
		No: Repair other fault codes first. After repairs are complete, retest for SPN 1378 FMI 14.

Step	Action	Decision
2	SPN 1378 FMI 14 is set when the Oil Service Interval Light is reset before the vehicle has reached the appropriate mileage interval. Determine why the light was reset and if the reset was purposeful. Was Oil Service Interval Light reset on purpose?	Yes: Explain to operator that SPN 1378 FMI 14 will set any time the Service Interval Light is reset before the appropraite mileage interval.
		No: Determine what caused the accidental reset of the Service Interval Light, and inform operator of ways to avoid future accidental resets.

NOTE: After doing all diagnostic steps, if SPN 1378 FMI 14 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SMC (Starter Motor Control) Circuit

SPN	FMI	Condition
None		Engine starter motor will not engage

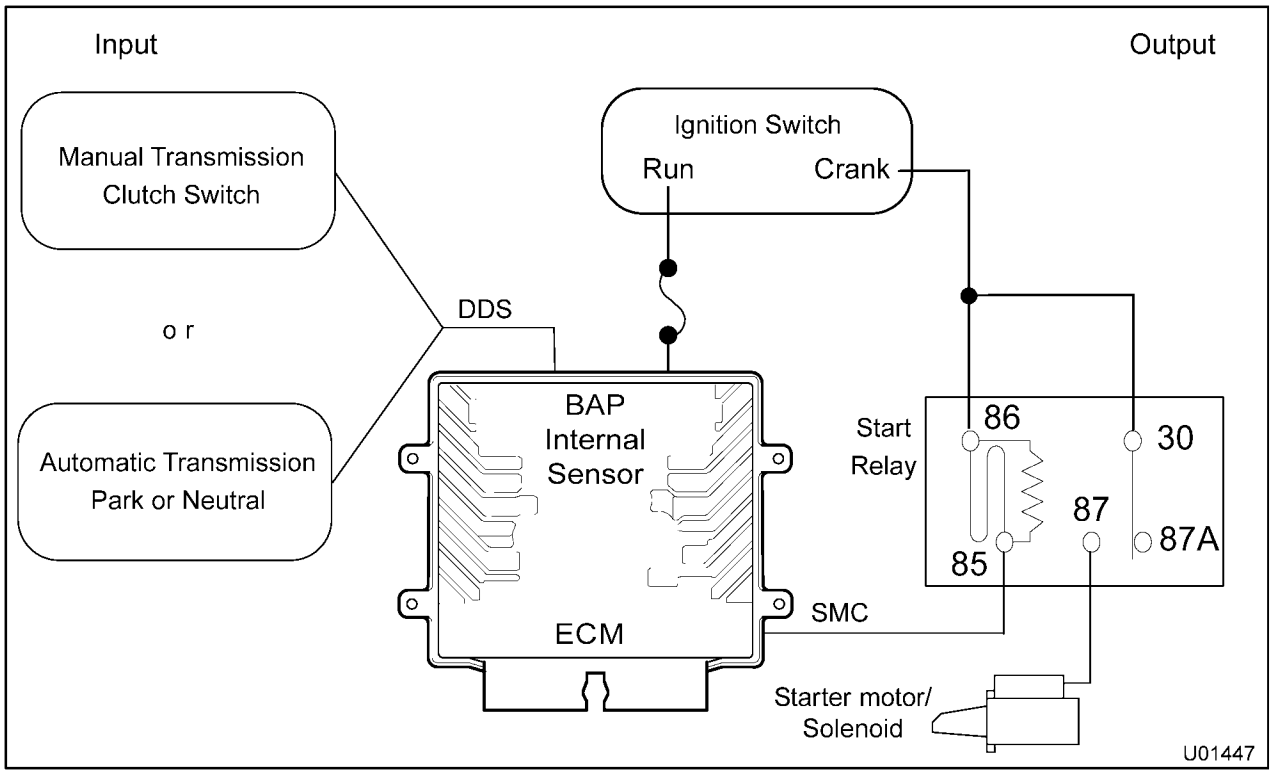


Figure 262 Function diagram for SMC circuit diagram

The SMC circuit function diagram includes the following:

- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Starter
- Start relay
- Starter Motor Control (SMC) circuit
- Driveline Disengagement Switch (DDS)

Function

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

Location

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

Tools

- Digital Multimeter (DMM)
- 00-00956-08 – 180-Pin Breakout Box

- Relay Breakout Harness ZTSE4908 (SMC)

SMC Circuit Diagnostics

SPN	FMI	Condition	Possible Causes
None	None	No engine crank	• Transmission in gear • Clutch pedal not pressed • No power to Transmission Control Module (TCM) • No power to ECM • Blown ignition switch fuse • Failed start relay • OPEN DDS circuit • OPEN SMC circuit • Failed ignition switch • Failed starter motor • Low battery state of charge. • High resistance or corroded cables to starter or battery. • Failed ECM • Failed TCM • Failed Manual Transmission clutch switch • Open VIGN circuit

- Open Relay Coil power circuit

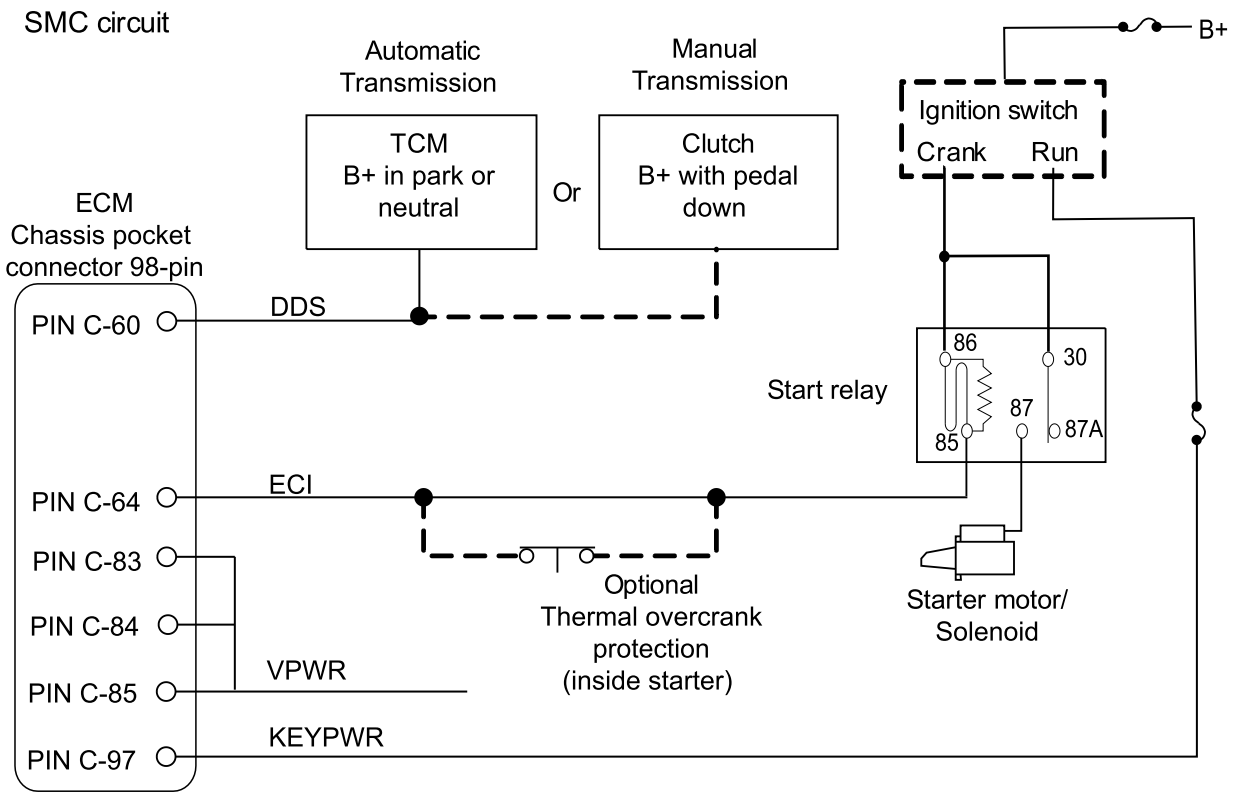


Figure 263 SMC circuit diagram

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

NOTE: Ensure battery is fully charged before starting the following procedures.

Voltage Check at Start Relay and Starter Solenoid

Connect Breakout Harness ZTSE4908 between relay and relay socket.

Test Point	Spec	Comment
Turn ignition switch to CRANK and hold. Use DMM to measure voltage.		
86 to GND	B+	If < B+, check power circuit to relay coil for OPEN or short to GND, blown fuse, or possible failed ignition switch.
85 to GND	< 2 V	If B+, check SMC control circuit for OPEN. If extended cranking attempt preceded the no crank condition, wait 15 minutes for Thermal Overcrank switch to reset.
87 to GND	B+	If < B+, replace relay. If B+, check voltage at starter solenoid's small control circuit wire terminal.
Solenoid Control to GND	B+	If < B+, check wiring between pin 87 of relay and solenoid control terminal for OPEN circuit.

Voltage Check at ECM

Connect 180-Pin Breakout Box between ECM and chassis harness. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
C-97 to GND	B+	If < B+, check VIGN circuit for OPEN or short to GND, blown fuse, or possible failed ignition switch.
C-86 to GND C-87 to GND C-88 to GND	0 V	If voltage is present, check for OPEN ECM GND circuit. See ECM PWR Pin-point Diagnostics (page 410) in this section.
C-83 to GND C-84 to GND C-85 to GND	B+	If < B+, check for OPEN ECM PWR circuit. See ECM PWR Pin-point Diagnostics (page 410) in this section.
Place automatic transmission in park or neutral (manual transmission, press clutch). Use DMM to measure voltage.		
C-60 to GND	B+	If < B+, check DDS for OPEN circuit. • For automatic transmission, see transmission diagnostics. • For manual transmission, check PWR circuit to clutch pedal or blown fuse. A failed clutch pedal switch is possible.
C-64 to GND	< 2 V	If > 2 V, check ECM programming.

Harness Resistance Check - ECM to Relay

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4908. Leave ECM and relay disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
85 to C-64	< 5 Ω	If > 5 Ω, check SMC control circuit for OPEN or possible failed thermal overcrank protection switch.
85 to GND	> 1 kΩ	If < 1 kΩ, check SMC control for short to GND.
87 to starter	< 5 Ω	If > 5 Ω, check SMC control for OPEN or possible failed thermal over crank protection switch.
87 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND.

Harness Resistance Check - Relay to Battery

Disconnect both battery GND cables and the inline connector on battery ground cable. Disconnect start relay. Use DMM to measure resistance while holding ignition switch in CRANK position.

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

86 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
30 to B+ battery post	< 5 Ω	If > 5 Ω, check circuit for OPEN or blown fuse.
30 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
C-60 DDS circuit	See *Chassis Electrical Circuit Diagram Manual*. Check for OPEN or short to GND. Possible failed clutch switch or automatic transmission module circuit faults.	

Operational Voltage Check

Connect 180-Pin Breakout Box between ECM and chassis harness. Leave battery cables connected. Turn ignition switch to ON. Use DMM to measure voltage at the conditions specified.

Test Point	Spec	Condition
DDS C-60 to GND	B+	ECM Input - Clutch pedal not pressed or automatic transmission in gear. Cranking is disabled.
	0 V	ECM Input - Clutch pedal to the floor or automatic transmission in park or neutral. Cranking is enabled.
Turn the ignition switch to the CRANK position. Use DMM to measure voltage.		
SMC C-64 to PWR	0 V	ECM Control - SMC enabled. To enable SMC, fully depress clutch pedal or shift automatic transmission to park or neutral.
	B+	ECM Control - SMC disabled. To disable SMC, do not depress clutch pedal or place shifter of automatic transmission in gear.

SMC Circuit Operation

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

Driveline Disengagement Switch (DDS) Circuit

The ECM monitors the DDS on Pin C-60. B+ indicates the drivetrain is disengaged and the engine is ready to start. Zero volts indicates the drivetrain is engaged and the engine is not ready to start. The source of this signal depends on the vehicle's hardware configuration. See appropriate electrical diagrams when diagnosing this circuit.

Ignition Switch

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

SMC Circuit

The ECM controls starter disable with the SMC circuit. Pin C-64 to relay coil Pin 85. Open or B+ will disable the relay. zero volts (GND) will enable the relay.

ECM

When the ECM recognizes the engine is not running and the driveline is not engaged, the ECM grounds Pin C-64. This provides a current path for the start relay to close when the start switch is engaged or the starter button is pressed.

When the ECM recognizes the engine is running or the driveline is engaged, it opens Pin C-64. This prevents the start relay from closing and the starter motor from engaging.

Start Relay

The engine start relay controls voltage to the starter solenoid. Turning the ignition switch to CRANK supplies current to energize the relay at Pin 86. If the engine is not running and the driveline is not engaged, ECM Pin C-64 enables the relay by supplying a ground to Pin 85. When the relay is closed, current passes through the relay to the starter solenoid.

Clutch Switch (Manual Transmission)

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

Neutral Signal (Automatic Transmission)

On vehicles equipped with Allison automatic transmissions the, TCM sends a signal to the ECM on the DDS circuit indicating transmission range position. A 0-volt signal indicates the transmission is in gear, while a 12-volt signal indicates the transmission is out of gear. When the transmission is out of gear, the ECM grounds Pin C-64. This provides a current path to energize the Starter Relay with the Ignition Switch in the CRANK position. When the transmission is in gear, no ground path is supplied, preventing starter engagement.

Fault Detection / Management

There are no DTCs associated with the SCM system.

TACH (Tachometer Output Circuit)

SPN	FMI	Condition
190	14	Tachometer Drive Output Error

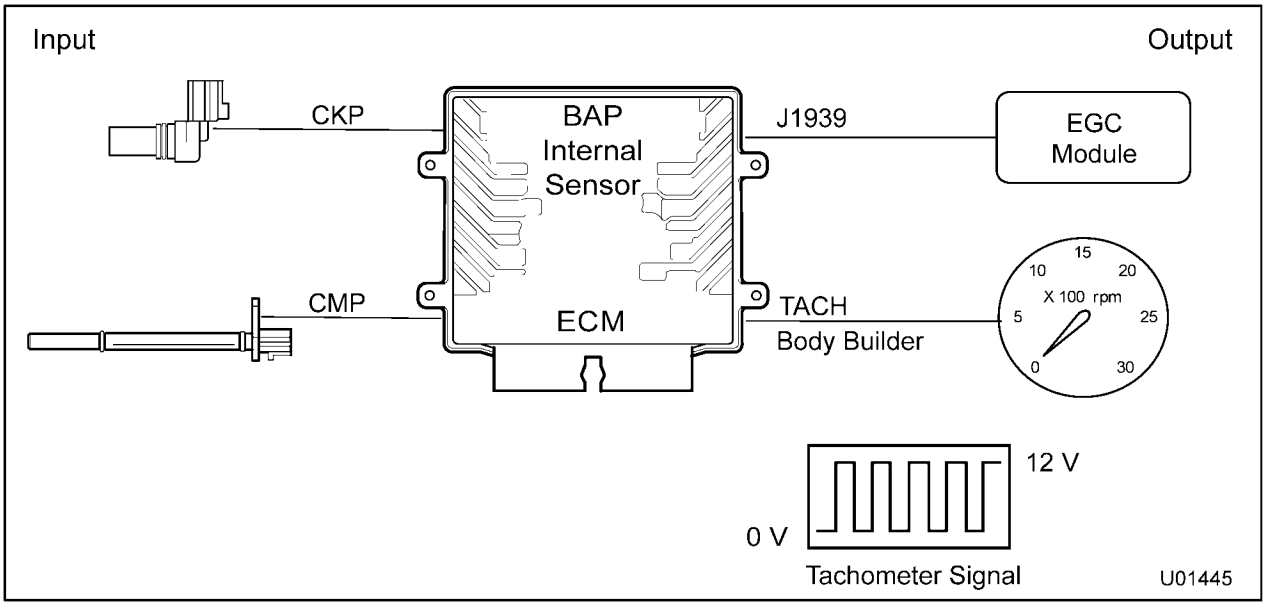


Figure 264 Function diagram for the tachometer output circuit

The tachometer output circuit function diagram includes the following:

- Remote tachometer
- Electronic Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Electronic Gauge Cluster (EGC) Module
- Crankshaft Position (CKP) sensor
- Camshaft Position (CMP) sensor

The tachometer signal is sent to the EGC through the public CAN network. The TACH signal is also supplied on one circuit to the body builder blunt cut-off circuits.

Tachometer Pin-point Diagnostics

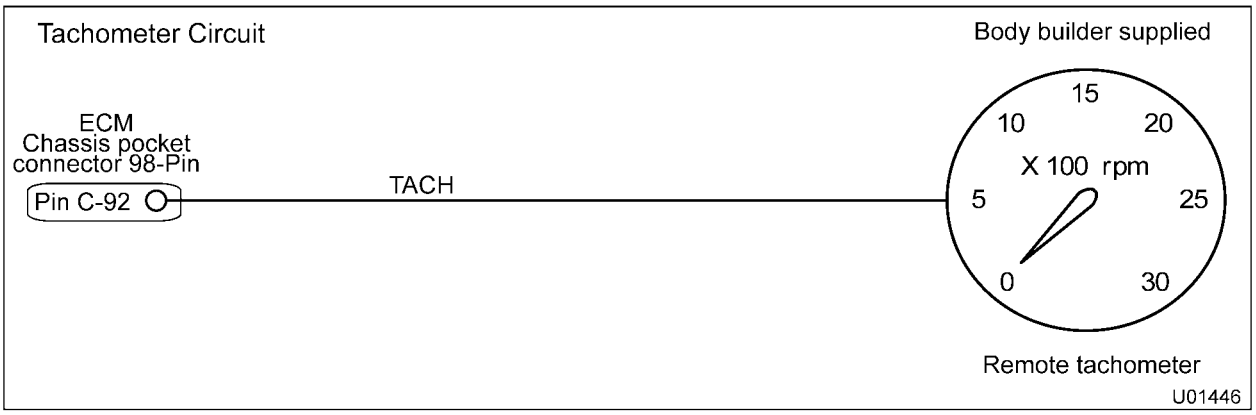


Figure 265 Tachometer circuit diagram

Circuit End Voltage Check

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

Disconnect component from the body builder blunt cut off circuit. Turn the ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
TACH to GND	12 V ± 1.0 V	If < 11.0 V, check for OPEN circuit
Start engine. Set DMM to ACV - RPM 2 to measure engine speed signal.		
TACH to GND	Low idle = 140 Hz at 700 RPM High idle = 590 Hz at 2950 RPM	If no signal, do Harness Resistance Check (page 696).

Harness Resistance Check

Connect breakout box, leave ECM and TACH component disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
C-92 to TACH	< 5 Ω	If > 5 Ω , check for OPEN circuit
C-92 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND

Tachometer Circuit Operation

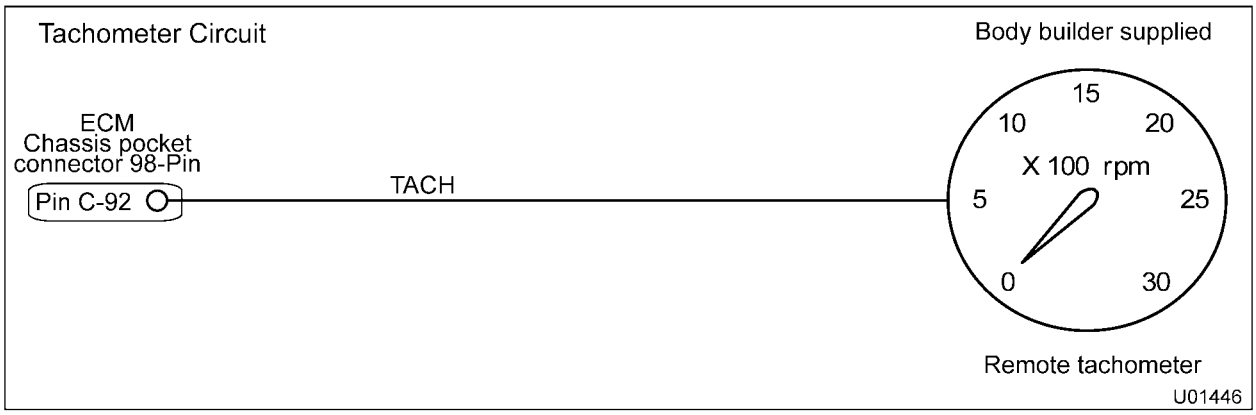


Figure 266 Tachometer circuit diagram

The ECM receives a signal from the CKP sensor and calculates engine speed (rpm). The ECM provides an output for a remote tachometer with a 0 to 12 volts digital signal that indicates engine speed. The frequency sent by the ECM is 1/5th of the actual engine rpm (12 pulses per engine revolution).

Diagnostic Trouble Codes (DTCs)

DTCs are not available for communication between the ECM and the remote tachometer.

TC2WG (Turbocharger 2 Wastegate) Solenoid

SPN	FMI	Condition
1189	3	TC2WG short to PWR
1189	4	TC2WG short to GND
1189	5	TC2WG open load / circuit

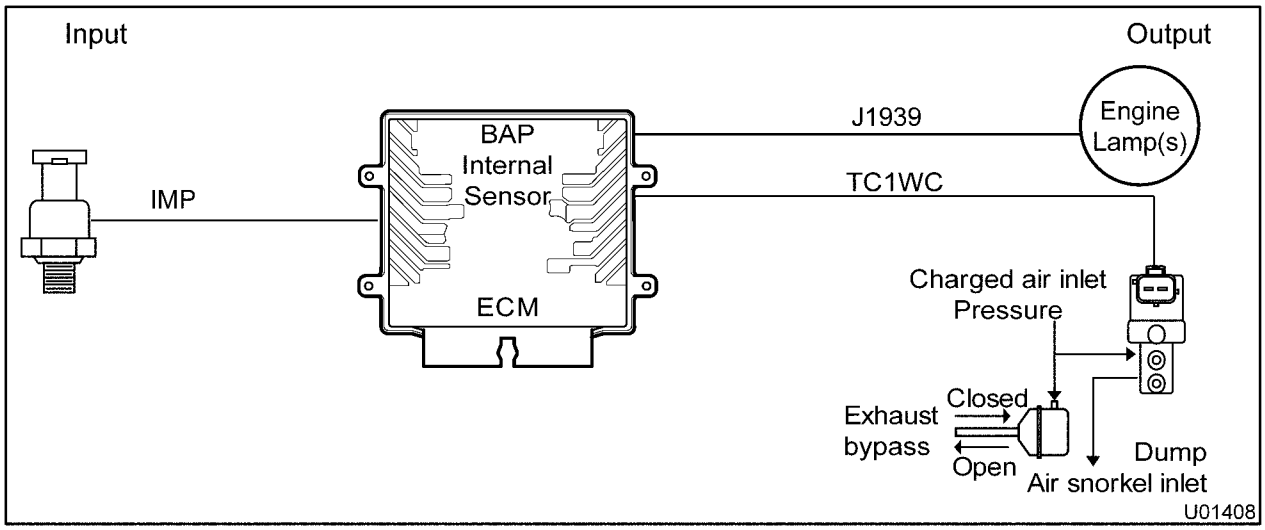


Figure 267 Function diagram for the TC2WG

The TC2WG function diagram includes the following:

- Turbocharger 2 Wastegate (TC2WG)
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Intake Manifold Pressure (IMP) sensor
- Engine Lamp(s)

Function

The ECM commands the TC2WG to control the turbocharger pneumatic actuator.

Sensor Location

The TC2WG is located towards the front of the engine, close to the turbo oil supply line.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 00-00956-08 – 180-Pin Breakout Box

- International® Electronic Engine Terminal Test Kit ZTSE4435C
- Breakout Harness ZTSE4831 (TCWC)

TC2WG Circuit Diagnostics

SPN	FMI	Condition	Possible Causes
1189	3	TC2WG short to PWR	• Signal circuit short to PWR / control circuit fault
1189	4	TC2WG short to GND	• Signal circuit short to GND / control circuit fault
1189	5	TC2WG open load / circuit	• Signal circuit OPEN / control circuit fault

TC1WC Circuit

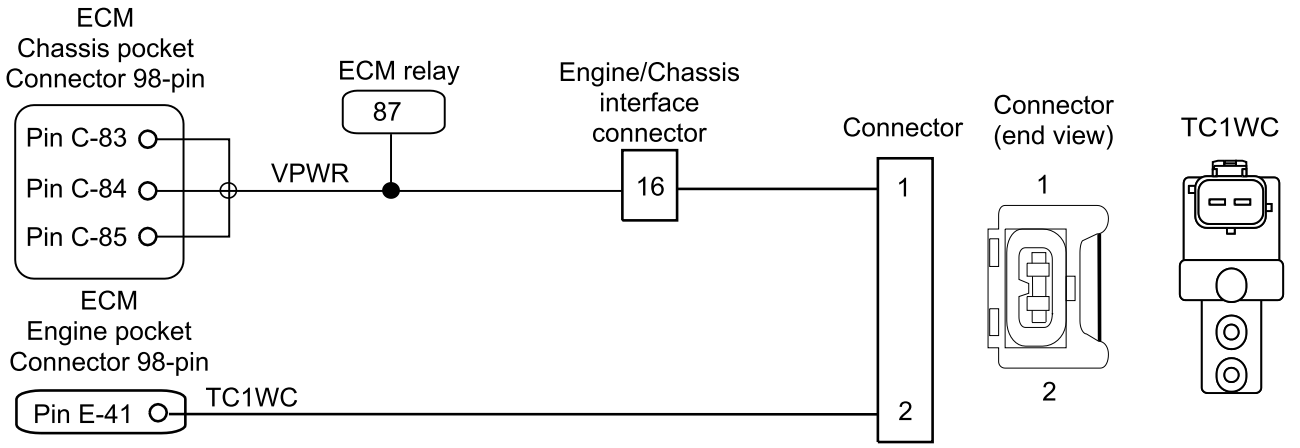


Figure 268 TC2WG circuit diagram

Voltage Check at TC2WG Connector - Output State Test

Disconnect TC2WG 2-pin connector. Turn the ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	B+	If < B+, check for OPEN circuit.
2 to B+	B+	If < B+, check for short to power or open circuit. Do Harness Resistance Checks (page 700).
Run Output State Test HIGH.		
2 to B+	B+	If <B+, check TC2WG circuit for OPEN or short to PWR. Harness Resistance Checks (page 700).
1 to 2	B+	If <B+, check VREF circuit for OPEN. Do Harness Resistance Checks (page 700).

