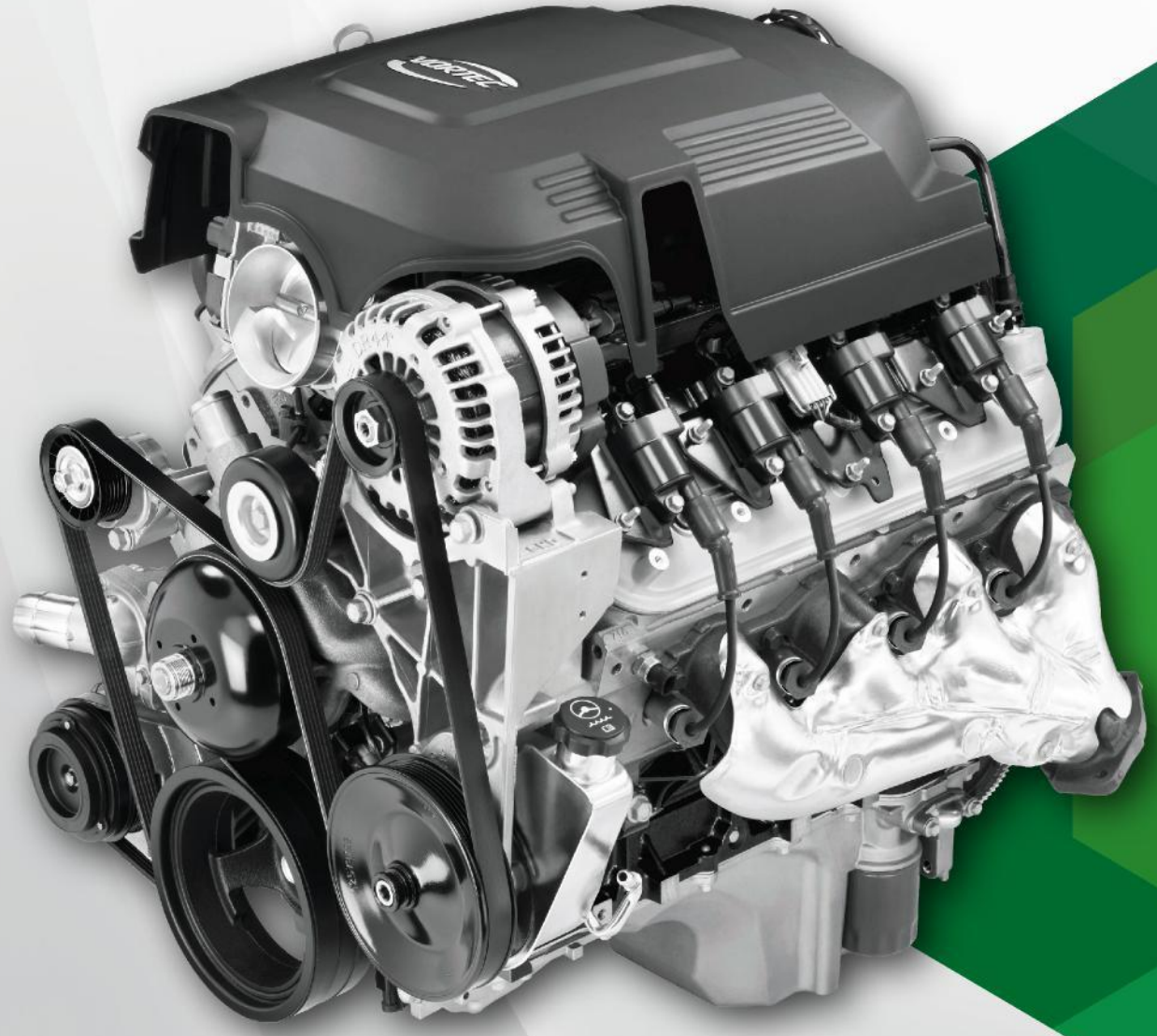
POWER SOLUTIONS INTERNATIONAL

PSI 6.0L OBD-HD ENGINE DIAGNOSTIC MANUAL



Pre-Released Document

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At date of publication, all information included in this manual is accurate to the best of our knowledge. PSI cannot be held responsible for information that has changed after publication date.

Power Solutions International (PSI)
201 Mittel Drive
Wood Dale, IL 60191
USA
(630)-350-9400

Warning Summary

- Keep all sources of ignition away from gasoline vehicles while the fuel system is being serviced. Even if the tank and fuel lines are empty, there may still be flammable vapors near the vehicle
- **DO NOT** disconnect any gasoline hoses unless they have been completely drained using the proper procedure.
- Always unplug the fuel control box or disconnect the battery before you work on any part of the fuel system
- Valve springs are under tension. Always wear eye protection when removing and installing valve springs. Failure to comply may result in injury to personnel.
- Wear proper eye protection during disassembly and assembly. Failure to comply may result in injury to personnel.
- Wear approved safety glasses or face shield when cleaning components.
  Failure to comply may result in injury to personnel.
- Wear rubber gloves and protective clothing when cleaning components. Failure to comply may result in injury to personnel.
- Wear approved safety glasses or face shield when using compressed air.
  Failure to comply may result in injury to personnel.
- Wear approved safety glasses or face shield when using a wire carbon brush to clean cylinder head ports. Failure to comply may result in injury to personnel.
- Always wear protective clothing and proper eye protection when cleaning components.
- Always wear proper eye protection when using compressed air.

Attention

All wiring schematics shown in this manual show only PSI Engine Harness wiring. For schematics regarding fuel supply system, components on the chassis side of any interface connectors (Vehicle Interface Connector, Powertrain Interface Connector, and Fuel Interface Connector) or for fuse and relay related wiring schematics and locations, refer to OEM manuals.

REVISION CONTROL INFORMATION

Revision Level	Release Date	Change Description (s)
A	04/03/2018	Initial release

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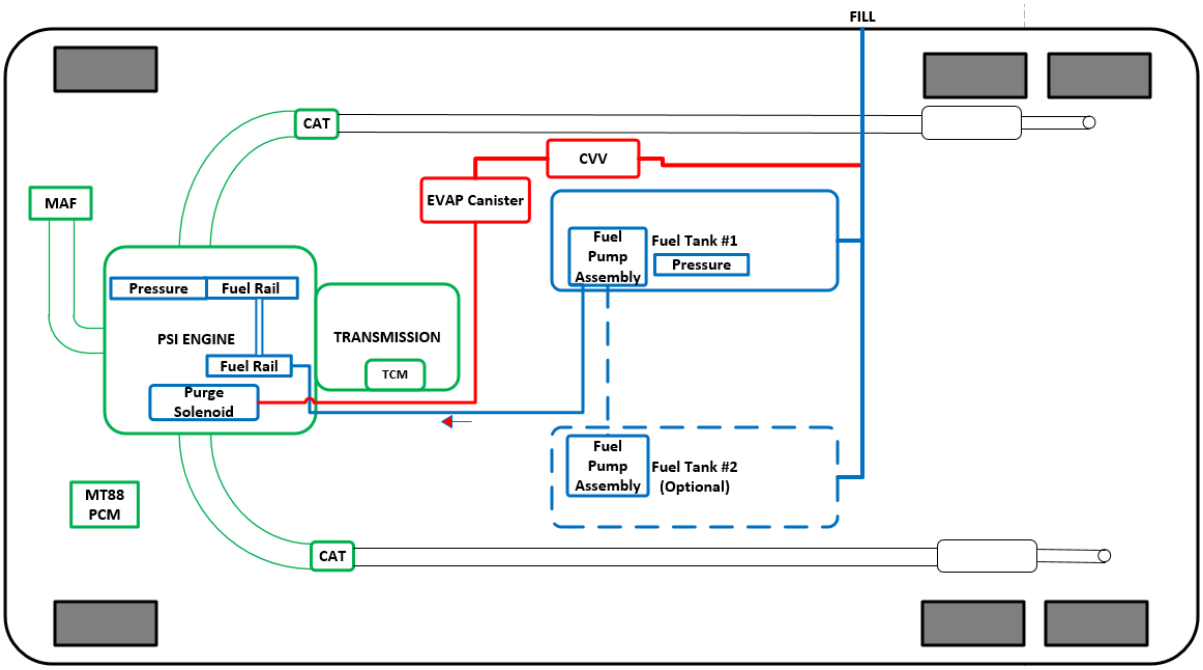
01 Theory of Operation

Gasoline Fuel System

Gasoline Delivery to Engine

The PSI 6.0L Gasoline engine is equipped with a returnless on-demand fuel system design. The fuel pressure regulator is a part of the fuel sender assembly, eliminating the need for a return pipe from the engine. A returnless fuel system reduces the internal temperature of the fuel tank by not retuning hot fuel from the engine to the fuel tank. Reducing the internal temperature of the fuel tank results in lower evaporative emissions.

An electric turbine style fuel pump attaches to the fuel sender assembly inside the fuel tank. The fuel pump supplies high pressure fuel through the fuel filter and the fuel feed pipe to the fuel injection system. The fuel pump provides fuel at a higher rate of flow than is needed by the fuel injection system. Excess fuel is returned internally inside the tank. The fuel pump also supplies fuel to a venturi pump located on the bottom of the fuel sender assembly. The function of the venturi pump is to fill the fuel sender assembly reservoir. The fuel pump and sender assembly contains a reverse flow check valve. The check valve maintains fuel pressure in the fuel feed pipe and the fuel rail in order to prevent long cranking times.



Gasoline Fuel Tank and Fuel Pump Module Assembly

The fuel tank stores the fuel supply and is installed by the chassis/vehicle manufacturer. The fuel tank location and capacity is also determined by the chassis/vehicle manufacturer.

The fuel tank fuel pump module assembly application is also specific to the chassis/vehicle manufacturer but will consist of the following major components:

- The fuel level sensor
- The fuel tank pressure (FTP) sensor
- The fuel strainer
- The fuel filter
- The pressure relief regulator valve

Fuel Level Sensor

The fuel level sensor consists of a float, a wire float arm, and a ceramic resistor cord. The position of the float arm indicates the fuel level. The fuel level sensor contains a variable resistor, which changes resistance in correspondence to the amount of fuel in the fuel tank. The engine control module (ECM) sends the fuel level information via CAN network to the instrument panel (I/P) cluster. This information is used for the I/P fuel gauge and the low fuel warning indicator.

Fuel Pump

The fuel pump is mounted in the fuel tank fuel pump module assembly reservoir. The fuel pump is an electric high pressure pump. Fuel is pumped to the fuel rail at a specified flow and pressure. The fuel pump delivers a constant flow of fuel to the engine during low fuel conditions and aggressive vehicle maneuvers. The engine control module (ECM) controls the electric fuel pump operation through a fuel pump relay. The fuel pump flex pipe acts to dampen the fuel pulses and noise generated by the fuel pump.

Pressure Relief Regulator

The fuel pressure regulator is contained in the fuel sender assembly.

Fuel Strainer

The fuel strainer attaches to the lower end of the fuel tank fuel pump module. The fuel strainer is made of woven plastic. The functions of the fuel strainer are to filter contaminants and to wick fuel. Fuel stoppage at this point indicates that the fuel tank contains an abnormal amount of sediment.

Fuel Filter

The fuel filter is contained in the fuel tank fuel pump module assembly inside the fuel tank. The paper filter element of the fuel filter traps particles in the fuel that may damage the fuel injection system. The fuel filter housing is made to withstand maximum fuel system pressure, exposure to fuel additives, and changes in temperature. There is no service interval for fuel filter replacement.

Gasoline Fuel Lines

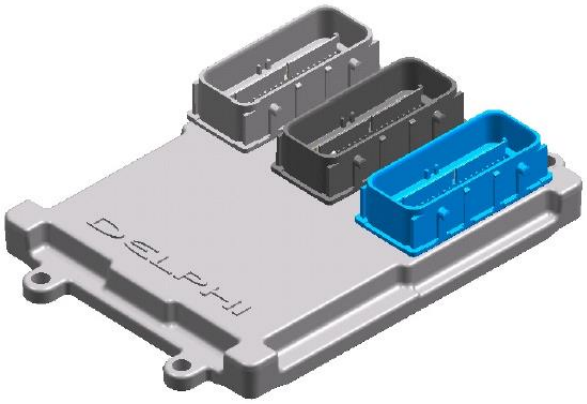
Fuel lines are constructed to withstand maximum fuel system pressure, exposure to fuel additives, and changes in temperature. Heat resistant rubber hose or corrugated plastic conduit may be used to protect the sections of the fuel lines that are exposed to chafing, to high temperatures, or to vibration. Some fuel lines are made of Nylon. Nylon fuel lines are somewhat

flexible and can be formed around gradual turns under the vehicle. However, if nylon fuel lines are forced into sharp bends, the lines may kink and restrict the fuel flow. Also, once exposed to fuel, nylon pipes may become stiffer and are more likely to kink if bent too far. Take special care when working on a vehicle with nylon fuel pipes.

On-Board Refueling Vapor Recovery System (ORVR)

The On-Board Refueling Vapor Recovery System (ORVR) is an on-board vehicle system designed to recover fuel vapors during the vehicle refueling operation. The flow of liquid fuel down the fuel filler pipe provides a liquid seal which prevents vapor from leaving the fuel filler pipe. An evaporative emission (EVAP) pipe transports the fuel vapor to the EVAP canister for use by the engine.

Engine Control Module (ECM)

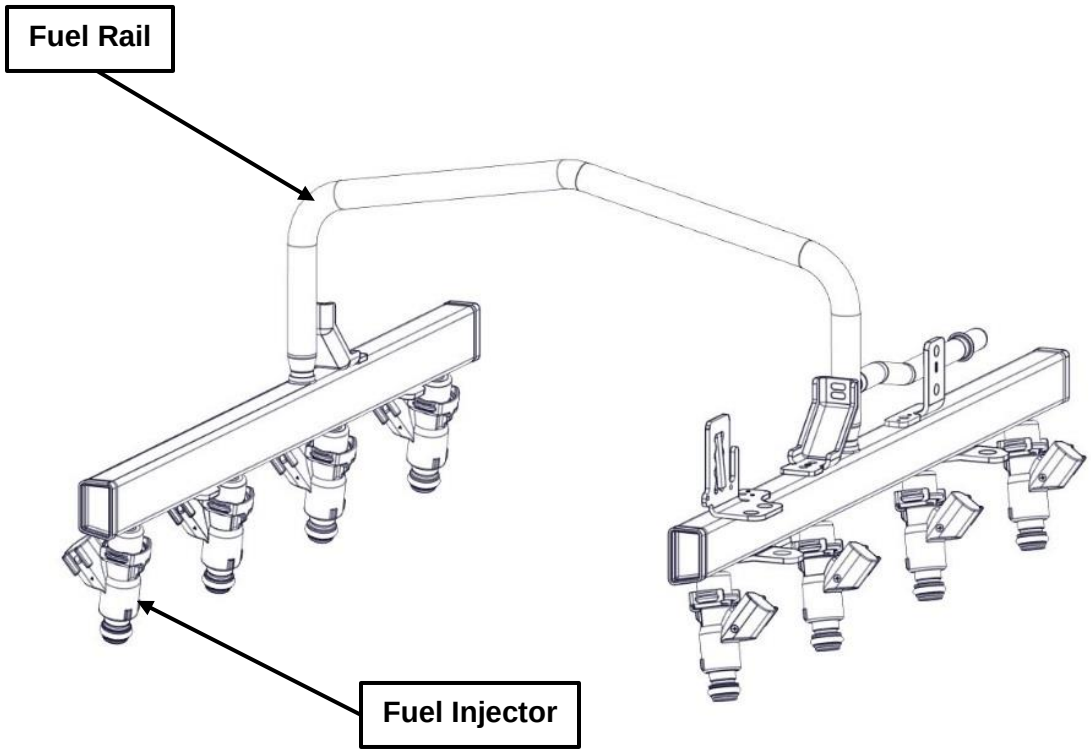


The ECM controls engine functions including spark-timing, fuel delivery, Electronic Throttle Control, inter-module communication via serial data, vehicle/platform functions, and diagnostics. The ECM operation is controlled by software and tailored by calibrations as it monitors and responds to the various inputs. **NOTE: When replacing the ECM, a Crankshaft Position System Variation Learn Procedure must be completed following installation. Failure to do so may result in inaccurate misfire detection and fault code SPN 4203 FMI 13 – Crankshaft Position System Variation Not Learned may set. The learn procedure is done using PowerLink. Refer to** SPN 4203 FMI 13 **for more detailed instructions on completing the learn procedure.**

Gasoline Fuel System Injectors and Rails

The fuel injector assembly is a solenoid device controlled by the engine control module (ECM) that meters pressurized fuel to a single engine cylinder. The ECM energizes the injector solenoid to open a normally closed pintle. This allows the fuel to flow into the top of the injector, past the valve, and through a director plate at the injector outlet. The director plate has machined holes that control the fuel flow, generating a spray of finely atomized fuel at the injector tip. Fuel from the injector tip is directed at the intake valve, causing the fuel to become further atomized and vaporized before entering the combustion chamber. This fine atomization improves fuel economy and emissions.

The fuel rail assembly attaches to the engine intake manifold. The purpose of the fuel rail assembly is to position the injectors into the cylinder head, and distribute fuel evenly to the injectors.



02 Component and Sensor Locations

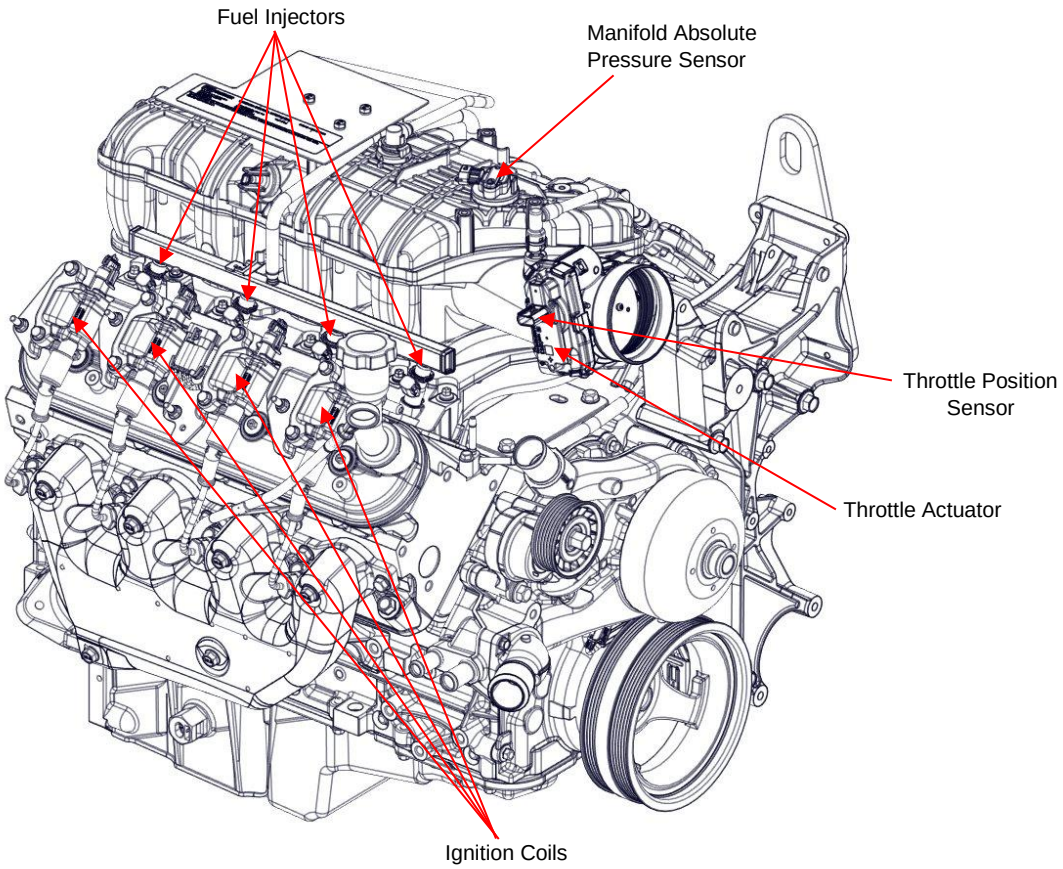
The PSI 6.0L Gasoline Engine Control Module (ECM) gather data from the following sensors:

- Accelerator Pedal Position (APP) sensor – APP1 and APP2
- Brake Switch
- Camshaft Position (CMP) sensor
- Crankshaft Position (CKP) sensor
- Engine Coolant Level (ECL) sensor
- Engine Coolant Temperature (ECT) sensor
- Engine Oil Pressure (EOP) sensor
- Engine Oil Temperature (EOT) sensor
- EVAP Pressure Sensor
- Fuel Level sensor (in tank float mechanism)
- Fuel Level sending unit (externally mounted on fuel tank)
- Fuel Supply Pressure sensor
- Fuel Supply Temperature sensor – combined with Fuel Supply Pressure sensor
- Oxygen sensor (O2 sensor) – two upstream (pre-catalyst), two downstream (post-catalyst)
- Intake Air Temperature (IAT) sensor – combined with MAF sensor unit
- Knock sensor (KS) – left and right
- Manifold Absolute Pressure (MAP) sensor
- Mass Air Flow (MAF) sensor
- Throttle Position (TP) sensor – TPS1 and TPS2

The 6.0L Gasoline Engine Control Module (ECM) control the following actuators:

- Fuel Injectors
- Ignition Coils
- Throttle Body
- Purge Solenoid
- Vent Control Valve
- Variable Camshaft Oil Control Solenoid

6.0L Gasoline Engine Front-Right View



Ignition Coils – Eight ignition coils are mounted on the engine valve covers, one coil for each cylinder.

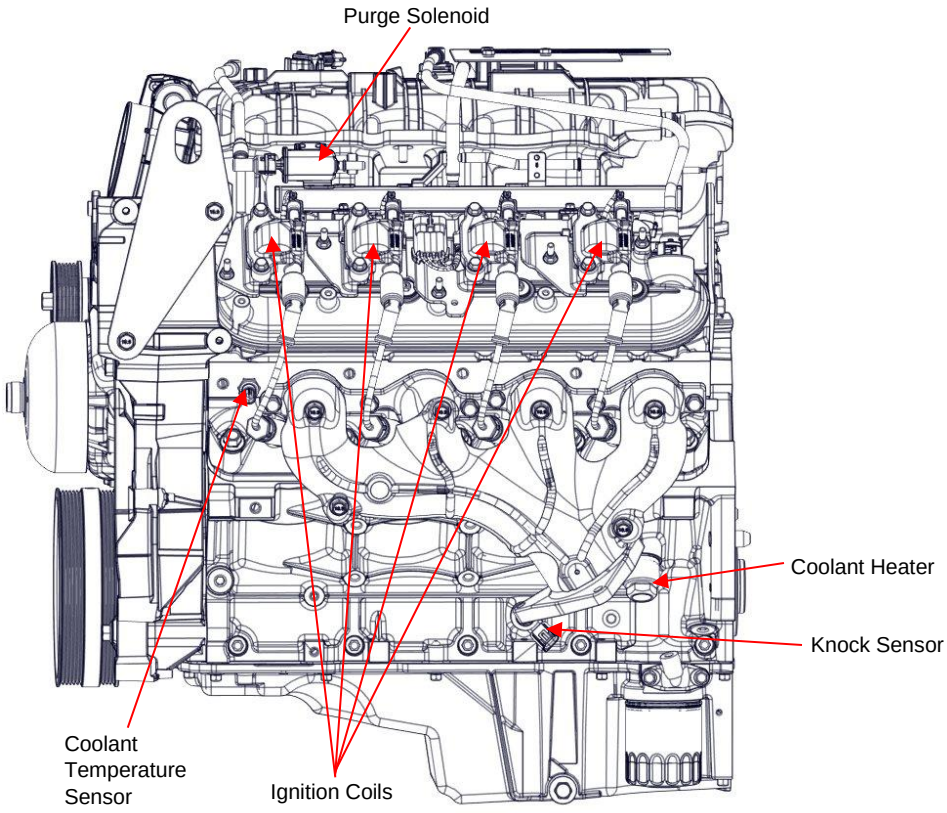
Throttle Actuator – The throttle actuator is an electric motor located within the throttle body assembly.