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box. Leave ECM and TC2WG disconnected.

Test Point	Spec	Comment
E-41 to 2	< 5 Ω	If > 5 Ω , check TC2WG for OPEN circuit.
E-41 to GND	> 1 kΩ	If < 1 kΩ , check TC2WG for short to GND.
1 to C-1, 3 and 5	< 5 Ω	If < 5 Ω, check VREF for OPEN in circuit.
1 to GND	> 1 kΩ	If < 1 kΩ, check VREF for short to GND.

TC2WG Circuit Operation

TC1WC Circuit

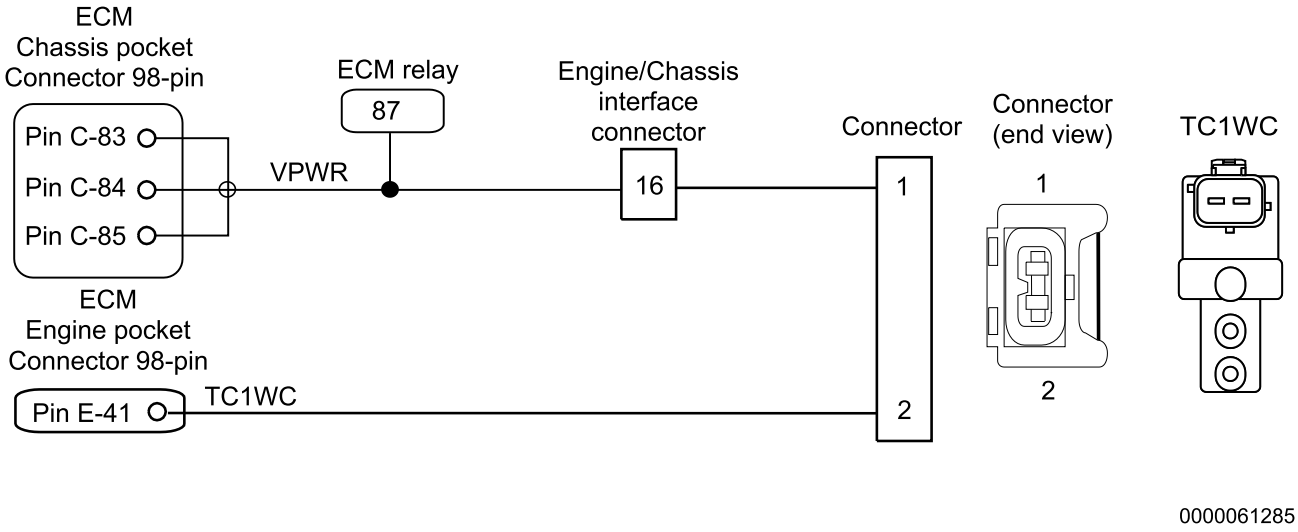


Figure 269 TC2WG circuit diagram

The TC2WG solenoid receives VPWR at Pin 1. The ECM controls the solenoid by grounding Pin 2.

Fault Detection / Management

The ECM monitors the internal BAP sensor as a base line for zeroing the IMP.

An OPEN or short to ground in the TC2WG can be detected by the ECM during an on-demand engine standard test.

TC1COT (Turbocharger 1 Compressor Outlet Temperature) Sensor

TC1COT Sensor End Diagnostics

SPN	FMI	Condition	Possible Causes	Actions
2629	2	TC1COT signal erratic, intermittent, or incorrect	• TC1COT biased sensor or circuit	Step-Based Diagnostics (page 705)
2629	3	TC1COT signal Out of Range HIGH	• TC1COT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor	Pin-Point Diagnostics (page 703)
2629	4	TC1COT signal Out of Range LOW	• TC1COT signal circuit short to GND • Failed sensor	Pin-Point Diagnostics (page 703)
2629	16	TC1COT Over temperature: Moderate De-Rate	• Biased TC1COT sensor or circuit • Exhaust restriction	Step-Based Diagnostics (page 709)
2629	21	TC1COT signal drifted LOW	• TC1COT biased sensor or circuit	Step-Based Diagnostics (page 712)

TC1COT

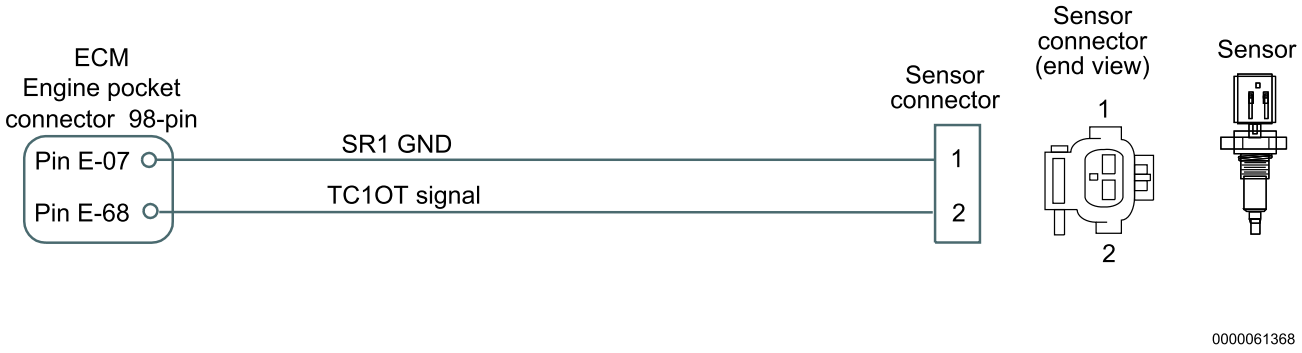
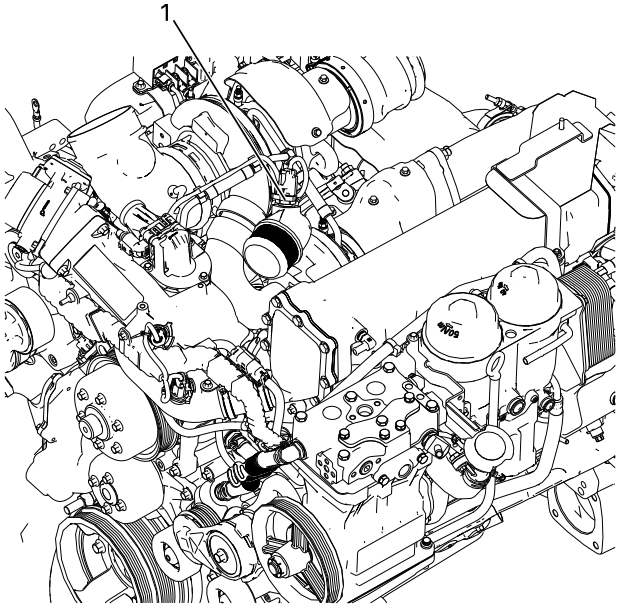


Figure 270 TC1COT Circuit Diagram

Overview

The Turbocharger 1 Compressor Outlet Temperature (TC1COT) sensor provides a feedback signal to the ECM indicating turbocharger compressor outlet air temperature for use in engine warning and protection system.



0000061370

Figure 271 TC1COT Sensor Location

1. TC1COT Sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 3-Banana Plug Harness ZTSE4498
- 00–00956–08 – 180-Pin Breakout Box
- Breakout Harness ZTSE4760A (TC1COT)
- Breakout Harness ZTSE4831 (TCWC)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

TC1COT

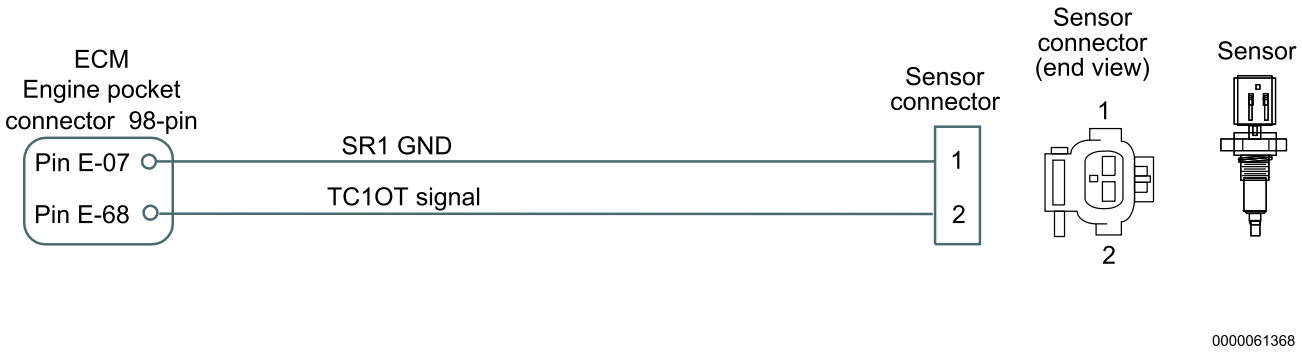


Figure 272 TC1COT Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

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

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, open the Continuous Monitor session.
2. Monitor sensor voltage. Verify an active Diagnostic Trouble Code (DTC) for the sensor.
   - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the DTC goes active.
   - If DTC is active, proceed to the next step.
3. Disconnect engine harness from sensor.

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

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

Sensor Circuit Check

Connect Breakout Harness ZTSE4760A. Leave sensor disconnected. Turn ignition switch to ON. Use Electronic Service Tool (EST) with ServiceMaxx™ software to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	SPN 2629 FMI 3	If SPN 2629 and FMI 4 is active, check TC1COT signal for short to GND. Do Harness Resistance Check (page 704).
EST - Check DTC Short a 3-banana plug harness across 2 and GND	SPN 2629 FMI 4	If SPN 2629 and FMI 3 is active, check TC1COT signal for OPEN. Do Harness Resistance Check (page 704).
EST - Check DTC Short a 3-banana plug harness across 1 and 2	SPN 2629 FMI 4	If SPN 2629 and FMI 3 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 704).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace sensor.		

TC1COT Pin-point Diagnostics

Connector Voltage Check

Connect Breakout Harness ZTSE4760A. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to B+	B+	If < B+ check for short to PWR or OPEN circuit. Do Harness Resistance Check (page 704).
2 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 704).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4760A. Leave sensor disconnected. Use DMM to measure resistance.

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

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4760A. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to E-07	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to E-68	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 2629 FMI 2 - TC1COT signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of sensor reading to other sensor readings after a calibratable cold soak period	Sum of failed temperature sensor comparisons as listed: Turbocharger 1 Compressor Outlet Temperature (TC1COT) vs. Air Inlet Temperature (AIT), Charge Air Cooler Outlet Temperature (CACOT), Intake Manifold Temperature (IMT), Exhaust Gas Recirculation Temperature (EGRT) >=4	Key OFF engine soak time > 8 hours	0.5 second
	Comparison between TC1COT and IMT sensor reading > 36°F (20°C)	Time in Key ON engine OFF state < 60 seconds	
	Comparison between TC1COT and AIT sensor reading > 36°F (20°C)	Engine not in running state	
		{[Comparison of AIT with IMT > 27°F (15°C) Comparison of AIT with CACOT > 27°F (15°C) Comparison of AIT with TC1COT > 27°F (15°C) Comparison of AIT with EGRT > 27°F (15°C) Comparison of IMT with CACOT > 27°F (15°C) Comparison of IMT with TC1COT > 27°F (15°C) Comparison of IMT with EGRT > 27°F (15°C) Comparison of CACOT with TC1COT > 27°F (15°C) Comparison of CACOT with EGRT > 27°F (15°C) Comparison of TC1COT with EGRT > 27°F (15°C)] and sum of true conditions from comparisons listed above} > 5	
	Comparison between TC1COT and CACOT sensor reading > 36°F (20°C)	The following SPN / FMIs are not active: 172/3, 172/4, 2629/3, 2629/4, 2630/3, 2630/4, 105/2, 105/3, 105/4, 412/3, and 412/4.	
	Comparison between TC1COT and EGRT sensor reading > 36°F (20°C)		

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the TC1COT signal value is erratic or incorrect when compared to other related sensor values.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N / A

TC1COT

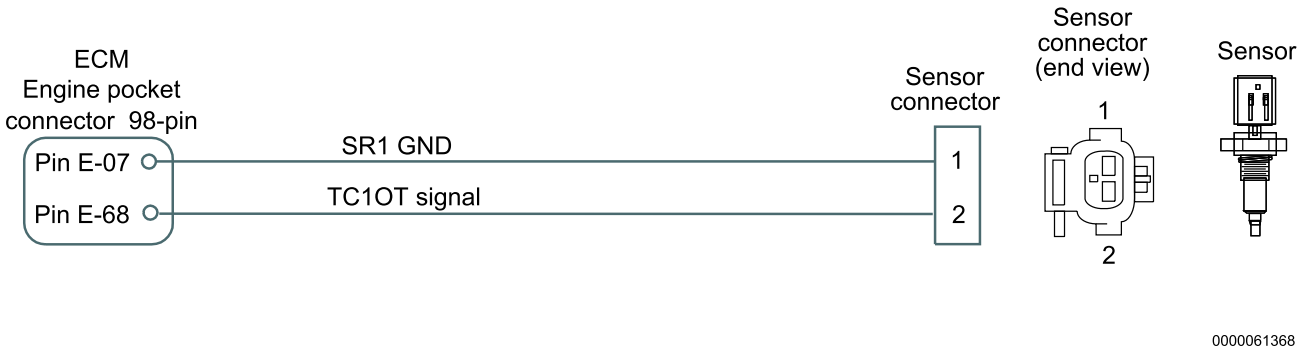


Figure 273 TC1COT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2629 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2629 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Turbocharger 1 Compressor Outlet Temperature (TC1COT) sensor. With key OFF, disconnect TC1COT sensor connector. Check TC1COT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are TC1COT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2629 FMI 2.

Step	Action	Decision
4	Test TC1COT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 704). Are TC1COT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 2629 FMI 2.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test (Key On, Engine Off (KOEO) Tests, page 68). Does circuit operate properly?	Yes: Go to Step 6. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 2629 FMI 2.

Step	Action	Decision
6	Test TC1COT sensor. Connect breakout harness 4760A between TC1COT sensor and TC1COT sensor connector. Perform KOEO voltage check (Key On, Engine Off (KOEO) Tests, page 68)of TC1COT sensor between TC1COT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 2629 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace TC1COT sensor. After repairs are complete, retest for SPN 2629 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 2629 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2629 FMI 16 - TC1COT Over temperature: Moderate De-Rate

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the Turbocharger 1 Compressor Outlet Temperature (TC1COT) sensor value is greater than a predetermined threshold.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

SPN / FMIs: 102/2, 102/3, 102/4, 102/10, 102/15, 102/16, 2629/2, 2629/3, 2629/4, 2629/15, and 2629/21

Drive Cycle to Determine Fault Status

N / A

TC1COT

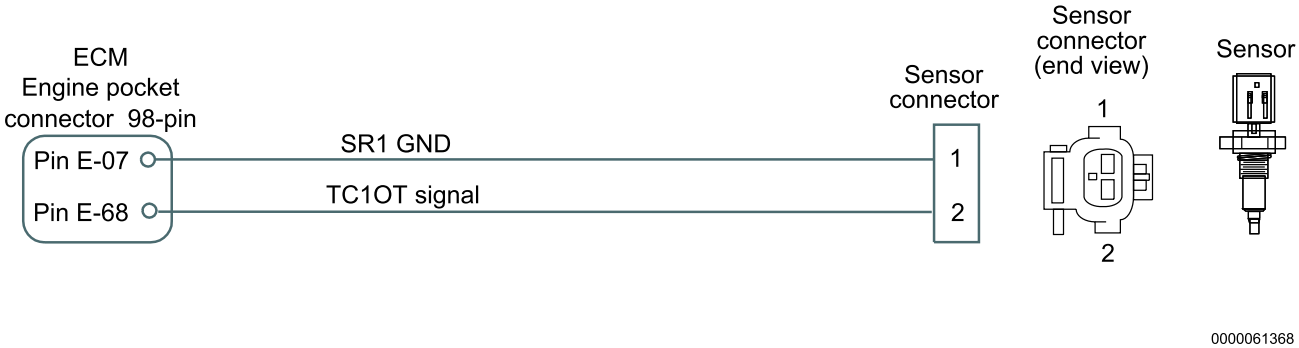


Figure 274 TC1COT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2629 FMI 16 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2629 FMI 16. No: Go to Step 3.

Step	Action	Decision
3	Visually inspect exhaust system components for damage or signs of restrictions. Is exhaust system free of restrictions and signs of physical damage?	Yes: Go to Step 4. No: Repair exhaust system as required. After repairs are complete, retest for SPN 2629 FMI 16.

Step	Action	Decision
4	Inspect air intake system and air filter for restrictions, air leaks, or physical damage. Is air intake system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to Step 5. No: Repair air intake system or replace air filter. After repairs are complete, retest for SPN 2629 FMI 16.

Step	Action	Decision
5	Inspect connections at Turbocharger 1 Compressor Outlet Temperature (TC1COT) sensor. With key OFF, disconnect TC1COT sensor connector. Check TC1COT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are TC1COT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 6. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2629 FMI 16.

Step	Action	Decision
6	Test TC1COT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 704). Are TC1COT circuits within specifications?	Yes: Go to step 7. No: Repair circuits as required. After repairs are complete, retest for SPN 2629 FMI 16.

Step	Action	Decision
7	Test TC1COT sensor. Connect breakout harness 4760A between TC1COT sensor and TC1COT sensor connector. Perform KOEO voltage check (Key On, Engine Off (KOEO) Tests, page 68) of TC1COT sensor between TC1COT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 2629 FMI 16 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace TC1COT sensor. After repairs are complete, retest for SPN 2629 FMI 16.

NOTE: After doing all diagnostic steps, if SPN 2629 FMI 16 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2629 FMI 21 - TC1COT signal drifted LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Turbocharger 1 Compressor Outlet Temperature (TC1COT) stuck in range LOW fault.	TC1COT < -40°F (-40°C)	Minimum engine speed value for incrementing accumulator > 1325 rpm	15 seconds
		Minimum engine torque command for incrementing accumulator > 710 N•m	
		Accumulator threshold for monitor enablement > 15 seconds	
		Minimum Intake Manifold Pressure (IMP) > 20.3 psi (140 kPa)	
		The following SPN / FMIs are not active: 108/3, 108/4, 172/2, 172/3, 172/4, 2629/2, 2629/3, and 2629/4.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the TC1COT value is erratic or incorrect when compared to other related sensor values.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, the Malfunction Indicator Lamp (MIL) will illuminate.

Associated Faults

N / A

Drive Cycle to Determine Fault Status

N / A

TC1COT

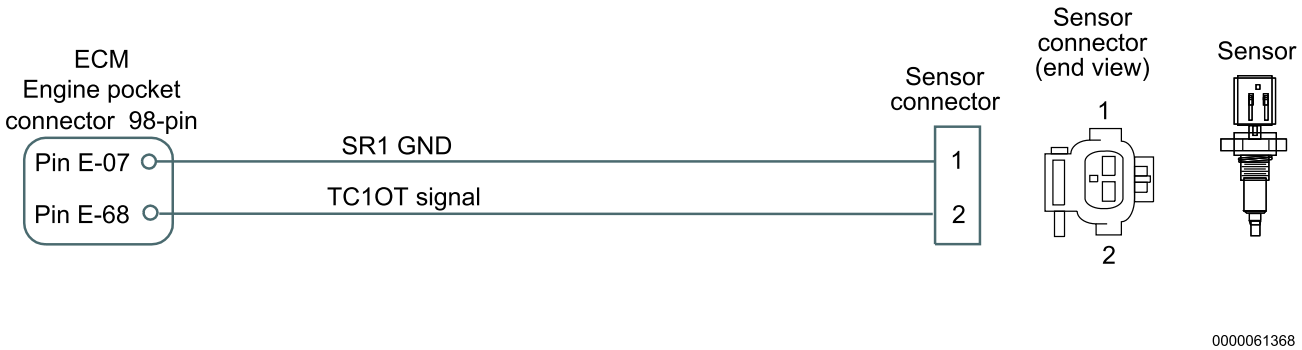


Figure 275 TC1COT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2629 FMI 21 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2629 FMI 21. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Turbocharger 1 Compressor Outlet Temperature (TC1COT) sensor. With key OFF, disconnect TC1COT sensor connector. Check TC1COT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are TC1COT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2629 FMI 21.

Step	Action	Decision
4	Test TC1COT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 704). Are TC1COT circuits within specifications?	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 2629 FMI 21.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Perform the Key On Engine Off (KOEO) Continuous Monitor Test (Key On, Engine Off (KOEO) Tests, page 68). Does circuit operate properly?	Yes: Go to Step 6. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 2629 FMI 21.

Step	Action	Decision
6	Test TC1COT sensor. Connect breakout harness 4760A between TC1COT sensor and TC1COT sensor connector. Perform KOEO voltage check (Key On, Engine Off (KOEO) Tests, page 68)of TC1COT sensor between TC1COT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 2629 FMI 21 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace TC1COT sensor. After repairs are complete, retest for SPN 2629 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 2629 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

VREF (Reference Voltage)

SPN	FMI	Condition
3509	3	VREF 1 voltage above maximum
3509	4	VREF 1 voltage below minimum
3510	3	VREF 2 voltage above maximum
3510	4	VREF 2 voltage below minimum
3511	3	VREF 3 voltage above maximum
3511	4	VREF 3 voltage below minimum

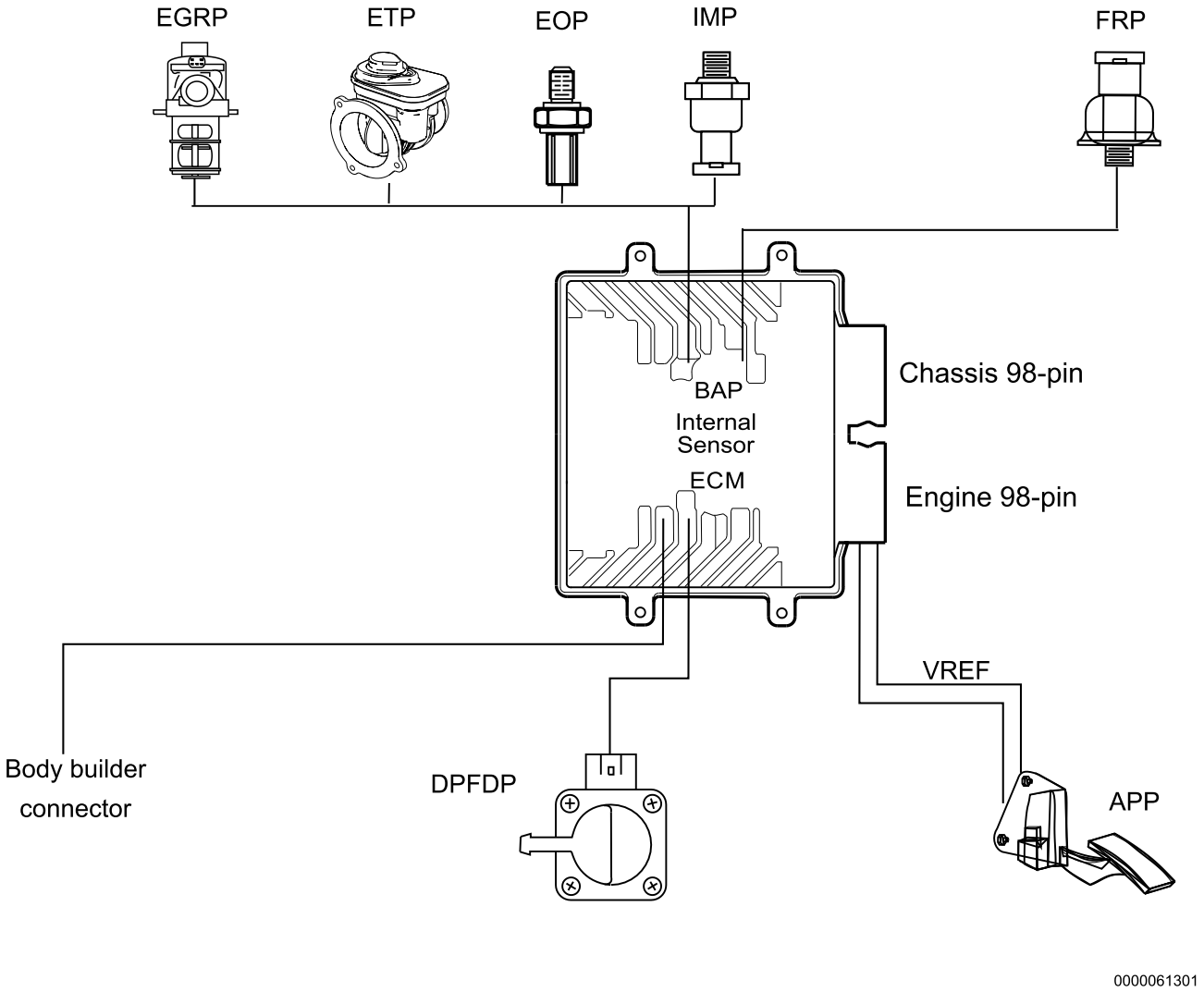


Figure 276 Function diagram for the VREF

The VREF function diagram includes the following:

- Accelerator Pedal Position (APP) sensor
- Body builder connector
- DPF Differential Pressure (DPFDP) sensor
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Engine Oil Pressure (EOP) sensor
- Engine Throttle Position (ETP) sensor
- Exhaust Gas Recirculation Position (EGRP) sensor
- Fuel Rail Pressure (FRP) sensor
- Intake Manifold Pressure (IMP) sensor

Function

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

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- 00-00956-08 – 180-Pin Breakout Box
- International® Electronic Engine Terminal Test Kit ZTSE4435C

VREF Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
3509	3	VREF 1 voltage above maximum	• VREF on engine connector short to VBAT
3509	4	VREF 1 voltage below minimum	• VREF on engine connector short to GND
3510	3	VREF 2 voltage above maximum	• VREF on chassis connector short to VBAT
3510	4	VREF 2 voltage below minimum	• VREF on chassis connector short to GND
3511	3	VREF 3 voltage above maximum	• VREF on body connector short to VBAT
3511	4	VREF 3 voltage below minimum	• VREF on body connector short to GND

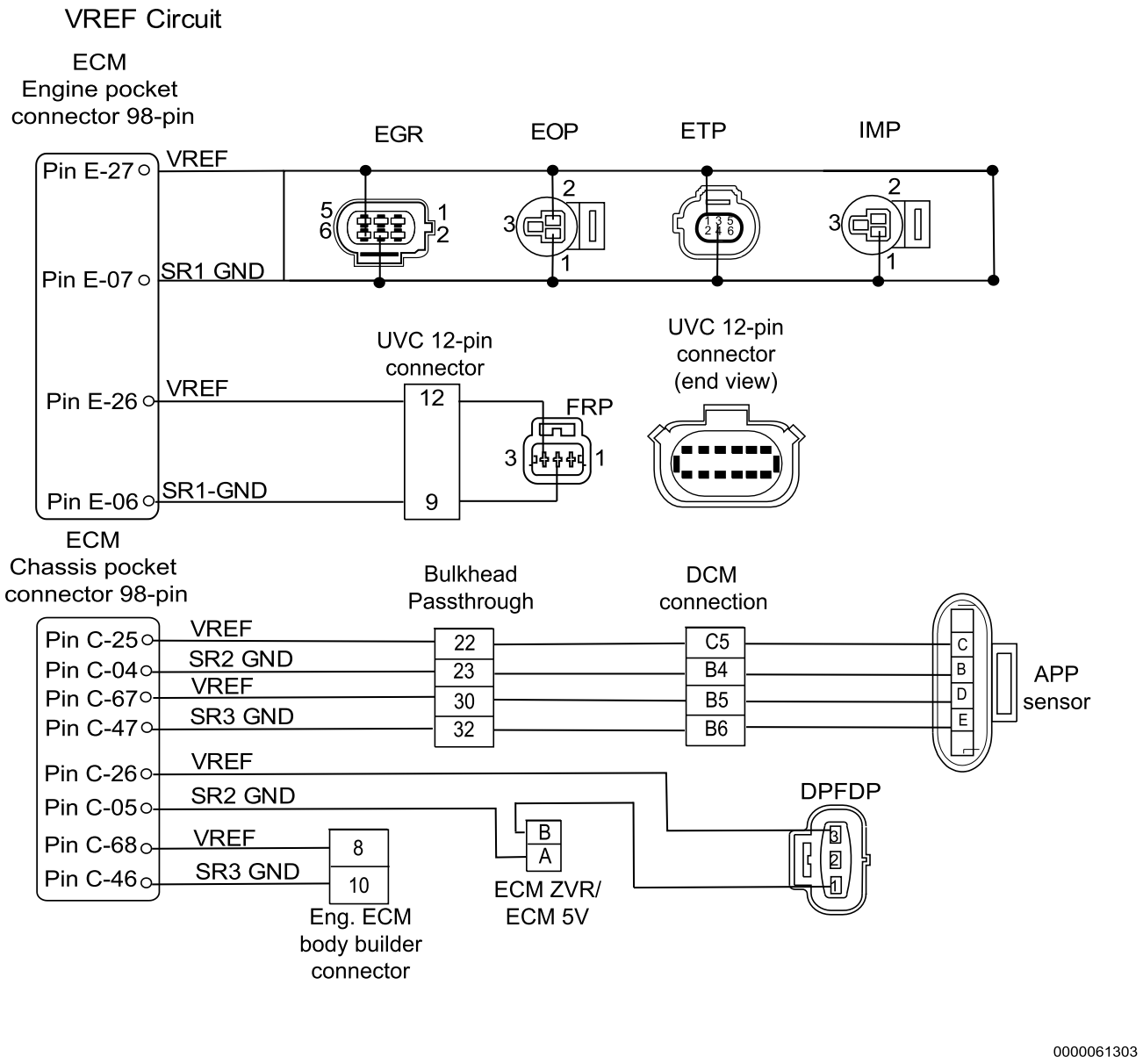


Figure 277 VREF circuit diagram

VREF Voltage Check

If multiple sensor SPNs and FMIs are set, turn ignition switch to ON. Disconnect each sensor one at a time. Use DMM to measure voltage at harness connector of each sensor.