Throttle Position Sensor – Both TPS1 and TPS2 are located within the throttle body assembly.

Manifold Absolute Pressure Sensor – The MAP sensor is mounted on top of the intake manifold, toward the front of the engine, behind the throttle body.

Fuel Injectors – Eight Fuel injectors are mounted on the fuel rail on one end and enter the intake manifold near the cylinder head mating surface.

6.0L Gasoline Engine Left Side View



Knock Sensor – The knock sensors (left side shown) are mounted to the back of each cylinder head near the mating surface of the engine block.

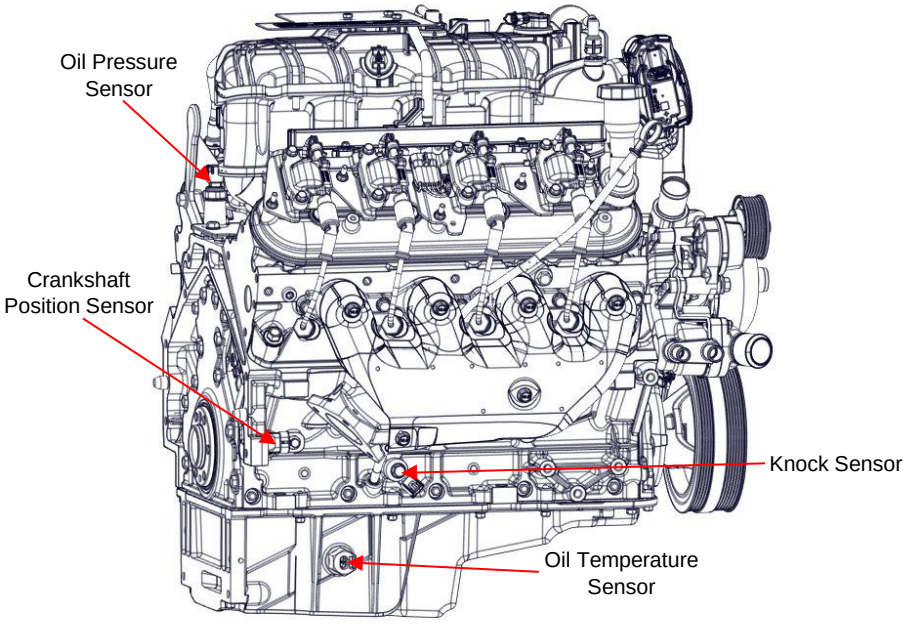
Engine Coolant Temperature Sensor – The ECT sensor is mounted on the driver's side cylinder head, in front of the front-most exhaust port.

Purge Solenoid – The purge solenoid is mounter on the front left corner of the fuel rail.

Ignition Coils – Eight ignition coils are mounted on the engine valve covers, one coil for each cylinder.

Coolant Heater – The coolant heater is mounted into the side of the block in place of a core plug.

6.0L Gasoline Engine Right View



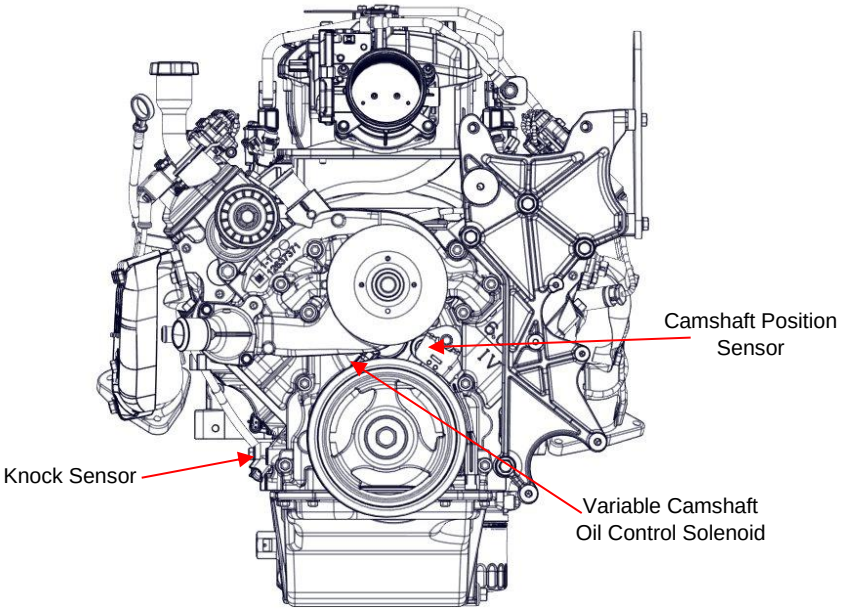
Crankshaft Position Sensor – The CKP sensor is mounted to the right side of the engine block, just in front of the starter mounting bracket.

Engine Oil Pressure – The engine oil pressure sensor is located on the back-left corner of the valley pan cover, just behind the intake manifold.

Temperature Sensor – The engine oil temperature

Knock Sensor – The knock sensors (right side shown) are mounted to the back of each cylinder head near the mating surface of the engine block.

6.0L Gasoline Engine Front View



Camshaft Position Sensor – The CMP sensor is located on the front cover of the engine between, but just to the right of, the harmonic balancer and water pump pulley.

Knock Sensor – The knock sensors (right side shown) are mounted to the back of each cylinder head near the mating surface of the engine block.

Variable Camshaft Oil Control Solenoid – The variable camshaft oil solenoid is located on the timing cover, behind the crankshaft pulley.

Components Not Shown

Accelerator Pedal Position Sensor – The APP1 and APP2 sensor assembly will be attached to the underside of the accelerator pedal.

Brake Switch – The brake switch for this vehicle is located in the pressure block for the air brakes.

Intake Air Temperature and Mass Airflow Sensors – The IAT is integrated into the MAF sensor. The MAF/IAT will be located in the air induction system between the air box and the throttle body but exact location will vary by vehicle.

Engine Coolant Level Sensor – The ECL sensor will be found in the coolant surge tank.

O2 Sensor (Oxygen Sensor) – There are a total of four O2 sensors. The sensors are described per side as Bank 1 (left) and Bank 2 (right). Two will be found before the catalysts and two will be located after the catalysts.

Gasoline Fuel Pump, Fuel Tank, Fuel Level Sensor – The gasoline fuel pump, tank, and level sensors are specific to the chassis/vehicle manufacturer. See OEM manuals for more information.

Vent Control Valve – The EVAP vent control valve is specific to the chassis/vehicle manufacturer. See OEM manuals for more information.

03 Diagnosis by Symptom

System Description

Symptoms cover conditions that are not covered by SPNs. Certain conditions may cause multiple symptoms, therefore the most prominent or urgent symptoms should be diagnosed first. This document routes a technician to the general area of concern.

How to Use Symptom Based Diagnostics

Begin symptom based diagnostics with section **1.1 Check for DTCs / Verify Customer Concern.** Each symptom based diagnostic section will refer to multiple visual inspection sections as well as System Test sections within this chapter (**03 Diagnosis By Symptom)**. In some situations, you will be referred to another chapter or diagnostic trouble code (DTC) within this manual. Perform the diagnostics as directed then return to the symptom based section and continue with diagnostics.

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1 – Operational Check / Symptom Verification

- **1.1 Check for DTCs / Verify Customer Concern**
  - 1.1 Check for DTC's / Verify Customer Concern
- **1.2 System Visual Inspections**
  - 1.2.1 Fuel Level and System Inspection
  - 1.2.2 Batteries and Electrical System Inspection
  - 1.2.3 Ignition System Inspection
  - 1.2.4 Component Connection Inspection
  - 1.2.5 Intake Air Inspection
  - 1.2.6 Exhaust System Inspection
  - 1.2.7 Oil Level and Quality Inspection
  - 1.2.8 Coolant Level and Quality Inspection
- **1.3 Intermittent Symptom Concerns**
  - 1.3 Intermittent Symptom Concerns

2 – Symptom Description and Diagnostics

- **2.1 Symptom List and Descriptions**
  - 2.1 Symptom List and Descriptions
- **2.2 Engine Does Not Start Symptoms**
  - 2.2.1 Engine Cranks Fast, Slow, or Does Not Crank
  - 2.2.2 Engine Cranks But Does Not Start
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  - 2.3.1 Engine Hard to Start (Long Cranking Time) or Starts Then Stalls

- **2.4 Engine Performance Problems Symptoms**
  - 2.4.1 Misfire / Rough Idle / Runs Rough
  - 2.4.2 Detonation or Spark Knock
  - 2.4.3 Engine Backfire
  - 2.4.4 Low Power (Slow Acceleration)
  - 2.4.5 Engine Surge (Inconsistent Engine RPM During Steady State)
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  - 2.4.7 Excessive Smoke From Exhaust
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- **2.5 Engine Coolant Symptoms**
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- **2.7 Engine Fuel System Symptoms**
  - 2.7.1 Gasoline Fumes In Cab or Around Vehicle (Outside of fuel fill process)
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- **3.1 Base Engine Diagnostics**
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- **3.7 Engine Intake and Exhaust Leaks**
- **3.8 Throttle Plate Operational Test and Cleaning**
- **3.9 Fuel Supply System Diagnostics**
- **3.10 Fuel Injector Diagnostics**
- **3.11 Fuel Level Monitoring System Diagnostics**
- **3.12 Testing for Contaminated Fuel**
- **3.13 Inspecting for Fuel Leaks**
- **3.14 Electronic Ignition System Diagnostics**
- **3.15 Oxygen Sensor (O2S) Operational Test**
- **3.16 Knock Sensor Operational Test**
- **3.17 MAP Sensor Operational Test**
- **3.18 MAF Sensor Operational Test**

1 - Operational Check / Symptom Verification

1.1 Check DTCs / Verify Customer Concern

Step	Action	Decision
1	Connect to the Vehicle using Interface Cable and PowerLink. With the Key ON, Verify there are no SPNs present. Are there any SPNs present?	Yes: Refer to proper SPN/FMI diagnostic. No: Go To Step 2.

Step	Action	Decision
2	Verify the customers concern. It may be necessary to operate the vehicle under the conditions described by the customer. Can customer concern be duplicated?	Yes: Go To Step 3. No: See section **1.3 Intermittent Concern**. If the condition cannot be duplicated, end diagnostics.

Step	Action
3	Review customer concern and based on engine operation during duplication, identify the specific symptom from section **2.1 Symptom List and Descriptions**. Once the symptom has been identified, refer to the diagnostic section for the symptom and perform the step based diagnostic routine.

1.2 System Visual Inspections

1.2.1 Fuel Level and System Inspection

Tools Required

- None

Equipment Condition

- None

Inspection Procedure (Gasoline)

1. Visually inspect the fuel rail and injector assemblies are intact and tight

NOTE: For further fuel level and system inspection procedures, reference OEM manual.

1.2.2 Batteries and Electrical System Inspection

Tools Required

- Digital Multi-Meter (DMM)
- Flash light (optional)
- Battery charger

Equipment Condition

- None

Inspection Procedure

1. Inspect electrical system for damaged electrical components or wiring, and loose connections (including engine grounds and starter connections). Repair damaged or loose components or connections.

NOTE: For further Battery and Electrical system inspection procedures, reference OEM manual.

1.2.3 Ignition System Inspection

Tools Required

- None

Equipment Condition

- All conditions

Inspection Procedure

Inspect both banks for the following:

1. All coils and spark plug wires are present and undamaged
    - Damaged: Replace coil and spark plug wire and retest
    - Not Damaged: Go To Step 2
2. All ignition coils are fully plugged in to the harness and secured to the valve cover
    - Issue Found: Fully seat harness or secure coil and retest
    - No Issues: Go To Step 3
3. Ignition coil harnesses are not melted or damaged
    - Harness damaged: Repair harness and see: SPN 1268, 1275, 1274, 1269, 1273, 1272, 1271, 1270 for further diagnostics.
    - Not damaged: Go To Step 4
4. All spark plug wires are fully seated on the coil and plugs
    - Spark Plug Wire Loose: Inspect the end for damage replace if necessary. Secure spark plug wire and retest
    - All Wires Are Secure: Go To Step 5
5. With the engine running, check all coils and wires for external arching
    - Aching Found: Replace spark plug wire and/or coil then retest
    - No arching found: End visual inspection

1.2.4 Component Connection Inspection

Tools Required

- None

Equipment Condition

- None

Inspection Procedure

1. Inspect engine harness for damage, rub through, or melting
2. Inspect all sensor and actuator connectors, ensure they are securely plugged in and locked (Refer to Chapter **02 Sensor and Actuator Locations**)

1.2.5 Intake Air Inspection

Tools Required

- None

Equipment Condition

- None

Inspection Procedure

1. Inspect for a dirty, damaged, or incorrectly installed air filter.
    - If air filter is clean, undamaged, and correctly installed, go to next step.
    - If air filter is dirty or damaged, replace air filter, go to next step.
2. Inspect for air flow restrictions in air intake tubing, tubing connections, and filter housing.
    - If air flow is restricted repair air flow restrictions, go to next step.
    - If no air flow restriction is found, no action is required, go to next step.
3. Inspect for loose or damaged intake hoses and pipes.
    - If loose or damaged air hoses and pipes are found, repair Intake.
    - If no loose or damaged air hoses and pipes are found, no action is required.
4. Inspect loose or damaged PCV hose
    - If loose or damaged PCV hose is found, repair.
    - If no loose or damaged PCV hose is found, no action is required.

1.2.6 Exhaust System Inspection

Tools Required

- None

Equipment Condition

- None

Inspection Procedure

1. Inspect all O2S (two on each bank pre/post-catalyst) make sure they are installed, tight, and plugged it without damage.
    - If loose or damaged, repair O2S.
    - If no loose or damaged O2S is found, no action required.
2. Inspect both bank catalysts ensure they are present and undamaged.
3. Visually inspect nuts and bolts on exhaust manifold flanges are present and secure

1.2.7 Oil Level and Quality Inspection

NOTE: Please see the Operators Manual for oil level testing procedures, warnings, cautions, oil quantities, oil weight, and recommended oil brand.

Tools Required

- None

Equipment Condition

- Park vehicle on level ground
- Engine warm, check oil within 10 minutes after shutdown (See Operators Manual for Testing Procedure)

Inspection Procedure

1. Park Vehicle on level ground
2. Shutdown engine and check oil level within 10 minutes
3. Remove dipstick from dipstick tube

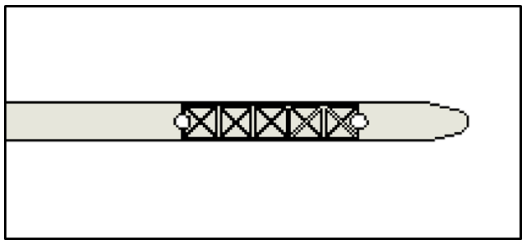


Figure 1 - Oil Level Gauge (typical)

4. Use oil level gauge (dipstick) to check the engine oil level

    - If engine oil level is below specification, inspect engine for leaks, oil consumption, or improper servicing. Repair cause of low engine oil prior to filling to proper level.
    - If engine oil level is above specification (See note above), inspect for coolant contamination, or improper servicing. If engine oil level is above specification, drain to proper level and diagnose cause of contamination, or improper servicing.
    - If engine oil is in specification but appears dirty or old, determine latest service interval. Advise customer or repair as necessary.

1.2.8 Engine Coolant Level and Quality Inspection

Note: Please see the Operators Manual for coolant level testing procedures, warnings, cautions, coolant quantities, coolant mixture, and recommended coolant brand.

Tools Required

- Coolant and Battery Refractometer ZTSE4796

Equipment Condition

- Park vehicle on level ground
- Allow engine to cool for 15 minutes or more.

Inspection Procedure

1. Inspect coolant level in surge tank
    - Coolant level should be between COLD MAX and COLD MIN
2. Wrap a thick cloth around surge tank cap.
3. Loosen cap slowly a quarter to half turn to vent pressure.
4. After pressure has been released, remove cap.
5. Check coolant for signs of contamination.
6. Take a sample from the surge tank.
7. Examine sample for engine oil
    - Oil contamination may result in a dark sludge.
8. If coolant is not contaminated, check freeze point.
9. Visually inspect radiator fins on outside of radiator for debris or damage.

1.3 Intermittent Symptom Concern

Overview

An intermittent concern is present when a symptom comes and goes with or without consistency. This section will briefly cover steps that can be taken when an intermittent concern is present.

WARNING! To prevent bodily injury or death, stay away from hot engine surfaces and rotating engine components.

- Inspect the wiring harness for proper routing, chaffing, or binding on other vehicle components. Repair as necessary.
- With the engine at idle, wiggle/shake the electrical harness while observing the idle quality, if the engine begins to run rough or stalls, inspect for chaffing, poor connections in the area.
- Temperature may affect intermittent concerns, it may be necessary to operate the vehicle under the conditions of the customer's concern.

Step	Action	Decision
1	Refer to Service write-up or customer interview to determine symptom type. Is a customer write up available with a detailed explanation of the concern and how/when it occurs?	Yes: Go To Step 2 No: Interview driver for incomplete information. Go To Step 2

Step	Action	Decision
2	Review overview and possible causes for the symptom type section (**Section 2.2 – 2.7**) but do not perform step based diagnostics. Was the section reviewed and possible causes noted?	Yes: Go To Step 3 No: See section **2.1 Symptom List and Descriptions.** Find the closest related concern and review possible causes (**Section 2.2 - 2.7**) then Go To Step 3

Step	Action	Decision
3	A. Check main engine to chassis grounds. Clean, repair, tighten if needed. B. Connect Electronic Service Tool (EST) with PowerLink software. C. Operate engine during symptom operational conditions. D. Attempt to recreate engine running problem. • If test is stationary, wiggle sensor connectors and engine wiring harness and watch available sensor readings in PowerLink. • If a sensor reading is unavailable use a breakout harness and DMM on desired sensors or circuits and monitor sensor voltage. Was concern duplicated when harness was wiggled or conditions replicated?	Yes: Go To Step 4 No: Re-evaluate concern with the customer. End diagnostics.

Step	Action
4	If the symptom or concern can be replicated by wiggling a sensor circuit see related SPN/DTC list and diagnose the sensor circuit while trying to reproduce the intermittent concern. If the symptom can be duplicated by wiggling bulk sections of the engine harness, replace the harness and then retest for concern. If concern is replicated by specific engine operational practices then see section **2.1 Symptom List and Descriptions.** Once the symptom has been identified refer to the diagnostic section for the symptom and perform the step based diagnostic routine.

2 – Symptom Descriptions and Diagnostics

2.1 Symptom List and Descriptions

1. **Engine Does Not Start Symptoms –** Refer to this diagnostic section if the engine under goes excessive cranking attempts where either the engine cranks very fast and does not start, cranks normal but does not start, cranks slowly and does not start, or does not crank at all.
    - 2.2.1 Engine Cranks Fast, Slow, or Does Not Crank
    - 2.2.2 Engine Cranks But Does Not Start

2. **Engine Hard to Start Symptoms –** Refer to this diagnostic section if the engine under goes excessive cranking but will eventually start or starts and then stalls shortly after.
    - 2.3.1 Engine Hard to Start (Long Cranking Time) or Starts Then Stalls

3. **Engine Performance Problems Symptoms –** Refer to this diagnostic section if the engine starts and runs but exhibits some form of performance issue or drivability concerns.
    - 2.4.1 Misfire / Rough Idle / Runs Rough
    - 2.4.2 Detonation or Spark Knock
    - 2.4.3 Engine Backfire
    - 2.4.4 Low Power (Slow Acceleration)
    - 2.4.5 Engine Surge (Inconsistent Engine RPM During Steady State)
    - 2.4.6 Poor Fuel Economy
    - 2.4.7 Excessive Smoke From Exhaust
    - 2.4.8 Engine Does Not Shut Down At Key OFF (Run-on)

4. **Engine Coolant Symptoms –** Refer to this diagnostic section if the engine is pushing coolant out of the surge tank, overheating, has coolant in the oil, or is consuming coolant.
    - 2.5.1 Coolant Over Flow
    - 2.5.2 Coolant Over Temperature
    - 2.5.3 Coolant Leak to Engine Oil
    - 2.5.4 Engine Coolant Consumption

5. **Engine Lubrication Symptoms –** Refer to this diagnostic section if the engine oil repeatedly shows it is over full, the engine is losing oil, or is exhibiting consistently low oil pressures.
    - 2.6.1 Engine Oil Over Full
    - 2.6.2 Engine Oil Consumption
    - 2.6.3 Low Engine Oil Pressure

6. **Engine Fuel System Symptoms –** Refer to this diagnostic section if fuel is suspected to be leaking, leaks during filling process, fuel level is inaccurate, or fuel tank will not fill.
    - 2.7.1 Gasoline Fumes In Cab or Around Bus (Outside of fuel fill process)
    - 2.7.2 Gasoline Leaking During Fuel Fill
    - 2.7.3 Inaccurate Fuel Level Readings
    - 2.7.4 Fuel Tank Does Not Fill or Takes Excessive Time

2.2 Engine Does Not Start Symptoms

Section Overview
Determine reason the engine will not crank, crank properly, or cranks properly but will not start.

2.2.1 Engine Cranks Fast, Slow, or Does Not Crank

Possible Causes

- Failed batteries or low charge
- Corroded or loose battery cables
- Master battery switch turned Off, or Open / high resistance in battery cable circuit
- Starting system faults
    - TCM Neutral Relay fault
    - Start Relay fault
    - Switched Crank Relay fault
    - Blown Starter Fuse
- Crank inhibit fault
- Charging system faults
- Crank sensor error
- Base engine concerns
- Starter or flywheel gear binding or not engaging properly

Test Procedure - Engine Cranks Fast, Slow, or Does Not Crank

Step	Action	Decision
1	Perform the following Visual Inspection Sections: **1.2.1 Fuel Level and System Inspection** **1.2.2 Batteries and Electrical System Inspection** **1.2.3 Ignition System Inspection** **1.2.4 Component Connection Inspection** **1.2.5 Intake Air Inspection** **1.2.6 Exhaust System Inspection** **1.2.7 Oil Level and Quality Inspection** Were any issues found?	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	Turn ignition key to the RUN position and observe instrument panel lights. Do instrument panel lights come ON?	Yes: Go To Step 3 No: Turn master battery switch ON, or repair battery cable circuit. After repairs are complete retest for original problem.