NOTE:

- If VREF = B+ after all sensors in this section are disconnected, check for short circuit between the VREF wire and VPWR wire, key PWR wire, or KAPWR wire. See ECM PWR Relay (page 408).
- If VREF is not present, but returns after disconnecting a sensor, inspect that sensor for internal short to GND.
- If VREF is not present after all sensors in this section are disconnected, check for an OPEN circuit between the ECM and sensors.

Test Point	Spec	Comment
APP C to GND	5 V ± 0.5 V	See above note.
APP D to GND	5 V ± 0.5 V	See above note.
Body builder connector 8 to GND	5 V ± 0.5 V	See above note.
DPFDP 3 to GND	5 V ± 0.5 V	See above note.
EGRP 6 to GND	5 V ± 0.5 V	See above note.
EOP 2 to GND	5 V ± 0.5 V	See above note.
ETP 1 to GND	5 V ± 0.5 V	See above note.
FRP 12-pin 12 to GND	5 V ± 0.5 V	If this sensor caused VREF to go below specification, see above note. Check under valve cover harness for a short to GND or an internal shorted sensor.
IMP 2 to GND	5 V ± 0.5 V	See above note.

Connector Resistance Check to GND

Turn ignition switch to OFF. Disconnect each sensor one at a time. Use DMM to measure resistance at harness connector of each device.

NOTE:

- If resistance is below 1 kΩ, but goes above 1 kΩ after disconnecting a sensor, inspect that sensor for internal short to GND.
- If resistance is below 1 kΩ after all devices in this section are disconnected, check for short to GND of VREF wire between ECM and sensors.

Test Point	Spec	Comment
APP C to GND	> 1 kΩ	See above note.
APP D to GND	> 1 kΩ	See above note.
Body builder connector 8 to GND	> 1 kΩ	See above note.
DPFDP 3 to GND	> 1 kΩ	See above note.
EGRP 6 to GND	> 1 kΩ	See above note.
EOP 2 to GND	> 1 kΩ	See above note.
ETP 1 to GND	> 1 kΩ	See above note.
FRP (UVC 12-pin) 12 to GND	> 1 kΩ	If this sensor caused VREF to go below specification, see above note. Check under valve cover harness for a short to GND or an internal shorted sensor.
IMP 2 to GND	> 1 kΩ	See above note.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and breakout harness. Disconnect ECM and all sensors in this section. Use DMM to measure resistance between 180-Pin Breakout Box and ECM connector.

Sensor	Test Point	Spec	Comment
APP			
VREF	C to C-25	< 5 Ω	If > 5 Ω, check for OPEN circuit.
VREF	D to C-67		
SR2 GND	B to C-04		
SR3 GND	E to C-47		
Body builder connector			
VREF	8 to C-68	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SR3 GND	10 to C-46		
DPFDP			
VREF	3 to C-26	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SR2 GND	1 to C-05		
EGRP			
VREF	6 to E-27	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SR1 GND	4 to E-07		
EOP			
VREF	2 to E-27	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SR1 GND	1 to E-07		
ETP			
VREF	1 to E-27	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SR1 GND	3 to E-07		

Harness Resistance Check (cont.)

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and breakout harness. Disconnect ECM and all sensors in this section. Use DMM to measure resistance between 180-Pin Breakout Box and ECM connector.

Sensor	Test Point	Spec	Comment
FRP (12–Pin UVC connector)			
VREF	12 to E-26	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SR1 GND	2 to E-06		
IMP			
VREF	2 to E-27	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SR1 GND	1 to E-07		

VREF Circuit Operation

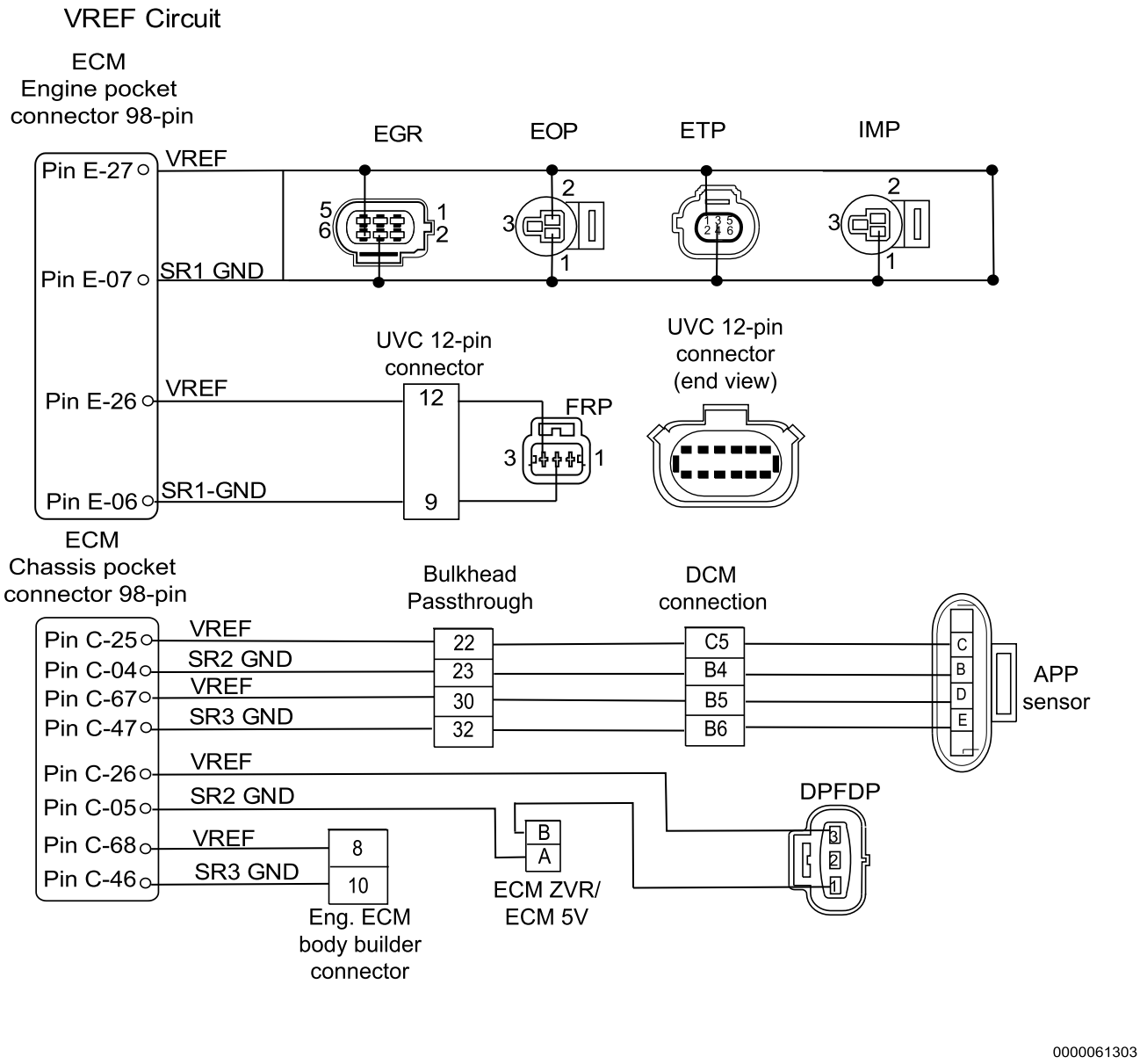


Figure 278 VREF circuit diagram

NOTE: See APP Sensor (page 272) and DPFDP Sensor (page 354) in this section of this manual for sensor circuit diagrams.

The ECM supplies VREF at Pins E-26 and E-27 (engine connector) and pins C-25, C-26, C-67, and C-68 (chassis connector) when the ignition switch is on.

VREF provides power to all 3-wire sensors on the engine and the chassis-mounted APP. The ECM also provides these sensors with a ground through the SRX GND circuit. Sensor signal voltage is between these two reference points based on the pressure or position the sensor is designed to measure.

Fault Detection / Management

When the ECM sets multiple sensor high or low DTCs, the VREF circuit could be open or shorted or the SIG GND circuit could be open. When a VREF signal is shorted to ground, the engine may stumble. To determine if the VREF circuits are the cause, complete the Pin-point diagnostics check.

VSO (Vehicle Speed Output)

SPN	FMI	Condition
837	14	Speedometer Drive Output Error

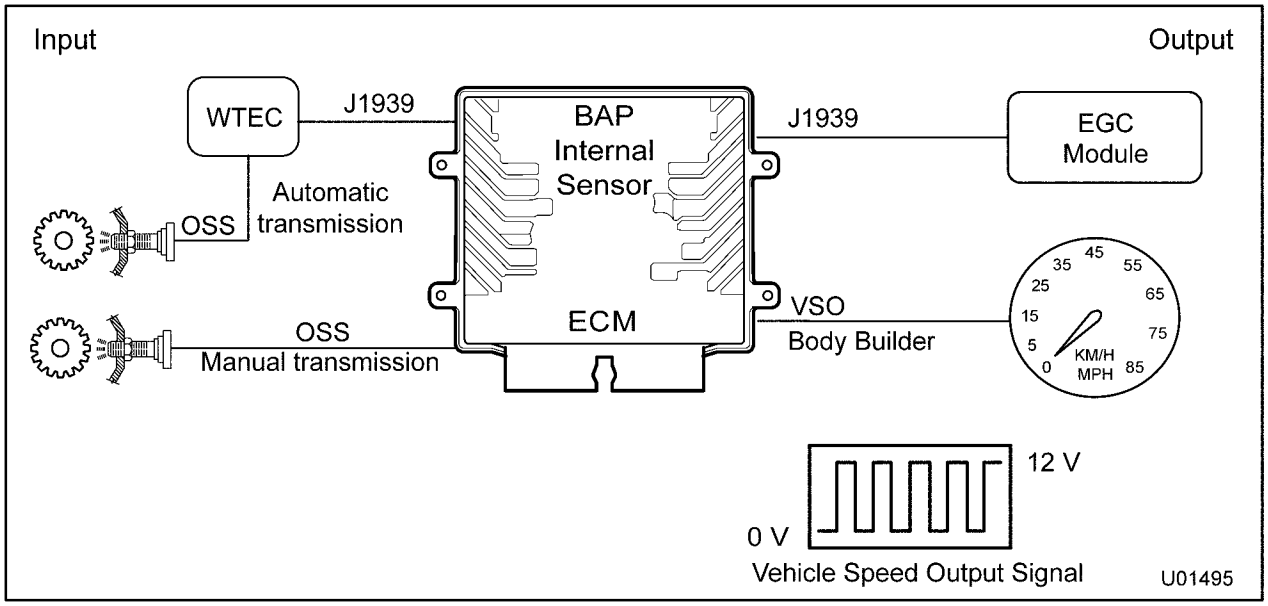


Figure 279 Function diagram for the tachometer output circuit

The vehicle speed output circuit function diagram includes the following:

- Remote speedometer
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Electronic Gauge Cluster (EGC) module
- Output Shaft Speed (OSS) sensor
- World Transmission Electronic Control (WTEC) ECM

The vehicle speed signal is sent to the EGC through the J1939 network. The VSO signal is also supplied on one circuit to the body builder blunt cutoff circuits.

Vehicle Speed Output Pin-point Diagnostics

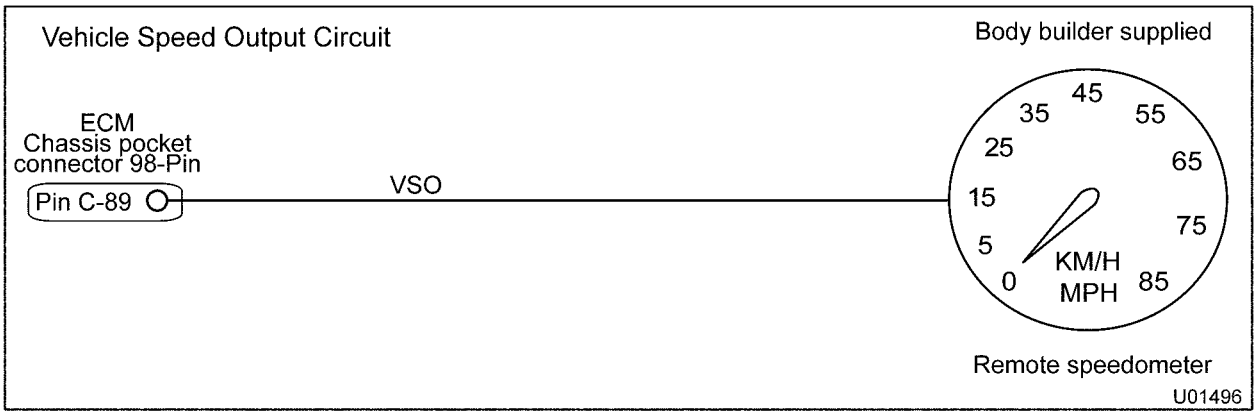


Figure 280 Vehicle Speed Output circuit diagram

Circuit End Voltage Check

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

Disconnect component from the body builder blunt cutoff circuit. Turn the ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
VSO to GND	12 V ± 1.0 V	If < 11.0 V, check for OPEN circuit.

Harness Resistance Check

Connect breakout box, leave ECM and remote speedometer component disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
C-89 to Speedometer	< 5 Ω	If > 5 Ω , check for OPEN circuit.
C-89 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Operational Check

Connect terminal probes between the C-89 Vehicle Speed Output (VSO) circuit and GND. Use DMM to measure Hz

Test Point	Spec	Comment
Vehicle moving at 15 mph	125 Hz	If not within specification, check for circuit fault or failed sensor.
Vehicle moving at 30 mph	250 Hz	

Vehicle Speed Output Circuit Operation

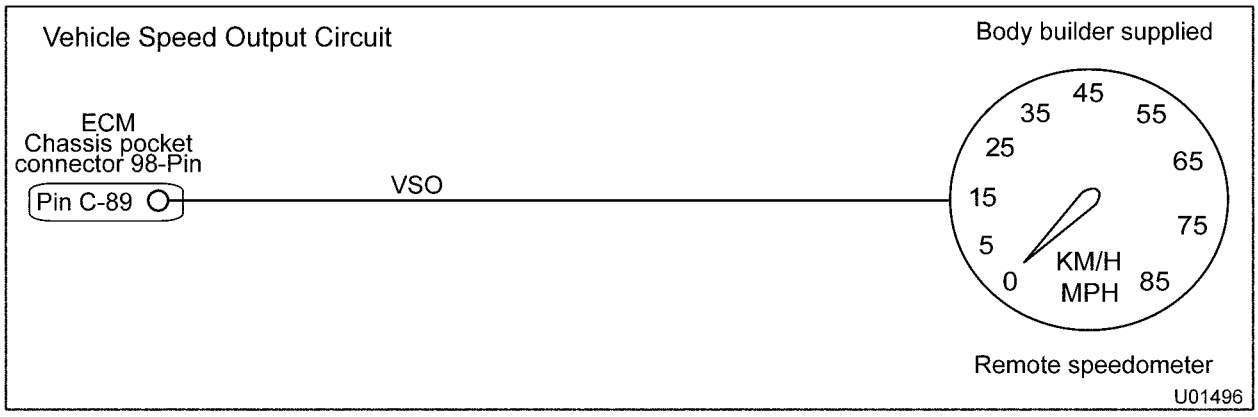


Figure 281 Vehicle Speed Output circuit diagram

The ECM receives a signal from the OSS sensor and calculates vehicle speed (mph). The ECM provides an output for a remote speedometer with a 0– to 12–volt digital signal that indicates vehicle speed. The frequency sent by the ECM is 8.33 of the actual engine rpm (30,000 pulses per mile).

Diagnostic Trouble Codes (DTCs)

DTCs are not available for communication between the ECM and the remote tachometer.

WIF (Water In Fuel) Sensor

SPN	FMI	Condition
4192	3	WIF signal Out of Range HIGH
4192	4	WIF signal Out of Range LOW
4192	31	Water in Fuel Detected

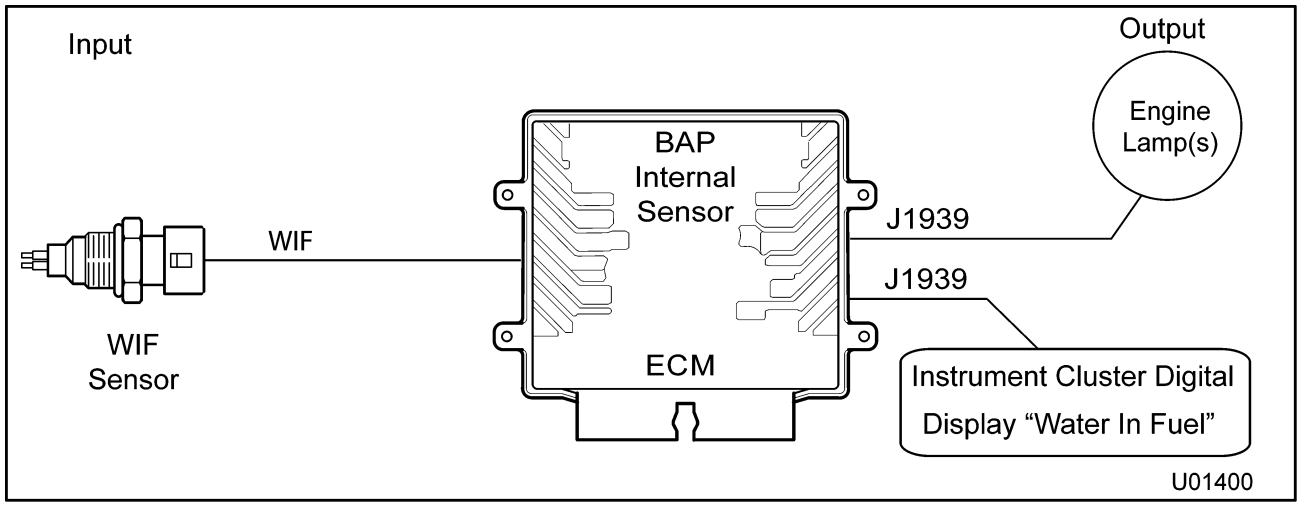


Figure 282 Function diagram for the WIF

The WIF function diagram includes the following:

- Water In Fuel (WIF) sensor
- Engine Control Module (ECM)
  with integrated Barometric Absolute Pressure (BAP) sensor
- Engine Lamp(s)
- Water In Fuel display message

Function

The WIF sensor provides a feedback signal to the ECM when water is detected in the fuel supply. If water is detected, the ECM turns on the "Water In Fuel" display message to alert the operator to drain water from the Primary Fuel Filter.

Sensor Location

The WIF sensor is installed in the primary fuel filter housing.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

WIF Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
4192	3	WIF signal Out of Range HIGH	• WIF signal circuit short to PWR • Failed sensor
4192	4	WIF signal Out of Range LOW	• WIF signal circuit short to GND • Failed sensor
4192	31	Water in Fuel Detected	• Water detected in primary fuel filter housing

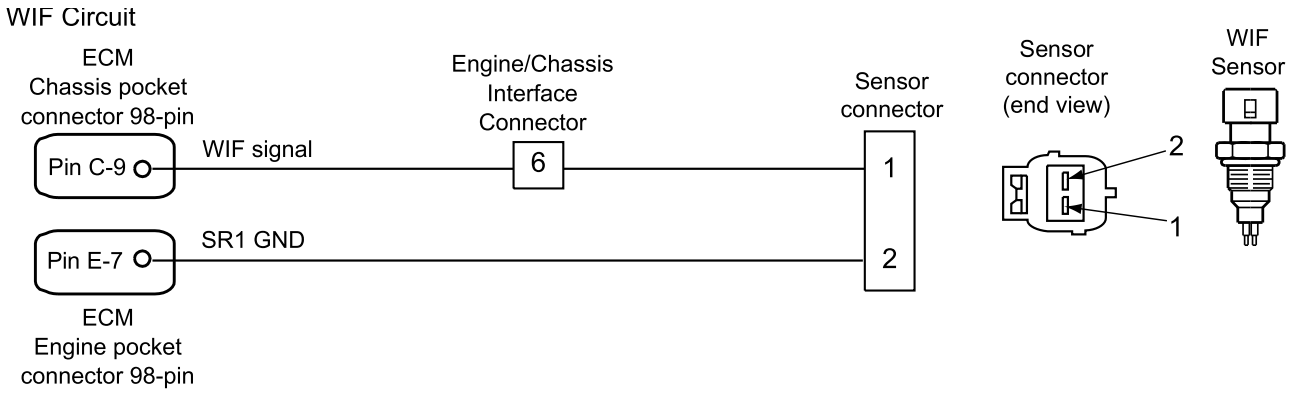


Figure 283 WIF circuit diagram

1. Drain a fuel sample from the water drain valve on the primary fuel filter housing. See Fuel Quality (page 131) in the “Hard Start and No Start Diagnostics" section of this manual.
   - If water is present, drain all water out of the system.
   - If no water is present in the fuel sample, continue to next step.
2. Use EST with ServiceMaxx™ Software.

   NOTE: The WIF signal will read YES if there is water in the fuel filter housing or if the WIF signal circuit is shorted high.

- If Diagnostic Trouble Code (DTC) is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal will change from No to Yes and the DTC goes active.
- If DTC is active, proceed to the next step.

3. Disconnect engine harness from sensor.

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

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

Voltage Check

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

Test Point	Spec	Comments
1 to GND	4.6 V	If > 4.6 V, check WIF circuit for short to PWR.
		If < 4.6 V, check WIF circuit for short to GND.
2 to B+	B+	If < B+, check SIG GND circuit for OPEN.

Connector Resistance Checks to GND

Turn ignition switch to OFF, disconnect harness from WIF sensor, use DMM to measure resistance.

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

Harness Resistance Check

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

Test Point	Spec	Comments
1 to C-9	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to E-7	< 5 Ω	If > 5 Ω, check for OPEN circuit.

WIF Circuit Operation

The WIF sensor is supplied with a 5-volt reference voltage at Pin 1 from the ECM Pin C-9. The sensor is grounded at Pin 2 from ECM Pin E-7. The WIF signal is 4.6 volts at normal state and below 3.6 volts when water is detected.

Fault Detection / Management

The ECM continuously monitors the WIF sensor. If voltage drops below 3.6 V, DTC sets and the “Water In Fuel” message is displayed. Two other DTCs can be set if there is a fault with the circuit or sensor.

Table of Contents

Diagnostic Trouble Codes.....733

Diagnostic Trouble Codes

SPN	FMI	Sub-section	Condition Description
27	3	EGR(page 458)	EGRP signal Out of Range HIGH
27	4	EGR(page 458)	EGRP signal Out of Range LOW
27	7	EGR(page 458)	EGRP does not agree with commanded position
27	10	EGR(page 458)	EGRP signal abnormal rate of change
51	3	ETV(page 509)	ETP signal Out of Range HIGH
51	4	ETV(page 509)	ETP signal Out of Range LOW
51	7	ETV(page 509)	ETP does not agree with commanded position
51	10	ETV(page 509)	ETP signal abnormal rate of change
69	19	Truck	Two Speed Axle Switch not detected on J1939 See applicable vehicle *Electrical System Troubleshooting Guide*.
91	2	APP(page 272)	APP1 and APP2 signal conflict
91	3	APP(page 272)	APP1 signal Out of Range HIGH
91	4	APP(page 272)	APP1 signal Out of Range LOW
91	7	APP(page 272)	APP1 and IVS signal conflict
94	0	FDP(page 538)	Fuel Filter Minder Above Maximum Pressure
94	3	FDP(page 538)	FDP signal Out of Range HIGH
94	4	FDP(page 538)	FDP signal Out of Range LOW
94	10	FDP(page 538)	FDP signal abnormal rate of change
94	17	EWPS(page 518)	Fuel Filter Minder Service Interval Soon
94	31	EWPS(page 518)	Fuel Filter Minder Service Interval Now
100	1	EWPS(page 518)	Engine Oil System below Critical Pressure
100	3	EOP(page 492)	EOP signal Out of Range HIGH
100	4	EOP(page 492)	EOP signal Out of Range LOW
100	10	EOP(page 492)	EOP signal abnormal rate of change
100	18	EWPS(page 518)	Engine Oil System below Warning Pressure
102	2	IMP(page 601)	IMP signal erratic, intermittent, or incorrect
102	3	IMP(page 601)	IMP signal Out of Range HIGH
102	4	IMP(page 601)	IMP signal Out of Range LOW
102	10	IMP(page 601)	Boost slow response fault
102	15	IMP(page 601)	Overboost
102	16	IMP(page 601)	Overboost
102	18	IMP(page 601)	Underboost
105	2	IMT(page 619)	IMT Signal Erratic, Intermittent, or Incorrect

SPN	FMI	Sub-section	Condition Description
105	3	IMT(page 619)	IMT signal Out of Range HIGH
105	4	IMT(page 619)	IMT signal Out of Range LOW
105	10	IMT(page 619)	IMT signal abnormal rate of change
105	21	IMT(page 619)	IMT signal drifted LOW
108	3	ECM Self(page 415)	BARO signal Out of Range HIGH
108	4	ECM Self(page 415)	BARO signal Out of Range LOW
110	0	EWPS(page 518)	Engine Coolant System above Critical Temperature
110	2	ECT1(page 421)	ECT1 signal erratic, intermittent, or incorrect
110	3	ECT1(page 421)	ECT1 signal Out of Range HIGH
110	4	ECT1(page 421)	ECT1 signal Out of Range LOW
110	10	ECT1(page 421)	ECT1 signal abnormal rate of change
110	15	EWPS(page 518)	Engine Coolant System above Warning Temperature
110	16	ECT1(page 421)	Engine Coolant System Above OBD Maximum Temperature
110	17	ECT1(page 421)	Engine Coolant System below OBD monitoring temperature
110	18	ECT1(page 421)	Engine Coolant System below closed loop minimum temperature
111	1	EWPS(page 518) ECL(page 404)	ECL below Warning / Critical Level
111	2	ECL(page 404)	ECL signal erratic, intermittent, or incorrect
111	3	ECL(page 404)	ECL Signal Out of Range HIGH
111	4	ECL(page 404)	ECL Signal Out of Range LOW
127	3	Truck	TOP signal Out of Range HIGH See applicable vehicle *Electrical System Troubleshooting Guide*.
127	4	Truck	TOP signal Out of Range LOW See applicable vehicle *Electrical System Troubleshooting Guide*.
132	2	MAF(page 657)	MAF signal erratic, intermittent, or incorrect
132	3	MAF(page 657)	MAF signal Out of Range HIGH
132	4	MAF(page 657)	MAF signal Out of Range LOW
132	10	MAF(page 657)	MAF signal abnormal rate of change
132	11	MAF(page 657)	MAF Sensor Calibration - Insufficient number of data points
132	13	MAF(page 657)	MAF Sensor Calibration Needed

SPN	FMI	Sub-section	Condition Description
132	14	MAF(page 657)	MAF Sensor Calibration Failed
157	3	FRP(page 552)	FRP signal Out of Range HIGH
157	4	FRP(page 552)	FRP signal Out of Range LOW
157	9	FRP(page 552)	FRP signal abnormal rate of change
157	10	FRP(page 552)	FRP signal abnormal rate of change
157	13	FRP(page 552)	FRP above KOEO Spec
158	15	ECM PWR Relay(page 408)	ECM Switched voltage too HIGH
158	17	ECM PWR Relay(page 408)	ECM Switched voltage too LOW
172	2	AIT(page 657)	IAT signal erratic, intermittent, or incorrect
172	3	AIT(page 657)	IAT signal Out of Range HIGH
172	4	AIT(page 657)	IAT signal Out of Range LOW
172	10	AIT(page 657)	AIT signal abnormal rate of change
173	0	EGT(page 482)	Exhaust Gas System above Critical Temperature
173	2	EGT(page 482)	EGT signal erratic, intermittent, or incorrect
173	3	EGT(page 482)	EGT signal Out of Range HIGH
173	4	EGT(page 482)	EGT signal Out of Range LOW
173	21	EGT(page 482)	EGT Signal Drifted LOW
174	0	EWPS(page 518)	Engine Fuel System above Critical Temperature
174	2	EFT(page 448)	EFT signal erratic, intermittent or incorrect
174	3	EFT(page 448)	EFT signal Out of Range HIGH
174	4	EFT(page 448)	EFT signal Out of Range LOW
174	10	EFT(page 448)	EFT signal abnormal rate of change
174	15	EWPS(page 518)	Engine Fuel System above Warning Temperature
174	21	EFT(page 448)	EFT Signal Drifted LOW
175	0	EWPS(page 518)	Engine Oil System above Critical Temperature
175	2	EOT(page 498)	EOT signal erratic, intermittent, or incorrect
175	3	EOT(page 498)	EOT signal Out of Range HIGH
175	4	EOT(page 498)	EOT signal Out of Range LOW
175	10	EOT(page 498)	EOT signal abnormal rate of change
175	15	EWPS(page 518)	Engine Oil System above Warning Temperature
175	21	EOT(page 498)	EOT signal drifted LOW
177	3	Truck	TOT signal Out of Range HIGH See applicable vehicle *Electrical System Troubleshooting Guide*.

SPN	FMI	Sub-section	Condition Description
			TOT signal Out of Range LOW
177	4	Truck	See applicable vehicle *Electrical System Troubleshooting Guide*.
			TOT above warning temperature
177	15	Truck	See applicable vehicle *Electrical System Troubleshooting Guide*.
188	0	EWPS(page 518)	Engine unable to achieve desired idle speed (too high)
188	1	EWPS(page 518)	Engine unable to achieve desired idle speed (too low)
190	0	EWPS(page 518)	Engine overspeed - Most Severe Level
190	14	TACH(page 695)	Tachometer Drive Output Error
191	1	TOSS(page 672)	TOSS / VSS not detected with vehicle moving
191	3	TOSS(page 672)	TOSS / VSS signal out of range HIGH
191	4	TOSS(page 672)	TOSS / VSS signal out of range LOW
191	19	TOSS(page 672)	TOSS / VSS not detected through J1939
412	0	EGRT(page 471)	EGRT above Critical Temperature
412	2	EGRT(page 471)	EGRT signal erratic, intermittent, or incorrect
412	3	EGRT(page 471)	EGRT signal Out of Range HIGH
412	4	EGRT(page 471)	EGRT signal Out of Range LOW
412	10	EGRT(page 471)	EGRT signal abnormal rate of change
412	21	EGRT(page 471)	EGRT signal drifted LOW
593	31	IST(page 653)	Engine stopped by IST
596	2	CCS(page 316)	SCCS switch or circuit fault
596	19	CCS(page 316)	Cruise Control Enable Switch not detected on J1939
597	2	Brake Switch(page 285)	Brake switch or circuit fault
			Brake switch not detected on J1939
597	19	Truck	See applicable vehicle *Electrical System Troubleshooting Guide*.
			Clutch switch circuit fault
598	0	Truck	See applicable vehicle *Electrical System Troubleshooting Guide*.
628	12	ECM Self Diag(page 415)	ECM memory error
628	14	ECM Self Diag(page 415)	ECM programming - EFRC error
629	2	ECM Self Diag(page 415)	ECM error - level 2 monitoring
629	9	ECM Self Diag(page 415)	Engine Off Timer Error
629	10	ECM Self Diag(page 415)	ECM error — Fuel injector performance bank B

SPN	FMI	Sub-section	Condition Description
629	12	ECM Self Diag(page 415)	ECM Internal chip Error
629	31	ECM Self Diag(page 415)	ECM Error - Level 3 monitoring
633	3	FPCV(page 543)	FPCV short to PWR
633	4	FPCV(page 543)	FPCV short to GND
633	5	FPCV(page 543)	FPCV open load / circuit
633	6	FPCV(page 543)	FPCV Current max limit exceeded
636	2	CMP(page 322)	CMP and CKP Synchronization Error
636	7	CMP(page 322)	CMP to CKP incorrect reference
636	10	CMP(page 322)	CMP signal inactive
637	8	CKP(page 319)	CKP incorrect signal signature
637	10	CKP(page 319)	CKP signal inactive
639	14	CAN(page 310)	J1939 Data Link Error (ECM unable to transmit)
647	3	EFC (page 444)	EFC short to PWR
647	4	EFC (page 444)	EFC short to GND
647	5	EFC (page 444)	EFC open load / circuit
651	4	INJ(page 630)	Injector 1 short circuit
651	5	INJ(page 630)	Injector 1 open load / circuit
652	4	INJ(page 630)	Injector 2 short circuit
652	5	INJ(page 630)	Injector 2 open load / circuit
653	4	INJ(page 630)	Injector 3 short circuit
653	5	INJ(page 630)	Injector 3 open load / circuit
654	4	INJ(page 630)	Injector 4 short circuit
654	5	INJ(page 630)	Injector 4 open load / circuit
655	4	INJ(page 630)	Injector 5 short circuit
655	5	INJ(page 630)	Injector 5 open load / circuit
656	4	INJ(page 630)	Injector 6 short circuit
656	5	INJ(page 630)	Injector 6 open load / circuit
657	4	INJ(page 630)	Injector 7 short circuit
657	5	INJ(page 630)	Injector 7 open load / circuit
658	4	INJ(page 630)	Injector 8 short circuit
658	5	INJ(page 630)	Injector 8 open load / circuit
729	2	IAH(page 591)	IAHC monitor circuit or failed relay
729	3	IAH(page 591)	IAHC short to PWR
729	4	IAH(page 591)	IAHC short to GND

SPN	FMI	Sub-section	Condition Description
729	5	IAH(page 591)	IAHC open load / circuit
729	18	IAH(page 591)	IAH Monitor fault: Lack of heat in the Intake Manifold
837	14	VSO(page 724)	Speedometer Drive Output Error
974	3	Truck	Remote APP signal Out of Range HIGH See applicable vehicle *Electrical System Troubleshooting Guide*.
974	4	Truck	Remote APP signal Out of Range LOW See applicable vehicle *Electrical System Troubleshooting Guide*.
1136	0	ECM Self(page 415)	ECM Error - over temperature
1136	1	ECM Self(page 415)	ECM Error - under temperature
1189	3	TC2WG(page 698)	TC2WG short to PWR
1189	4	TC2WG(page 698)	TC2WG short to GND
1189	5	TC2WG(page 698)	TC2WG open load / circuit
1209	0	AMS(page 239)	EBP above desired level
1244	3	FVCV(page 587)	FVCV short to PWR
1244	4	FVCV(page 587)	FVCV short to GND
1244	5	FVCV(page 587)	FVCV open load / circuit
1244	6	FVCV(page 587)	FVCV Current max limit exceeded
1322	31	Cyl Bal(page 328)	Misfire - Multiple Cylinders
1323	31	Cyl Bal(page 328)	Misfire - Cylinder 1
1324	31	Cyl Bal(page 328)	Misfire - Cylinder 2
1325	31	Cyl Bal(page 328)	Misfire - Cylinder 3
1326	31	Cyl Bal(page 328)	Misfire - Cylinder 4
1327	31	Cyl Bal(page 328)	Misfire - Cylinder 5
1328	31	Cyl Bal(page 328)	Misfire - Cylinder 6
1329	31	Cyl Bal(page 328)	Misfire - Cylinder 7
1330	31	Cyl Bal(page 328)	Misfire - Cylinder 8
1378	14	Truck	Change Engine Oil Service Interval Reset ahead of schedule *See Engine Operation and Maintenance Manual*.
1378	17	Truck	Change Engine Oil Service Interval Soon *See Engine Operation and Maintenance Manual*.
1378	31	Truck	Change Engine Oil Service Interval *See Engine Operation and Maintenance Manual*.

SPN	FMI	Sub-section	Condition Description
			Transmission Control Module not detected on J1939
1482	19	Truck	See applicable vehicle *Electrical System Troubleshooting Guide*.
1639	3	Truck	EFS unrealistically HIGH
			See applicable vehicle *Electrical System Troubleshooting Guide*.
1639	4	Truck	EFS unrealistically LOW
			See applicable vehicle *Electrical System Troubleshooting Guide*.
			EFS unrealistically HIGH
1639	15	Truck	See applicable vehicle *Electrical System Troubleshooting Guide*.
			EFS unrealistically LOW
1639	17	Truck	See applicable vehicle *Electrical System Troubleshooting Guide*.
1659	20	ECT1(page 421)	ECT1 below expected: Check Thermostat
1692	0	AMS (page 239)	Boost High / above desired level detected
1692	17	AMS(page 239)	Service Tool Test - Boost was unable to achieve desir set-point
1692	18	AMS(page 239)	Boost unable to achieve desired set-point
2623	3	APP(page 272)	APP2 signal Out of Range HIGH
2623	4	APP(page 272)	APP2 signal Out of Range LOW
2629	2	TCOT(page 701)	TC1COT signal erratic, intermittent or incorrect
2629	3	TCOT(page 701)	TC1COT signal Out of Range HIGH
2629	4	TCOT(page 701)	TC1COT signal Out of Range LOW
2629	15	EWPS(page 518)	TC1COT Over temperature: Severe De-Rate
2629	16	TCOT(page 701)	TC1COT Over temperature: Moderate De-Rate
2629	21	TCOT(page 701)	TC1COT signal drifted LOW
2630	2	CACOT(page 289)	CACOT signal erratic, intermittent, or incorrect
2630	3	CACOT(page 289)	CACOT signal Out of Range HIGH
2630	4	CACOT(page 289)	CACOT signal Out of Range LOW
2630	16	CACOT(page 289)	CACOT Undercooling
2630	21	CACOT(page 289)	CACOT signal drifted LOW
2659	10	AMS(page 239)	EGR Slow Response Fault
2659	15	AMS(page 239)	EGR High Flow Rate Detected
2659	17	AMS(page 239)	EGR Low Flow Rate Detected

SPN	FMI	Sub-section	Condition Description
2659	20	AMS(page 239)	EGR High Flow Rate detected
2659	21	AMS(page 239)	EGR Low Flow Rate detected
2791	3	EGR(page 458)	EGRC short to PWR
2791	4	EGR(page 458)	EGRC short to GND
2791	5	EGR(page 458)	EGRC open load / circuit
2791	7	EGR(page 458)	EGR Valve unable to achieve commanded position
2791	17	EGR(page 458)	EGR Valve unable to achieve commanded position
2797	2	INJ(page 630)	Injector Control Group 1 Open Circuit (INJ 1, 3, 5, 7)
2797	3	INJ(page 630)	Injector Control Group 1 Open Circuit (INJ 1, 3, 5, 7)
2797	4	INJ(page 630)	Injector Control Group 1 Short Circuit (INJ 1, 3, 5, 7)
2797	11	INJ(page 630)	Injector Group 1 short circuit (INJ 1, 3, 5, 7)
2798	2	INJ(page 630)	Injector Control Group 2 Open Circuit (INJ 2, 4, 6, 8)
2798	3	INJ(page 630)	Injector Control Group 2 Open Circuit (INJ 2, 4, 6, 8)
2798	4	INJ(page 630)	Injector Control Group 2 Short Circuit (INJ 2, 4, 6, 8)
2798	11	INJ(page 630)	Injector Group 2 short circuit (INJ 2, 4, 6, 8)
3055	0	FRP System(page 568)	FRP exceeded maximum
3055	1	FRP System(page 568)	Low Fuel Pressure at start
3055	2	FRP System(page 568)	FPCV / FVCV adaptation in-range fault
3055	13	FRP System(page 568)	Fuel pressure offset check
3055	15	FRP System(page 568)	FRP below minimum with maximum command
3055	16	FRP System(page 568)	FRP below minimum with maximum command
3055	17	FRP System(page 568)	FRP above maximum with minimum command
3055	18	FRP System(page 568)	FRP above maximum with minimum command
3055	31	FRP System(page 568)	FPCV / FVCV adaptation in-range fault
3242	2	DPFIT(page 375)	DPFIT signal erratic, intermittent, or incorrect
3242	3	DPFIT(page 375)	DPFIT signal Out of Range HIGH
3242	4	DPFIT(page 375)	DPFIT signal Out of Range LOW
3242	10	DPFIT(page 375)	DPFIT in range stuck fault
3242	11	DPFIT(page 375)	DPFIT signal abnormal rate of change
3242	21	DPFIT(page 375)	DPFIT signal drifted LOW
3246	2	DPFOT(page 390)	DPFOT signal erratic, intermittent, or incorrect
3246	3	DPFOT(page 390)	DPFOT signal Out of Range HIGH
3246	4	DPFOT(page 390)	DPFOT signal Out of Range LOW
3246	10	DPFOT(page 390)	DPFOT in range stuck fault

SPN	FMI	Sub-section	Condition Description
3246	21	DPFOT(page 390)	DPFOT signal drifted LOW
3251	0	DPFDP(page 354)	DPFDP excessively high (plugged filter)
3251	1	DPFDP(page 354)	DPFDP Negative Delta Pressure
3251	3	DPFDP(page 354)	DPFDP signal Out of Range HIGH
3251	4	DPFDP(page 354)	DPFDP signal Out of Range LOW
3251	8	DPFDP(page 354)	DPFDP signal abnormal rate of change
3251	10	DPFDP(page 354)	DPFDP in range stuck fault
3251	18	DPFDP(page 354)	DPFDP excessively low
3251	21	DPFDP(page 354)	DPFDP excessively low
3387	20	Cyl Bal(page 328)	Cyl 1 Balance max limit exceeded
3387	21	Cyl Bal(page 328)	Cyl 1 Balance below min limit
3388	20	Cyl Bal(page 328)	Cyl 2 Balance max limit exceeded
3388	21	Cyl Bal(page 328)	Cyl 2 Balance below min limit
3389	20	Cyl Bal(page 328)	Cyl 3 Balance max limit exceeded
3389	21	Cyl Bal(page 328)	Cyl 3 Balance below min limit
3390	20	Cyl Bal(page 328)	Cyl 4 Balance max limit exceeded
3390	21	Cyl Bal(page 328)	Cyl 4 Balance below min limit
3391	20	Cyl Bal(page 328)	Cyl 5 Balance max limit exceeded
3391	21	Cyl Bal(page 328)	Cyl 5 Balance below min limit
3392	20	Cyl Bal(page 328)	Cyl 6 Balance max limit exceeded
3392	21	Cyl Bal(page 328)	Cyl 6 Balance below min limit
3393	20	Cyl Bal(page 328)	Cyl 7 Balance max limit exceeded
3393	21	Cyl Bal(page 328)	Cyl 7 Balance below min limit
3394	20	Cyl Bal(page 328)	Cyl 8 Balance max limit exceeded
3394	21	Cyl Bal(page 328)	Cyl 8 Balance below min limit
3464	3	ETV(page 509)	ETC short to PWR
3464	4	ETV(page 509)	ETC short to GND
3464	5	ETV(page 509)	ETC open load / circuit
3509	3	VREF(page 715)	VREF 1 voltage above maximum
3509	4	VREF(page 715)	VREF 1 voltage below minimum
3510	3	VREF(page 715)	VREF 2 voltage above maximum
3510	4	VREF(page 715)	VREF 2 voltage below minimum
3511	3	VREF(page 715)	VREF 3 voltage above maximum
3511	4	VREF(page 715)	VREF 3 voltage below minimum

SPN	FMI	Sub-section	Condition Description
			Transfer Case Status not detected on J1939
3645	19	Truck	See applicable vehicle *Electrical System Troubleshooting Guide*.
3719	0	AFT System(page 207)	DPF Soot Load - Highest (level 3/3)
3719	15	AFT System(page 207)	DPF Soot Load - Lowest (level 1/3)
3719	16	AFT System(page 207)	DPF Soot Load - Moderate (level 2/3)
3720	0	AFT System(page 207)	DPF Ash load at maximum limit (Remove DPF for cleaning)
3936	0	AFT System(page 207)	DPF Soot Load - Severe De-Rate
3936	2	AFT System(page 207)	DPF System Feedback Control Fault
3936	8	AFT System(page 207)	DPF regenerations are occurring too frequently
3936	10	AFT System(page 207)	DPF Overtemp Monitor
3936	16	AFT System(page 207)	DPF Overtemp Monitor
3936	20	AFT System(page 207)	DOC Inlet unable to achieve light off temperature
4082	2	Fuel Pump(page 548)	FPC Relay Circuit Fault
4082	3	Fuel Pump(page 548)	FPC short to PWR
4082	4	Fuel Pump(page 548)	FPC short to GND
4082	5	Fuel Pump(page 548)	FPC Open Load / Circuit
4192	3	WIF(page 727)	WIF signal Out of Range HIGH
4192	4	WIF(page 727)	WIF signal Out of Range LOW
4192	31	WIF(page 727)	Water in Fuel Detected
4227	14	Truck	Change Breather Service Interval Reset ahead of schedule *See Engine Operation and Maintenance Manual*.
4227	17	Truck	Change Breather Service Interval Soon *See Engine Operation and Maintenance Manual*.
4227	31	Truck	Change Breather Service Interval NOW *See Engine Operation and Maintenance Manual*.
4752	4	EGR(page 458)	EGR Cooler Efficiency: EGR Outlet Temp above expected
4765	2	DOCIT(page 336)	DOCIT signal erratic, intermittent, or incorrect
4765	3	DOCIT(page 336)	DOCIT signal Out of Range HIGH
4765	4	DOCIT(page 336)	DOCIT signal Out of Range LOW
4765	8	DOCIT(page 336)	DOCIT signal abnormal rate of change
4765	10	DOCIT(page 336)	DOCIT in range stuck fault

SPN	FMI	Sub-section	Condition Description
4765	21	DOCIT(page 336)	DOCIT signal drifted LOW
4766	10	AFT System(page 207)	Catalyst System Efficiency Below Threshold
5298	2	AFT System(page 207)	Reduced DOC Efficiency - De-Rate
5319	17	AFT System(page 207)	DPF incomplete Regeneration
5319	31	AFT System(page 207)	DPF incomplete Regeneration
5395	0	EWPS(page 518)	Engine unable to achieve desired idle torque (too high
5395	1	EWPS(page 518)	Engine unable to achieve desired idle torque (too low)
5543	4	AMS(page 239)	EBPC valve electrical fault
5543	7	AMS(page 239)	EBPC Actuator Fault
5543	12	AMS(page 239)	EBPC Actuator Fault
5543	16	AMS(page 239)	EBPC valve over temperature fault
5543	19	AMS(page 239)	EBPC Valve not detected on J1939
5543	20	AMS(page 239)	EBP valve Electrical fault
522283	3	Fuel Cooler Control Valve(page 534)	FCC short to PWR
522283	4	Fuel Cooler Control Valve(page 534)	FCC short to GND
522283	5	Fuel Cooler Control Valve(page 534)	FCC open load / circuit

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Electrical Tools

42-Pin Engine to Chassis Interface Cable

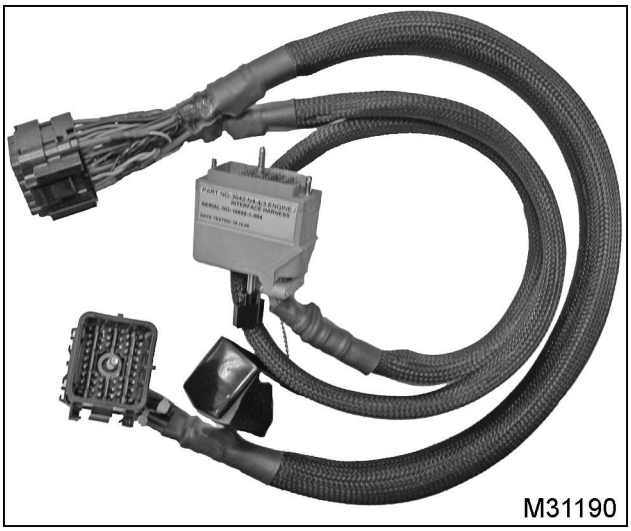

Figure 284 00–00979–01

The 42-pin Engine to Chassis Interface Cable with breakout box overlay (pin identifier) sheet is used with the 180-pin Breakout Box to test the 42-pin connector circuits.

98-Pin Engine and Chassis Cables

The 98-pin Engine and Chassis Cables (2 cables) with breakout box overlay (pin identifier) sheet are used with the 180-pin Breakout Box. These cables are used to test the circuits going to the engine and chassis 98-pin connectors on the Engine Control Module (ECM).