Step	Action	Decision
3	Crank the engine while observing engine rpm. Does engine crank between 150 - 250rpm? Note: If engine cranks but displays no RPMs or RPMs glitch, perform SPN 636 diagnostics and retest.	Yes: Go to Section **2.2.2 Engine Cranks But Does Not Start**
		No, Higher: Go To Step 4
		No, Lower or Does Not Crank: Go To Step 5

Step	Action	Decision
4	Perform section **3.1 Base Engine Diagnostics** Were any issues found?	Yes: Repair engine and retest.
		No: Go to Section **2.2.2 Engine Cranks But Does Not Start**

Step	Action	Decision
5	Using Midtronics – inTELLECT EXP HD – Battery and Electrical System tester (EXP1000HD), test fully charged batteries. Follow directions in tester instruction manual. Do batteries pass test?	Yes: Go To Step 6
		No: Slow charge or replace each battery that fails test. After repairs are complete, retest for original problem.

Step	Action	Decision
6	Using Midtronics – inTELLECT EXP HD – Battery and Electrical System tester (EXP1000HD), test starting system. Follow directions in tester instruction manual. Does starting system pass test? Note: For zero current draw condition check/test Start Relay, Switched Crank Relay, TCM Neutral Switch Relay, and Starter Fuse. Inspect Vehicle Interface Connectors (VIC) for damaged wiring or pushed back terminals.	Yes: End Diagnostic Steps
		No, low current draw: Perform voltage drop test on main positive and negative battery cables. If voltage drop is 0.5 volts or more, clean or replace cable. After repairs are complete, retest for original problem.
		No, zero current draw: Check for crank inhibit faults, starter solenoid or circuit faults, failed starter, and ignition switch. After repairs are complete, retest for original problem.
		No, high current draw: Go To Step 7

Step	Action	Decision
7	Rotate engine over by hand two full rotations. Does engine rotate without locking up?	Yes: Test for faulty starter or starter circuit, repair and retest.
		No: Go To Step 8

Step	Action	Decision
8	Remove all 8 spark plugs inspect plugs for damage. Rotate engine by hand or crank engine.	Yes: Engine hydrolocked. Check cylinders for fluid evacuation. See appropriate fluid consumption diagnostics repair and retest.
	Does engine crank or rotate freely?	No: Diagnose and repair base engine. Refer to Engine Service manual for inspection procedures.

2.2.2 Engine Cranks but Does Not Start

Possible Causes

- Cranking engine before purge cycle is complete (Wait to Start Lamp ON)
  - Excessive vapor in the fuel lines
- Low/No Fuel (Incorrect fuel readings)
- Low Fuel Supply Pressure (Boosted)
- Ignition system concerns
  - Spark Plug(s)
  - Spark Plug Wire(s)
  - Ignition Coil(s)
- Crankshaft or Camshaft sensor error
- Injector(s)
- Vacuum leaks
- MAP sensor concerns
- Plugged exhaust
- Fuel line concerns
- Base engine concerns

Test Procedure - Engine Cranks but Does Not Start

Step	Action	Decision
1	Perform the following Visual Inspection Sections: **1.2.1 Fuel Level and System Inspection** **1.2.2 Batteries and Electrical System Inspection** **1.2.3 Ignition System Inspection** **1.2.4 Component Connection Inspection** **1.2.5 Intake Air Inspection** **1.2.6 Exhaust System Inspection** **1.2.7 Oil Level and Quality Inspection** Were any issues found?	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	Perform three cranking/starting sessions following the procedure below. While cranking monitor engine RPM in PowerLink. • Key ON • Observe “Wait to Start Lamp” turn OFF • Crank Engine for 10 seconds – If engine starts idle for 10 seconds • Key OFF for 10 seconds Is engine speed between 150 and 250 RPM while cranking? Note: If engine cranks but displays no RPMs or RPMs glitch, perform SPN 636 diagnostics and retest.	Yes: Go To Step 3 No: Perform **2.2.1 Engine Cranks Fast, Slow, or Does Not Crank**

Step	Action	Decision
3	Using PowerLink, check for codes. Are there active or pending codes in PowerLink?	Yes: Perform corresponding SPN FMI diagnostics. No: Go To Step 4

Step	Action	Decision
4	Key OFF, fully install Relay Breakout harness 69000090 on Powertrain Relay. Measure voltage between (terminal 30) and engine/chassis ground. Key OFF, is voltage less than 0.1V? With Key ON, is voltage B+ ± 0.5V?	Yes: Go To Step 5 No: See SPN 1485 to diagnose relay.

Step	Action	Decision
5	Perform section **3.9 Fuel Supply System Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 6

Step	Action	Decision
6	Perform section **3.10 Fuel Injector Diagnostics** Were any issues found? **Note:** Some tests are performed engine running. Perform tests while the engine is cranking.	Yes: Repair and retest. No: Go To Step 7

Step	Action	Decision
7	Perform section **3.14 Electronic Ignition System Diagnostics** Were any issues found? **Note:** Some tests are performed engine running. Perform tests while the engine is cranking.	Yes: Repair and retest. No: Go To Step 8

Step	Action	Decision
8	Perform section **3.17 MAP Sensor Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 9

Step	Action	Decision
9	Perform section **3.1 Base Engine Diagnostics** Were any issues found?	Yes: Repair and retest. No: Reassemble and retest.

2.3 Engine Hard to Start Symptoms

Section Overview
Determine reason the engine requires excessive cranking to start or starts and then stalls shortly thereafter.

2.3.1 Engine Hard to Start (Long Cranking Time) or Starts Then Stalls

Possible Causes

- Cranking engine before purge cycle is complete (Wait to Start Lamp ON)
  - Excessive vapor in the fuel lines
- Low/No Fuel (Incorrect fuel readings)
- Low Fuel Supply Pressure (Boosted)
- Ignition system concerns
  - Spark Plug(s)
  - Spark Plug Wire(s)
  - Ignition Coil(s)
- Injector(s)
- Vacuum leaks
- MAP sensor concerns
- Plugged exhaust
- Fuel line concerns
- Base engine concerns

Test Procedure - Engine Hard to Start (Long Cranking Time) or Starts Then Stalls

Step	Action	Decision
1	Perform the following Visual Inspection Sections: **1.2.1 Fuel Level and System Inspection** **1.2.2 Batteries and Electrical System Inspection** **1.2.3 Ignition System Inspection** **1.2.4 Component Connection Inspection** **1.2.5 Intake Air Inspection** **1.2.6 Exhaust System Inspection** **1.2.7 Oil Level and Quality Inspection** Were any issues found?	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	Key ON, allow system to complete purge cycle. Once “Wait To Start” turns OFF, crank engine. Does engine start normally?	Yes: Review customer concern and condition of complaint. Replicate concern conditions. If no issues found End Diagnostics. No: Go To Step 3

Step	Action	Decision
3	Perform three cranking/starting sessions following the procedure below. While cranking monitor engine RPM in PowerLink. • Key ON • Observe “Wait to Start Lamp” turn OFF • Crank Engine for 10 seconds – If engine starts idle for 10 seconds • Key OFF for 10 seconds Is engine speed between 150 and 250 RPM while cranking? Note: If engine cranks but displays no RPMs or RPMs glitch, perform SPN 636 diagnostics and retest.	Yes: Go To Step 4 No: Perform **2.2.1 Engine Cranks Fast, Slow, or Does Not Crank**

Step	Action	Decision
4	Using PowerLink, check for codes. Are there active or pending codes in PowerLink?	Yes: Perform corresponding SPN FMI diagnostics. No: Go To Step 5

Step	Action	Decision
5	Perform section **3.9 Fuel Supply System Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 6

Step	Action	Decision
6	Perform section **3.14 Electronic Ignition System Diagnostics** Were any issues found? **Note:** Some tests are performed engine running. Perform tests while the engine is cranking if required.	Yes: Repair and retest. No: Go To Step 7

Step	Action	Decision
7	Perform section **3.10 Fuel Injector Diagnostics** Were any issues found? **Note:** Some tests are performed engine running. Perform tests while the engine is cranking if required.	Yes: Repair and retest. No: Go To Step 8

Step	Action	Decision
8	Perform section **3.7 Engine Intake and Exhaust Leaks** Were any issues found?	Yes: Repair and retest. No: Go To Step 9

Step	Action	Decision
9	Perform section **3.17 MAP Sensor Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 10

Step	Action	Decision
10	Perform section **3.4 Evaluating Fuel Trims** Were any issues found?	Yes: Repair and retest. No: Go To Step 11

Step	Action	Decision
11	Perform section **3.1 Base Engine Diagnostics** Were any issues found?	Yes: Repair and retest. No: Reassemble and retest.

2.4 Engine Performance Symptoms

Section Overview
This section will help a technician identify performance symptoms as well as guide them to take proper steps to repair the symptom. Diagnosis of the symptom cannot begin until there is a clear understanding of when the symptom exists and how long the symptom lasts. Reviewing previous repairs and maintenance records can be helpful before starting diagnosis.

2.4.1 Misfire / Rough Idle / Runs Rough

Overview
The Engine will start and run, but runs rough or has abnormal vibrations. It is important to pay close attention to how long the condition takes place and the severity of the condition. A cylinder that is not firing at all will have a very consistent misfire that will be more noticeable under load. A rough idle can be felt with the vehicle in gear or in neutral, but when the accelerator pedal is depressed the condition will improve or go away. A general rough running engine can vary from as harsh as a misfire, to a less noticeable feel only under certain conditions.

Possible Causes

- Starting the engine before purge cycle was complete
- Ignition System Concerns
    - Ignition Coil
    - Spark Plug Wire
    - Spark Plug
- Fuel Supply Restrictions
- Fuel Supply Pressure
- Injector Concerns
- Intake Vacuum Leaks
- Intake Restrictions
- MAP Sensor Concerns
- MAF Sensor Concerns
- O2S Concerns
- Excessive Engine Downtime (60+ Days)
- Contaminated Fuel
- Base Engine Concerns

Test Procedure - Misfire / Rough Idle / Runs Rough

Step	Action	Decision
1	Has the vehicle been sitting for 60 days, or longer, without the engine running?	Yes: Road test vehicle for up to 15 minutes and retest. If engine continues to run rough Go To Step 2.
		No: Go To Step 2

Step	Action	Decision
2	Perform the following Visual Inspection Sections: **1.2.1 Fuel Level and System Inspection** **1.2.2 Batteries and Electrical System Inspection** **1.2.3 Ignition System Inspection** **1.2.4 Component Connection Inspection** **1.2.5 Intake Air Inspection** **1.2.6 Exhaust System Inspection** **1.2.7 Oil Level and Quality Inspection** Were any issues found?	Yes: Repair and retest. No: Go To Step 3

Step	Action	Decision
3	Key ON, allow system to complete purge cycle. Once “Wait To Start” turns OFF, crank engine and idle for 2 minutes. Does engine start and run normally?	Yes: Review customer concern and condition of complaint. Replicate concern conditions. If no issues found End Diagnostics. No: Go To Step 4

Step	Action	Decision
4	Perform section **3.7 Engine Intake and Exhaust Leaks** Were any issues found?	Yes: Repair and retest. No: Go To Step 5

Step	Action	Decision
5	Perform section **3.17 MAP Sensor Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 6

Step	Action	Decision
6	Perform section **3.15 Oxygen Sensor (O2S) Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 7

Step	Action	Decision
7	Perform section **3.9 Fuel Supply System Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 8

Step	Action	Decision
8	Perform section **3.4 Evaluating Fuel Trims** Were any issues found?	Yes: Go To Step 9. Perform remaining tests only on bank found to have a Rich or Lean condition. No: Go To Step 9. Perform Tests on ALL cylinders.

Step	Action	Decision
9	Perform section **3.2 Cylinder Power Balance Test** Was one or more cylinders found to have a misfire?	Yes: Go To Step 10. Perform remaining tests on cylinder(s) found to have a misfire. No: Go To Step 10. Perform Tests on ALL cylinders.

Step	Action	Decision
10	Perform section **3.10 Fuel Injector Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 11

Step	Action	Decision
11	Perform section **3.14 Electronic Ignition System Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 12

Step	Action	Decision
12	Perform section **3.1 Base Engine Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 13

Step	Action	Decision
13	Perform section **3.12 Testing for Contaminated Fuel** Were any issues found?	Yes: Repair and retest. No: Reassemble and reevaluate.

2.4.2 Detonation or Spark Knock

Overview
The air/fuel mixture within an engine combustion chamber should only be ignited by the spark plug. However, sometimes conditions within the combustion chamber cause the air/fuel mixture to be ignited by other means. When this occurs, flame fronts in the cylinder collide producing detonation, or spark knock. Long term detonation can result in mechanical damage to the engine. The ECM primarily uses Knock Sensor information to determine ignition timing. An engine experiencing detonation cannot operate with optimized ignition advance and the ECM will start to use less ignition advance (thus less engine power) in order to reduce detonation.

Possible Causes

- Contaminated or Incorrect fuel
- Ignition System malfunction
- Fuel system malfunction
- Carbon build-up in combustion chamber

Test Procedure - Detonation or Spark Knock

Step	Action	Decision
1	Perform the following Visual Inspection Sections: **1.2.1 Fuel Level and System Inspection** **1.2.2 Batteries and Electrical System Inspection** **1.2.3 Ignition System Inspection** **1.2.4 Component Connection Inspection** **1.2.5 Intake Air Inspection** **1.2.6 Exhaust System Inspection** **1.2.7 Oil Level and Quality Inspection** **1.2.8 Coolant Level and Quality Inspection** Were any issues found?	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	With engine COLD. Key ON, compare Intake Air Temperature (IAT), Engine Coolant Temperature (ECT), and Engine Oil Temperature (EOT). Are IAT, ECT, and EOT within 10F degrees of each other?	Yes: Go To Step 3 No: Perform section SPN 110 ECT, SPN 172 IAT, and SPN 175 EOT for mismatched sensor(s).

Step	Action	Decision
3	Start engine and run off idle until reaching operating temperature. Monitor coolant temperature. Did engine coolant temperature rise above 220F at any time?	Yes: Perform section **2.5.2 Coolant Over Temperature** No: Got To Step 4

Step	Action	Decision
4	Perform section **3.14 Electronic Ignition System Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 5

Step	Action	Decision
5	Remove and inspect spark plugs for excessive carbon build up. Using a bore scope inspect combustion chambers on all 8 cylinders. Was excessive carbon buildup found in any cylinder?	Yes: Perform **2.6.2 Engine Oil Consumption** No: Go To Step 6

Step	Action	Decision
6	Perform section **3.16 Knock Sensor Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 7

Step	Action	Decision
7	Perform **3.12 Testing for Contaminated Fuel** Were any issues found?	Yes: Repair and retest. No: Go To Step 5

2.4.3 Engine Backfire

Overview
Engine backfires can occur in the intake or the exhaust of the engine. It is important to identify where the backfire is occurring before diagnosing the symptom. An intake backfire will typically be caused by an ignition event occurring at the incorrect time or a lean running condition. An ignition event occurring at the incorrect time could be due to a mechanical issue causing the air fuel mixture to pre-ignite or detonate. A backfire in the exhaust system will typically be caused by the engine running excessively rich.

Possible Causes

- Ignition System Concerns
  - Ignition Coil
  - Spark Plug Wire
  - Spark Plug
- Fuel Supply Restrictions
- Fuel Supply Pressure
- Injector Concerns
- Excessive Engine Downtime (60+ Days)
- Intake Vacuum Leaks
- Intake Restrictions
- Base Engine Concerns
- MAP Sensor Concerns
- MAF Sensor Concerns
- O2S Concerns
- Contaminated Fuel

Test Procedure - Engine Backfire

Step	Action	Decision
1	Perform the following Visual Inspection Sections **1.2.1 Fuel Level and System Inspection** **1.2.2 Batteries and Electrical System Inspection** **1.2.3 Ignition System Inspection** **1.2.4 Component Connection Inspection** **1.2.5 Intake Air Inspection** **1.2.6 Exhaust System Inspection** **1.2.7 Oil Level and Quality Inspection** **1.2.8 Coolant Level and Quality Inspection** Were any issues found?	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	Has the vehicle been sitting for 60 days, or longer, without the engine running?	Yes: Road test vehicle for up to 15 minutes and retest. If engine continues to run rough Go To Step 3.
		No: Go To Step 3

Step	Action	Decision
3	Perform section **3.14 Electronic Ignition System Diagnostics** Were any issues found?	Yes: Repair and retest.
		No: Go To Step 4

Step	Action	Decision
4	Perform section **3.9 Fuel Supply System Diagnostics** Were any issues found?	Yes: Repair and retest.
		No: Go To Step 5

Step	Action	Decision
5	Perform section **3.10 Fuel Injector Diagnostics** Were any issues found?	Yes: Repair and retest.
		No: Go To Step 6

Step	Action	Decision
6	Perform section **3.7 Engine Intake and Exhaust Leaks** Were any issues found?	Yes: Repair and retest.
		No: Go To Step 7

Step	Action	Decision
7	Perform section **3.4 Evaluating Fuel Trims** Run engine and monitor fuel trims. Were fuel trims found to be excessively positive or negative?	Yes, Positive: Perform Section **3.5 Rich Fuel Trim Diagnostics**
		Yes, Negative: Perform Section **3.6 Lean Fuel Trim Diagnostics**
		No OR Cannot Test: Go To Step 8

Step	Action	Decision
8	Perform section **3.1 Base Engine Diagnostics** Were any issues found?	Yes: Repair and retest.
		No: Go To Step 9

Step	Action	Decision
9	Perform section **3.17 MAP Sensor Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 10

Step	Action	Decision
10	Perform section **3.18 MAF Sensor Functionality Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 11

Step	Action	Decision
11	Perform section **3.15 Oxygen Sensor (O2S) Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 12

Step	Action	Decision
12	Perform **3.12 Testing for Contaminated Fuel** Were any issues found?	Yes: Repair and retest. No: Reassemble and reevaluate

2.4.4 Low Power (Slow Acceleration)

Overview
A suspected low power symptom should be verified with the customer whenever possible. Different driving styles and conditions can have a large effect on the performance of the engine. Before starting any diagnostics, the vehicle must be test driven and the low power complaint must be confirmed.

Possible Causes

- Fuel System
- Fuel Supply Restrictions
- Fuel Supply Pressure
- Injector Concerns
- Ignition System Concerns
  - Ignition Coil
  - Spark Plug Wire
  - Spark Plug
- Intake and Exhaust Restrictions
- Intake Throttle Valve Concerns
- MAP Sensor Concerns
- MAF Sensor Concerns
- Parasitic Loading
- Transmission Shift Parameters (Operator Input)
  - Light Throttle Input – Transmission Stacks Gears
- Base Engine Concerns
- O2S Concerns
- Contaminated Fuel

Test Procedure - Low Power (Slow Acceleration)

Step	Action	Decision
1	Perform the following Visual Inspection Sections: **1.2.1 Fuel Level and System Inspection** **1.2.2 Batteries and Electrical System Inspection** **1.2.3 Ignition System Inspection** **1.2.4 Component Connection Inspection** **1.2.5 Intake Air Inspection** **1.2.6 Exhaust System Inspection** **1.2.7 Oil Level and Quality Inspection** **1.2.8 Coolant Level and Quality Inspection** Were any issues found?	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	Start engine and idle until reaching operating temperature. At any point did engine develop a misfire symptom?	Yes: Perform section **2.4.1 Misfire / Rough Idle / Runs Rough** No: Got To Step 3

Step	Action	Decision
3	Review vehicle maintenance history. Has maintenance been performed to manufacturer's recommendations?	Yes: Go To Step 4 No: Perform needed maintenance and retest.

Step	Action	Decision
4	Perform section **3.3 Engine Performance Assessment** Did engine pass Performance Assessment?	Yes: End Diagnostics. No: Go To Step 5

Step	Action	Decision
5	Perform section **3.4 Evaluating Fuel Trims** Run engine and monitor fuel trims. Were fuel trims found to be excessively positive or negative?	Yes, Positive: Perform Section **3.5 Rich Fuel Trim Diagnostics** Yes, Negative: Perform Section **3.6 Lean Fuel Trim Diagnostics** No OR Cannot Test: Go To Step 6

Step	Action	Decision
6	Perform section **3.2 Cylinder Power Balance Test** Were any issues found?	Yes: Repair misfire condition and retest. No: Go To Step 7

Step	Action	Decision
7	Perform section **3.7 Engine Intake and Exhaust Leaks** Were any issues found?	Yes: Repair and retest. No: Go To Step 8

Step	Action	Decision
8	Perform section **3.8 Throttle Plate Operational Test and Cleaning** Were any issues found?	Yes: Repair and retest. No: Go To Step 9

Step	Action	Decision
9	Perform section **3.9 Fuel Supply System Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 10

Step	Action	Decision
10	Perform section **3.14 Electronic Ignition System Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 11

Step	Action	Decision
11	Perform section **3.10 Fuel Injector Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 12

Step	Action	Decision
12	Perform section **3.17 MAP Sensor Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 13

Step	Action	Decision
13	Perform section **3.16 Knock Sensor Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 14

Step	Action	Decision
14	Perform section **3.18 MAF Sensor Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 15

Step	Action	Decision
15	Perform section **3.15 Oxygen Sensor (O2S) Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 16

Step	Action	Decision
16	Perform section **3.1 Base Engine Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 17

Step	Action	Decision
17	Perform section **3.12 Testing for Contaminated Fuel** Were any issues found?	Yes: Repair and retest. No: Reassemble and reevaluate

2.4.5 Excessive Engine Surge (Inconsistent Engine RPM During Steady State)

Overview
A surge greater than 100 RPM is considered excessive. A slight rise and fall in engine RPM is acceptable during normal engine operation.

Possible Causes

- Vacuum Leaks
- Intake and Exhaust Restrictions
- MAP Sensor Concerns
- Fuel System
- Fuel Supply Restrictions
- Fuel Supply Pressure
- Injector Concerns
- Ignition System Concerns
    - Ignition Coil
    - Spark Plug Wire
    - Spark Plug
- Intake Throttle Concerns
- O2S Concerns
- MAF Sensor Concerns
- Parasitic Loading
- Base Engine Concerns
- Contaminated Fuel

Test Procedure - Excessive Engine Surge (Inconsistent Engine RPM During Steady State)

Step	Action	Decision
1	Perform the following Visual Inspection Sections: **1.2.1 Fuel Level and System Inspection** **1.2.2 Batteries and Electrical System Inspection** **1.2.3 Ignition System Inspection** **1.2.4 Component Connection Inspection** **1.2.5 Intake Air Inspection** **1.2.6 Exhaust System Inspection** **1.2.7 Oil Level and Quality Inspection** **1.2.8 Coolant Level and Quality Inspection** Were any issues found?	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	Start Engine and warm to operating temperature. Cycle ON and OFF all engine accessories, lights, and shift in and out of Drive. Does engine load change surging?	Yes: Isolate accessory, repair and retest. No: Go To Step 3

Step	Action	Decision
3	Perform section **3.8 Throttle Plate Operational Test and Cleaning** Were any issues found?	Yes: Repair and retest. No: Go To Step 4

Step	Action	Decision
4	Perform section **3.7 Engine Intake and Exhaust Leaks** Were any issues found?	Yes: Repair and retest. No: Go To Step 5

Step	Action	Decision
5	Remove exhaust pipe before muffler and run engine. Is the surge still present?	Yes: Go To Step 6 No: Replace muffler and retest.