180-Pin Breakout Box

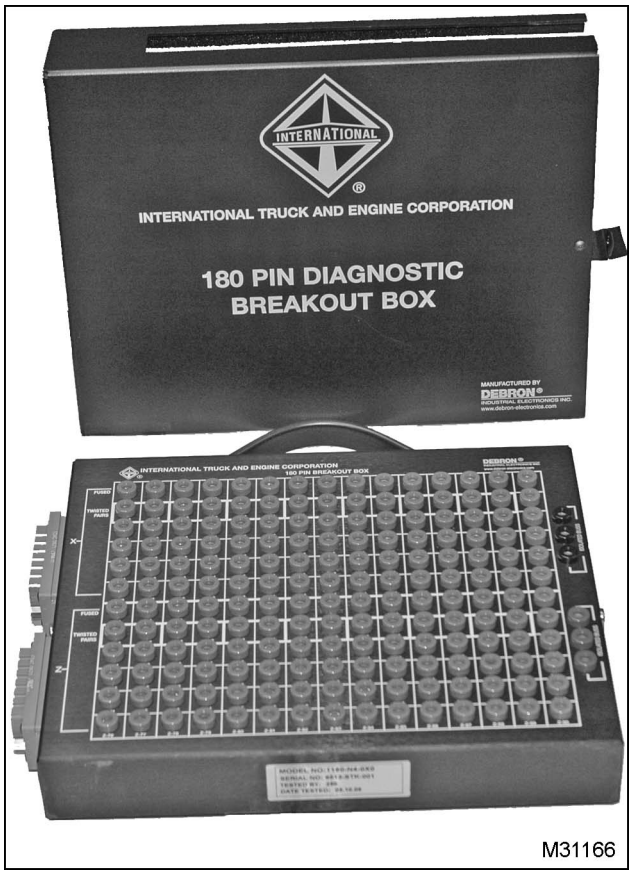

Figure 285 00–00956–08

The 180-Pin Breakout Box allows testing of electronic control system components without disturbing connections or piercing wire insulation to access various signal voltages in the electronic control system.

CAUTION: To prevent damage to the breakout box, the breakout box is used for measurement only, not to activate or control circuits. High current levels passing through the breakout box will burn out the internal circuitry.

This box is universal and can adapt to any control system by means of a unique jumper harness. Each jumper harness is a separate part, complete with a breakout box overlay (pin identifier) sheet.

The standard box layout is as follows:

- Two 90-pin connectors, which feed 90 banana plug probing points.
- Each 90-pin section of the box is basically a stand-alone box.
- The top row is all fuse protected circuits, the second row is all twisted pair circuits.

Digital IR Thermometer

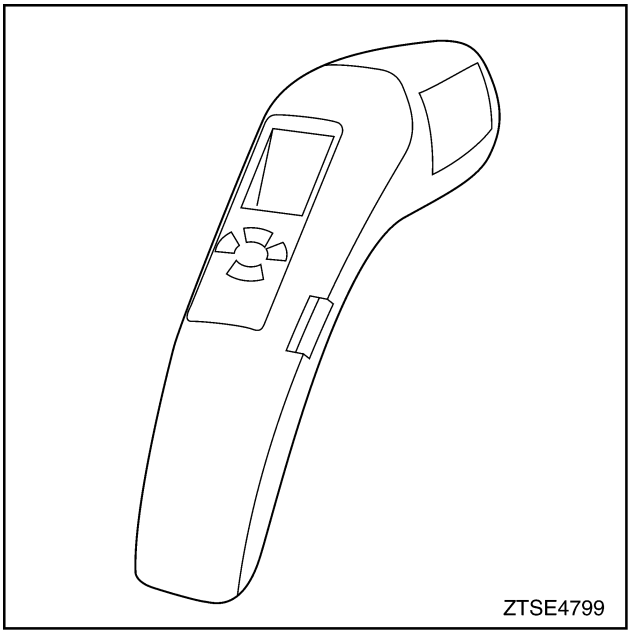

Figure 286 ZTSE4799

The Digital Infrared (IR) Thermometer is used to take temperature readings when Electronic Service Tool (EST) and dash gauge readings need to be verified.

Digital Multimeter (DMM)

Figure 287 ZTSE4357

The DMM is used to troubleshoot electrical components, sensors, injector solenoids, relays, and wiring harnesses. The DMM has a high input impedance that allows testing of sensors while the engine is running, without loading the circuit being tested. This ensures the signal voltage measurement will not be affected by the voltmeter.

EXP-1000 HD by Midtronics

Figure 288 EXP-1000 HD INTL

The EXP-1000 HD by Midtronics is used to measure amperage draw for the inlet air heater.

EZ-Tech® Electronic Service Tool (EST)

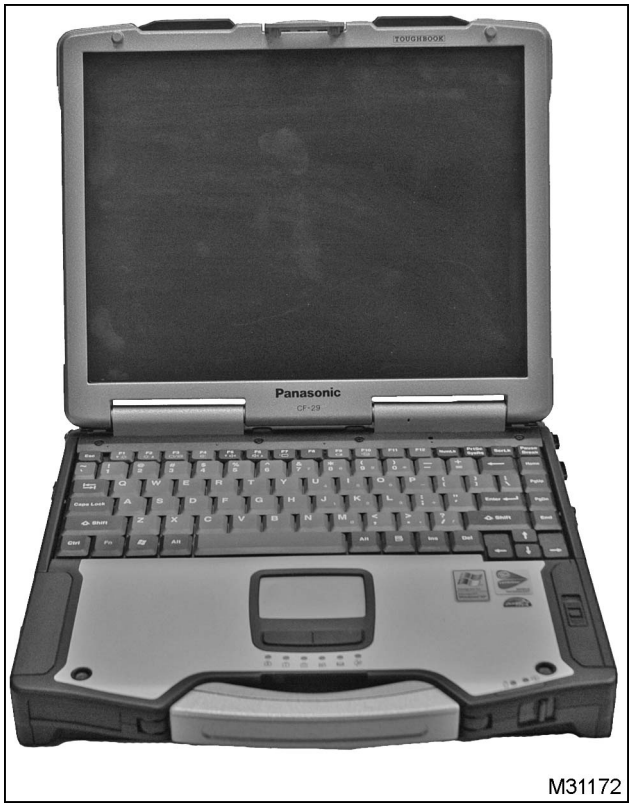

Figure 289 J-45067

The EST is used to run ServiceMaxx™ software for diagnosing and troubleshooting engine and vehicle problems.

The EZ-Tech® Interface Kit cables are included with the EST.

International® Electronic Engine Terminal Test Kit

Figure 290 ZTSE4435C

The International® Electronic Engine Terminal Test Kit is used to access circuits in the connector harness and allows for the use of a DMM without damaging the harness connectors. The probes may also be used as a guide to determine whether the harness connector is retaining correct tension on the mating terminal.

Interface cable (RP1210B compliant supporting J1939 and J1708)

Figure 291 Interface cable (RP1210B compliant supporting J1939 and J1708)

The Interface cable (RP1210B compliant supporting J1939 and J1708) is used to connect the EST to ECM. The Interface cable (RP1210B compliant supporting J1939 and J1708) is an alternative to the NAVCoM Interface Kit.

3-Banana Plug Harness

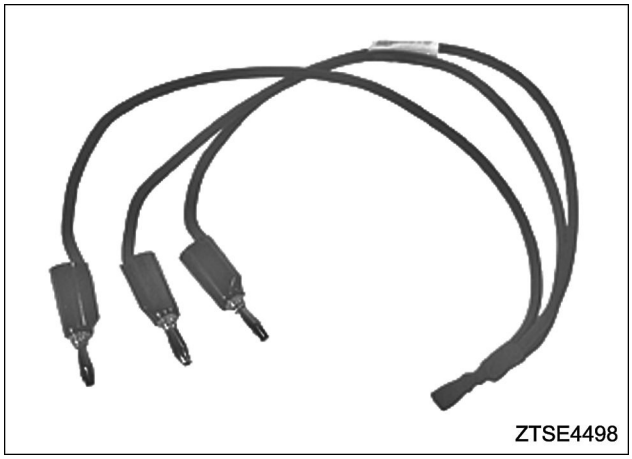

Figure 292 ZTSE4498

The 3-Banana Plug Harness is used for sensor end diagnostics of sensor circuits.

16-Way Breakout Harness

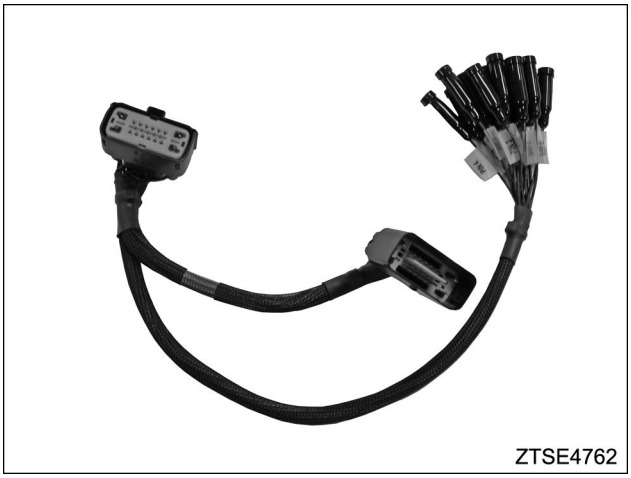

Figure 293 ZTSE4762

The 16-Way Breakout Harness is used for circuit diagnostics for actuator power and ground. Additional applications include the A/C clutch, alternator, and fuel heater.

500-Ohm Resistor Harness

Figure 294 ZTSE4497

The 500-Ohm Resistor Harness is used for sensor end diagnostics of sensor circuits.

Breakout Harness 4485A (APP)

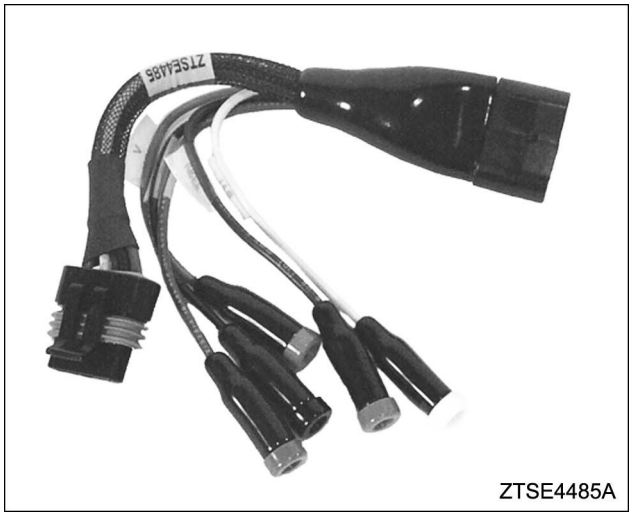

Figure 295 ZTSE4485A

Breakout Harness 4485A is used to measure voltage and resistance on circuits that go to the Accelerator Pedal Position (APP) sensor.

Breakout Harness 4602 (ECT, EFT, EOT, and IMT)

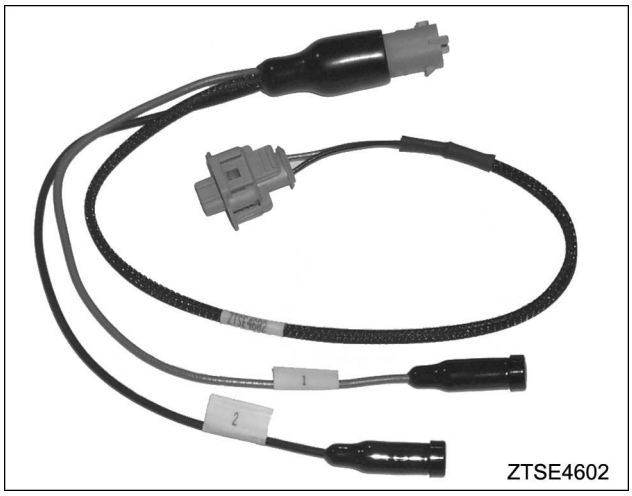

Figure 296 ZTSE4602

Breakout Harness 4602 is used to measure voltage and resistance on circuits that go to the Engine Coolant Temperature (ECT), Engine Fuel Temperature (EFT), Engine Oil Temperature (EOT), and Intake Manifold Temperature (IMT) sensors.

Breakout Harness 4760A (DOCIT, DPFIT, DPFOT, and TC1COT)

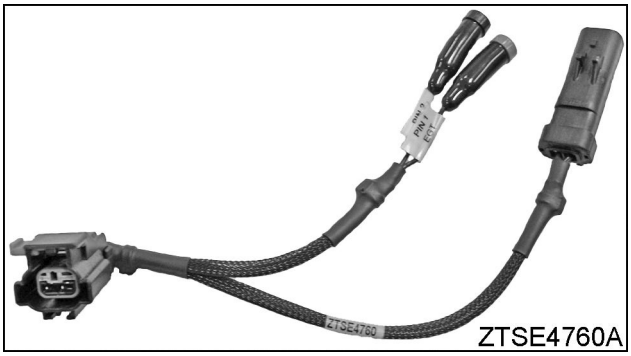

Figure 297 ZTSE4760A

Breakout Harness 4760A is used to measure voltage and resistance on circuits that go to the Diesel Oxidation Catalyst Inlet Temperature (DOCIT), Diesel Particulate Filter Inlet Temperature (DPFIT), Diesel Particulate Filter Outlet Temperature (DPFOT), and Turbocharger 1 Compressor Outlet Temperature (TC1COT) sensors.

Breakout Harness 4761A (DPFDP)

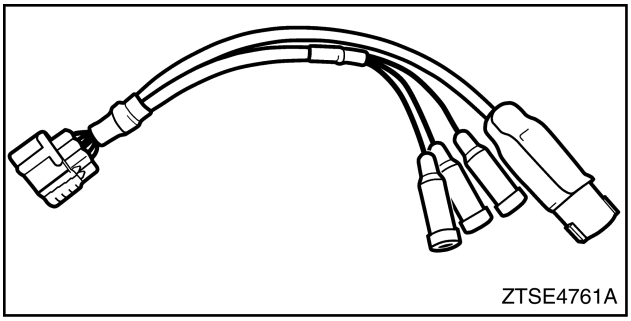

Figure 298 ZTSE4761A

Breakout Harness 4761A is used to measure voltage and resistance on circuits that go to the Diesel Particulate Filter Differential Pressure (DPFDP) sensor.

Breakout Harness 4762 (IPR, EGR, and VGT)

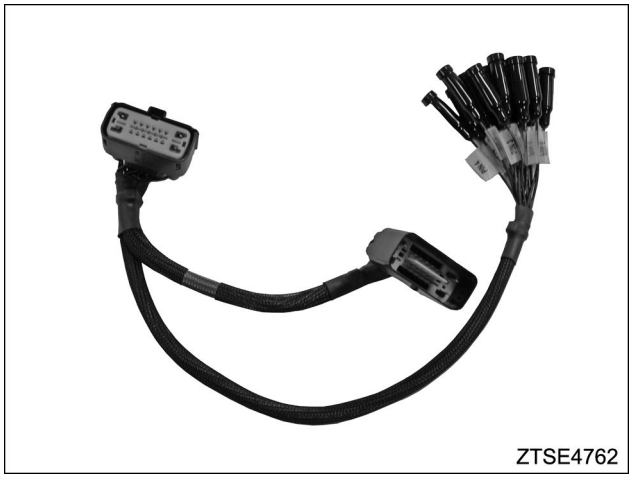

Figure 299 ZTSE4762

Breakout Harness 4762 is used for circuit diagnostics for actuator power and ground that go to Injection Pressure Regulator (IPR) and Exhaust Gas Recirculation (EGR) valve. Additional applications include the A/C clutch, alternator, and fuel heater.

Breakout Harness 4831 (TC2WG)

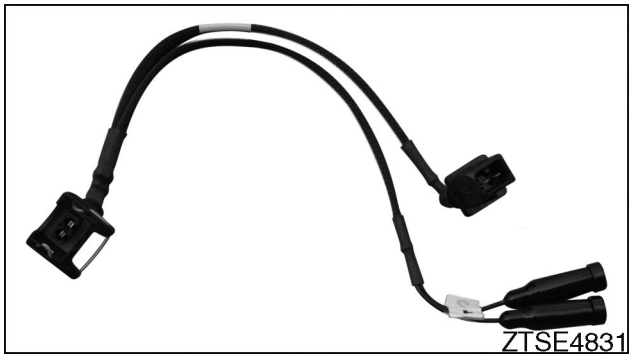

Figure 300 ZTSE4831

Breakout Harness 4831 is used to measure voltage and resistance on circuits connected to the Turbocharger 2 Wastegate (TC2WG) actuator .

Breakout Harness 4850 (IMP)

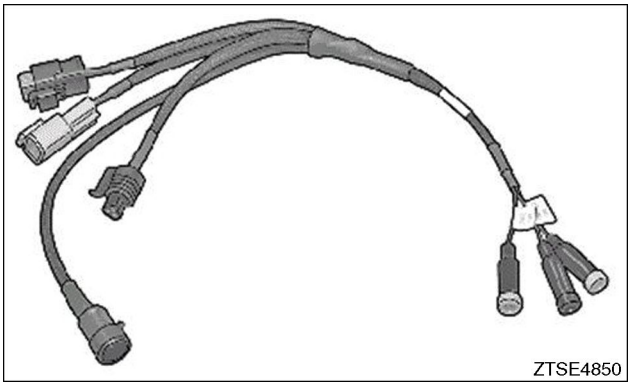

Figure 301 ZTSE4850

Breakout Harness 4850 is used to measure voltage and resistance on circuits connected to the Intake Manifold Pressure (IMP) sensor.

Breakout Harness 4908 (ECM Relay)

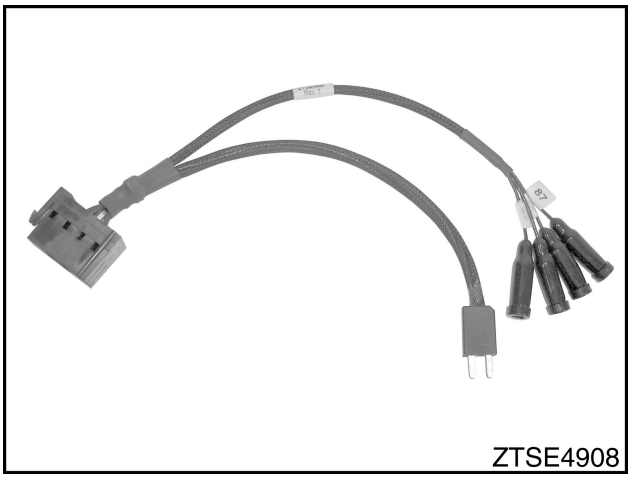

Figure 302 ZTSE4908

Breakout Harness 4908 is used to measure voltage and resistance on circuits to the Starter Motor Control (SMC) relay.

Breakout Harness 4946 (EGT)

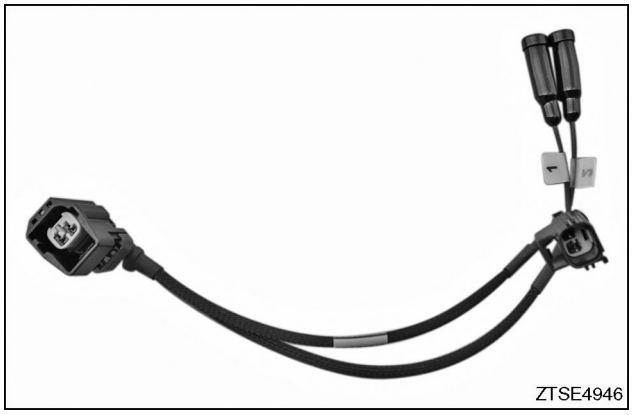

Figure 303 ZTSE4946

Breakout Harness 4946 enables the technician to quickly connect a voltmeter and read voltage signals for the Exhaust Gas Temperature (EGT) sensor.

Breakout Harness 4950 (CMP)

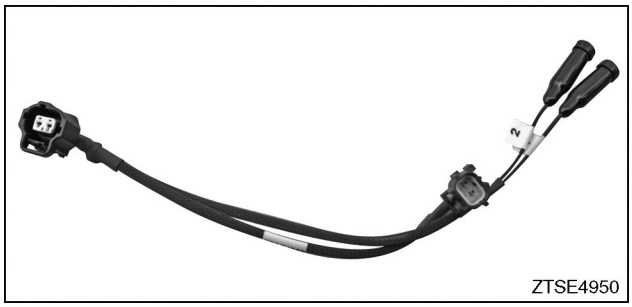

Figure 304 ZTSE4950

Breakout Harness 4950 is used to measure voltage and resistance on circuits connected to the Camshaft Position (CMP) sensor.

Breakout Harness 4951 (CKP)

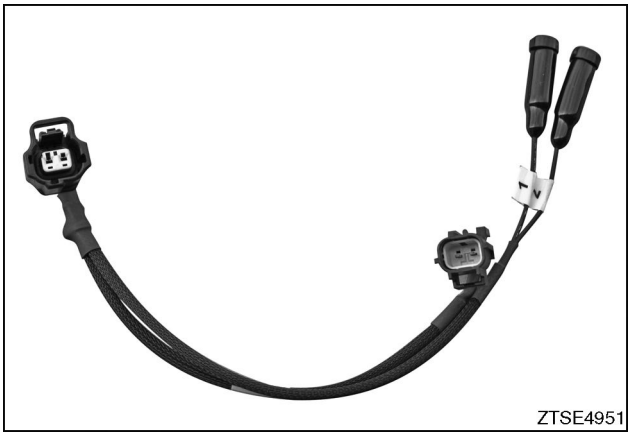

Figure 305 ZTSE4951

Breakout Harness 4951 is used to measure voltage and resistance on circuits connected to the Crankshaft Position (CKP) sensor.

Breakout Harness 4958 (FPCV and FVCV)

Figure 306 ZTSE4958

Breakout Harness 4958 is used to measure voltage and resistance on circuits connected to the Fuel Pressure Control Valve (FPCV) and Fuel Volume Control Valve (FVCV).

Breakout Harness 4960 (MAF)

Figure 307 ZTSE4960

Breakout Harness 4960 is used to measure voltage and resistance on circuits that go to the Mass Air Flow (MAF) sensor.

Breakout Harness 4993 (IMT and CACOT)

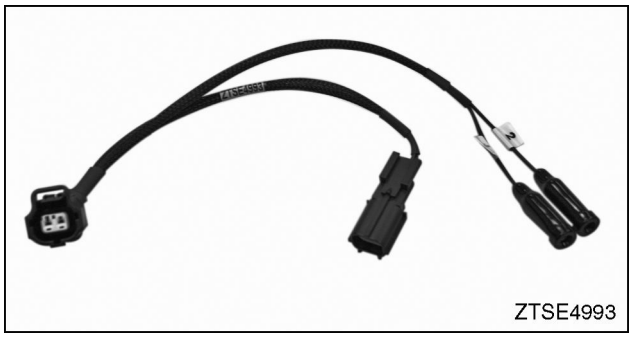

Figure 308 ZTSE4993

Breakout Harness 4993 is used to measure voltage and resistance on circuits that go to the Intake Manifold Temperature (IMT) and Charge Air Cooler Outlet Temperature (CACOT) sensors.

Breakout Harness 6000 (UVC)

Figure 309 ZTSE6000

Breakout Harness 6000 is used to measure continuity of the Under Valve Cover (UVC) wiring and injector coils.

Breakout Harness 6001 (Fuel Pump)

Figure 310 ZTSE6001

Breakout Harness ZTSE6001 is used to measure voltage and resistance on circuits that go to the Fuel Pump.

Breakout Harness 6002 (WIF)

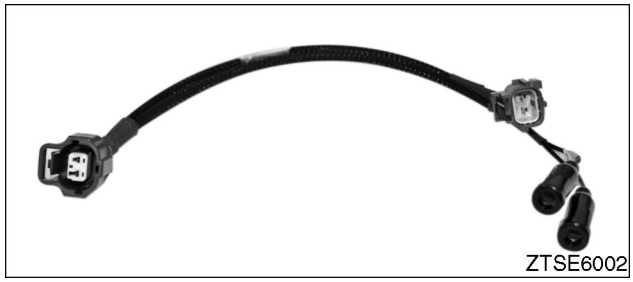

Figure 311 ZTSE6002

Breakout Harness 6002 is used to measure voltage and resistance on circuits that go to the Water In Fuel (WIF) sensor.

Breakout Harness 6005 (EBPV)

Figure 312 ZTSE6005

Breakout Harness 6005 is used to measure voltage and resistance on circuits that go to the Exhaust Back Pressure Valve (EBPV).

Breakout Harness 6025 (IAH)

Figure 313 ZTSE6025

Breakout Harness 6025 is used to measure voltage and resistance on circuits that go to the Inlet Air Heater (IAH) relay.

Breakout Harness 6038 (FRP)

Figure 314 ZTSE6038

Breakout Harness 6038 is used to measure voltage and resistance on circuits that go to the Rail Fuel Pressure (FRP) sensor.

Mechanical Tools

Charge Air Cooler Test Kit

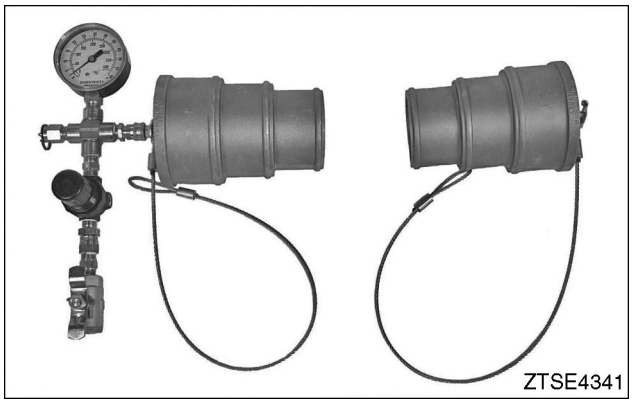

Figure 315 ZTSE4341

The Charge Air Cooler Test Kit is used to pressurize the charge air cooler and piping to check for leaks.

Clean Fuel Source Tool

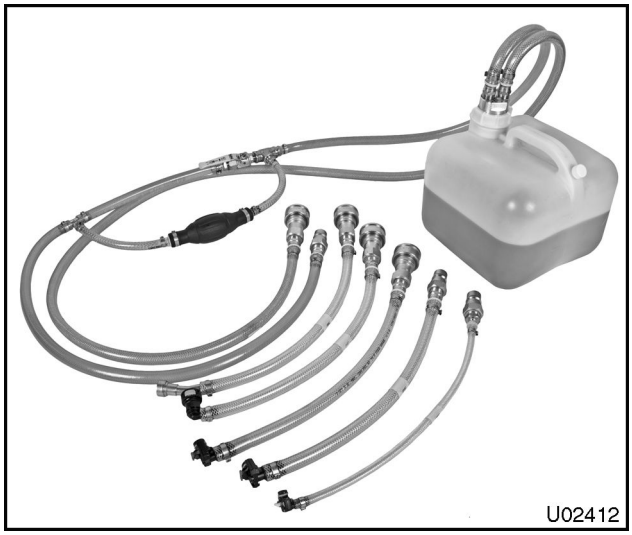

Figure 316 15-637-01

The Clean Fuel Source Tool is used to provide a clean, alternative fuel source to aid in the diagnosis of the fuel system.