Step	Action	Decision
6	Perform diagnostics for SPN 3050 and 3051 Catalyst Efficiency. Were any issues found?	Yes: Repair and retest. No: Go To Step 7

Step	Action	Decision
7	Perform section **3.4 Evaluating Fuel Trims** Run engine and monitor fuel trims. Were fuel trims found to be excessively positive or negative?	Yes, Positive: Perform Section **3.5 Rich Fuel Trim Diagnostics** Yes, Negative: Perform Section **3.6 Lean Fuel Trim Diagnostics** No OR Cannot Test: Go To Step 8

Step	Action	Decision
8	Perform section **3.17 MAP Sensor Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 9

Step	Action	Decision
9	Perform section **3.9 Fuel Supply System Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 10

Step	Action	Decision
10	Perform section **3.10 Fuel Injector Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 11

Step	Action	Decision
11	Perform section **3.14 Electronic Ignition System Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 12

Step	Action	Decision
13	Perform section **3.18 MAF Sensor Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 14

Step	Action	Decision
14	Perform section **3.1 Base Engine Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 15

Step	Action	Decision
15	Perform section **3.12 Testing for Contaminated Fuel** Were any issues found?	Yes: Repair and retest. No: Reassemble and reevaluate

2.4.6 Poor Fuel Economy

Overview
When evaluating fuel economy refer to vehicle-to-engine specifications published by the Original Manufacture. Fuel economy varies between applications, vehicle weight, driving habits, and topographical conditions/locations. Poor fuel economy is typically a symptom of a condition whether it is a biased sensor, failing injector(s), vacuum leaks, incomplete combustion, etc.

Possible Causes

- Fuel Injector Concerns
- Vacuum Leaks
- External Fuel Leaks
- Intake and Exhaust Restrictions
- Ignition System Concerns
    - Ignition Coil
    - Spark Plug Wire
    - Spark Plug
- MAP Sensor Concerns
- Intake Throttle Concerns
- O2S Concerns
- MAF Sensor Concerns
- Base Engine Concerns
- Transmission Shift Parameters (Operator Input)
    - Light Throttle Input – Transmission Stacks Gears
- Contaminated Fuel
- Powertrain Parasitic Loading

Test Procedure - Poor Fuel Economy

Step	Action	Decision
1	Perform the following Visual Inspection Sections: **1.2.1 Fuel Level and System Inspection** **1.2.2 Batteries and Electrical System Inspection** **1.2.3 Ignition System Inspection** **1.2.4 Component Connection Inspection** **1.2.5 Intake Air Inspection** **1.2.6 Exhaust System Inspection** **1.2.7 Oil Level and Quality Inspection** **1.2.8 Coolant Level and Quality Inspection** Were any issues found?	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	Has the vehicle been sitting for 60 days, or longer, without the engine running?	Yes: Return to customer for operation and monitoring. No: Go To Step 3

Step	Action	Decision
3	Perform section **2.7.1 Gasoline Fumes In Cab or Around Bus (Outside of fuel fill process)** Were any issues found?	Yes: Repair and retest. No: Go To Step 4

Step	Action	Decision
4	Perform section **3.4 Evaluating Fuel Trims** Run engine and monitor fuel trims. Were fuel trims found to be excessively positive or negative?	Yes, Positive: Perform Section **3.5 Rich Fuel Trim Diagnostics** Yes, Negative: Perform Section **3.6 Lean Fuel Trim Diagnostics** No OR Cannot Test: Go To Step 5

Step	Action	Decision
5	Perform section **3.7 Engine Intake and Exhaust Leaks** Were any issues found?	Yes: Repair and retest. No: Go To Step 6

Step	Action	Decision
6	Perform section **3.10 Fuel Injector Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 7

Step	Action	Decision
7	Perform section **3.14 Electronic Ignition System Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 8

Step	Action	Decision
8	Perform section **3.15 Oxygen Sensor (O2S) Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 9

Step	Action	Decision
9	Perform section **3.17 MAP Sensor Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 10

Step	Action	Decision
10	Perform section **3.9 Fuel Supply System Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 11

Step	Action	Decision
12	Perform section **3.8 Throttle Plate Operational Test and Cleaning** Were any issues found?	Yes: Repair and retest. No: Go To Step 13

Step	Action	Decision
13	Perform section **3.18 MAF Sensor Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 14

Step	Action	Decision
14	Perform section **3.1 Base Engine Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 15

Step	Action	Decision
15	Perform section **3.12 Testing for Contaminated Fuel** Were any issues found?	Yes: Repair and retest. No: Go To Step 16

Step	Action	Decision
16	Refer to OEM Chassis and Powertrain Diagnostic manual for abnormal parasitic loading (Transmission, transfer case, braking system, tires, bearings, alignment, etc.) Were any issues found?	Yes: Repair and retest. No: Reassemble and reevaluate

2.4.7 Excessive Smoke From Exhaust

Overview
Gasoline is a fuel which emits little to no particulates after combustion. If smoke is identified coming from the exhaust it should be addressed quickly to avoid catalyst damage.

Possible Causes

- Engine Oil Overfilled
- Coolant Consumption
- Oil Consumption
- Fuel Injector Concerns
- Ignition System Concerns
    - Ignition Coil
    - Spark Plug Wire
    - Spark Plug
- Failed Catalyst
- MAP Sensor Concerns
- Intake and Exhaust Restrictions
- O2S Concerns
- MAF Sensor Concerns
- Base Engine Concerns
- Contaminated Fuel

Test Procedure - Excessive Smoke from Exhaust

Step	Action	Decision
1	Perform the following Visual Inspection Sections: **1.2.1 Fuel Level and System Inspection** **1.2.2 Batteries and Electrical System Inspection** **1.2.3 Ignition System Inspection** **1.2.4 Component Connection Inspection** **1.2.5 Intake Air Inspection** **1.2.6 Exhaust System Inspection** Were any issues found?	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	Perform Engine System Visual Check **1.2.8 Coolant Level and Quality Inspection** Were any issues found? Note: If engine is burning coolant, smoke emitted from exhaust will be white in color.	Yes: Perform section **2.5.4 Engine Coolant Consumption** and retest. No: Go To Step 3

Step	Action	Decision
3	Perform Engine System Visual Check **1.2.7 Oil Level and Quality Inspection** Were any issues found? Note: If engine is burning oil, smoke emitted from exhaust will be blue/black in color.	Yes: Perform section **2.6.2 Engine Oil Consumption** and retest. No: Go To Step 4

Step	Action	Decision
4	Perform section **3.4 Evaluating Fuel Trims** Run engine and monitor fuel trims. Were fuel trims found to be excessively positive or negative?	Yes, Positive: Perform Section **3.5 Rich Fuel Trim Diagnostics** Yes, Negative: Perform Section **3.6 Lean Fuel Trim Diagnostics** No OR Cannot Test: Go To Step 5

Step	Action	Decision
5	Perform section **3.10 Fuel Injector Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 6

Step	Action	Decision
6	Perform section **3.14 Electronic Ignition System Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 7

Step	Action	Decision
7	Perform diagnostics for SPN 3050 and 3051 Catalyst Efficiency. Were any issues found?	Yes: Repair and retest. No: Go To Step 8

Step	Action	Decision
8	Perform section **3.15 Oxygen Sensor (O2S) Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 9

Step	Action	Decision
9	Perform section **3.17 MAP Sensor Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 10

Step	Action	Decision
10	Perform section **3.18 MAF Sensor Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 11

Step	Action	Decision
11	Perform section **3.1 Base Engine Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 12

Step	Action	Decision
12	Perform section **3.12 Testing for Contaminated Fuel** Were any issues found?	Yes: Repair and retest. No: Reassemble and retest

2.4.8 Engine Does Not Shut Down At Key OFF (Run-on or Dieseling)

Overview
Gasoline requires spark ignition to combust in the cylinder during normal operation which is controlled by the ECM. To experience a long-standing run-on condition, spark (or ignition source) and fuel must be supplied to the cylinders after the key has been turned off. If the engine does not shut down at Key OFF electrical conditions with the ignition switch, coils, and relays should be investigated first. Run-on or Dieseling can occur if fuel injection continues while the cylinder maintains an ignition source such spark or heat (burning carbon, piston or spark plug temperature, excessive ambient heat) to ignite the fuel.

Possible Causes

- Contaminated or Incorrect fuel
- Electrical System Concerns
- Fuel Injector Concerns
- Ignition System Concerns
- Vacuum Leaks
- Carbon build-up in combustion chamber
- ECM Failure

Test Procedure - Engine Does Not Shut Down At Key OFF (Run-on or Dieseling)

Step	Action	Decision
1	Perform the following Visual Inspection Sections: **1.2.1 Fuel Level and System Inspection** **1.2.2 Batteries and Electrical System Inspection** **1.2.3 Ignition System Inspection** **1.2.4 Component Connection Inspection** **1.2.5 Intake Air Inspection** **1.2.6 Exhaust System Inspection** **1.2.7 Oil Level and Quality Inspection** **1.2.8 Coolant Level and Quality Inspection** Were any issues found?	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	A. Key OFF B. Disconnect Vehicle Interface Connector (VIC) C. Check Vehicle Interface Connector (VIC) terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Is Vehicle Interface Connectors (VIC), harnesses, and terminals clean and undamaged?	Yes: Go To Step 3 No: Repair connector, harness, or terminal damage. After repairs are complete, retest

Step	Action	Decision
3	Perform section **3.14 Electronic Ignition System Diagnostics** and analyze the following in parallel. - During this inspection and testing procedure, while using OTC6589 to test spark, shut engine down. Monitor spark, immediately after Key OFF. Spark should cease for each cylinder. - With Spark Plugs removed, inspect spark plugs for excessive carbon build up. Using a bore scope inspect combustion chambers on all 8 cylinders. Were any issues found?	Yes, Spark Ceases After Key OFF: Repair concern and retest. Yes, Spark Continues After Key OFF: Repair concern and Go To Step 4 Yes, Excessive Carbon Built Up On Spark Plug(s): Repair concern and perform **2.6.2 Oil Consumption Diagnostics** No: Go To Step 5

Step	Action	Decision
4	Review OEM Starting and Charging System diagnostics. Diagnose the following relays and circuits: • Ignition Switch (Key Switch) • Powers and Grounds • Start Relay • Switched Crank Relay • ECM Relay • Powertrain Relay Were any issues found?	Yes: Repair and retest. No: Go To Step 5

Step	Action	Decision
5	Perform section **3.10 Fuel Injector Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 6

Step	Action	Decision
6	Perform section **3.4 Evaluating Fuel Trims** Run engine and monitor fuel trims. Were fuel trims found to be excessively positive or negative?	Yes, Positive: Perform Section **3.5 Rich Fuel Trim Diagnostics** Yes, Negative: Perform Section **3.6 Lean Fuel Trim Diagnostics** No OR Cannot Test: Go To Step 7

Step	Action	Decision
7	Perform section **3.7 Engine Intake and Exhaust Leaks** Were any issues found?	Yes: Repair and retest. No: Go To Step 8

Step	Action	Decision
8	Perform section **3.12 Testing for Contaminated Fuel** Were any issues found?	Yes: Repair and retest. No: Replace ECM and retest.

2.5 Engine Coolant Symptoms

Section Overview
Determine root cause of coolant over flowing, over temperature (over heat), coolant leaking into oil, or coolant consumption or loss.

2.5.1 Coolant Over Flow

Overview
Determine root cause of coolant over flowing surge tank.

Possible Causes

- Coolant over filled
- Contamination from other systems
- Excess pressure in cooling system
- Restriction in cooling system
- Engine overheat

Test Procedure - Coolant Over Flow

Step	Action	Decision
1	Perform the following Visual Inspection: **1.2.8 Coolant Level and Quality Inspection** Were any issues found?	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	Has cooling system work recently taken place? Could the engine have previously been overfilled with coolant?	Yes: Drain excess coolant and retest. No: Go To Step 3

Step	Action	Decision
3	Review maintenance information and speak with vehicle driver asking specifically for any engine overheat events. Does engine have a history of overheat event(s)?	Yes: Perform section **2.5.2 Coolant Over Temperature** No: Go To Step 4

Step	Action	Decision
4	Check and test cooling system cap for proper rating. Is the cooling system cap in specification and functioning?	Yes: Reassemble and Reevaluate concern. No: Repair and retest.

2.5.2 Coolant Over Temperature

Overview
Determine root cause of coolant overheating.

Possible Causes

- Engine Thermostat stuck closed
- Restriction in cooling system
- Air pockets in cooling system (if recent repairs have been performed)

Test Procedure - Coolant Over Temperature

Step	Action	Decision
1	Perform the following Visual Inspection: **1.2.8 Coolant Level and Quality Inspection** Were any issues found?	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	Has cooling system work recently taken place?	Yes: Air stuck in the cooling system. Attempt to bleed air out, or refill using a vacuum fill tool. No: Go To Step 3

Step	Action	Decision
3	Warm engine and monitor upper and lower radiator hoses. Do coolant hoses stay cool the entire time the engine runs, including overheat condition?	Yes: Replace thermostat and retest. No: Go To Step 4

Step	Action	Decision
4	Monitor coolant flow while running engine. Does coolant steadily flow through the surge tank?	Yes: Perform SPN 110 FMI 0 diagnostics. No: Cooling system restriction or water pump issue. Repair and retest.

2.5.3 Coolant Leak to Engine Oil

Overview
Determine root cause of coolant leaking into engine oil.

Possible Causes
- Engine oil cooler internal leak to cooling system.
- Base engine issue

Tools Required
- Cooling System Pressure Tester

Test Procedure - Coolant Leak to Engine Oil

Step	Action	Decision
1	Perform the following Visual Inspections: **1.2.7 Oil Level and Quality Inspection** **1.2.8 Coolant Level and Quality Inspection** Were any issues found?	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	Perform the following 1. Top off cooling system 2. Drain engine oil leave oil plug removed 3. Remove oil supply and return lines from oil cooler 4. Pressurize cooling system. Inspect for coolant leaks. Is coolant leaking?	Yes, Oil Cooler: Replace oil cooler and retest. Yes, Oil Pan Drain Plug: Remove oil pan and inspect for leak location. Repair and retest. No: Go To Step 3

Step	Action	Decision
3	Perform **3.1 Base Engine Diagnostics.** Were any issues found?	Yes: Repair and retest. No: Change engine oil. Reevaluate concern.

2.5.4 Engine Coolant Consumption

Overview
Determine root cause of engine using coolant.

Possible Causes

- External Coolant leak
- Internal Coolant leak
- Base engine issue
- Head gasket failure
- Oil cooler failure

Tools Required

- Cooling System Pressure Tester

Test Procedure - Engine Coolant Consumption

Step	Action	Decision
1	Perform the following Visual Inspections: **1.2.7 Oil Level and Quality Inspection** **1.2.8 Coolant Level and Quality Inspection** Were any issues found? Note: If oil is over full and has evidence of coolant contamination see section **2.5.3 Coolant Leak to Engine Oil**	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	Pressure test cooling system. Inspect for external coolant leaks. Were any leaks found?	Yes: Repair and retest. No: Go To Step 3

Step	Action	Decision
3	Perform **3.1 Base Engine Diagnostics.** **Note: During diagnostics note condition of spark plugs look for discoloring or a wet plug.** Were any issues found?	Yes: Repair and retest. No: Change engine oil. Reevaluate concern.

2.6 Engine Lubrication Symptoms

Section Overview
Determine root cause of the engine oil being over full, oil consumption, or low oil pressure.

2.6.1 Engine Oil Over Full

Overview
Determine root cause of the engine oil being over full

Possible Causes

- Engine Oil Checking Procedure was improperly or not followed.
- Excessive engine oil was added during an engine oil change.

Tools Required

- Clean Rag

Test Procedure - Engine Oil Over Full

Step	Action	Decision
1	Perform the following inspection: **1.2.7 Oil Level and Quality Inspection** Is engine oil over full following proper checking procedure?	Yes: Go To Step 2 No: Enform customer of proper checking procedure. End Diagnosis.

Step	Action	Decision
2	Is engine oil contaminated with coolant or other substance? Note: Engine oil will become sludge and have a white/foam color when mixed with coolant or water.	Yes: Perform section **2.5.3 Coolant Leak to Engine Oil** No: Go To Step 3

Step	Action	Decision
3	Has engine oil recently been changed?	Yes: Review servicing procedure with customer. Remove excess engine oil. Release vehicle and monitor level. No: Drain and refill engine oil with correct type and amount.

Step	Action	Decision
4	Has engine oil been added by the operator without performing proper Engine Oil Checking Procedure?	Drain and refill engine oil with correct type and amount.

2.6.2 Engine Oil Consumption

Overview
Excessive oil consumption, not due to leaks, is defined as using more than 0.95 liter (1 quart) of engine oil within 379 liters (100 gallons) of fuel used. However, during initial engine break-in periods, 5000-6500 kilometers (3000-4000 miles), oil consumption may exceed 1.9 liters (2 quarts) or more per 379 liters (100 gallons) of fuel used.

Possible Causes

- Engine Oil Checking Procedure was improperly or not followed.
- Improper oil viscosity or type
- Base engine issue

Test Procedure - Engine Oil Consumption

Step	Action	Decision
1	Perform the following inspection: **1.2.7 Oil Level and Quality Inspection** Is engine oil over full following proper checking procedure?	Yes: Go To Step 2 No: Enform customer of proper checking procedure. End Diagnosis.

Step	Action	Decision
2	Perform **3.1 Base Engine Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 3

Step	Action	Decision
3	Fill engine with proper type and amount of engine oil and request customer monitor oil level daily keeping detailed notes of oil consumption and miles driven. Does engine have excessive oil consumption?	Yes: Repair base engine and retest. No: End Diagnostics.

2.6.3 Low Engine Oil Pressure

Engine Oil Pressure Specifications

Minimum Oil Pressure (Hot at 1000RPM)	152 kPa (22 psi)

Possible Causes

- Extended Oil Change Interval
- Defective engine oil pressure sending unit
- Improper oil viscosity or type
- Base engine issue

Tools Required

- Oil Pressure Test Fitting EN-21867-16
- Pressure Gauge EN-21867

Test Procedure – Low Engine Oil Pressure

Step	Action	Decision
1	Perform the following inspection: **1.2.7 Oil Level and Quality Inspection** Were any issues found?	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	Verify low engine oil pressure with a mechanical gauge. Use special tool EN-21867. Compare values in PowerLink to mechanical oil pressure gauge. Are readings within 5± PSI of each other?	Yes: Go To Step 3 No: Perform diagnostics for to SPN 100 Engine Oil Pressure.

Step	Action	Decision
3	Change engine oil and filter with recommended oil weight and brand (See Operators Manual). When draining oil sample and inspect for debris or heavy metal shavings. Were any issues found?	Yes: Repair and retest No: Refill engine with proper oil then Retest. If pressure is still low Go To Step 4.

Step	Action	Decision
4	Remove engine oil pump and inspect for damage. Were any issues found?	Yes: Repair and retest. No: Reassemble and reevaluate for concern, if oil pressure is still low, repair base engine.

2.7 Engine Fuel System Symptoms

Section Overview
This diagnostic section reviews and diagnoses symptoms in relation to fuel level, fuel leaks, or the fuel tank not accepting fuel.

2.7.1 Gasoline Fumes In or Around Vehicle (Outside of fuel fill process)

Overview
Determine cause of gasoline fumes or leak location.

Possible Causes

- Fuel Leaks at Fill Port
- Fuel Leaks at Fuel Fill Filter Connections
- Fuel Leaks at Fuel Tank Fittings
- Fuel Leaks from Fuel Lines
- Fuel Leaks at Fuel Rails
- Fuel Leaks at Injectors or Injector Ports
- Injector Stuck Open

Test Procedure – Gasoline Fumes In or Around Vehicle (Outside of fuel fill process)

Step	Action	Decision
1	Perform section **1.2.1 Fuel Level and System Inspection** Are any issues present?	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	Is gasoline vapor noted at front of bus or in driver's cab?	Yes: Go To Step 3 No: Go To Step 5

Step	Action	Decision
3	Key ON, perform visual inspection of each injector on both banks for signs of leaks. Were any injectors leaking?	Yes: Replace suspected injector(s) and retest. No: Go To Step 4

Step	Action	Decision
4	Key ON, perform visual inspection of the fuel rail connector for signs of leaks. Were any leaks detected?	Yes: Remove fuel line from fuel rail and inspect fuel rail for damage, if damage is suspected, replace fuel rail and retest. If no signs of damage are present on the fuel rail and the cause of the leak is suspected to be the fuel line connection, see OEM manual for instruction.
		No: See OEM manual for instruction.

2.7.2 Gasoline Leaking During Fuel Fill

Overview
Determine root cause of gasoline leak only during fuel fill process.

Possible Causes

- Leaking connections
  - Fuel Fill Hose
  - Fuel Tank Connection
- Damaged Fill Station Supply Pump

Test Procedure – Gasoline Leaking During Fuel Fill

Step	Action	Decision
1	See OEM manual for procedure regarding Gasoline Fuel Fill System leak detection. After completing OEM procedure has the leak been fixed?	Yes: End Diagnostic. No: Reassemble and retest.

2.7.3 Inaccurate Fuel Level Readings

Overview
Determine root cause of dashboard fuel level gauge not corresponding with fuel tank fuel level gauge.

Possible Causes

- Fuel Level Sending Unit Assembly
- Fuel Level Sensor
- Dashboard Fuel Level Gauge
- Fuel Level Sending Unit Wiring
- Fuel Tank Does Not Fill

Test Procedure - Inaccurate Fuel Level Readings

Step	Action	Decision
1	See OEM manual for procedure regarding Inaccurate Fuel Level Readings. After completing OEM procedure, is the fuel level reading accurate?	Yes: End Diagnostics. No: Reassemble and retest.

2.7.4 Fuel Tank Does Not Fill or Takes Excessive Time

Overview

Reference OEM manual for details on this issue. Fuel tank and associated components are installed by the chassis/vehicle manufacturer.

Test Procedure - Fuel Tank Does Not Fill or Takes Excessive Time

Step	Action	Decision
1	See OEM manual for procedure regarding Fuel Tank Does Not Fill or Takes Excessive Time. After completing OEM procedure, does the fuel tank fill properly?	Yes: End Diagnostics. No: Reassemble and retest.

3 – System Tests

3.1 Base Engine Diagnostics

System Description

The engine block is made of cast iron and it has eight cylinders arranged in a 90 degree V shape with four cylinders in each bank. The engine block is a one-piece casting with the cylinders encircled by coolant jackets. The engine has four bolt main bearing caps. The engine is equipped with one cooling jet per cylinder. The pistons are forged aluminum that use two compression rings and three-piece oil control ring assembly. The piston pins are a floating fit in the pistons and connecting rod. The pins are retained by circlip's on both sides of the piston. The connecting rods are forged steel. The cylinder heads are made of cast iron and have parent metal intake & exhaust valves. The intake and exhaust seats are powdered metal. The water crossover pipe attaches to the front of each cylinder head. The cylinder heads are ported to accepted fuel injectors.

Engine Compression Test

A cylinder compression test can be performed to understand general cylinder and valve sealing health. A cylinder with worn piston rings, scored cylinders, or valves that are not sealing will have less compression than a properly functioning cylinder.

Engine Compression Test Diagnostic Tips

- Compression should build quickly and evenly for each cylinder.
- No cylinder should read less than 100 psi of compression.
- Lowest compression cylinder should be no more than 30% lower than highest compression cylinder (EX. 180psi X 70% = 126psi) OR (Ex. 180psi X 30% = 54psi, lowest cylinder must be greater than 180psi – 54psi = 126psi)
- Air bubbles in the cooling system may indicate damaged head gasket or cracked cylinder heads.

Cylinder Leakage Test

A cylinder leak-down test can be extremely beneficial in identifying why a cylinder has low compression. A leakdown tool keeps a regulated amount of air pressure in the cylinder. The tool measures the difference in supply pressure to how much pressure the cylinder can continuously hold. A cylinder with a low leakdown percentage is healthier than a cylinder with a high leakdown percentage. 100% cylinder leakdown indicates the cylinder cannot hold any pressure. Alternatively, a cylinder with 0% leakdown holds full pressure supplied to it.

Tools Required

- Cylinder Leakage Tester OTC5609
- Compression Tester OTC5606
- Spark Plug Socket

Test Procedure - Base Engine Diagnostics

Step	Action	Decision
1	Perform Engine Compression Test. Refer to Engine Service Manual – **04 Mechanical Diagnostic Procedures – Engine Compression Test**. Were any cylinders less than 100PSI or less than 70% of the cylinder with highest compression?	Yes: Go To Step 2. Perform on low compression cylinder(s) only. No: End Diagnostics.

Step	Action	Decision
2	Perform Cylinder Leakage Test. Refer to Engine Service Manual – **04 Mechanical Diagnostic Procedures – Cylinder Leakage Test**. Were any cylinders found to have greater than 25% leakage?	Yes: Go To Step 3 No: Re-evaluate compression on suspect cylinder.

Step	Action	Decision
3	Remove Air Intake Duct from Throttle body. Perform Cylinder Leakage Test on suspect cylinder. Listen through intake for pressure loss from the cylinder. Refer to Engine Service Manual – **04 Mechanical Diagnostic Procedures – Cylinder Leakage Test**. Is suspected cylinder leaking into intake?	Yes: Leaking intake valve, repair and retest. No: Go To Step 4

Step	Action	Decision
4	Perform Cylinder Leakage Test on suspect cylinder. Listen through exhaust for pressure loss from the cylinder. Refer to Engine Service Manual – **04 Mechanical Diagnostic Procedures – Cylinder Leakage Test**. Is suspected cylinder leaking into exhaust?	Yes: Leaking exhaust valve, repair and retest. No: Go To Step 5

Step	Action	Decision
5	Perform Cylinder Leakage Test on suspect cylinder. Listen through oil fill tube for pressure loss from the cylinder. Refer to Engine Service Manual – **04 Mechanical Diagnostic Procedures – Cylinder Leakage Test**. Is suspected cylinder leaking into crankcase?	Yes: Leaking past compression rings, repair and retest. No: Go To Step 6

Step	Action	Decision
6	Perform Cylinder Leakage Test on suspect cylinder. Inspect surge tank for bubbles or pressurization. Refer to Engine Service Manual – **04 Mechanical Diagnostic Procedures – Cylinder Leakage Test**. Is suspected cylinder leaking into cooling system?	Yes: Leaking past head gasket or cylinder head, repair and retest. No: Re-evaluate compression on suspect cylinder.

3.2 Cylinder Power Balance Test

Overview

A misfire condition can be the result of many different types of failures. The first step in finding any misfire condition is to identify the cylinder or cylinders affected. This is done by removing fuel from each cylinder one at a time and reviewing engine data provided in PSI PowerLink. The two main points of data to review are Engine Demand – Percent Torque and Actual Engine – Percent Torque. When a misfire is present manifold pressure will naturally be higher due to the extra load put on the engine from the cylinder(s) that are not contributing. In this test it is represented as a higher percent of torque needed to maintain running conditions. Listening to the engine change tone as misfires occur can also be very helpful.

When a cylinder is commanded off by a Cylinder Power Balance Test by manually inducing a misfire these results should be expected. When a cylinder is disabled and there is no change in percentage or no audible change in engine tone, a misfire has been identified.

Diagnostic Tips

- To avoid catalyst damage always disconnect a fuel injector when manually inducing a misfire.
- If a code is set when manually inducing a misfire that cylinder must be re-tested after clearing active and inactive codes.
- Using a heat gun to verify a suspected misfire can be helpful.
- Using Oxygen sensor or fuel trim data can help determine what bank the misfire is occurring on for intermittent misfires.

Tools Needed

- PowerLink

Test Procedure - Cylinder Power Balance Test

Step	Action	Decision
1	Connect PowerLink to the vehicle. Start engine and leave at idle. If any active codes are present repair the fault first. If a misfire condition is not initially felt put the engine in gear with the wheels locked and parking brake engaged. A light brake torque can be applied if needed. Is a misfire condition currently suspected?	Yes: Go To Step 2 No: Review customer complaint and speak with vehicle operator if necessary to find when the misfire is suspected. Run vehicle in needed condition for misfire to occur.

Step	Action	Decision
2	Engine idling in neutral, set up graph to find misfires: Note: Figures direct how to perform the stated action. • Click “Data Monitor” in PowerLink selection tabs. Then “All” Tab – **Figure 3.2.1** • Type “Engine Torque” in the search bar, select check boxes for “Actual Engine – Percent Torque” and “Engine Demand – Percent Torque” – **Figure 3.2.2** • Select “Graph” – **Figure 3.2.3** Is the graph formatted similar to **Figure 3.2.3**?	Yes: Go To Step 3 No: Restart Step 2. NOTE: Scaling can be changed by clicking the + or – buttons on either axis.

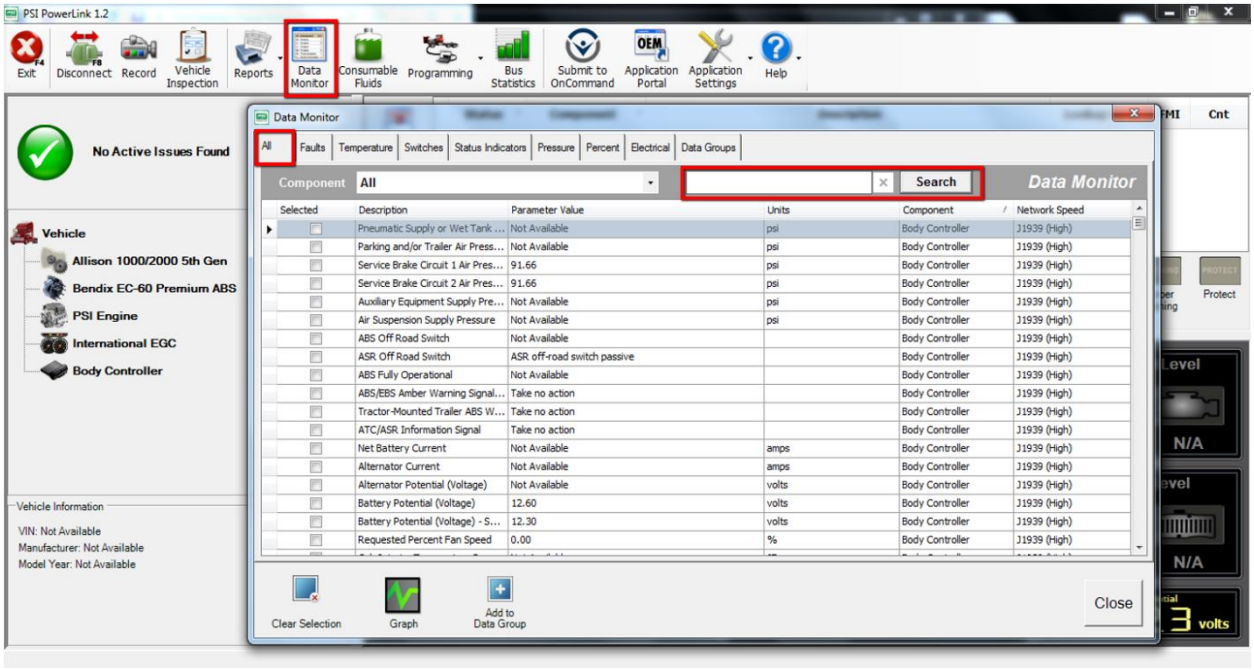


Figure 3.2.1: Click “Data Monitor” on the top row of selections. A window will appear. Ensure the “All” tab is selected and the search bar is present.

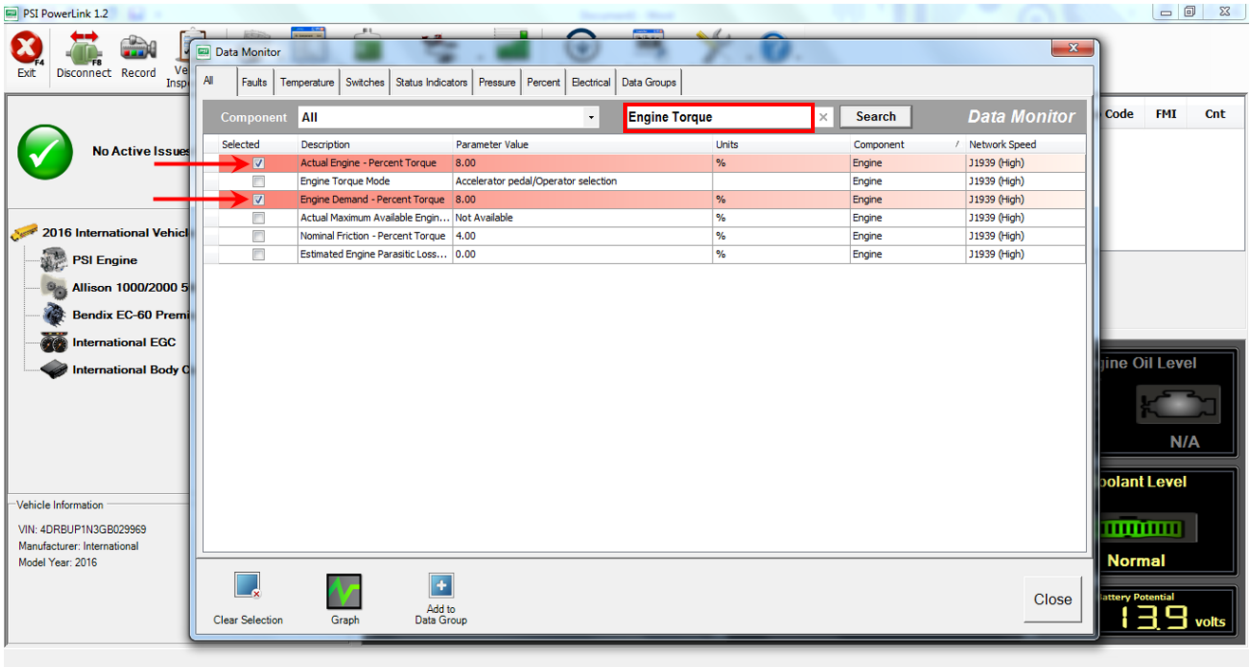


Figure 3.2.2: Type “Engine Torque” into the search bar on the upper right of the window. Select the check boxes for “Actual Engine – Percent Torque” and “Engine Demand – Percent Torque”. The data will stay selected until it is manually unchecked.

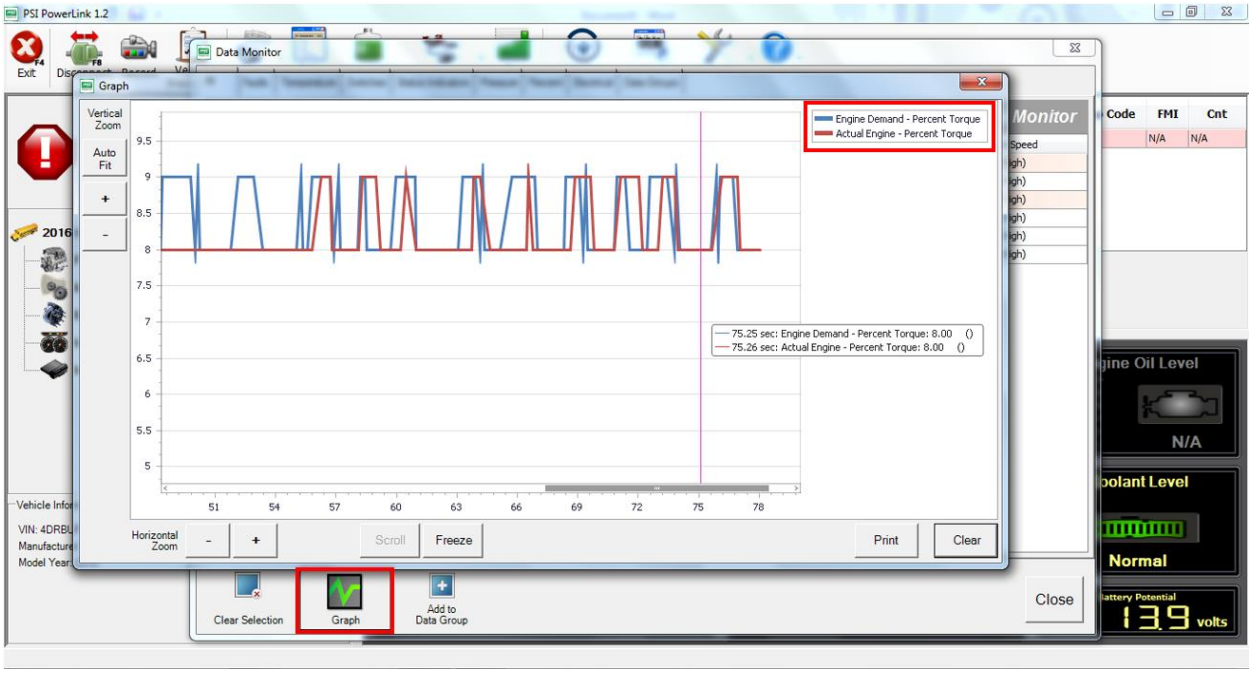


Figure 3.2.3: Near the bottom left of the “Data Monitor” window click the “Graph” icon. A plotting window will appear. Verify selected data is present.

Step	Action	Decision
3	Allow engine to idle and review engine torque: • It is normal for the graph to slightly rise and fall as the engine is running. • Place cursor near the end of the graph to show real-time values – **Figure 3.2.4** Unplug each fuel injector one at a time. <u>DO NOT</u> unplug longer than 5 seconds. Test will be invalid! • View graph and listen to the engine when each injector is unplugged. • Engine tone should change each time an injector is unplugged then reconnected. • Both torque percentages should rise when an injector is unplugged, then fall when plugged back in. **Figure 3.2.5** shows an example of a misfiring engine. NOTE: If any codes are set during this process clear and retest. Do one or more cylinders have NO RISE Engine Percent Torque or make no audible difference when the injector is disconnected?	Yes: Cylinder(s) suspect to a misfire. Can be verified with Infrared Heat Gun on the exhaust manifold if needed. No: Review customer complaint and retest.

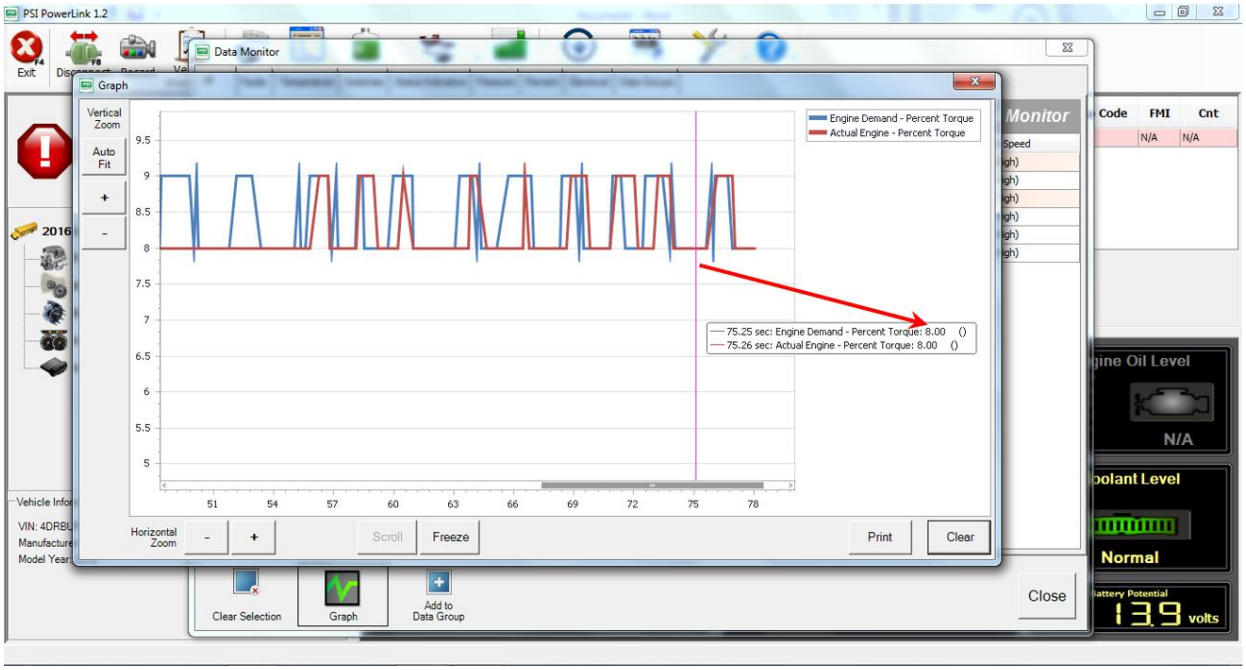


Figure 3.2.4: Engine running with plot. It is normal for values to slightly rise and fall.

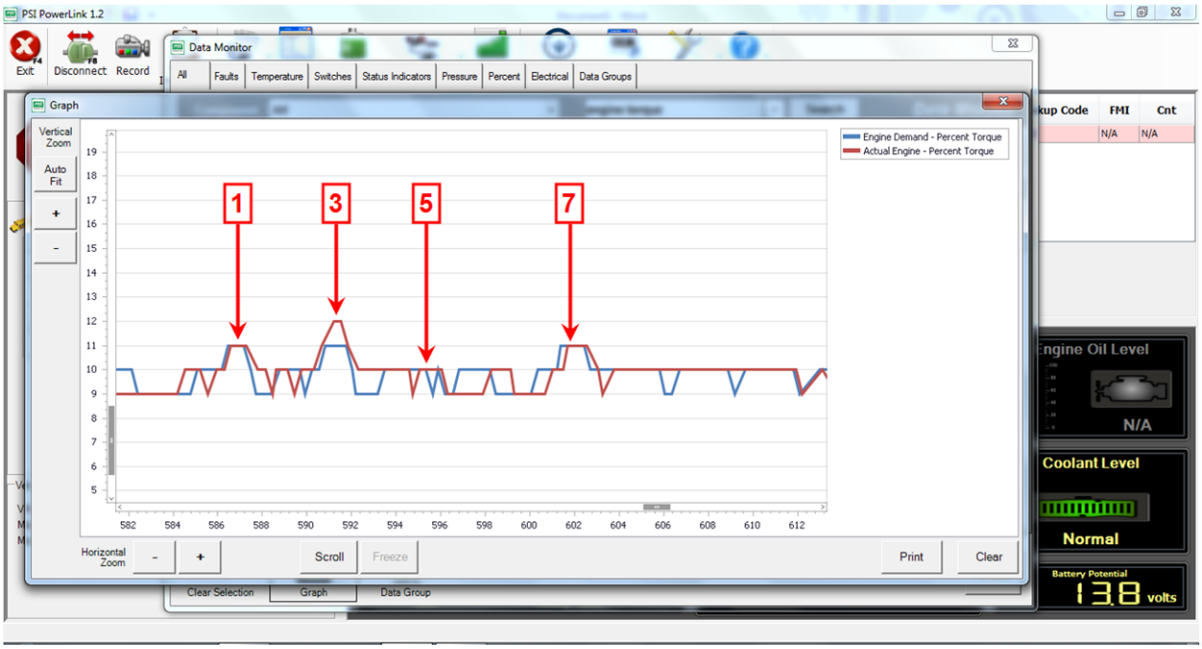


Figure 3.2.5: Example of a cylinder misfire

Notes:

Cylinder 1 Test – OK – Values rise when injector is unplugged. Drop when plugged in.
Cylinder 3 Test – OK – Values rise when injector is unplugged. Drop when plugged in.
Cylinder 5 Test – FAIL – NO RISE when injector was unplugged. NO Audible change in engine tone.
Cylinder 7 Test – OK – Values rise when injector is unplugged. Drop when plugged in.

3.3 Engine Performance Assessment

Overview
Determine if engine is producing adequate power.

Diagnostic Tips
- Key ON engine OFF MAP pressure should be within 0.5 PSI of Barometric Pressure
- Engine at full load MAP pressure should be within 0.5 PSI of Barometric Pressure
- O2 Sensors should read Rich at wide open throttle (WOT).

Tools Required
- PowerLink

Test Procedure – Engine Performance Assessment

Step	Action	Decision
1	Key ON, Using PowerLink record MAP Pressure. Find current local barometric pressure (convert reading to psi if necessary, typical reading 14.7psi). Is MAP Pressure and Barometric Pressure ± 0.5 PSI?	Yes: Go To Step 2 No: Perform SPN 3563 diagnostics. Repair and then retest.

Step	Action	Decision

2	With engine at operating temperature. Start engine allow to idle for approximately 3 minutes.
	
	Perform the following in PowerLink:
	• Select “Record” in PowerLink selection tabs.
	• Open “Data Monitor” select “All”
	• Search and Select Checkboxes for:
	  ○ MAP Pressure
	  ○ Barometric Pressure
	  ○ Engine Demand – Percent Actual
	  ○ Actual Engine – Percent Torque
	• Select “Graph”
	
	With vehicle in neutral, parking brake engaged, and vehicle accessories OFF (lights, air conditioning, air compressor, etc). Monitor graph in PowerLink.
	
	Is MAP Pressure between 3.0 - 4.5psi while idling?
		Yes: Go To Step 3
		No: Fail Performance Assessment.
		
		Note: Altitude can affect MAP Pressure. If at high altitude compare to other vehicles.