Crankcase Pressure Test Adaptor

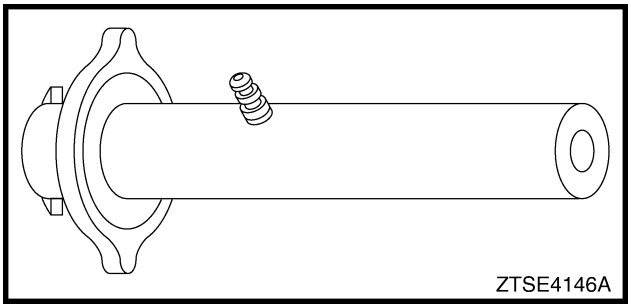

Figure 317 ZTSE4146A

The Crankcase Pressure Test Adaptor is used measure combustion gas flow from the engine breather and may be used with the magnehelic gauge or manometer. Pressure readings obtained with this adapter are used as the main indication of engine condition.

Oil consumption trend data must also be used if the pressure readings are over the specified limits. Neither changes in oil consumption trends nor crankcase diagnostic pressure trends can establish a specific problem. These changes only indicate a problem exists.

Crankcase Pressure Test Adaptor

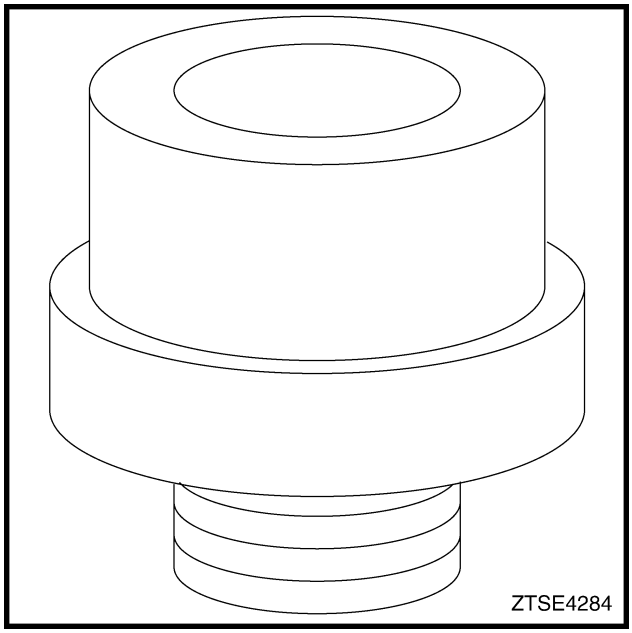

Figure 318 ZTSE4284

The Crankcase Pressure Test Adaptor is used to connect the Orifice Restrictor Tool to the oil fill tube.

Digital Manometer

Figure 319 Obtain locally

The Digital Manometer is used to measure low vacuum due to intake restriction or low crankcase pressure. A variety of digital manometers are available for purchase locally. The Water Manometer kit (ZTSE2217A) is an alternative to the Digital Manometer

EGR Cooler Leak Detection Kit

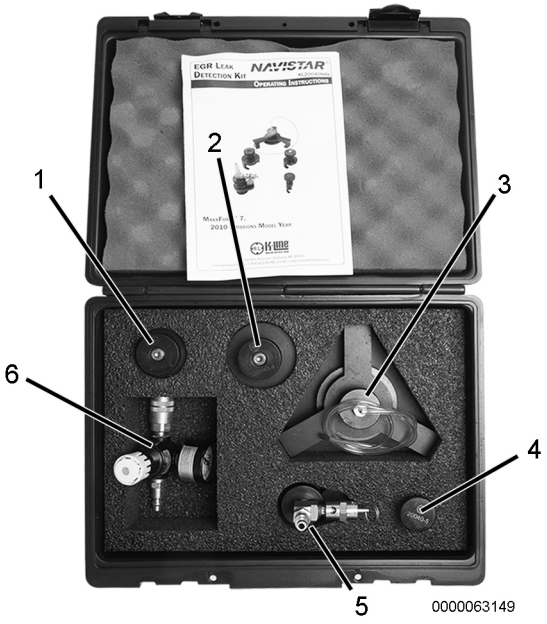

Figure 320 KL20040NAV 2010 MaxxForce® 7 EGR Leak Detection Kit

1. KL20040–3 EGR Cooler Inlet Tool (End Seal [small diameter])
2. KL20040–4 EGR Gas Outlet Tool (End Seal [large diameter])
3. KL20040–2 EGR Turbocharger Inlet Flange Tool (Flange End Seal Leak Detection)
4. KL20040–5 EGR Cooler Vent Tool (Small Port Plug)
5. KL20040–1 EGR Coolant Return Tool (Single Hole Seal Air Inlet)
6. KL20020–13 Air Regulator

The EGR Cooler Leak Detection Test Kit is used to pressure test the Exhaust Gas Recirculation (EGR) cooler for leaks.

Fuel Inlet Restriction and Aeration Tool

Figure 321 ZTSE6009

The Fuel Inlet Restriction and Aeration Tool is used to check for pressure and aerated fuel in the low fuel pressure system.

Fuel / Oil Pressure Test Coupler

Figure 322 ZTSE4526

The Fuel / Oil Pressure Test Coupler is used with the fuel pressure test fitting for an easy connection to measure fuel pressure.

Fuel Pressure Test Kit

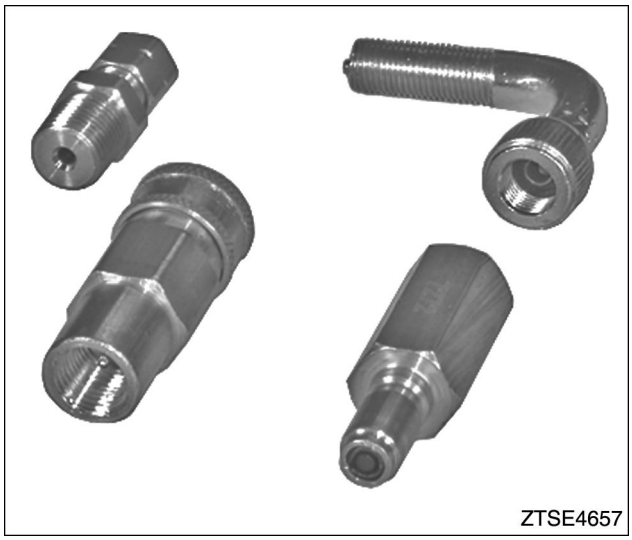

Figure 323 ZTSE4657

1. Compression fitting 1/8 NPT
2. 90° elbow
3. Quick disconnect check valve
4. Fuel pressure test adapter

The Fuel Pressure Test Kit includes a quick disconnect check valve and fittings that can be used to make a test line to check fuel pressure at the high-pressure fuel rail.

Fuel Rail Block Off Plugs

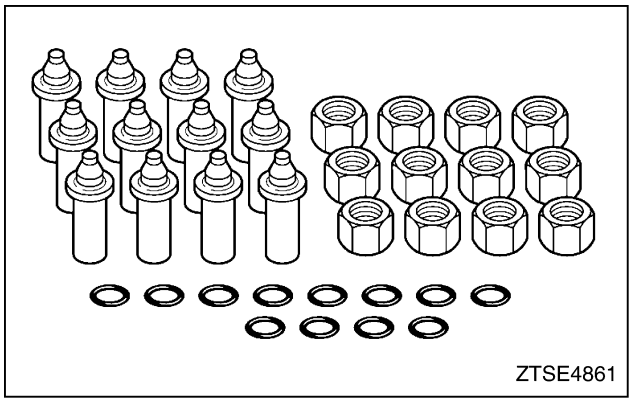

Figure 324 ZTSE4861

The Fuel Rail Block Off Plugs are used to test the high-pressure fuel system.

Fuel System Caps

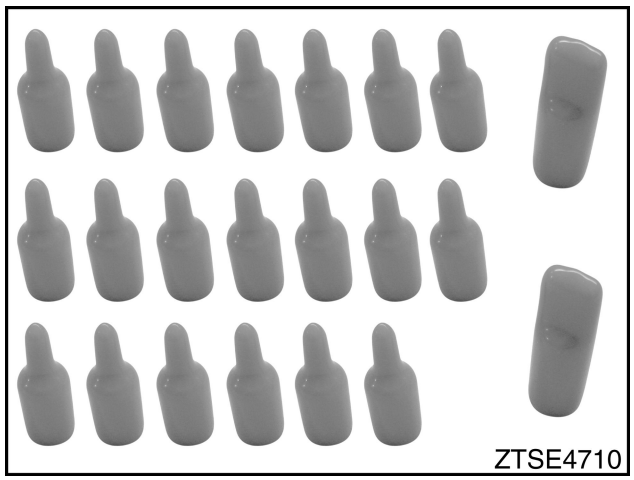

Figure 325 ZTSE4710

The Fuel System Caps provide the required sizes needed to cap the fuel system fittings and injectors when the system has been disassembled for service. The caps prevent dirt and particles from entering the fuel system.

High-pressure Pump Test Fitting

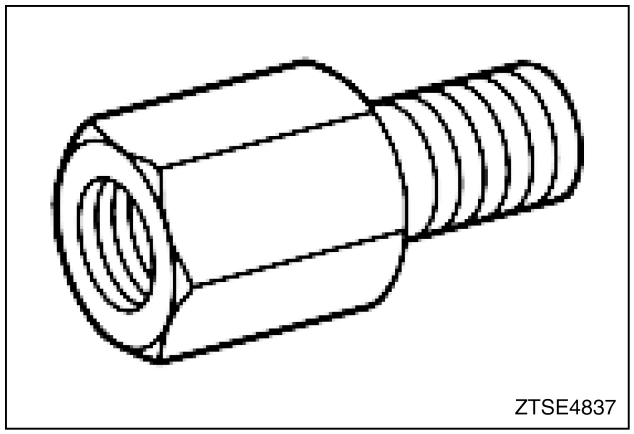

Figure 326 ZTSE4837

The High-pressure Pump Test Fitting is used to test high-pressure system for leaks.

Fuel Injector Cups

Figure 327 ZTSE4709

Injector Cups are plastic liners that fit in rack (ZTSE4299). The injectors fit tightly in the cups to prevent dirt from damaging the injectors.

Inline Shut-off Valve

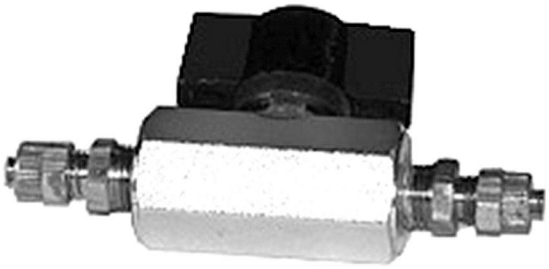

Figure 328 Part No. 221406

The Inline Shut-off Valve is used to make a test line to check for aerated oil, specifically at the Engine Oil Temperature (EOT) sensor port. The Shut-Off valve can also be used to make a test line assembly to check for aerated fuel.

Oil Cooler Block Off

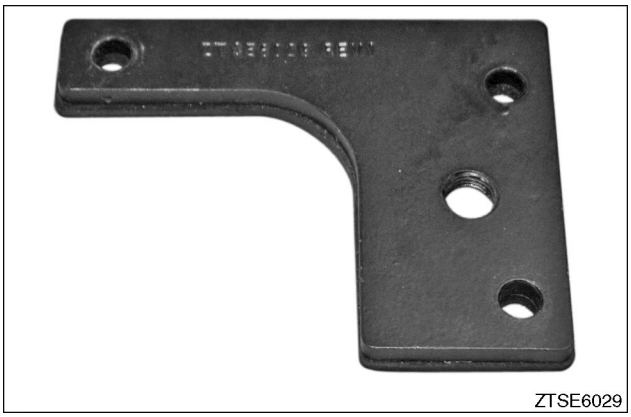

Figure 329 ZTSE6029

The Oil Cooler Block Off is used to pressure test the oil cooler for leaks.

Pressure Test Kit

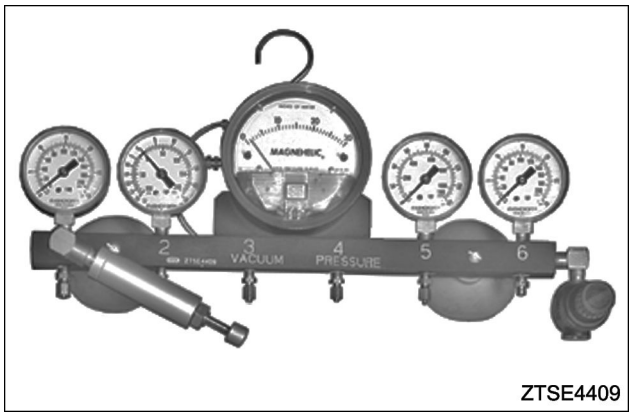

Figure 330 ZTSE4409

The Pressure Test Kit is used to measure intake manifold (boost) pressure, fuel system inlet restriction, fuel pressure, oil pressure, air cleaner intake restriction, and crankcase pressure.

- 0 to 200 kPa (0 to 30 psi) measures intake manifold pressure.
- 0-30 in Hg vacuum /0 to 200 kPa (0 to 30 psi) compound gauge measures fuel system inlet restriction and intake manifold pressure.

  0-30 in H_2O 0 to 7.5 kPa (0 to 1 psi) maximum pressure magnehelic gauge measures crankcase pressure and air inlet restriction.
- 60 to 1100 kPa (0 to 160 psi) gauge may be used to check the fuel pressure and oil pressure.

Radiator Pressure Test Kit

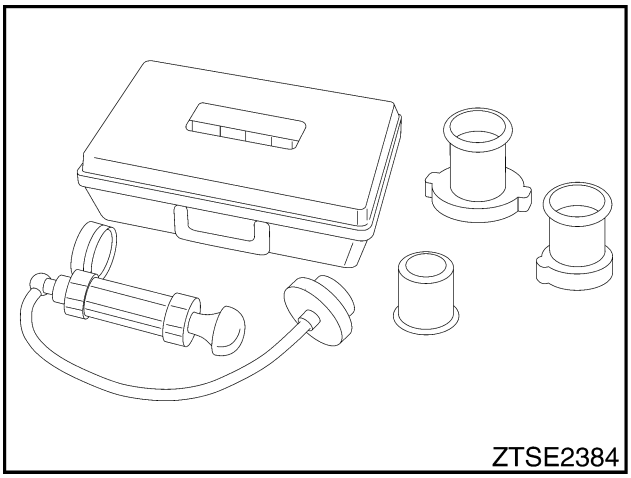

Figure 331 ZTSE2384

The Radiator Pressure Test Kit is used to check pressure caps and cooling systems. The pressure gauge indicates if the pressure cap holds the correct pressure and whether the cooling system has leaks or holds pressure.

Slack Tube® Manometer

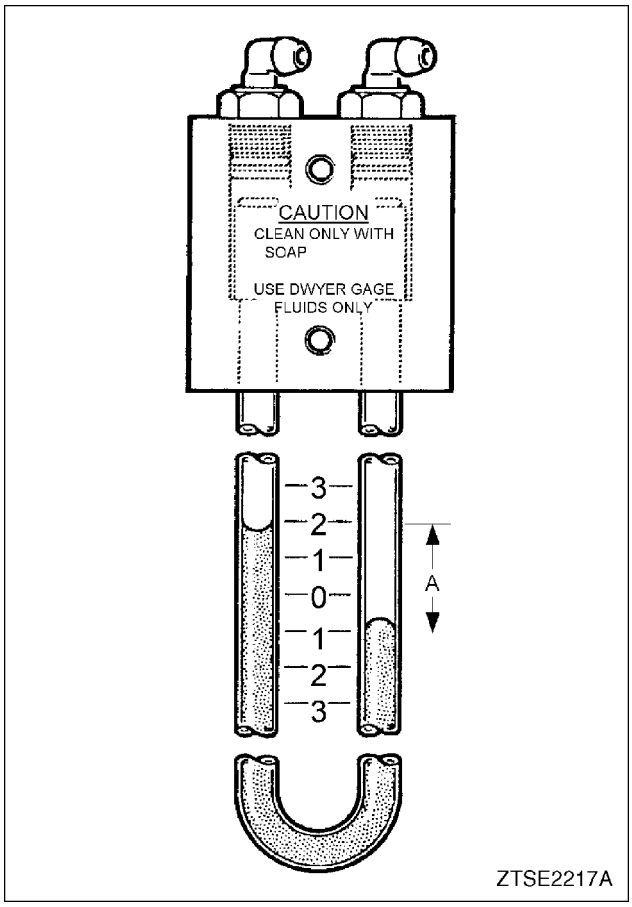

Figure 332 ZTSE2217A

The Slack Tube® Manometer is a U-shaped tube with a scale mounted between the legs of the tube. When the portability of the Pressure Test Kit is not required, this manometer is used to measure low vacuum for intake restriction, low pressure for crankcase, or exhaust back pressure.

Filling

Fill the manometer with water before checking pressure. Use only distilled water. Add some colored water vegetable dye so the scale can be read more easily. With both legs of the manometer open to the atmosphere, fill the tube until the top of the fluid column is near the zero mark on the scale. Shake the tube to eliminate any air bubbles.

Installing, Reading, and Cleaning

1. Support the manometer vertically. Make sure the fluid level is in line with the zero indicator on the graduated scale.
2. Connect one leg of the manometer to the source of the pressure or vacuum. Leave the other leg open to atmospheric pressure.
3. Start the engine and allow it to reach normal operating temperature. Then run the engine to high idle. The manometer can be read after 10 seconds.
4. Record the average position of the fluid level when it is above and below the zero indicator. Add the two figures together. The sum of the two is the total column of fluid (distance A). This represents the crankcase pressure in inches of water (in H_2O).

   At times, both columns of the manometer will not travel the same distance. This is no concern if the leg not connected to the pressure or vacuum source is open to the atmosphere.
5. Compare the manometer reading with engine specifications.
6. When the test is done, clean the tube thoroughly using soap and water. Avoid liquid soaps and solvents.

Turbocharger Drain Block Off Plug

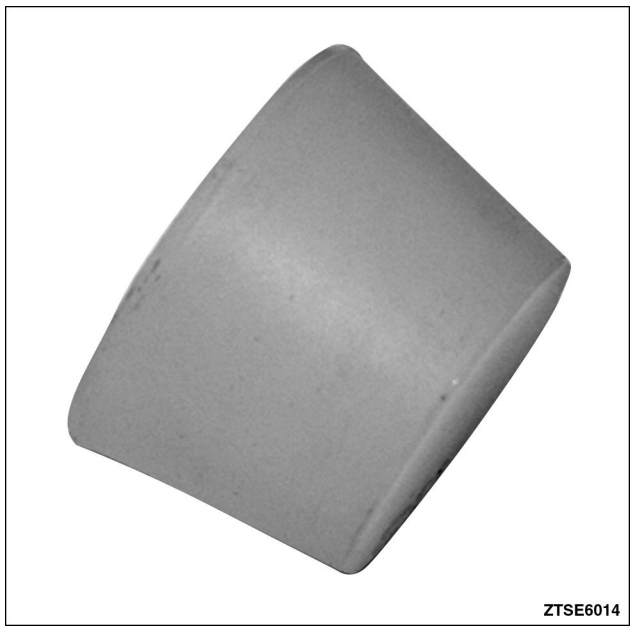

Figure 333 ZTSE6014

The Turbocharger Drain Block Off Plug is used to block off the turbocharger oil drain line.

Turbocharger Oil Supply Block Off

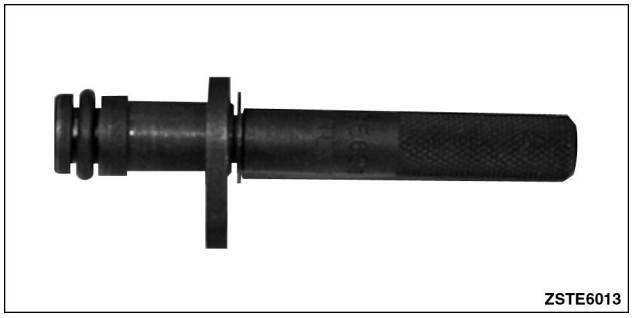

Figure 334 ZTSE6013

The Turbocharger Oil Supply Block Off is used to block off the turbocharger oil supply ports and feed line so the engine can be operated to verify repairs.

Turbocharger Supply Block Off Plug

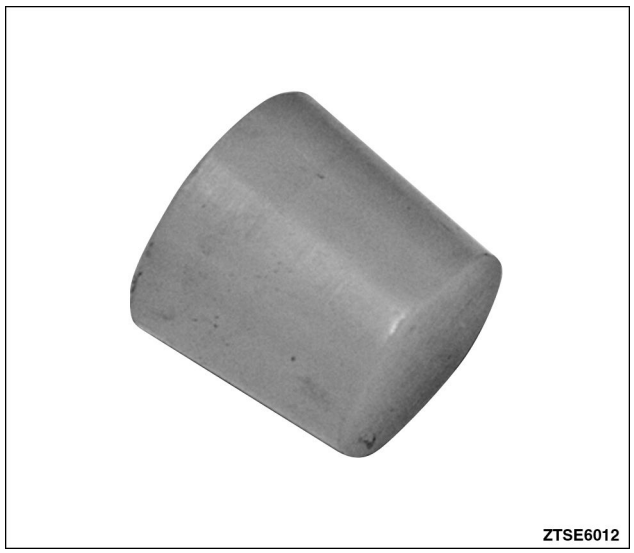

Figure 335 ZTSE6012

The Turbocharger Oil Supply Block Off Plug is used to block off the turbocharger lines.

UV Leak Detection Kit

Figure 336 ZTSE4618

The UV Leak Detection Kit is used with fuel dye to quickly identify leaks. The fuel dye combines with fuel and migrates out at the leak. The ultraviolet lamp illuminates the leaking fuel dye, which appears fluorescent yellow-green in color.

Vacuum Analyzer and Fuel Pump Tester

Figure 337 ZTSE2499

The Vacuum Analyzer and Fuel Pump Tester is used to test the operation of the fuel pump.

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Abbreviations and Acronyms

Abbreviations and Acronyms

A or amp – Ampere
AAT – Ambient Air Temperature
ABDC – After Bottom Dead Center
ABS – Antilock Brake System
AC – Alternating Current
A/C – Air Conditioner
ACC – Air Conditioner Control
ACCEL – Accelerate
ACD – Air Conditioner Demand
ACM – Aftertreatment Control Module
ACT PWR GND – Actuator Power Ground
ACV – Air Control Valve
AF – Air to Fuel ratio
AFT – Aftertreatment
AFTFD – Aftertreatment Fuel Doser
AFTFDH – Aftertreatment Fuel Doser High
AFTFDL – Aftertreatment Fuel Doser Low
AFTFIT – Aftertreatment Fuel Inlet Temperature
AFTFIS – Aftertreatment Fuel Inlet Sensor
AFTFP – Aftertreatment Fuel Pressure
AFTFP1 – Aftertreatment Fuel Pressure 1
AFTFP2 – Aftertreatment Fuel Pressure 2
AFTFSH – Aftertreatment Fuel Shutoff High
AFTFSL – Aftertreatment Fuel Shutoff Low
AFTFSV – Aftertreatment Fuel Shutoff Valve
AIT – Air Inlet Temperature
Amb – Ambient
amp or A – Ampere
AMS – Air Management System
API – American Petroleum Institute
APP – Accelerator Pedal Position
APP1 – Accelerator Pedal Position 1
APP2 – Accelerator Pedal Position 2
ASTM – American Society for Testing and Materials
ATA – American Trucking Association
ATAH – American Trucking Association Link High
ATAL – American Trucking Association Link Low
ATDC – After Top Dead Center
AWG – American Wire Gauge
AWL – Amber Warning Lamp
B+ or VBAT – Battery Voltage
BARO – Barometric Absolute Pressure
BBDC – Before Bottom Dead Center
BC – Body Controller
BDC – Bottom Dead Center
bhp – Brake Horsepower
BOO – Brake On / Off
BPP – Brake Pedal Position

BPS – Brake Pressure Switch
BTDC – Before Top Dead Center
BTU – British Thermal Unit
C – Celsius
CAC – Charge Air Cooler
CACOT – Charge Air Cooler Outlet Temperature
CAN – Controller Area Network
CAP – Cold Ambient Protection
CARB – California Air Resources Board
cc – Cubic centimeter
CCA – Cold Cranking Ampere
CCOSS – Crankcase Oil Separator Speed
CCS – Cruise Control Switches
cfm – Cubic feet per minute
cfs – Cubic feet per second
CFV – Coolant Flow Valve
CID – Cubic Inch Displacement
CKP – Crankshaft Position
CKPH – Crankshaft Position High
CKPL – Crankshaft Position Low
CKPO – Crankshaft Position Out
cm – Centimeter
CMP – Camshaft Position
CMPH – Camshaft Position High
CMPL – Camshaft Position Low
CMPO – Camshaft Position Out
CMV – Coolant Mixer Valve
CO – Carbon Monoxide
COO – Cruise On / Off switch
CPU – Central Processing Unit
CSFI – Cold Start Fuel Igniter
CSFS – Cold Start Fuel Solenoid
CSR – Cold Start Relay
CTC – Coolant Temperature Compensation
Cyl – Cylinder
DB – Decibel
DC – Direct Current
DCA – Diesel Coolant Additive
DDI – Digital Direct Fuel Injection
DDS – Driveline Disengagement Switch
DLC – Data Link Connector
DME – Dimethyl Ether
DMM – Digital Multimeter
DOC – Diesel Oxidation Catalyst
DOCIT – Diesel Oxidation Catalyst Inlet Temperature
DOCOT – Diesel Oxidation Catalyst Outlet Temperature
DPF – Diesel Particulate Filter
DPFDP – Diesel Particulate Filter Differential Pressure
DPFIT – Diesel Particulate Filter Inlet Temperature
DPFOT – Diesel Particulate Filter Outlet Temperature
DSI – Down Stream Injection