Step	Action	Decision
3	With graph is still active, Test drive vehicle (If possible up a steep grade) with engine at full load (WOT). When vehicle returns to a safe stopping area review data. Note: It may be necessary to scroll through the plot and change scaling to view data. Under full load is MAP and Barometric Pressure within 0.5 PSI? Under full load do both Torque Percentages match during road test?	Yes: Go To Step 4 No: Fail Performance Assessment.

Step	Action	Decision
4	During road test, did vehicle perform with adequate power?	Yes: Pass Performance Assessment. No: Fail Performance Assessment.

3.4 Evaluating Fuel Trims

System Overview

The ideal stoichiometric air/fuel (A/F) ratio for gasoline it is 14.7:1 (by mass). When a vehicle operates at this ideal air/fuel ratio, the fuel burns completely resulting in the lowest amount of emissions. The best fuel economy occurs at leaner ratios and the most power is made at richer ratios. In rich conditions, the emissions output will increase. The Engine Control Module (ECM) will attempt to operate at the ideal air/fuel ratio. The primary input for monitoring air/fuel ratio is the O2 sensor. Lean codes are set when excessive oxygen is detected within the exhaust gas and rich codes are set when too little oxygen is detected. Bank 1 is the side of the engine that has cylinder #1 (Left-Hand Side of engine as viewed from the flywheel), bank 2 would be on the opposite side (Right-Hand Side of engine as viewed from the flywheel).

Short Term Fuel Trim

Short Term Fuel Trim (STFT1 and STFT2) is the ECM's immediate response to adjust the air/fuel ratio. In positive corrections, fuel is added to adjust for a lean condition, while negative corrections reduce fuel in response to a rich condition. STFT corrections represent the current engine run cycle and react very quickly to O2 sensor input. For example, a large vacuum leak, would cause the ECM to immediately add positive fuel trim to balance the A/F mixture. STFT is not stored in Keep Alive Memory (KAM) after shut down and automatically resets to 0 for the next start/run cycle.

Long Term Fuel Trim

Unlike STFT, Long Term Fuel Trim (LTFT1 and LTFT2) is learned over time while in closed loop operation. It is a table stored in the KAM and also used for open loop fuel calculations (like start up and wide-open throttle). LTFT works to keep STFT within specification.

Normal Readings

A normal STFT reading will generally fluctuate between negative and positive every 1-3 seconds. With LPG applications, usually they will stay around ± 15%, but they may occasionally go up depending on the efficiency of the engine, age of the components, and other factors. A normal LTFT reading will appear to stay the same, giving a long-term average of fuel added. In LPG applications, it can be as much as ± 20%. It will fluctuate much slower than STFT readings and possibly appearing static.

Diagnosing with Fuel Trims

Knowing whether a vehicle is running too rich, or too lean will help narrow down diagnosis. Fuel trims that differ greatly from one cylinder bank to the other will also provide key information. Always evaluate fuel trims at idle and at 1500 RPM.

Running too rich – High negative fuel trim corrections can be caused by MAF sensor problems, MAP/BARO sensor problems, leaking fuel injectors, aging O2 sensors and base engine issues such as low compression and incorrect camshaft timing.
Running too lean – High positive fuel corrections can be traced to MAF, MAP/BARO, aging O2 sensors, vacuum leaks, unmetered air leaks, clogged or dirty fuel injectors, fuel quality issues and fuel delivery issues.

Vacuum Leaks vs Fuel Delivery Issues

With the engine idling, look at the Short Term Fuel Trim (STFT) and Long term Fuel Trim (LTFT) values. Normal STFT range may be as high as ± 15%. If the numbers are +15% or higher for STFT and LTFT, the engine is running lean. Increase the engine RPM to 1500 and hold for 30 seconds. If the STFT drops back down to a more normal reading, it confirms the engine has a vacuum leak at idle. This is because vacuum leaks have less of a leaning effect on the fuel mixture as engine speed and load increase. If the fuel trim readings do not change much, the lean fuel condition is more likely due to a fuel delivery problem.

Positive LTFT Readings

When LTFT readings trend positive, it means the ECM is compensating for an air/fuel mixture that is becoming progressively leaner over time. Vacuum leaks, restricted fuel injectors, restrictions in the fuel delivery system, fouled spark plugs that misfire occasionally and incorrect fuel pressure are likely causes. Sensors that affect fuel strategy can also cause a lean condition such as MAP, MAF, Fuel Pressure, and O2 Sensor.

Negative LTFT Readings

When LTFT readings trend negative, it means the ECM is compensating for an air/fuel mixture that is becoming progressively richer over time. Plugged catalysts causing excessive exhaust back-pressure to build up, ignition system or fuel injectors are likely causes. Sensors that affect fuel strategy can cause a rich condition such as MAP, MAF, Fuel Pressure, and O2 Sensor. An engine that does not go into closed loop will also use more fuel, so any issue that results in the ECM thinking that the engine is still cold can cause a rich condition such as; ECT, IAT, or a stuck open thermostat.

Tools Required

- PowerLink

Evaluating Fuel Trims with PowerLink

Step	Action	Decision
1	Connect PowerLink tool to vehicle. Start engine, click on Data Monitor icon, click on Status Indicators tab and locate Engine Exhaust Gas Oxygen Sensor Closed Loop Operation, Bank 1 and Bank 2. The gray dot should turn to green for Closed Loop – using oxygen sensors as feedback for fuel control on both banks 1 and 2 within 1-5 minutes of runtime. ***Figure 3.4.1** Does the engine go into closed loop on both banks as it warms up?	Yes: Go To Step 2 No: Go To Step 4

Step	Action	Decision
2	With engine at or above 104F engine coolant temp. In the PowerLink data monitor screen click on the Percent tab to monitor Short Term (STFT). It is normal for the STFT to fluctuate as much as ±15%. Monitor the STFT on both banks at idle for 1-2 minutes. ***Figure 3.4.2** Are the Short Term Fuel Trims within Specification ±15%?	Yes: Go To Step 3 No: Go To Step 6

Step	Action	Decision
3	In the PowerLink Data Monitor screen click on the percent tab to monitor Long Term Fuel Trims (LTFT). It is normal for the LTFT to fluctuate as much as ±20%. A normal LTFT reading will appear to stay the same, giving a long-term average of fuel added. Monitor the LTFT on both banks at idle for 1-2 minutes. ***Figure 3.4.2** Are Long Term Fuel Trims within Specification ±20%?	Yes: Go To Step 5 No: Go To Step 6

Step	Action	Decision
4	If the engine will not go into closed loop mode within a few minutes of startup then there is a possibility that either the thermostat is stuck open (engine coolant temp always cooler than normal) or ECT sensor has faulted within range • ECT – Cold soak engine and compare ECT to ambient temp • Thermostat – Once ECT sensor operation has been verified, ensure engine gets up to operating temperature. • Active engine faults will keep the engine from entering closed loop, these faults need to be addressed first. Depending on what type of fault it is (Type A, B or C) it may take up to 2 key cycles before a fault appears. Have all the criteria been met?	Yes: Verify that all other engine/fuel system issues have been repaired and no faults are active. No: Diagnose and repair issue. Re-evaluate fuel trims after repair is made.

Step	Action	Decision
5	When evaluating fuel trims, it is common to see a small difference (0-10%) in fuel trims from one bank to the other. A larger difference in bank to bank fuel trims could indicate an issue that is isolated to 1 of the 2 banks. The ECM strategy is that each bank works independently of the other to control air/fuel ratio to the ideal 14.7:1 for gasoline. Possible causes for fuel trim bank to bank discrepancy: • Fuel system components • Ignition system components • Engine mechanical issues • Vacuum and/or exhaust leak • Faulty O2 sensor Are fuel trim readings within 10% bank to bank at idle with the engine up to temp?	Yes: Go To Step 6 No: For the Bank furthest from 0% if positive see Lean Fuel Trim diagnostics below. If negative from 0% see Rich Fuel Trim diagnostics below.

Step	Action	Decision
6	Bring engine to 1500rpm and hold steady for 1-2 minutes. Monitor both LTFT's and STFT's. It is normal for the STFT to fluctuate as much as ±15%. It is normal for the LTFT to fluctuate as much as ±20%. A normal LTFT reading will appear to stay the same, giving a long-term average of fuel added. ***Figure 3.4.2CP** Are fuel trims within specification (STFT ±15%) (LTFT ±20%) at 1500rpm?	Yes: If fuel trims were not in specification at idle but are at 1500rpm then refer to Air Management System Diagnostics. No: Go To Step 7

Step	Action	Decision
7	When Fuel Trim readings are out of specification, it means the ECM is compensating for an air/fuel mixture that is rich or lean. When Fuel Trim readings are negative, it means the ECM is compensating for an air/fuel mixture that is rich. When Fuel Trim readings are positive, it means the ECM is compensating for an air/fuel mixture that is lean. ***Figure 3.4.4** Are the Fuel Trim readings excessively positive or negative?	Positive: Go To Step 8 Negative: Go To Step 9

Step	Action	Decision
8	When Fuel Trim readings are positive, it means the ECM is compensating for an air/fuel mixture that is **lean**. You can graph Fuel Trims by selecting the Data Groups tab in the Data Monitor. ***Figure 3.4.3** Possible causes for positive fuel trim readings: • Vacuum leaks • Restricted fuel injectors • Restrictions in fuel delivery system • Fouled spark plugs • Incorrect fuel pressure • MAP, MAF, ECT, IAT, Fuel Pressure and O2 sensors not reading correctly Note: If a lean fault has set, follow the diagnostic procedure for the specific code.	Refer to **Section 3.6 System Lean** to diagnose.

Step	Action	Decision
9	When Fuel Trim readings are negative, it means the ECM is compensating for an air/fuel mixture that is **rich**. You can graph Fuel Trims by selecting the Data Groups tab in the Data Monitor. ***Figure 3.4.3** Possible causes for negative fuel trim readings: • Plugged Catalysts/excessive back-pressure • Fuel delivery system components • Stuck open thermostat • MAP, MAF, ECT, IAT, Fuel Pressure and O2 sensors not reading correctly Note: If a rich fault has set, follow the diagnostic procedure for the specific code.	Refer to **Section 3.5 System Rich** to diagnose.

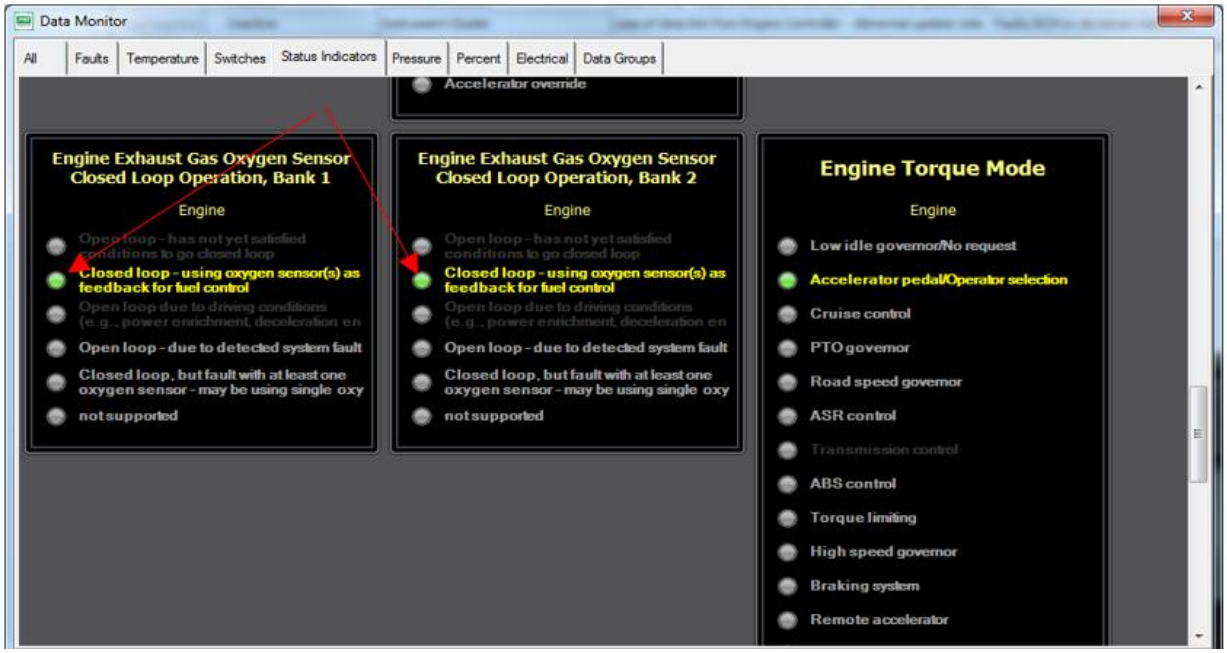


Figure 3.4.1 Status Indicators page showing vehicle in closed loop – using oxygen sensors as feedback for fuel control.



Figure 3.4.2 Short Term and Long Term fuel trims on Percent page of PowerLink Data Monitor. Engine at idle in example shown.



Figure 3.4.3 STFT and LTFT graphed. Engine at idle in example shown.



Figure 3.4.4 Example of LTFTs showing a lean condition on both banks. Engine at idle in example shown.

3.5 Rich Fuel Trim Diagnostics

Overview

The ideal stoichiometric air/fuel (A/F) for gasoline it is 14.7:1 (by mass). The Engine Control Module (ECM) will attempt to operate at the ideal gasoline ratio. The primary input for monitoring air/fuel ratio is the “sensor 1” O2 sensor, or the first O2 sensor in the exhaust stream closest to the engine. The O2 sensor will report oxygen levels in the exhaust as a voltage to the ECM. The absence of oxygen will be a high O2 sensor voltage and interpreted as a “Rich” condition. The ECM will remove fuel resulting in a Negative fuel trim.

NOTE: Completely diagnose and repair any DTCs or drivability symptoms prior to beginning diagnosis of excessive fuel trim readings

Negative LTFT Readings

When LTFT (Long Term Fuel Trim) readings trend negative, it means the ECM is compensating for an air/fuel mixture that is becoming progressively richer over time. Plugged catalysts causing excessive exhaust back-pressure to build up, ignition system or fuel injectors are likely causes. Sensors that affect fuel strategy can cause a rich condition such as MAP, MAF, Fuel Pressure, and O2 Sensor. An engine that does not go into closed loop will also use more fuel, so any issue that results in the ECM thinking that the engine is still cold can cause a rich condition such as; ECT, IAT, or a stuck open thermostat.

Diagnostic Tips

- Bank 1 is the Left-Hand Side of engine (as viewed from the flywheel), also side of the engine that has cylinder #1
- Bank 2 would be on the Right-Hand Side of engine (as viewed from the flywheel)

Tools Needed

- PSI PowerLink
- Digital Multimeter (DMM)
- OEM Recommended Leak Tester
- Fuel Pressure Gauge – CH-48027
- MAP sensor breakout harness - 69000045
- O2 Sensor Breakout harness - 69000046

Test Procedure - Rich Fuel Trim Diagnostics

Step	Action	Decision
1	Verify there are no fault codes present. Are any other fault codes present?	Yes: Diagnose and repair other fault codes then refer to “Evaluating Fuel Trims with PowerLink.” No: Go To Step 2

Step	Action	Decision
2	Perform section **3.7 Engine Intake and Exhaust Leaks** Were any issues found?	Yes: Repair and retest. No: Go To Step 3

Step	Action	Decision
3	Perform Section **3.9 Fuel Supply System Diagnosis**. Were any issues found?	Yes: Repair and retest. No: Go To Step 4

Step	Action	Decision
4	Perform Section **3.10 Fuel Injector Diagnostics**. Were any issues found?	Yes: Repair and retest. No: Go To Step 5

Step	Action	Decision
5	Perform section **3.15 Oxygen Sensor (O2S) Operational Test**. Were any issues found?	Yes: Repair and retest. No: Go To Step 6

Step	Action	Decision
6	Perform section **3.17 MAP Sensor Operational Test**. Were any issues found?	Yes: Repair and retest. No: Go To Step 7

Step	Action	Decision
7	Perform section **3.18 MAF Sensor Operational Test**. Were any issues found?	Yes: Repair and retest. No: Go To Step 8

Step	Action	Decision
8	Perform section **3.1 Base Engine Diagnostics**. Were any issues found?	Yes: Repair and retest. No: Go To Step 9

Step	Action	Decision
9	Perform section **3.12 Testing Contaminated Fuel.** Were any issues found?	Yes: Repair and retest. No: Reevaluate concern.

3.6 Lean Fuel Trims

Overview
The ideal stoichiometric air/fuel (A/F) for gasoline it is 14.7:1 (by mass). The Engine Control Module (ECM) will attempt to operate at the ideal gasoline ratio. The primary input for monitoring air/fuel ratio is the “sensor 1” O2 sensor, or the first O2 sensor in the exhaust stream closest to the engine. The O2 sensor will report oxygen levels in the exhaust as a voltage to the ECM. The presence of oxygen will be a low O2 sensor voltage and interpreted as a “Lean” condition. The ECM will add fuel resulting in a Positive fuel trim.

NOTE: Completely diagnose and repair any DTCs or drivability symptoms prior to beginning diagnosis of excessive fuel trim readings

Positive LTFT Readings

When LTFT (Long Term Fuel Trim) readings trend positive, it means the ECM is compensating for an air/fuel mixture that is becoming progressively leaner over time. Vacuum leaks, restricted fuel injectors, restrictions in the fuel delivery system, fouled spark plugs that misfire occasionally and incorrect fuel pressure are likely causes. Sensors that affect fuel strategy can also cause a lean condition such as MAP, MAF, Fuel Pressure, and O2 Sensor.

Diagnostic Tips

- Bank 1 is the Left-Hand Side of engine (as viewed from the flywheel), also side of the engine that has cylinder #1
- Bank 2 would be on the Right-Hand Side of engine (as viewed from the flywheel)

Tools Needed

- PSI PowerLink
- Digital Multimeter (DMM)
- Leak Locator Kit
- Fuel Pressure Gauge – CH-48027
- MAP sensor breakout harness - 69000045
- O2 Sensor Breakout harness - 69000046

Test Procedure – Lean Fuel Trim Diagnostics

Step	Action	Decision
1	Verify there are no fault codes present. Are any other fault codes present?	Yes: Diagnose and repair other fault codes then Perform section "Evaluating Fuel Trims with PowerLink." No: Go To Step 2

Step	Action	Decision
2	Perform section **3.7 Engine Intake and Exhaust Leaks**. Were any issues found?	Yes: Repair and retest. No: Go To Step 3

Step	Action	Decision
3	Perform section **3.9 Fuel Supply System Diagnostics.** Were any issues found?	Yes: Repair and retest. No: Go To Step 4

Step	Action	Decision
4	Perform section **3.10 Fuel Injector Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 5

Step	Action	Decision
5	Perform section **3.15 Oxygen Sensor (O2S) Operational Test**. Were any issues found?	Yes: Repair and retest. No: Go To Step 6

Step	Action	Decision
6	Perform section **3.17 MAP Sensor Operational Test.** Were any issues found?	Yes: Repair and retest. No: Go To Step 7

Step	Action	Decision
7	Perform section **3.18 MAF Sensor Operational Test**. Were any issues found?	Yes: Repair and retest. No: Go To Step 8

Step	Action	Decision
8	Perform section **3.1 Base Engine Diagnostics**. Were any issues found?	Yes: Repair and retest. No: Go To Step 9

Step	Action	Decision
9	Perform section **3.12 Testing Contaminated Fuel**. Were any issues found?	Yes: Repair and retest. No: Reevaluate concern.

3.7 Engine Intake and Exhaust Leaks
Leak Locator Instructions for PSI Engines

WARNING: Read all safety instructions in the "Safety Information" section of the *Engine Service Manual* or *Engine Diagnostic Manual* to prevent personal injury or death.

WARNING: Park vehicle on hard flat surface, turn the engine off, set the parking brake, and install wheel chocks to prevent the vehicle from moving in either direction. Failure to comply may result in property damage, personal injury, and / or death.

WARNING: Always wear safe eye protection when performing vehicle maintenance. Failure to comply may result in personal injury and / or death.

WARNING: To prevent personal injury or property damage do not exceed 2psi of pressure in the intake or exhaust systems.

Note: Review Tool Instructions in full before attempting to use this tool on the PSI 6.0L engine equipped vehicles.

Tools Required
OEM Recommended Leak Locator
Tool Instruction Leak Locator
Hose pinch-off pliers – Locally
3/8" vacuum cap

3.7.1 Intake Smoke Test

Overview
Smoke testing the intake is used to detect leaks in the Air Management System. Induction system and vacuum leaks can lead to such conditions such as running rich or lean, inaccurate mass air flow readings, elevated engine idle, inaccurate torque calculations, engine surging, and more. Please review all safety precautions before proceeding with smoke testing the Air Management System. **Never pressurize to more than 2psi**, over pressurization of the intake can lead to property damage and injury.

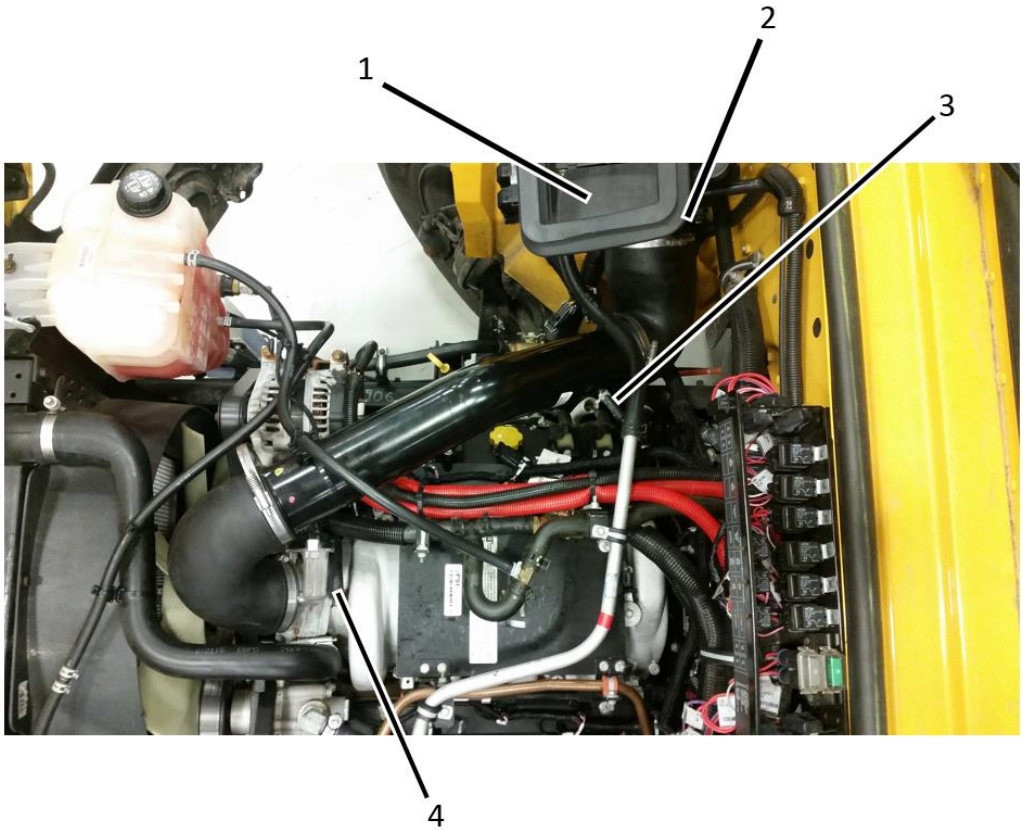


Figure 3.7.1: PSI 8.8L Air Management System

1. Intake Air Box
2. Air intake piping
3. Crankcase Fresh Air Inlet (PCV system)
4. Crankcase Outlet to Intake Manifold (PCV system)

PSI 6.0L Air Intake Leak Test Tool Installation

1. Remove Intake Air Box (Figure 3.7.1, Item 1) and set to the side.

2. Install Graduated Intake Adapter into air intake piping (Figure 3.7.1, Item 2) with clamp.

3. Remove the Crankcase Fresh Air Inlet (Figure 3.7.1, Item 3) from air intake piping (Figure 3.7.1, Item 2). Install vacuum cap into air intake piping (Figure 3.7.1, Item 2).