DT – Diesel Turbocharged
DTC – Diagnostic Trouble Code
DTRM – Diesel Thermo Recirculation Module
EAWD – Engine Assisted Windshield Defrost
EBP – Exhaust Back Pressure
EBPD – Exhaust Back Pressure Desired
EBPV – Exhaust Back Pressure Valve
ECB – Engine Compression Brake
ECB1 – Engine Compression Brake 1
ECB2 – Engine Compression Brake 2
ECBP – Engine Compression Brake Pressure
ECI – Engine Crank Inhibit
ECL – Engine Coolant Level
ECM – Engine Control Module
ECM GND – Engine Control Module Ground
ECM PWR – Engine Control Module Power
ECS – Engine Coolant System
ECSR – Engine Controlled Shutdown Request
ECT – Engine Coolant Temperature
ECT1 – Engine Coolant Temperature 1
ECT2 – Engine Coolant Temperature 2
EFAN – Engine Fan
EFC – Engine Fan Control
EFRC – Engine Family Rating Code
EFS – Engine Fan Speed
EFT – Engine Fuel Temperature
EG – Ethylene Glycol
EGC – Electronic Gauge Cluster
EGBP – Exhaust Gas Back Pressure
EGDP – Exhaust Gas Differential Pressure
EGR – Exhaust Gas Recirculation
EGRC – Exhaust Gas Recirculation Control
EGRH – Exhaust Gas Recirculation High control
EGRL – Exhaust Gas Recirculation Low control
EGROT – Exhaust Gas Recirculation Outlet Temperature
EGRP – Exhaust Gas Recirculation Position
EGRT – Exhaust Gas Recirculation Temperature
EGT – Exhaust Gas Temperature
EGT1 – Exhaust Gas Temperature 1
EGT2 – Exhaust Gas Temperature 2
EGT3 – Exhaust Gas Temperature 3
EMI – Electromagnetic Interference
EMP – Exhaust Manifold Pressure
EMT – Exhaust Manifold Temperature
EOL – Engine Oil Level
EOP – Engine Oil Pressure
EOT – Engine Oil Temperature
EPA – Environmental Protection Agency
EPR – Engine Pressure Regulator
ESC – Electronic System Controller
ESN – Engine Serial Number

EST – Electronic Service Tool
ETC – Engine Throttle Control
ETCH – Engine Throttle Control High
ETCL – Engine Throttle Control Low
ETP – Engine Throttle Position
ETV – Engine Throttle Valve
EWPS – Engine Warning Protection System
F – Fahrenheit
FCV – Fuel Coolant Valve
FDP – Fuel Delivery Pressure
FEL – Family Emissions Limit
fhp – Friction horsepower
FMI – Failure Mode Indicator
FPC – Fuel Pump Control
FPCV – Fuel Pressure Control Valve
fpm – Feet per minute
FPM – Fuel Pump Monitor
fps – Feet per second
FRP – Fuel Rail Pressure
ft – Feet
FVCV – Fuel Volume Control Valve
GND – Ground (electrical)
gal – Gallon
gal/h – U.S. Gallons per hour
gal/min – U.S. Gallons per minute
GCW – Gross Combined Weight
GCWR – Gross Combined Weight Rating
GPC – Glow Plug Control
GPD – Glow Plug Diagnostic
GPR – Glow Plug Relay
GVW – Gross Vehicle Weight
H_2O – Water
HC – Hydrocarbons
HEST – High Exhaust System Temperature
HFCM – Horizontal Fuel Conditioning Module
Hg – Mercury
hp – Horsepower
HPCAC – High-Pressure Charge Air Cooler
HPCR – High-Pressure Common Rail
HPFP – High-Pressure Fuel Pump
hr – Hour
HS – Humidity Sensor
Hyd – Hydraulic
IAH – Inlet Air Heater
IAHC – Inlet Air Heater Control
IAHD – Inlet Air Heater Diagnostic
IAHR – Inlet Air heater Relay
IC – Integrated Circuit
ICP – Injection Control Pressure
ICPR – Injection Control Pressure Regulator
ICG1 – Injector Control Group 1

ICG2 – Injector Control Group 2
ID – Inside Diameter
IGN – Ignition
ILO – Injector Leak Off
IMP – Intake Manifold Pressure
IMT – Intake Manifold Temperature
in – Inch
inHg – Inch of mercury
inH_2O – Inch of water
INJs – Injectors
IPR – Injection Pressure Regulator
IPR PWR – Injection Pressure Regulator Power
ISC – Interstage Cooler
ISIS – International Service Information System
IST – Idle Shutdown Timer
ITP – Internal Transfer Pump
J1939H – J1939 Data Link High
J1939L – J1939 Data Link Low
JCT – Junction (electrical)
kg – Kilogram
km – Kilometer
km/h – Kilometers per hour
km/l – Kilometers per liter
KOEO – Key On Engine-Off
KOER – Key On Engine-Running
kPa – Kilopascal
L – Liter
L/h – Liters per hour
L/m – Liters per minute
L/s – Liters per second
lb – Pound
lb – Pounds of force
lb/s – Pounds per second
lb ft – Pounds of force per foot
lb in – Pounds of force per inch
lbm – Pounds of mass
LSD – Low Sulfur Diesel
m – Meter
m/s – Meters per second
MAF – Mass Air Flow
MAF GND – Mass Air Flow Ground
MAG – Magnetic
MAP – Manifold Absolute Pressure
MAT – Manifold Air Temperature
mep – Mean effective pressure
mi – Mile
MIL – Malfunction Indicator Lamp
mm – Millimeter
mpg – Miles per gallon
mph – Miles per hour
MPR – Main Power Relay

MSDS – Material Safety Data Sheet
MSG – Micro Strain Gauge
MSM – Multiplex System Module
MY – Model Year
NC – Normally closed (electrical)
NETS – Navistar Electronics Technical Support
Nm – Newton meter
NO – Normally Open (electrical)
NO_x – Nitrogen Oxides
O2S – Oxygen Sensor
O2SH – Oxygen Sensor Heater
OAT – Organic Acid Technology
OCC – Output Circuit Check
OCP – Overcrank Protection
OD – Outside Diameter
OL – Over Limit
ORH – Out-of-Range High
ORL – Out-of-Range Low
OSHA – Occupational Safety and Health Administration
OWL – Oil / Water Lamp
PID – Parameter Identifier
P/N – Part Number
PDOC – Pre-Diesel Oxidation Catalyst
ppm – Parts per million
PROM – Programmable Read Only Memory
psi – Pounds per square inch
psia – Pounds per square inch absolute
psig – Pounds per square inch gauge
pt – Pint
PTO – Power Takeoff
PWM – Pulse Width Modulate
PWR – Power (voltage)
qt – Quart
RAM – Random Access Memory
RAPP – Remote Accelerator Pedal Position
RAS – Resume / Accelerate Switch (speed control)
REPTO – Rear Engine Power Takeoff
RFI – Radio Frequency Interference
rev – Revolution
rpm – Revolutions per minute
RPRE – Remote Preset Power Take Off
RSE – Radiator Shutter Enable
RVAR – Remote Variable
SAE – Society of Automotive Engineers®
SCA – Supplemental Cooling Additive
SCCS – Speed Control Command Switches
SCS – Speed Control Switch
SHD – Shield (electrical)
SID – Subsystem Identifier
SIG GND – Signal Ground
SIG GNDB – Signal Ground Body

SIG GNDC – Signal Ground Chassis
SIG GNDE – Signal Ground Engine
S/N – Serial Number
SPEEDO – Speedometer
SPN – Suspect Parameter Number
SW – Switch (electrical)
SWBAT – Switch Battery
SYNC – Synchronization
TACH – Tachometer output signal
TBD – To Be Determined
TC2CIS – Turbocharger 2 Compressor Inlet Sensor
TC2CIT – Turbocharger 2 Compressor Inlet Temperature
TC1TOP – Turbocharger 1 Turbine Outlet Pressure
TC2TOP – Turbocharger 2 Turbine Outlet Pressure
TC2WG – Turbocharger 2 Wastegate
TC2WC – Turbocharger 2 Wastegate Control
TCAPE – Truck Computer Analysis of Performance and Economy
TCM – Transmission Control Module
TCWC – Turbocharger Wastegate Control
TDC – Top Dead Center
TDE – Transmission Driving Engaged
TOP – Transmission Oil Pressure
TOSS – Transmission Output Shaft Speed
TOT – Transmission Oil Temperature
TTS – Transmission Tailshaft Speed
ULSD – Ultra Low Sulfur Diesel
UVC – Under Valve Cover
V – Volt
VBAT or B+ – Battery Voltage
VC – Volume Control
VEPS – Vehicle Electronics Programming System
VIGN – Ignition Voltage
VIN – Vehicle Identification Number
VOP – Valve Opening Pressure
VRE – Vehicle Retarder Enable
VREF – Reference Voltage
VREFB – Reference Voltage Body
VREFC – Reference Voltage Chassis
VREFE – Reference Voltage Engine
VSO – Vehicle Speed Output
VSS – Vehicle Speed Sensor
VSSH – Vehicle Speed Sensor High
VSSL – Vehicle Speed Sensor Low
WTSL – Wait to Start Lamp
WEL – Warn Engine Lamp
WIF – Water In Fuel
WIFL – Water In Fuel Lamp
WTEC – World Transmission Electronically Controlled automatic transmissions (Allison)
XCS – Transfercase
XMSN – Transmission

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Terminology

Terminology

Terms

Accelerator Pedal Position (APP) sensor – A potentiometer sensor that indicates the position of the throttle pedal.

Accessory work – The work per cycle required to drive engine accessories (normally, only those essential to engine operation).

Actuator – A device that performs work in response to an input signal.

Actuator Control – The ECM controls the actuators by applying a low-level signal (low-side driver) or a high-level signal (high side driver). When switched on, both drivers complete a ground or power circuit to an actuator.

Aeration – The entrainment of air or combustion gas in coolant, lubricant, or fuel.

Aftercooler (Charge Air Cooler) – See **Charge Air Cooler**.

Aftertreatment (AFT) system – A part of the exhaust system that processes engine exhaust to meet emission requirements and traps particulate matter (soot) to prevent it from leaving the tailpipe.

Aftertreatment Fuel Doser (AFTFD) – A part of the Downstream Injection (DSI) unit that sends pressurized fuel to the Aftertreatment Fuel Injector (AFI) to inject fuel into the exhaust pipe.

Aftertreatment Fuel Inlet Sensor (AFTFIS) – A sensor that monitors fuel temperature in the DSI system and provides constant feedback to the ECM.

Aftertreatment Fuel Pressure 2 (AFTFP2) sensor – A sensor that monitors fuel pressure in the DSI system and provides constant feedback to the ECM.

Aftertreatment Fuel Shutoff Valve (AFTFSV) – A valve used to prevent fuel flow to the Aftertreatment Fuel Injector (AFI), and prevents all uncontrolled fuel delivery for the Aftertreatment system during an AFTFD valve malfunction.

Air Control Valve (ACV) – Contains the LP turbocharger wastegate control port, HP turbocharger wastegate control port, the EBPV control port, and the TC1TOP port. Although these components are integral to the ACV, each circuit is controlled by the ECM. The ACV controls compressed air for each control valve.

Air Inlet Temperature (AIT) sensor – A thermistor sensor that monitors intake air temperature.

Ambient Air Temperature (AAT) sensor – A sensor that sends an ambient air temperature signal to the ECM.

Ambient temperature – The environmental air temperature in which a unit is operating. In general, the temperature is measured in the shade (no solar radiation) and represents the air temperature for other engine cooling performance measurement purposes. Air entering the radiator may or may not be the same ambient due to possible heating from other sources or recirculation. (SAE J1004 SEP81)

American Trucking Association (ATA) Datalink – A serial datalink specified by the American Trucking Association and the SAE.

Ampere (amp) – The standard unit for measuring the strength of an electrical current. The flow rate of a charge in a conductor or conducting medium of one coulomb per second. (SAE J1213 NOV82)

Analog – A continuously variable voltage.

Analog to digital converter (A / D) – A device in the ECM that converts an analog signal to a digital signal.

Barometric Absolute Pressure (BAP) sensor – A sensor built into the ECM that provides barometric pressure information to the ECM.

Bobtailing – Operating a truck / tractor without a trailer attached.

Boost pressure – 1. The pressure of the charge air leaving the turbocharger.

2. Inlet manifold pressure that is greater than atmospheric pressure. Obtained by turbocharging.

Bottom Dead Center (BDC) – The lowest position of the piston during the stroke.

Brake Horsepower (bhp) – The power output from an engine, not the indicated horsepower. The power output of an engine, sometimes-called flywheel horsepower, is less than the indicated horsepower by the amount of friction horsepower consumed in the engine.

Brake Horsepower (bhp) net – Net brake horsepower is measured with all engine components. The power of an engine when configured as a fully equipped engine. (SAE J1349 JUN90)

Brake On / Off (BOO) switch – A switch located on the brake pedal lever, that provides a brake pedal position signal to the ECM.

Brake Pressure Switch (BPS) – A switch located in the brake pressure line that provides a brake pedal position signal to the ECM.

Calibration – ECM programming strategy to solve engine performance equations and make decisions. Calibration values are stored in ROM and put into the processor during programming to allow the engine to operate within certain parameters.

Camshaft Position (CMP) sensor – A magnetic pickup sensor that provides the ECM with a camshaft speed and position signal.

Carbon Monoxide (CO) – A colorless, odorless, highly poisonous gas that is formed by the incomplete combustion of carbon burning diesel engine. It is present in the exhaust gases of diesel engines.

Catalyst – A substance that produces a chemical reaction without undergoing a chemical change itself.

Catalytic converter – An antipollution device in the exhaust system that contains a catalyst for chemically converting some pollutants in the exhaust gases (carbon monoxide, unburned hydrocarbons, and oxides of nitrogen) into harmless compounds.

Cavitation – A dynamic condition in a fluid system that forms gas-filled bubbles (cavities) in the fluid.

Cetane number – 1. The auto-ignition quality of diesel fuel.

2. A rating applied to diesel fuel similar to octane rating for gasoline.

3. A measure of how readily diesel fuel starts to burn (self-ignites) at high compression temperature.

Diesel fuel with a high cetane number self-ignites shortly after injection into the combustion chamber. Therefore, it has a short ignition delay time. Diesel fuel with a low cetane number resists self-ignition. Therefore, it has a longer ignition delay time.

Charge air – Dense, pressurized, heated air discharged from the turbocharger.

Charge Air Cooler (CAC) – A heat exchanger mounted in the charge air path between the turbocharger and engine intake manifold. The charge air cooler reduces the charge air temperature by transferring heat from the charge air to a cooling medium (usually air).

Charge Air Cooler Outlet Temperature (CACOT) sensor – A thermistor sensor that monitors the temperature of charge air entering the intake air duct.

Closed crankcase – A crankcase ventilation that recycles crankcase gases through a breather, then back to the clean air intake.

Closed loop operation – A system that uses sensors to provide feedback to the ECM. The ECM uses the sensor input to continuously monitor variables and adjust actuators to match engine requirements.

Cloud point – The point when wax crystals occur in fuel, making fuel cloudy or hazy. Usually below -12 °C (10 °F).

Cold cranking ampere rating (battery rating) – The sustained constant current (in amperes) needed to produce a minimum terminal voltage under a load of 7.2 volts per battery after 30 seconds.

Cold soak – Allowing engine to remain OFF for a period of eight or more hours.

Cold Start Fuel Ignitor (CSFI) – The CSFI heats the intake air by vaporizing and igniting fuel in the air inlet duct.

Cold Start Fuel Solenoid (CSFS) – As the engine is cranked, the ECM energizes the CSFS valve, introducing fuel into the CSFI, which ignites and warms the air being drawn into the engine.

Cold Start Relay (CSR) – The CSR provides voltage to the CSFI, and is controlled by the ECM.

Continuous Monitor Test – An ECM function that continuously monitors the inputs and outputs to ensure that readings are within set limits.

Controller Area Network (CAN) – A J1939 high speed communication link.

Coolant – A fluid used to transport heat from one point to another.

Coolant Flow Valve (CFV) – The CFV is ECM controlled and redirects coolant through the fuel cooler, based on EFT, when directed.

Coolant level switch – A switch sensor used to monitor coolant level.

Coolant Mixer Valve (CMV) – Controls coolant flow through the low-temperature radiator.

Crankcase – The housing that encloses the crankshaft, connecting rods, and allied parts.

Crankcase breather – A vent for the crankcase to release excess interior air pressure.

Crankcase Oil Separator Speed (CCOSS) sensor – The CCOSS sensor sends the ECM information about the speed of the crankcase oil separator internal components.

Crankcase pressure – The force of air inside the crankcase against the crankcase housing.

Crankshaft Position (CKP) sensor – A magnetic pickup sensor that determines crankshaft position and speed.

Cruise Control Switches (CCS) – A set of switches used for cruise control, Power Take Off (PTO), and remote hand throttle system.

Current – The flow of electrons passing through a conductor. Measured in amperes.

Cylinder Balance – An ECM control strategy to even-out the power contributions of each power cylinder.

Damper – A device that reduces the amplitude of torsional vibration. (SAE J1479 JAN85)

Deaeration – The removal or purging of gases (air or combustion gas) entrained in coolant or lubricating oil.

Deaeration tank – A separate tank in the cooling system used for one or more of the following functions:

- Deaeration
- Coolant reservoir (fluid expansion and afterboil)
- Coolant retention
- Filling
- Fluid level indication (visible)

Diagnostic Trouble Code (DTC) – 2010 model year vehicles no longer utilize DTC identification by number. DTCs are now identified using the Suspect Parameter Number (SPN) and Failure Mode Indicator (FMI) identifiers only.

Diamond Logic Builder (DLB) – The diagnostics software for chassis related components and systems.

Diesel Oxidation Catalyst (DOC) – A DOC is part of the diesel exhaust Aftertreatment system. DOCs are devices that use a chemical process to break down pollutants in the exhaust stream into less harmful

components. More specifically, DOCs utilize rare metals such as palladium and platinum to reduce hydrocarbon based Soluble Organic Fraction (SOF) and carbon monoxide content of diesel exhaust by simple oxidation. The DOC can be used during an active regeneration to create higher exhaust temperatures, thereby reducing soot in the DPF.

Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor – A sensor that provides DOC inlet temperature signal to the ECM.

Diesel Particulate Filter (DPF) – A diesel particulate filter, sometimes called a DPF, is a device designed to remove diesel particulate matter or soot from the exhaust gas of a diesel engine.

Diesel Particulate Filter Differential Pressure (DPFDP) sensor – A sensor that measures pressure difference between the inlet and outlet of the DPF and provides feedback to the ECM.

Diesel Particulate Filter Inlet Temperature (DPFIT) sensor – A sensor that provides DOC inlet temperature signal to the ECM.

Diesel Particulate Filter Outlet Temperature (DPFOT) sensor – A sensor that provides DOC outlet temperature signal to the ECM.

Digital Multimeter (DMM) – An electronic meter that uses a digital display to indicate a measured value. Preferred for use on microprocessor systems because it has a very high internal impedance and will not load down the circuit being measured.

Disable – A computer decision that deactivates a system and prevents operation of the system.

Displacement – The stroke of the piston multiplied by the area of the cylinder bore multiplied by the number of cylinders in the engine.

Down Stream Injection (DSI) – The DSI system injects fuel into the exhaust system to increase temperature of the exhaust gases, and is necessary for DPF regeneration.

Driver (high side) – A transistor within an electronic module that controls the power to an actuator circuit.

Driver (low side) – A transistor within an electronic module that controls the ground to an actuator circuit.

Dual Stage Turbocharger – An assembly of two turbochargers (low-pressure and high-pressure) in series to provide a wide range of charge air pressures efficiently.

Duty cycle – A control signal that has a controlled on / off time measurement from 0 to 100%. Normally used to control solenoids.

EGR Cooler – A cooler that allows heat to dissipate from the exhaust gasses before they enter the intake manifold.

Engine Back Pressure Valve (EBPV) – The ECM commands the EBPV to control the Exhaust Brake.

Engine Compression Brake (ECB) valve – The ECB valve controls pressure entering the brake oil gallery from the high-pressure oil rail gallery. This activates the brake actuator pistons and opens the exhaust valves.

Engine Compression Brake 1 (ECB1) solenoid – The ECB1 solenoid controls pressure entering the brake oil gallery from the high-pressure oil rail gallery.

Engine Compression Brake 2 (ECB2) solenoid – The ECB2 solenoid controls pressure entering the brake oil gallery from the high-pressure oil rail gallery.

Engine Compression Brake Pressure (ECBP) sensor – A high-pressure sensor that provides a feedback signal to the ECM indicating brake control pressure.

Engine Control Module (ECM) – An electronic processor that monitors and controls the engine.

Engine Coolant Level (ECL) sensor – A switch sensor that monitors coolant level.

Engine Coolant Temperature 1 (ECT1) sensor – A thermistor sensor that detects engine coolant temperature.

Engine Coolant Temperature 2 (ECT2) sensor – A thermistor sensor that detects engine coolant temperature.

Engine Fuel Temperature (EFT) sensor – A thermistor sensor that measures fuel temperature.

Engine lamp – An instrument panel lamp that comes on when DTCs are set. DTCs can be read as flash codes (red and amber instrument panel lamps).

Engine OFF tests – Tests that are done with the ignition switch ON and the engine OFF.

Engine Oil Pressure (EOP) sensor – A variable capacitance sensor that measures oil pressure.

Engine Oil Temperature (EOT) sensor – A thermistor sensor that measures oil temperature.

Engine rating – Engine rating includes **Rated hp** and **Rated rpm**.

Engine RUNNING tests – Tests done with the engine running.

Engine Throttle Valve (ETV) and Engine Throttle Position Sensor – The ETV valve is used to control airflow during a regeneration process of the aftertreatment system. The ETV valve is also used to ensure a smooth engine shut down by restricting airflow to the engine at shut down.

Engine Warning Protection System (EWPS) – Safeguards the engine from undesirable operating conditions to prevent engine damage and to prolong engine life.

Exhaust Back Pressure (EBP) – The pressure present in the exhaust system during the exhaust period.

Exhaust Back Pressure Valve (EBPV) – A valve that regulates the amount of air pressure applied to the EBPV pneumatic actuator.

Exhaust brake – A brake device using engine exhaust back pressure as a retarding medium.

Exhaust Gas Recirculation (EGR) – A system used to recirculate a portion of the exhaust gases into the power cylinder in order to reduce oxides of nitrogen.

Exhaust Gas Recirculation Temperature (EGRT) sensor – A thermistor sensor that detects the exhaust gas temperature entering the EGR cooler.

Exhaust Gas Recirculation (EGR) valve – The EGRV controls the flow of exhaust gases to the intake manifold. The EGRV is integrated with an EGR Position (EGRP) sensor.

Exhaust Gas Temperature (EGT) – The temperature of exhaust gases.

Exhaust manifold – Exhaust gases flow through the exhaust manifold to the turbocharger exhaust inlet and are directed to the EGR cooler.

Exhaust Manifold Pressure (EMP) sensor – A variable capacitance sensor used to indicate air pressure in the exhaust manifold.

Exhaust Manifold Temperature (EMT) sensor – A thermistor style sensor used to indicate air temperature in the exhaust manifold.

Failure Mode Indicator (FMI) – Identifies the fault or condition effecting the individual component.

Fault detection / management – An alternate control strategy that reduces adverse effects that can be caused by a system failure. If a sensor fails, the ECM substitutes a good sensor signal or assumed sensor value in its place. A lit amber instrument panel lamp signals that the vehicle needs service.

Filter restriction – A blockage, usually from contaminants, that prevents the flow of fluid through a filter.

Flash code – See **Diagnostic Trouble Code (DTC)**.

Fuel Cooler Control Valve – A valve used to redirect coolant through the fuel cooler.

Fuel Delivery Pressure (FDP) sensor – A variable capacitance sensor that monitors fuel pressure coming from the fuel tank and sends a signal to the ECM.

Fuel inlet restriction – A blockage, usually from contaminants, that prevents the flow of fluid through the fuel inlet line.

Fuel pressure – The force fuel exerts on the fuel system as it is pumped through the fuel system.

Fuel Pressure Control Valve (FPCV) – The FPCV controls the fuel pressure to the fuel rails and is controlled by the ECM. FPCV control depends on fuel pressure and fuel temperature.

Fuel Rail Pressure (FRP) – The amount of pressure in the fuel rail.

Fuel Rail Pressure (FRP) sensor – A variable capacitance sensor that monitors fuel pressure in the fuel rail and sends a signal to the ECM.

Fuel strainer – A pre-filter in the fuel system that keeps larger contaminants from entering the fuel system.

Fuel Volume Control Valve (FVCV) – The FVCV regulates the volume of flow sent to the HPFP. The FVCV allows a sufficient quantity of fuel to be delivered to the HPFP depending on engine load, speed, injector quantity, fuel temperature, and number of injections per cycle.

Fully equipped engine – A fully equipped engine is an engine equipped with only those accessories necessary to perform its intended service. A fully equipped engine does not include components that are used to power auxiliary systems. If these components are integral with the engine or, for any reason are included on the test engine, the power absorbed may be determined and added to the net brake power. (SAE J1995 JUN90)

Fusible link (fuse link) – A fusible link is a special section of low tension cable designed to open the circuit when subjected to an extreme current overload. (SAE J1156 APR86)

Gradeability – The maximum percent grade, which the vehicle can transverse for a specified time at a specified speed. The gradeability limit is the grade upon which the vehicle can just move forward. (SAE J227a)

Gross brake horsepower – The power of a complete basic engine, with air cleaner, without fan, and alternator, and air compressor not charging.

Gross Combined Weight Rating (GCWR) – Maximum combined weight of towing vehicle (including passengers and cargo) and the trailer. The GCWR indicates the maximum loaded weight that the vehicle is allowed to tow.

H-Bridge Circuit – An H-Bridge (bipolar) circuit operates like putting a power source on one side of a motor and connecting the other side of the motor to a ground. This turns the motor. By shifting the leads on the motor, it will turn in the opposite direction.

Hall effect – The development of a transverse electric potential gradient in a current-carrying conductor or semiconductor when a magnetic field is applied.

Hall effect sensor – Transducer that varies its output voltage in response to changes in a magnetic field. Commonly used to time the speed of wheels and shafts.

High Pressure Fuel Pump (HPFP) assembly – The HPFP is a volumetric pump that supplies fuel at high pressure. The HPFP is mounted in the rear valley on the top of the engine and is driven by the camshaft.

High-pressure Piezo Common Rail (HPCR) – The HPFP pumps fuel through separate tubes to each fuel rail. Each fuel rail has four fuel tubes, one for each injector, that maintain constant pressure from the high-pressure pump to each injector.