4. Using hose pinch-off pliers, clamp crankcase outlet to intake manifold hose (Figure 3.7.1, Item 4).

5. See tool instruction sheet to perform Intake Smoke Test.

PSI 6.0L Air Intake Leak Test Tool Removal

1. Remove hose pinch-off pliers from crankcase outlet to intake manifold hose (Figure 3.7.1, Item 4).

2. Remove vacuum cap from air intake piping (Figure 3.7.1, Item 2). Install the Crankcase Fresh Air Inlet (Figure 3.7.1, Item 3) into air intake piping (Figure 3.7.1, Item 2).

3. Remove Graduated Intake Adapter from air intake piping (Figure 3.7.1, Item 2).

4. Install Intake Air Box (Figure 3.7.1, Item 1) and torque.

3.7.2 Exhaust Smoke Test Instructions

Overview

Smoke testing the exhaust is used to detect leaks in the Exhaust System. An exhaust leak can lead to conditions such as simulating lean conditions and codes, fumes in or around the cab, engine running rough or surging, and loud engine operation. Please review all safety precautions before proceeding with smoke testing the Exhaust System. **Never pressurize to more than 2psi**, over pressurization of the exhaust can lead to property damage and injury.

PSI 6.0L Exhaust Leak Test Tool Installation

1. Remove exhaust diffuser and set to the side.

2. Install properly sized tailpipe adapter into tailpipe and inflate per OEM Recommended Leak Locator Operation Manual.

3. Connect Leak Locator supply line to tailpipe adapter.

4. See tool instruction sheet to perform Intake Smoke Test.

PSI 6.0L Exhaust Leak Test Tool Removal

1. Remove Leak Locator supply line from tailpipe adapter.

2. Deflate tailpipe adapter and remove from the tailpipe per Leak Locator Operation Manual.

3. Install exhaust diffuser and torque.

3.8 Throttle Plate Operational Test and Cleaning

System Overview

During normal operation oil deposits and dirt can buildup on the Throttle Plate and Throttle Bore. This may cause the Throttle function to become lagged or impaired. A sticking Throttle Plate may cause a hesitation during acceleration or a lag in response on a deceleration. When cleaning the Throttle Plate, never spray solution directly on or in the Throttle Body assembly. Lightly wet a rag or non-shedding towel and wipe the Throttle Plate and Bore out. Directly spraying cleaner on the Throttle Plate could result in premature Throttle Body failure. If deposits are extensive in certain areas, a soft nylon bristled brush can be used to clean.

Diagnostic Tips

- Key OFF and Disconnect Throttle Body connector when servicing Throttle Body
- DO NOT spray cleaner directly on the Throttle Plate or Bore.
- Use a clean lint-free rag to wipe out Throttle or soft bristled brush for extensive buildup.

Tools Required

- Brake or Parts cleaner (locally)
- Lint-Free rag
- Soft nylon bristled brush
- Flathead Screwdriver

WARNING! Personal Injury can occur if the vehicle ignition key is not turned OFF with the Throttle Body connector DISCONNECTED. Do not attempt to inspect or clean Throttle Plate without ensuring both conditions are met!

CAUTION! DO NOT directly spray Throttle Body or Plate with cleaning solvent. Failure to do so may result in premature failure or damage to Throttle Body components.

Test Procedure - Throttle Plate Operational Test and Cleaning

Step	Action	Decision
1	Key OFF, disconnect Throttle Body connector. Remove air intake duct from Throttle Body. Without removing Throttle Body, inspect Throttle Plate and Bore. Is Throttle Plate and Bore in good condition and free of damage, debris, or blockages?	Yes: Go To Step 2 No: Repair and retest.

Step	Action	Decision
2	Does Throttle Plate or Bore have a buildup of deposits? See **Figure 3.8.1** below.	Yes: Go To Step 3 No: Go To Step 4

Step	Action	Decision
3	Lightly wet a lint-free rag and/or soft nylon bristled brush, clean Throttle Plate and Throttle Bore. See **Figure 3.8.2** and **Figure 3.8.3** below. Cleaning tips: • Do not spay Throttle Plate or Bore directly with cleaner. • Lightly wet towel or brush to wipe clean. • Do not remove Throttle Body to clean. • Do not use abrasive materials. • Clean the Throttle Plate and Bore before cleaning the pivot points. Did Throttle Plate and Bore come clean?	Yes: Go To Step 4 No: If deposits cannot be removed and it inhibits Throttle Plate range of motion replace Throttle Body. Otherwise Go To Step 4.

Step	Action	Decision
4	Move Throttle Plate by hand. Sweep to wide open and then allow it to return to a closed position. Press Throttle Plate fully closed and then release. See **Figure 3.8.4** below. Does Throttle Plate move freely without sticking?	Yes: End Diagnostics. No: Replace Throttle Body and retest.

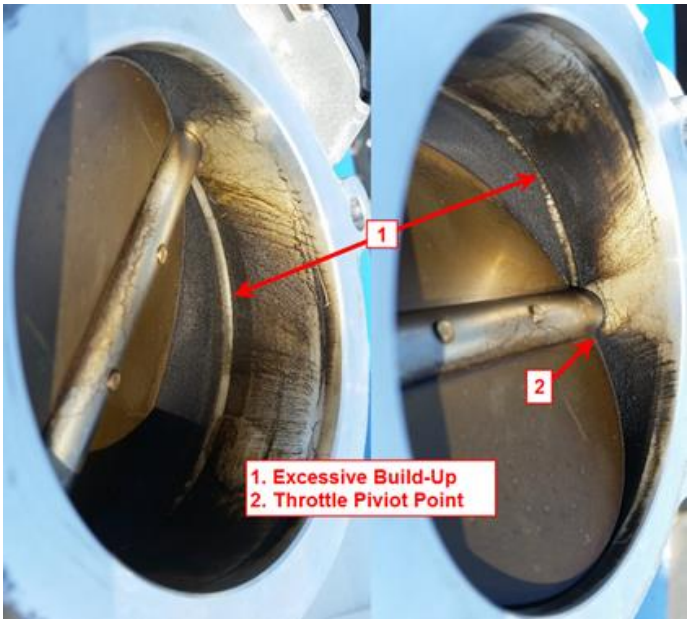


Figure 3.8.1: Excessive buildup in the Throttle Bore and Throttle Plate (Item 1). Buildup will also occur at the pivot point (Item 2).



Figure 3.8.2: Throttle Plate and Bore being cleaned with a clean, lightly wetted rag. Note the edges of the Throttle Plate have been cleaned.



Figure 3.8.3: Throttle pivot points being cleaned with a lightly wetted soft bristled brush.

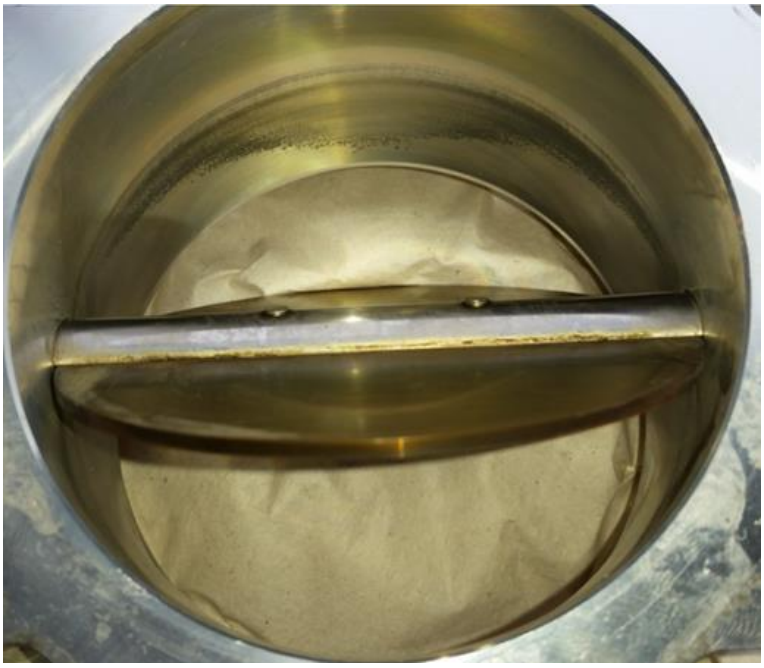


Figure 3.8.4: Cleaned Throttle Bore (viewed with Throttle removed). Some light wear similar to what is shown is acceptable.

3.9 Fuel Supply System Diagnostics

Gasoline Fuel Supply System Overview
The Engine Control Module (ECM) activates the fuel pump relay when the ignition switch is turned ON. The ECM will turn the fuel pump off after 30 seconds if no engine RPM is detected. When engine RPM is detected with the ignition switch in the ON position, the ECM activates the fuel pump relay. Fuel pressure is regulated internal to the fuel pump by a mechanical regulator.

The fuel pump, tank and associated components are installed by the chassis/vehicle manufacturer.

Tools Required – 6.0L Gasoline
- Fuel Pressure Gauge – CH-48027

Step-Based Diagnostic Routine

Step	Action	Decision
1	A. Key OFF B. Relieve fuel pressure **Note: To relieve fuel pressure, start engine and remove fuel pump relay, and allow engine to consume fuel within fuel rail.** C. Remove fuel line from rail, and install fuel pressure gauge adapter and fuel pressure gauge to fuel rail, and the fuel line D. Install fuel pressure gauge Key ON, allow fuel to fill fuel rail and observed fuel pressure. Is fuel pressure 58 psi ± 3 psi (4 bar ± 0.2 bar)?	Yes: Go To Step 2 No: Go To Step 2

Step	Action	Decision
2	A. Key OFF B. Fuel pressure gauge and adapter fully installed Start engine and observe fuel pressure. Is fuel pressure 58 psi ± 3 psi (4 bar ± 0.2 bar)?	Yes: Go To Step 4 No: Go To Step 3

Step	Action	Decision
3	A. Key OFF B. Fuel pressure gauge and adapter fully installed C. Relieve fuel pressure **Note: To relieve fuel pressure, start engine and remove fuel pump relay, and allow engine to consume fuel within fuel rail.** D. Remove fuel supply line from fuel rail Inspect rail for debris or blockage between fuel supply line connection and Schrader valve. Was any debris or blockage found?	Yes: Clean out debris or blockage from fuel rail, if necessary, replace fuel rail and retest. No: See OEM Diagnostics.

Step	Action	Decision
4	A. Key OFF B. Install fuel pressure gauge to Schrader valve on fuel rail C. Carefully route fuel gauge into vehicle cabin With assistance of another person, one person test drive the vehicle, while the other monitors fuel pressure. Observe fuel pressure in various conditions and under various engine loads. Does fuel pressure drop below 58 psi ± 3 psi (4 bar ± 0.2 bar)?	Yes: See OEM Diagnostics. No: End diagnostics.

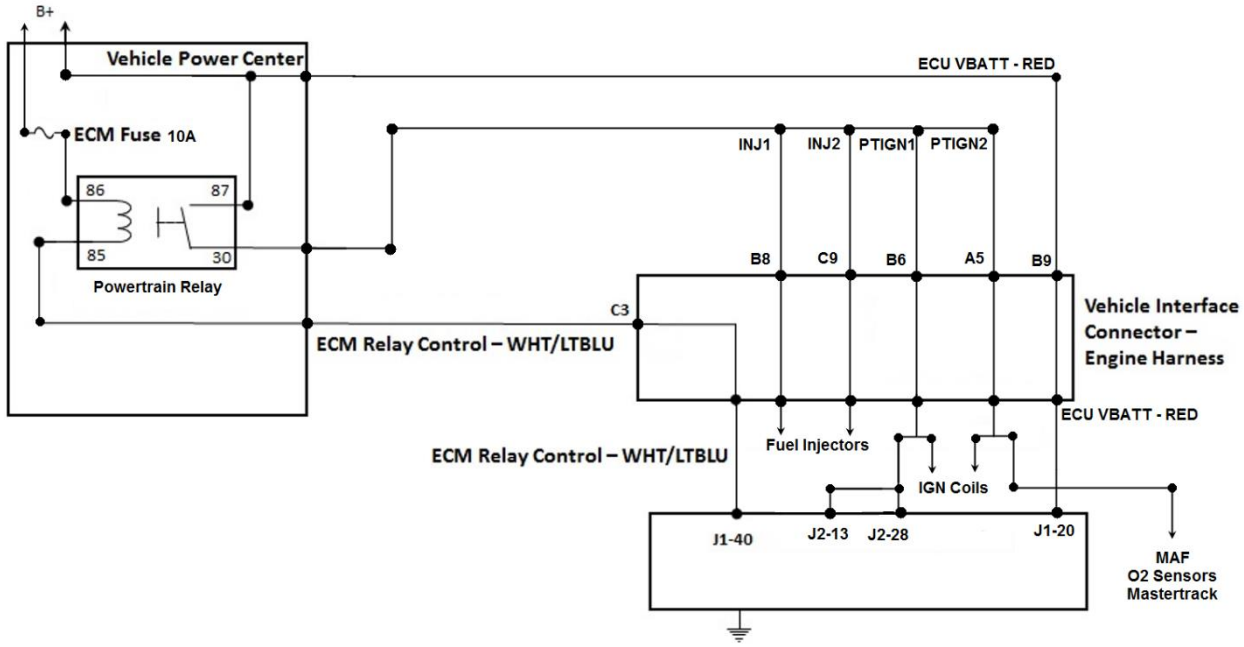
Please reference the OEM manual as fuel supply components are installed by the chassis/vehicle manufacturer.

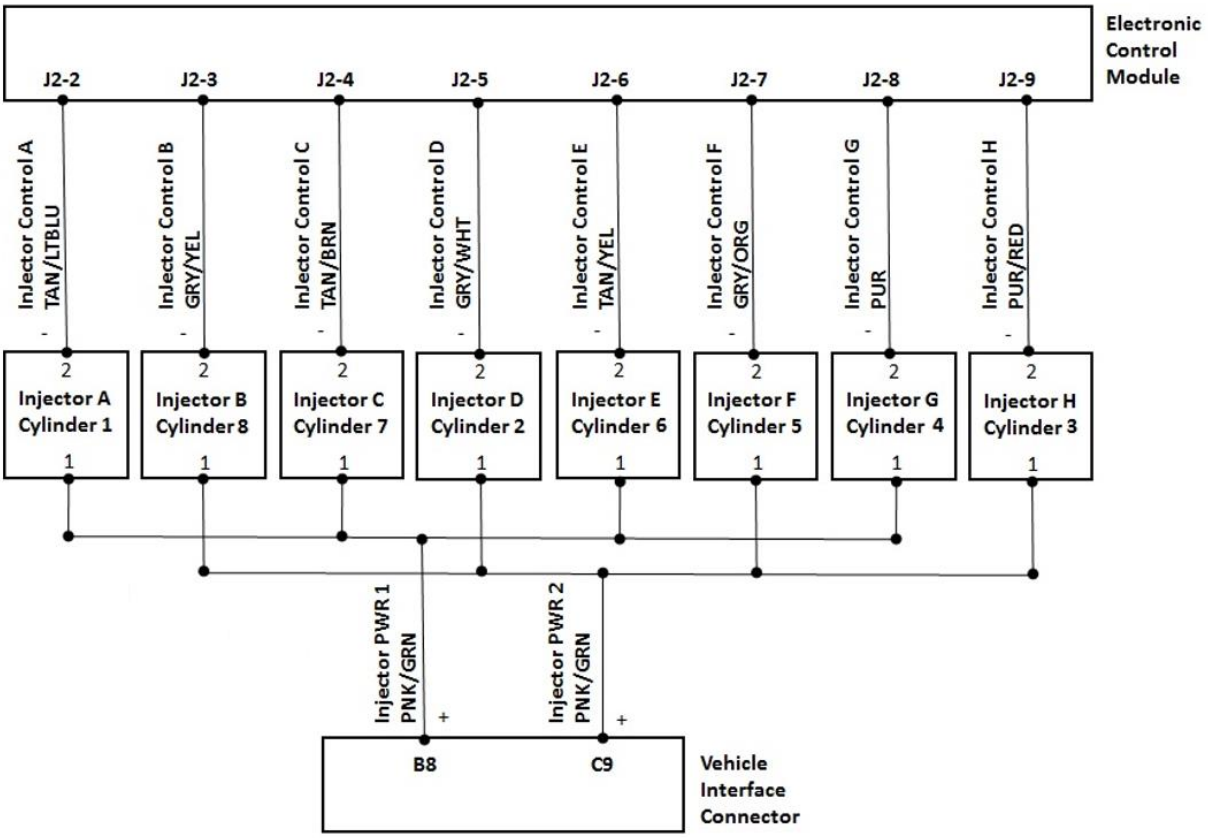
3.10 Fuel Injector Diagnostics

System Description

There is one fuel injector per cylinder of the engine. Gasoline is supplied directly to the injector though the fuel rail. The fuel flows through an internal filter at the injector. If this screen becomes clogged the injectors flow rate will be decreased. This will limit performance of the injector and can cause a misfire or low power cylinder.

Ignition voltage is supplied through the powertrain relay, injector fuses, then to each fuel injector. The Engine Control Module (ECM) provides the appropriate injector timing and pulse width by individually grounding each control circuit. A fuel injector coil winding resistance that is too high or too low will affect the engine drivability. A fuel injector control circuit SPN may not set, but a misfire or rough running condition may be apparent. The fuel injector coil windings are affected by temperature. The resistance of the fuel injector coil windings will increase as the temperature of the fuel injector increases.





Diagnostic Tips

- Fuel injectors have the potential to fail mechanically open causing poor fuel economy. Listen for an audible hissing sound with the Key ON and OFF. This condition may be accompanied by an SPN.
- Operating the vehicle over a wide temperature range may help isolate the fuel injector that is causing the condition.
- Test for intermittent or poor connections.
- Test for injector circuits shorted to the fuel injector body.

Required Tools

- Digital Multi Meter (DMM)
- PowerLink
- Fuel Injector Breakout Harness ZTSE4831
- Noid Light J-34730-2C

Circuit/System Verification

WARNING! Wear proper protective gear when handling or working with gasoline. Proper gear includes but is not limited to goggles, gloves, clothing, eye and respiratory protection.

WARNING! To prevent bodily injury or death, stay away from hot engine surfaces and rotating engine components.

Test Procedure - Fuel Injector Diagnostics

Step	Action	Decision
1	Key ON, perform visual inspection of each injector on both banks for signs of leaks. Were any injectors leaking?	Yes: Replace suspected injector(s) and retest. No: Go To Step 2

Step	Action	Decision
2	A. Key OFF B. Disconnect all Fuel Injector Harness Connectors. C. Check all Fuel Injector Harness Connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Are all Fuel Injector connectors, harnesses, and terminals clean and undamaged?	Yes: Go To Step 3 No: Repair connector, harness, or terminal damage. After repairs are complete, retest for DTC.

Step	Action	Decision
3	Perform the following resistance test under both ECT conditions. Install breakout harness ZTSE4831 onto fuel injector, leaving it disconnected from injector harness. 1. With ECT between 50–90°F (10–32°C), on each injector measure resistance between (terminal 1) and (terminal 2). 2. With ECT greater than 90°F (32°C), on each injector measure resistance between (terminal 1) and (terminal 2). With ECT between 50–90°F (10–32°C), are all injector resistances between 10–14 Ω? With ECT greater than 90°F (32°C), is difference between the lowest and highest resistance value equal to or less than 3 Ω?	Yes: Go To Step 4 No: Replace suspected injector(s) and retest.

Step	Action	Decision
4	Disconnect ALL fuel injector connectors from fuel injectors. Install Noid Light J-34730-2C to each fuel injector harness and crank engine. Does Noid light flash at each injector during engine cranking? Note: Disconnecting injectors and cranking engine will set SPNs.	Yes: End Diagnostics No: Perform SPN 651-658 diagnostics for suspected injector harness and retest.

3.11 Fuel Level Monitoring System Diagnosis

NOTE: Please reference the OEM manual as fuel level monitoring components are installed by the chassis/vehicle manufacturer.

System Overview

The fuel level Sending Unit Assembly is a potentiometer located on the fuel tank assembly and is attached to the Fuel Level Sensor, a float mechanism. As the float mechanism raises and lowers it changes the resistance within the potentiometer, thus changing the voltage drop through the sensor. Resistance through the sensor is lowest with the tank full (40 ohms) and highest with the tank empty (250 ohms). The sensor has two circuits; a signal and a low reference. On a system with two tanks, the low reference is shared between the two sensors.

Float Level	Resistance (ohms)
	Min
Empty Tank	250
Full Tank	40

Note: Fuel Level Sensor “A” refers to Fuel Level Sensor 1 located in the primary fuel tank. Fuel Level Sensor “B” refers to Fuel Level Sensor 2 located in the secondary fuel tank if one is present.

On a dual tank system, the fuel level reading of the two sensors is averaged and displayed on the fuel gauge. As the fuel level in tank one decreases, fuel from tank two will be transferred to tank one. Therefore, it is possible for the fuel gauge to read half a tank, yet run out of fuel if the fuel pump for tank 2 fails or opens a fuse.

3.12 Testing for Contaminated Fuel

NOTE: Please reference the OEM manual as the fuel tank and associated components are installed by the chassis/vehicle manufacturer.

Overview
Contaminated gasoline has been known to cause drivability concerns. There are many ways gasoline in the fuel system can become contaminated. In some cases, the problem can be as wide spread as the supply chain of the gasoline itself. The contamination could also be caused by an internally failed part on one vehicles fuel system.

3.13 Inspecting for Fuel Leaks

Overview

All fuel components, less fuel rail and injectors are supplied and installed by the chassis/vehicle manufacturer. Once fuel rail and injectors have been inspected as instructed below, refer to OEM manual for further instruction.