High speed digital inputs – Inputs to the ECM from a sensor that generates varying frequencies (engine speed and vehicle speed sensors).

Horsepower (hp) – Horsepower is the unit of work done in a given period of time, equal to 33,000 pounds multiplied by one foot per minute. 1hp = 33,000 lb x 1 ft /1 min.

Humidity Sensor (HS) – A sensor that measures the moisture content of filtered air entering the intake system.

Hydrocarbons – Organic compounds consisting of hydrogen and carbon (fuel and oil).

Hydrocarbon Injector – Injects fuel into the exhaust system to increase temperature of the exhaust gases.

Idle Shutdown Timer (IST) – An engine calibration that allows the ECM to shut down the engine during extended engine idle times.

Injection Control Pressure (ICP) sensor – Provides a feedback signal to the ECM indicating injection control pressure.

Injection Pressure Regulator (IPR) valve – A valve that is used to maintain desired injection control pressure.

Inlet Air Heater (IAH) – The IAH is primarily used to assist in starting the engine during cold weather. In addition, it helps to reduce white smoke emissions by heating the incoming air.

Intake manifold – Engine component that evenly supplies air to each intake port in the cylinder head(s).

Intake Manifold Pressure (IMP) sensor – A variable capacitance sensor used to indicate air pressure in the intake manifold.

Intake Manifold Temperature (IMT) sensor – A thermistor sensor used to indicate air temperature in the intake manifold.

Internal Transfer Pump (ITP) – The ITP is part of the HPFP assembly and driven off the same shaft as the HPFP assembly. The ITP supplies fuel at a slightly higher pressure and flow to the HPFP though the Fuel Volume Control Valve (FVCV). The ITP also provides fuel for cooling and lubrication of the HPFP. Fuel is rerouted as pump return flow through the HPFP cooling and lubrication valve. Pressure is maintained at the inlet of the HPFP piston pump by an ITP regulator.

Interstage Cooler (ISC) – Uses cooled coolant to lower the charged air temperature that exits from the turbocharger low-pressure compressor and enters the turbocharger high-pressure compressor.

Low speed digital inputs – Switched sensor inputs that generate an on / off (high / low) signal to the ECM. The input to the ECM from the sensor could be from a high input source switch (usually 5 or 12 volts) or from a grounding switch that grounds the signal from a current limiting resistor in the ECM that creates a low signal (0 volts).

Low temperature radiator thermostat – Coolant flow to the low temperature radiator is regulated by the low temperature radiator thermostat.

Lubricity – Lubricity is the ability of a substance to reduce friction between solid surfaces in relative motion under loaded conditions.

Lug (engine) – A condition when the engine is run at an overly low RPM for the load being applied.

Magnehelic Gauge – A gauge that measures pressure in inches of water.

Magnetic Pickup Sensor – A magnetic pickup sensor generates an alternating frequency that indicates speed. Magnetic pickups have a two-wire connection for signal and ground. This sensor has a permanent magnetic core surrounded by a wire coil. The signal frequency is generated by the rotation of the gear teeth that disturb the magnetic field.

Malfunction Indicator Lamp (MIL) – An indicator lamp in the Electronic Instrument Cluster that will illuminate when a detected emissions fault occurs.

Manifold Absolute Pressure (MAP) – Boost pressure in the manifold that is a result of the turbocharger.

Manifold Absolute Pressure (MAP) sensor – A variable capacitance sensor that measures boost pressure.

Manometer – A double-leg liquid-column gauge, or a single inclined gauge, used to measure the difference between two fluid pressures. Typically, a manometer records in inches of water.

Mass Airflow – The intake airflow in an engine.

Mass Airflow (MAF) sensor – The MAF sensor is used for closed loop control of the EGR valve and ITV. The ECM monitors the MAF signal so that the ECM can control the EGR and intake throttle systems.

Metering unit valve assembly – The Metering unit valve assembly provides a metered amount of fuel to the Aftertreatment Fuel Injector (AFI).

Microprocessor – An integrated circuit in a microcomputer that controls information flow.

Micro Strain Gauge (MSG) Sensor – A MSG sensor measures pressure. Pressure exerts force on a pressure vessel that stretches and compresses to change resistance of strain gauges bonded to the surface of the pressure vessel. Internal sensor electronics convert the changes in resistance to a ratiometric voltage output.

Nitrogen Oxides (NO_x) – Nitrogen oxides form by a reaction between nitrogen and oxygen at high temperatures and pressures in the combustion chamber.

Normally closed – Refers to a switch that remains closed when no control force is acting on it.

Normally open – Refers to a switch that remains open when no control force is acting on it.

Ohm (Ω) – The unit of electrical resistance. One ohm is the value of resistance through which a potential of one volt will maintain a current of one ampere. (SAE J1213 NOV82)

On demand test – A self-test the technician initiates using the EST that is run from a program in the software.

Output Circuit Check (OCC) – An on-demand test done during an Engine OFF self-test to check the continuity of selected actuators.

Output Shaft Speed (OSS) sensor – A sensor mounted to the rear of the transmission that supplies a vehicle speed signal to the ECM. The ECM uses this signal to control PTO, road speed limiting, and cruise control. Automatic transmissions use this signal for shift scheduling.

Oxides of Nitrogen (NOx) – Nitrogen oxides formed by a reaction between nitrogen and oxygen at high temperatures.

Oxygen Sensor (O2S) – A sensor that monitors oxygen levels in the exhaust.

Particulate matter – Particulate matter includes mostly burned particles of fuel and engine oil.

pH – A measure of the acidity or alkalinity of a solution.

Piezometer – An instrument for measuring fluid pressure.

Power – Power is a measure of the rate at which work (force x distance) is done during a specific time. Compare with Torque.

Power TakeOff (PTO) – Accessory output, usually from the transmission, used to power a hydraulic pump for a special auxiliary feature (garbage packing, lift equipment, etc).

Pre-DOC – Refers to exhaust gases that have not passed through the DOC.

Pulse Width Modulation (PWM) – Succession of digital electrical pulses, rather than an analog signal. Efficient method of providing power between fully on and fully off.

Radiator Shutter Enable (RSE) – A feature that uses various input signals to open or close radiator shutters by energizing or de-energizing a solenoid that controls an air or hydraulic cylinder.

Random Access Memory (RAM) – Computer memory that stores information. Information can be written to and read from RAM. Input information (current engine speed or temperature) can be stored in RAM to be compared to values stored in Read Only Memory (ROM). All memory in RAM is lost when the ignition switch is turned off.

Rated gross horsepower – Engine gross horsepower at rated speed as declared by the manufacturer. (SAE J1995 JUN90)

Rated horsepower – Maximum brake horsepower output of an engine as certified by the engine manufacturer. The power of an engine when configured as a basic engine. (SAE J1995 JUN90)

Rated net horsepower – Engine net horsepower at rated speed as declared by the manufacturer. (SAE J1349 JUN90)

Rated speed – The speed, as determined by the manufacturer, at which the engine is rated. (SAE J1995 JUN90)

Rated torque – Maximum torque produced by an engine as certified by the manufacturer.

Ratiometric Voltage – In a Micro Strain Gauge (MSG) sensor, pressure to be measured exerts force on a pressure vessel that stretches and compresses to change resistance of strain gauges bonded to the surface of the pressure vessel. Internal sensor electronics convert the changes in resistance to a ratiometric voltage output.

Regeneration – Oxidation of accumulated soot (carbon-based particulates) in the Diesel Particulate Filter (DPF). The soot is reduced to ash and stored in the DPF.

Reference voltage (V_{REF}) – A 5 volt reference supplied by the ECM to operate the engine sensors.

Remote Accelerator Pedal Position (RAPP) – A feature that allows the operator to set and maintain a constant engine speed from outside the vehicle cab. This feature may also be known as Remote Engine Speed Control (RESC). Control over engine speed is accomplished by using remote mounted switches to turn on the RESC and select the desired engine speed.

Remote Engine Speed Control (RESC) – See **Remote Accelerator Pedal Position**.

Reserve capacity – Time in minutes that a fully charged battery can be discharged to 10.5 volts at 25 amperes.

Return Fuel System – The return fuel system moves unused fuel from the fuel injectors to the fuel cooler. Excess fuel out of the FVCV and the FPCV mix with fuel from the fuel injectors on the way to the fuel cooler.

ServiceMaxx™ software – Diagnostics software for engine related components and systems.

Signal Conditioner – The signal conditioner in the internal microprocessor converts analog signals to digital signals, squares up sine wave signals, or amplifies low-intensity signals to a level that the ECM microprocessor can process.

Signal ground – The common ground wire to the ECM for the sensors.

Speed Control Command Switches (SCCS) – A set of switches used for cruise control, Power TakeOff (PTO), and remote hand throttle system.

Starter Motor Control (SMC) – An ECM function that prevents starter engagement while the engine is running (above a set calibrated rpm), when the automatic transmission is in gear, or when the manual transmission clutch pedal is not depressed.

Steady state condition – An engine operating at a constant speed and load and at stabilized temperatures and pressures. (SAE J215 JAN80)

Strategy – A plan or set of operating instructions that the microprocessor follows for a desired goal. Strategy is the computer program itself, including all equations and decision making logic. Strategy is always stored in ROM and cannot be changed during calibration.

Stroke – The movement of the piston from Top Dead Center (TDC) to Bottom Dead Center (BDC).

Substrate – Material that supports the wash coating or catalytic materials.

Suspect Parameter Number (SPN) – A 19-bit number used to identify the item for which diagnostics are being reported. The SPN is used for multiple purposes, some that are specific to diagnostics are as follows;

- Identify the least repairable subsystem that has failed.
- Identify subsystems or assemblies that may not have hard failures but may be exhibiting abnormal operating performance.
- Identify a particular event or condition that will be reported.
- Report a component and non-standard failure mode.

System restriction (air) – The static pressure differential that occurs at a given airflow from air entrance through air exit in a system. Usually measured in inches (millimeters) of water. (SAE J1004 SEP81)

Tachometer output signal – Engine speed signal for remote tachometers.

Thermistor – A semiconductor device. A sensing element that changes resistance as the temperature changes.

Thermistor Sensor – Changes electrical resistance with changes in temperature. Resistance in the thermistor decreases as temperature increases, and increases as temperature decreases. Thermistors work with a resistor that limits current to form a voltage signal matched with a temperature value.

Thrust load – A thrust load pushes or reacts through a bearing in a direction parallel to the shaft.

Top Dead Center (TDC) – The uppermost position of the piston during the stroke.

Torque – A force having a twisting or turning effect. For a single force, the cross product of a vector from some reference point to the point of application of the force within the force itself. Also known as moment of force or rotation moment. Torque is a measure of the ability of an engine to do work.

Truck Computer Analysis of Performance and Economy (TCAPE) – A computer program that simulates the performance and fuel economy of trucks.

Turbocharger – A turbine driven compressor mounted on the exhaust manifold. The turbocharger increases the pressure, temperature and density of intake air to charge air.

Turbocharger 1 Turbine Outlet Pressure (TC1TOP) sensor – A variable capacitance sensor that monitors exhaust back-pressure.

Turbocharger 2 Compressor Inlet Temperature (TC2CIT) sensor – The TC2ICT sensor is thermistor-based sensor that monitors the temperature of charge air entering the HP turbocharger.

Turbocharger 2 Compressor Inlet (TC2CIS) sensor – The TC2CIS sensor includes a thermistor sensor that monitors the temperature of charge air entering the HP turbocharger. This sensor also monitors boost pressure for the LP turbocharger.

Turbocharger Outlet Temperature (TCOT) sensor – A sensor that provides a turbocharger outlet temperature signal to the ECM.

Turbocharger 2 Wastegate (TC2WG) solenoid – Controls the TC2WG actuator by regulating the amount of charge air pressure supplied to the TC2WG actuator. The TC2WG solenoid is controlled by signals from the ECM in response to engine speed, required fuel quantity, boost, exhaust back-pressure, and altitude. The TC2WG actuator is part of the turbocharger assembly.

Turbocharger Wastegate Control (TCWC) solenoid – Controls the TCWC actuator by regulating the amount of charge air pressure supplied to the TCWC actuator. The TCWC solenoid is controlled by signals from the ECM in response to engine speed, required fuel quantity, boost, exhaust back-pressure, and altitude.

Turbocharger 2 Wastegate Control (TC2WC) solenoid – Controls the TC2WC actuator by regulating the amount of charge air pressure supplied to the wastegate actuator. The TC2WC solenoid is controlled by signals from the ECM in response to engine speed, required fuel quantity, boost, exhaust back-pressure, and altitude. The TC2WC actuator is part of the turbocharger assembly.

Variable capacitance sensor – A variable capacitance sensor measures pressure. The pressure forces a ceramic material closer to a thin metal disc in the sensor, changing the capacitance of the sensor.

Vehicle Electronic System Programming System – The computer system used to program electronically controlled vehicles.

Vehicle Retarder Enable / Engage – Output from the ECM to a vehicle retarder.

Vehicle Speed Output (VSO) – A vehicle speed signal sent to the EGC through the J1939 network.

Vehicle Speed Sensor (VSS) – Normally a magnetic pickup sensor mounted in the tailshaft housing of the transmission, used to indicate ground speed.

Viscosity – The internal resistance to the flow of any fluid.

Viscous fan – A fan drive that is activated when a thermostat, sensing high air temperature, forces fluid through a special coupling. The fluid activates the fan.

Volt (v) – A unit of electromotive force that will move a current of one ampere through a resistance of one Ohm.

Voltage – Electrical potential expressed in volts.

Voltage drop – Reduction in applied voltage from the current flowing through a circuit or portion of the circuit current multiplied by resistance.

Voltage ignition – Voltage supplied by the ignition switch when the key is ON.

Washcoat – A layer of alumina applied to the substrate in a monolith-type converter.

Water In Fuel (WIF) sensor – A switch sensor that measures the amount of water in the fuel.

Wiggle Test – A test used to detect intermittent faults in harnesses and / or connectors. This test, usually used in conjunction with the ServiceMaxx™ Continuous Monitor Test, involves gently wiggling connectors and wiring without detaching connectors while monitoring signal voltage on the EST. When a voltage spike is noted (either high or low) the technician will have located a potential open, short or high resistance in the circuit.

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MaxxForce® 7 (6.4L)
All Ratings @ 2600 rpm (12NSH)

MaxxForce® 7/220, 240, 260, 300 hp @ 2600 rpm/660 (560 ft•lb for 220 hp) ft•lb @ 1400 rpm

50-State 2010 Model Year (MY)

Engine Unit Code 12NSH

MaxxForce® 7 diesel engine specifications	
Engine model	MaxxForce® 7
Engine rating	220, 240, 260, 300 hp @ 2600 rpm
Engine Family Rating Code (EFRC)	1122, 1132, 1142, 1152
Injection timing	Nonadjustable
High idle speed - manual transmission	2950 rpm
High idle speed - automatic transmission	2950 rpm
Low idle speed	700 rpm

KOEO (Key ON, Engine OFF)

Barometric pressure at 620 ft above sea level	97 kPa (14 psi)
Engine oil pressure	0 kPa (0 psi)
Diesel particulate filter differential pressure	0 kPa (0 psi)
Fuel rail pressure	0 kPa (0 psi)
Manifold boost pressure	0 kPa (0 psia)
Accelerator position sensor (at idle)	1.12 V / 0%
Accelerator position sensor (depressed to floor)	4.18 V / 100%
Exhaust gas recirculation valve position	0%
Engine throttle valve position	0%

Engine cranking

Minimum recommended battery voltage	10 V
Minimum cranking rpm	90 rpm
30 seconds maximum crank time per attempt. Wait 2 to 3 minutes before repeating.	
Minimum fuel rail pressure	14 MPa (2031 psi)
Inlet air heater amperage draw	125 A
Inlet air heater on-time and ambient temperature when initiated	0 seconds @ 16 °C (60 °F) or more 30 seconds @ -18 °C (0 °F) or less
EGRP starting	0 %
Minimum fuel pressure	34 kPa (5 psi)

Low Idle, no load, stabilized engine operating temperature

Engine coolant temperature (at thermostat opening)	92 °C (198 °F) @ thermostat opening
Engine oil temperature should not go 5 °C (10 °F) above engine coolant temperature.	
Engine fuel temperature	38 °C (100 °F) ± 4 °C (7 °F)
Minimum fuel pressure	34 kPa (5 psi)
Manifold boost pressure	97 kPa (14 psia) ± 7 kPa (1 psia)
Minimum oil pressure	69 kPa (10 psi) - engine hot

High Idle, no load, stabilized engine operating temperature

Manifold boost pressure	145 kPa (21 psia) ± 21 kPa (3 psi)
Maximum air cleaner restriction	3.1 kPa (12.5 in H_20)
Turbocharger wastegate control actuator	100%
Maximum crankcase pressure using dipstick tube attachment to digital manometer	5.98 kPa (24 in H_20)
Minimum fuel pressure	34 kPa (5 psi)
Blow-by pressure using ZTSE4146A while blocking off the breather down tube	2.24 kPa (9 in. H_20)
Minimum oil pressure	276 kPa (40 psi)

Full load, rated speed on highway, stabilized engine operating temperature

Water temperature differential across radiator (top and bottom)	6.7 - 8.3 °C (12 - 15 °F) minimum
Maximum air cleaner restriction	6.2 kPa (25 in. H_2O)
Minimum fuel rail pressure	190 mPa (27557 psi) ± 10 mPa (1450 psi)
Minimum fuel pressure	34 kPa (5 psi) ± 14 kPa (2 psia)
Maximum fuel inlet restriction	5 - 6.2 kPa (20 - 25 in. H_2O)
Minimum oil pressure	276 kPa (40 psi)
Intake manifold pressure	255 kPa (37 psia) ± 21 kPa (3 psia) at sea level 186 kPa (27 psia) ± 21 kPa (3 psia) at higher elevation
Maximum exhaust restriction (after turbocharger)	356 mm Hg (14 in. Hg) @ 2600 rpm

Stabilized engine operating temperature

Torque converter stall (rpm/time)	2200 rpm or greater @ 5 seconds or less
Maximum lube oil temperature (oil gallery)	118 °C (245 °F)
Engine oil temperature should not go 17 °C (30 °F) above engine coolant temperature.	

Miscellaneous sensors and components

Fuel pressure control valve	10.14% @ KOEO
	10.61% @ engine cranking
	15.20% @ KOER
	81.32% @ 2875 rpm
	85.34% @ acceleration
Fuel volume control valve	20.40% @ KOEO
	20.42% @ engine cranking
	19.37% @ KOER
	21.86% @ 2875 rpm
	25.92% @ acceleration
Engine fuel pump volume	400 - 450 mL @ 18-20 seconds (pump stays on additional 8-10 seconds after key off)

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Signal Values

NOTE: Key On, Engine Off (KOEO) measurements were taken at approximately 21 °C (70 °F)

Key On, Engine Running (KOER) measurements were taken at approximately 86 °C (186 °F)

ECM Chassis Pocket Connector 98-pin			
ECM Pin	**Abbreviation**	**Circuit Name**	**KOEO**
C-04	SR2-GND	Signal Return Ground 2	1.1 Ω
C-05	SR2 GND	Signal Return Ground 2	1.1 Ω
C-06	APP2	Accelerator Pedal Position 2	0.05 V - 2.09 V 0% -100%
C-07	DOCIT	DOC Inlet Temperature	0.78 V 100 °C (212 °F)
C-08	ECL	Engine Coolant Level	4.76 V
C-09	WIF	Water in Fuel	4.62 V
C-13	RVAR	Remote Variable PTO	0 V
C-25	VREF2	Voltage Reference 2	4.98 V
C-26	VREF2	Voltage Reference 2	4.98 V
C-29	DPFOT	DPF Outlet Temperature	0.76 V 69 °C (156 °F)
C-31	ATA-L	ATA Data Link Low	0.4 V
C-32	ATA-H	ATA Data Link High	4 V
C-34	XCS	Transfercase	0 V
C-35	OWL / RSL	Oil Warning Lamp / Red Stop Lamp	2.47 V
C-41	WEL / AWL	Warn Engine Lamp / Amber Warning Lamp	2.48 V
C-46	SR3-GND	Signal Return Ground 3	0.7 Ω
C-47	SR3-GND	Signal Return Ground 3	0.7 Ω
C-48	OSS-L	Output Shaft Speed Low	3.61 V @ 0 mph
C-51	DPFDP	DPF Differential Pressure	0.49 - 0.91 V 0 psi
C-53	CAN1-H	Controller Area Network 1 Communication Data Link High	2.72 V
C-54	CAN1-L	Controller Area Network 1 Communication Data Link Low	2.24 V
C-58	FCM	Fan Clutch Motor	0 V
C-60	DDS	Driveline Disconnect Switch	12.41 V
C-63	MPR	Main Power	0.88 V

ECM Chassis Pocket Connector 98-pin			
ECM Pin	**Abbreviation**	**Circuit Name**	**KOEO**
C-64	ECI	Engine Crank Inhibit	0 V
C-67	VREF3	Voltage Reference 3	4.98 V
C-68	VREF	Voltage Reference	4.98 V
C-69	OSS-H	Output Shaft Speed High	11.94 V @ 0 mph
C-72	APP1	Accelerator Pedal Position 1	1.10 V - 4.18 V 0% - 100%
C-73	DPFIT	Diesel Particulate Filter Inlet Temperature	0.83 V 82 °C (180 °F)
C-74	RPS	Remote Pedal Sensor	0 V
C-75	RAS	Resume Acceleration Switch	0 V
C-77	SCS	Speed Control Switch	0 V
C-79	RPRE	Remote Preset PTO	0 V
C-83, 84, 85	VPWR	Vehicle Power	12.41 V
C-86, 87, 88	PWR GND	Powered Ground	0.03 V
C-89	VSO	Vehicle Speed Output	11.80 V
C-91	EFC	Engine Fan Control	2.48 V
C-92	TACH	Tachometer	11.85 V
C-97	KEYPWR	Key Power	12.38 V
C-98	KAPWR	Keep Alive Power	12.37 V

NOTE: Key On, Engine Off (KOEO) measurements were taken at approximately 21 °C (70 °F)

Key On, Engine Running (KOER) measurements were taken at approximately 86 °C (186 °F)

ECM Engine Pocket Connector 98-pin

ECM Pin	Abbreviation	Circuit Name	KOEO	KOER
E-01	CKP-L	Crankshaft Position Low	1.72V	1.71 V
E-02	CKP-H	Crankshaft Position High	1.67 V	1.71 V
E-03	SHD GND	Shield Ground	0.3 Ω	77k Ω
E-06	SR1 GND	Signal Return Ground 1	0.5 Ω	0.8 V
E-07	SR1 GND	Signal Return Ground 1	2 Ω	0.8 V
E-09	IMP	Intake Manifold Pressure	0.74 V	0.8 V
E-10	FRP	Fuel Rail Pressure	0.50 V	1.26 V 5,435 psi @ 700 rpm
E-11	HS	Humidity Sensor	0 V	0.07 V
E-13	CAN1-H	Controller Area Network 1 Communication Data Link High	2.71 V	2.71 V
E-14	CAN1-L	Controller Area Network 1 Communication Data Link Low	2.24 V	2.21 V
E-16	FVCV	Fuel Volume Control Valve	12.37 V Duty Cycle 18.9%	11.96 V Duty Cycle 82%
E-18	FPCV	Fuel Pressure Control Valve	12.37 V Duty Cycle 9.3%	12.55 V Duty Cycle 86.5%
E-20	FCC	Fan Clutch Control	2.49 V	N / A
E-22	CMP-L	Camshaft Position Low	2.46 V	2.54 V
E-23	CMP-H	Camshaft Position High	2.46 V	2.21 V
E-26	VREF1	Voltage Reference 1	4.97 V	5.06 V
E-27	VREF1	Voltage Reference 1	4.97 V	5.05 V
E-30	EOP	Engine Oil Pressure	0.58 V 1.6 psi	1.95 V 25.69 psi
E-41	TC2WG	Turbocharger 2 Wastegate	0.3 V 100%	0.43 V 100%
E-44	EGRT	Exhaust Gas Recirculation Temperature	4.5 V 70 °C (158 °F)	4.19 V 85 °C (185 °F)
E-45	EOT	Engine Oil Temperature	3.28 V 33 °C (91 °F)	1.81 V 79 °C (175 °F)
E-46	EGRP	Exhaust Gas Recirculation Position	0.82 V 0%	2.54 V 90%
E-47	IMT	Intake Manifold Temperature	3.17 V 35 °C (95 °F)	2.50 V 58 °C (136 °F)

ECM Engine Pocket Connector 98-pin				
ECM Pin	**Abbreviation**	**Circuit Name**	**KOEO**	**KOER**
E-48	ECT1	Engine Coolant Temperature 1	3.28 V 33 °C (91 °F)	1.62 V 86 °C (187 °F)
E-49	ETP	Engine Throttle Position	1.13 V 0%	4.12 V 84.2%
E-52	IAHD	Inlet Air Heater Driver	-0.08 V	0.15 V
E-55	FS	Fan Speed	4.97 V	5 V
E-59	ETC-H	Engine Throttle Control High	0 V	10.61 V
E-60	ETC-L	Engine Throttle Control Low	0 V	13.62 V
E-64	IAHC	Inlet Air Heater Control	-0.06 V	0.09 V
E-67	EFT	Engine Fuel Temperature	3.25 V 60 °C (140 °F)	3.35 V 32 °C (90 °F)
E-69	AIT	Air Inlet Temperature	2.36 V 34 °C (93 °F)	2.51 V 31 °C (88 °F)
E-72	EGT	Exhaust Gas Temperature	4.63 V 72 °C (161 °F)	4.66 V 160 °C (320 °F)
E-75	MAF-GND	Mass Air Flow Ground	0 V 8.2 Ω	0.09 V
E-76	MAF	Mass Air Flow	2.68 V	2.66 V 40-45 kg / hr
E-79	FPC-L	Fuel Pump Control Low	0 V	0.45 V
E-80	FPC-H	Fuel Pump Control High	0 V	13.43 V
E-81	EGRC-L	Exhaust Gas Recirculation Control Low	12.14 V	0.13 V
E-82	EGRC-H	Exhaust Gas Recirculation Control High	11.04 V	0.56 V

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Technical Service Information (TSI) letters are periodically published to inform service technicians of product enhancements and field service issues. File TSIs in this section for supplemental reference.