Test Procedure - Inspecting for Gasoline Leaks

Step	Action	Decision
1	Key ON and OFF 3 times to prime the fuel system. Visually inspect fuel injectors and fuel rail for any signs of leakage. Has the leakage area been identified?	Yes: Replace leaking component. No: Go see OEM manual for further instruction.

3.14 Ignition System Inspections and Diagnostics

Overview
The ignition coil delivers a spark to the cylinder in the same sequence as the ignition firing order. The ECM matches delivery of the spark with fuel delivery and intake valve timing to deliver the desire power output from the engine.
The ignition system in this application uses Coil-On-Plug technology with four circuits; 12V Ignition Power, Coil Ground, Ignition Control, and Low Reference Return. 12V Ignition Power is supplied through the Vehicle Interface Connector (VIC) after originating in the Vehicle Power Center. Ground for the coil is provided through the VIC and back to the chassis/battery ground. An igniter within the ignition coil is controlled by the ignition control circuit from the ECM and after being triggered returns low reference back to the ECM.
Diagnosis of the ignition system includes:

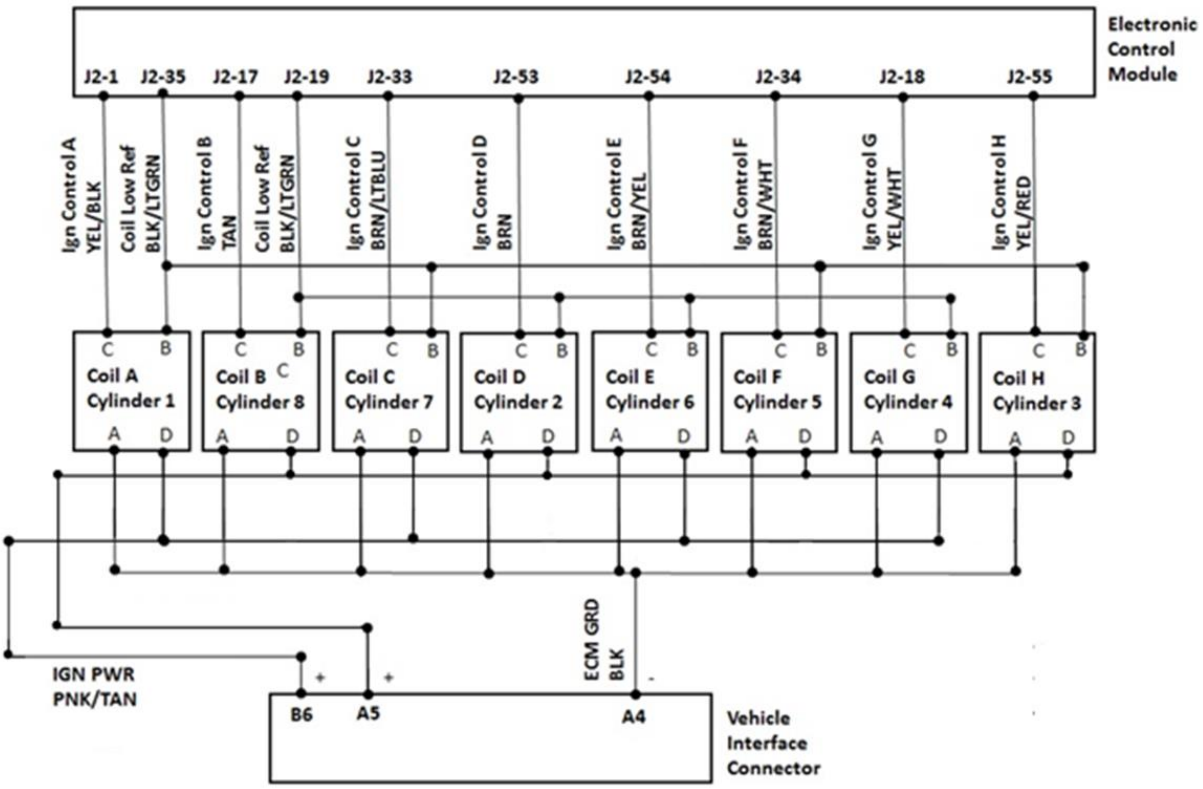
- Verifying the Ignition Coils are generating consistent spark
- Verifying the spark plugs are in good operating condition
- Verifying the Knock Sensors are functioning properly
- Verifying the engine is in good mechanical condition
- Verifying the fuel injectors are functioning properly

Tools Required

- PSI PowerLink
- DMM
- Spark Tester - OTC6589
- Spark Plug Boot Puller – SES824A
- Spark Plug Gapping Tool - Locally

Diagnostic Tips

- After removing a spark plug wire visually confirm the wire did not come apart, check the spark plug and ensure the clip did not pull out of the wire.
- The condition of the spark plug can indicate an issue with a cylinder
- PTIGN1 fuse powers the ignition coils for cylinders 1, 7, 6, 4
- PTIGN2 fuse powers the ignition coils for cylinders 8, 2, 5, 3



WARNING: To prevent property damage, personal injury, and / or death, NEVER perform ignition system testing near open fuel sources.

WARNING: To prevent property damage, personal injury, and / or death, NEVER touch or reseat spark tester with the engine running.

Test Procedure - Ignition System Inspections and Diagnostics

Step	Action	Decision
1	Check PTIGN1 and PTIGN2 fuses in the Vehicle Power Center Are either fuses blown?	Yes: See SPN 1268, 1275, 1274, 1269, 1273, 1272, 1271, 1270 for further diagnostics. No: Go To Step 2

Step	Action	Decision
2	With the engine OFF, wiggle test and lightly pull all spark plug wires from the coil and spark plugs. Are all spark plug wires fully seated and tight?	Yes: Go To Step 3 No: Repair and retest.

Step	Action	Decision
3	Using OTC6589 Spark Tester, perform the following for ALL cylinders, one at a time, before continuing. 1. With the Key OFF 2. Remove spark plug wire from spark plug and ignition coil. 3. Inspect connector ends and wire for issues, replace if necessary. 4. Measure spark plug wire resistance, replace if necessary (Spec 980-1470 ohms per foot) 5. Reinstall spark plug wire onto ignition coil 6. Install Spark Tester OTC6589 7. Clip Spark Tester to nearest grounding bolt 8. Start the engine and monitor spark Does the ignition coil generate consistent spark on every cylinder?	Yes: Go To Step 4 No: See SPN 1268, 1275, 1274, 1269, 1273, 1272, 1271, 1270 for further diagnostics on each suspected coil.

Step	Action	Decision
4	Remove the spark plugs and inspect the ends for the following 1. Damage (Melting or deformation) 2. Electrode Deterioration 3. Discoloration 4. Body Cracks 5. Excessive Deposit Build-up 6. Proper Gapping (0.030” – 0.035”) *Note, for the gasoline engine, spark plugs come gapped from the manufacturer. Do not attempt to re-gap or measure spark plug gap as damage to the spark plug can occur and cause a misfire, or in extreme cases, engine damage is possible. Are the spark plugs in good condition and properly gapped?	Yes: End Diagnostics. No: Replace spark plug or repair concern. If spark plug indicates possible combustion issues or cylinder damage, Perform **3.1 Base Engine and Compression Diagnostics.**

3.15 Oxygen Sensor (O2S) Operational Test

O2S Description
The O2 sensor (O2S) uses a ceramic and platinum probe that generates voltage based on the difference in oxygen in the exhaust gas and air external to the exhaust system. The sensor will generate around 0.9 volts when the fuel mixture is rich meaning there are lower amounts of oxygen in the exhaust. When the air/fuel mixture is lean and there are higher amounts of oxygen present in the exhaust, the sensor's output voltage will drop down around 0.1 volts. O2 sensor input is critical to the ECM for managing fuel trims when in closed loop. The ECM will command additional fuel if it perceives a lean condition from either pre-catalyst O2 sensors and reduce fuel when it perceives a rich condition from either pre-catalyst O2 sensors.
To operate, the sensor must be hot (about 600 degrees or higher) before it will generate a reliable voltage signal. Therefore, in order to get the sensor up to operating temperature quickly, a heating element is added to the sensor assembly.
There are a total of four O2 sensors on this vehicle application, two located with the exhaust system for each bank with one before the catalyst and one after. The two located before the catalyst (Bank 1, Sensor 1, and Bank 2, Sensor 1) are the sensors used by the ECM to control fuel trims. The two located after the catalyst (Bank 1, Sensor 2, and Bank 2, Sensor 2) provide data to the ECM regarding catalyst efficiency. However, it is important to understand that all four O2 sensors function the same and are the same part number.

Catalyst Description
The PSI 6.0L Gasoline Engine utilizes two three-way catalytic converters, one for each bank. The purpose of the catalysts are to store oxygen and then use stored oxygen to convert harmful combustion by-products (CO and NOx) and fuel (Hydrocarbons) to less harmful compounds (N_2, O_2, H_2O, CO_2). As a catalyst ages, the storing capacity and conversion of these gases/fuels becomes less efficient and results in higher emissions output of the engine. To detect the catalysts efficiency the ECM uses oxygen content before and after the catalyst because oxygen is stored and used in the conversion process by the catalyst.

$$Carbon\ Monoxide\ (CO) + Oxygen\ (O_2) \rightarrow Carbon\ Dioxide\ (CO_2)$$
$$Hydrocarbons\ (HC) + Oxygen\ (O_2) \rightarrow Water\ (H_2O) and\ Carbon\ Dioxide\ (CO_2)$$
$$Nitrogen\ Oxides\ (NO_x) \rightarrow Nitrogen\ (N_2)\ and\ Oxygen\ (O_2)$$

By observing the downstream O2 Sensor signal, the deterioration of the catalyst can be detected. At idle the engine cycles between rich and lean air/fuel ratios. This causes the pre-catalyst O2 sensor to fluctuate between 0.01V (Lean Fueling - High O2 Content) and 0.9V (Rich Fueling – Low O2 Content) see *Figure 1 below. This exhaust mixture then passes through the catalytic converter which induces a chemical reaction storing and converting the oxygen content of the exhaust. The post-catalyst oxygen sensor signal will remain stable in the low oxygen voltage range (typically higher than 0.5V) with minor fluctuations as the engine cycles between rich and lean air/fuel ratios see *Figure 2 below. As a catalyst ages, it loses the ability to store oxygen and convert the engine by-products efficiently and the post-catalyst oxygen sensor will begin to fluctuate similar to the pre-catalyst oxygen sensor. A catalyst that has lost all storing and converting capabilities will generate a nearly identical pattern on the pre and post catalyst oxygen sensors.

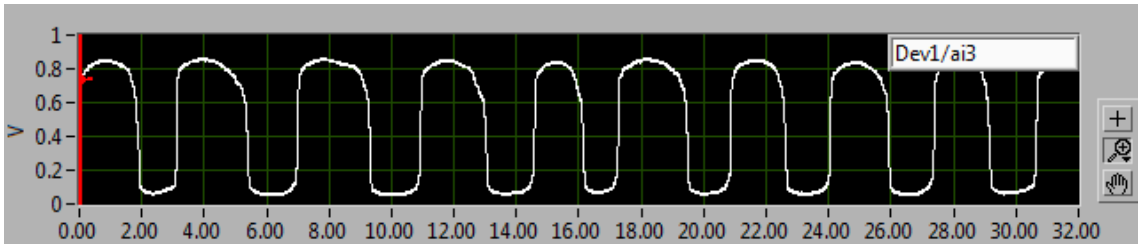


Figure 3.15.1: Typical Pre-Catalyst O2S signal as the engine goes through typical rich and lean stoichiometric ratios

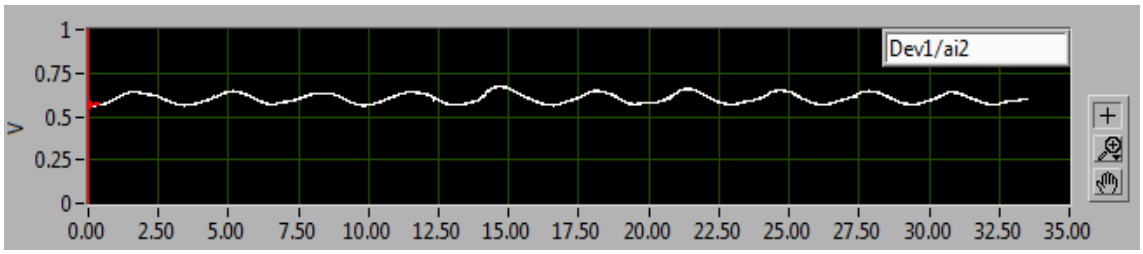
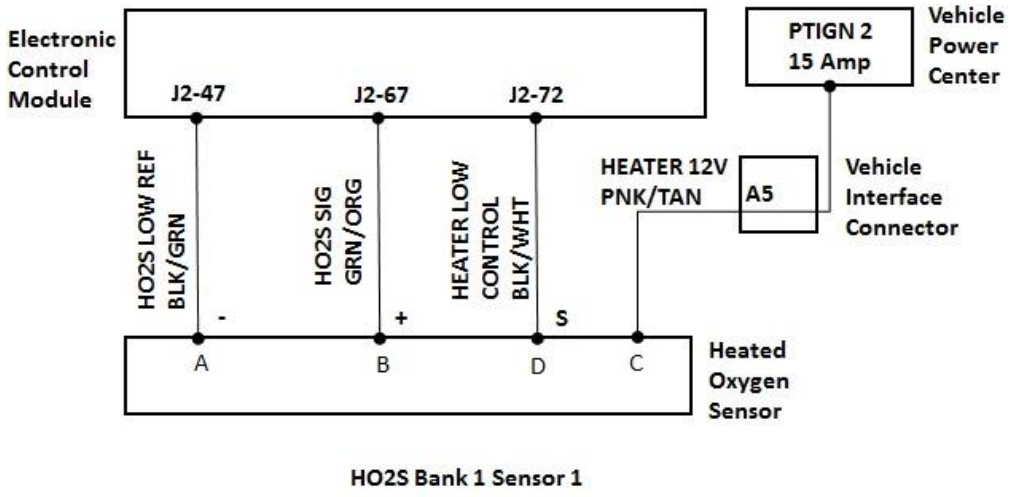
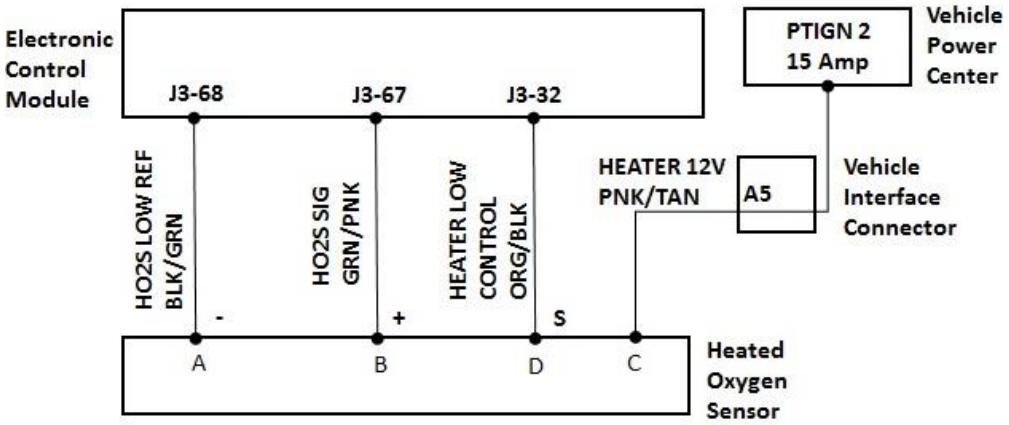
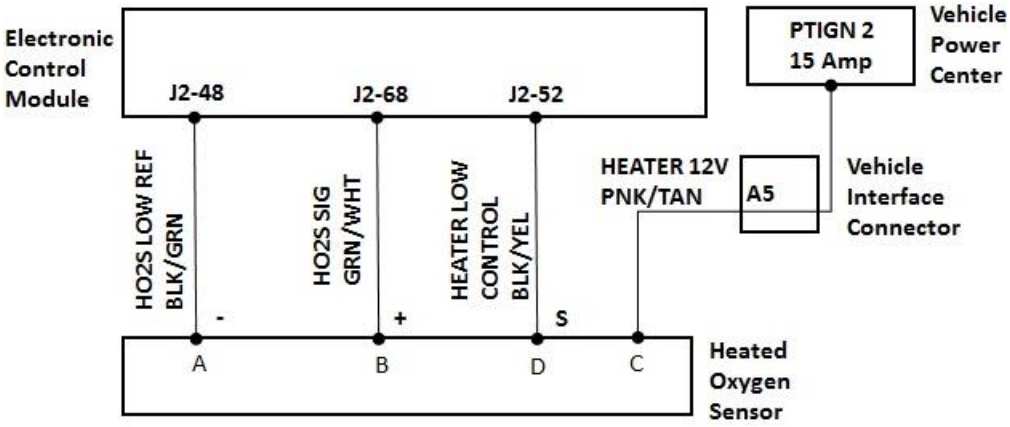


Figure 3.15.2: Typical Post-Catalyst O2S signal. Minor fluctuations follow standard engine stoichiometric ratios but remains above 0.5V due to low oxygen content caused by the catalyst storing and converting oxygen.

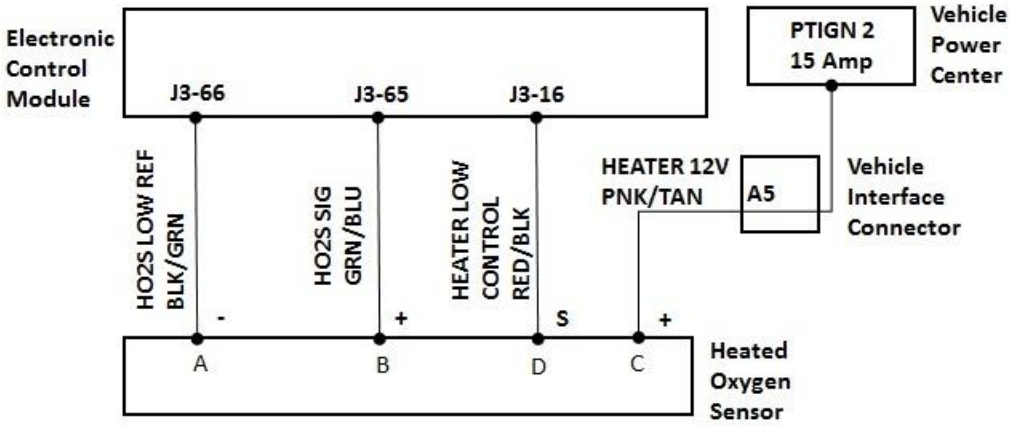




HO2S Bank 1 Sensor 2



HO2S Bank 2 Sensor 1



HO2S Bank 2 Sensor 2

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)
- Automotive Lab Scope (If Available)
- OEM Recommended Leak Locator Kit
- Compressed Air and Soapy Water
- Power / Hand Tools for Removing Exhaust Components
- O2 Sensor Breakout harness - 69000046
- Oxygen Sensor Socket 88750B

Diagnostic Tips

- The O2S signal depends on oxygen content in the exhaust therefore analyzing the O2S signal requires logical understanding of what the sensor is doing and may require a bank to bank comparison.
- Fully read and understand the O2S and Catalyst Description sections of this document before proceeding.
- If using a DMM, understand that the DMM has limited capabilities and sampling rates. If the DMM has a high-resolution feature, enable it. It is preferred to use an automotive lab scope when available.
- The more ineffective the catalytic converter, the more the post-catalyst O2S will resemble the pre-catalyst O2S.

Test Procedure – Oxygen Sensor (O2S) Operational Test

Step	Action	Decision
1	For each exhaust bank, perform the following for both O2S. A. Key OFF B. Visually confirm the catalyst is present and the canister is undamaged C. Visually confirm both of the O2 sensor are fully seated in the exhaust, secure, and undamaged. D. Disconnect the O2 sensors. E. Check the O2 sensor connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Are the O2 sensors, harnesses, and terminals clean and undamaged? Are the sensors fully seated and secure?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. If the sensor is not fully seated remove and inspect, if damaged replace it, if undamaged reinstall. After repairs are complete, release to the customer to monitor.

Step	Action	Decision
2	For both exhaust banks, perform the following. Verify the Pre-catalyst oxygen sensor(s) are operating properly. Key OFF, install the breakout harness on the pre-catalyst O2 sensor and perform the following. A. Connect DMM or Lab Scope to monitor sensor voltage between (terminal B) and (terminal A) on the O2S breakout harness B. In PowerLink under Status Indicators find “Engine Exhaust Gas Oxygen Sensor Closed Loop Operation, Bank 1&2.” C. Warm the engine to operating temperature ECT 150F+ D. Idle the engine Once in Closed Loop operation while at idle the sensor voltage should cycle between 0.01 – 1V, rising and falling every 1-3 seconds. ***Figure 3.15.1** Does the sensor output voltage cycle smoothly between 0.01 – 1V?	Yes: Go To Step 3 No: See SPN 3217, 3227, 3256, 3266 to diagnose the questionable O2S circuit. **(Example *Figure 3.15.3 or *Figure 3.15.4)**

Step	Action	Decision
3	For both exhaust banks, perform the following. Verify the Post-catalyst oxygen sensor(s) are operating properly. Key OFF, install the breakout harness on the post-catalyst O2 sensor and perform the following. A. Connect DMM or Lab Scope to monitor sensor voltage between (terminal B) and (terminal A) on the O2S breakout harness B. In PowerLink under Status Indicators find “Engine Exhaust Gas Oxygen Sensor Closed Loop Operation, Bank 1&2.” C. Warm the engine to operating temperature ECT 150F+ D. Idle the engine Once in Closed Loop operation at idle the sensor voltage should remain stable between 0.5 – 0.8V indicating the catalyst is converting the remaining fuel vapors and oxygen to heat. Does the sensor output voltage remain between 0.5 – 0.8V? ***Figure 3.15.2**	Yes: End Diagnostics. No: See SPN 3222, 3232, 3262, 3272 to diagnose questionable O2S circuit or Catalyst **(Examples *Figure 3.15.1, *Figure 3.15.3, or *Figure 3.15.4)**

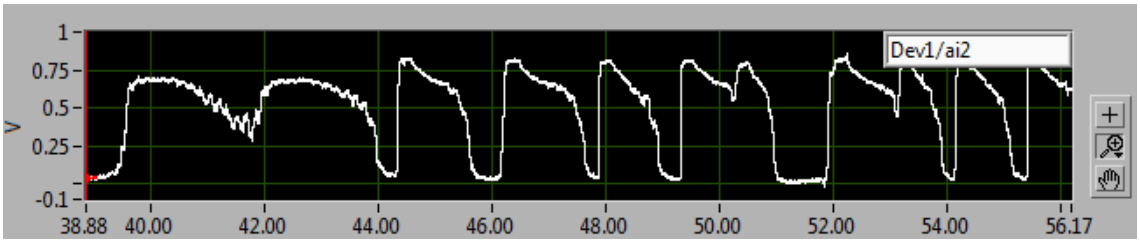


Figure 3.15.3: Erratic Pre-Catalyst O2S signal due to engine performance and combustion concerns

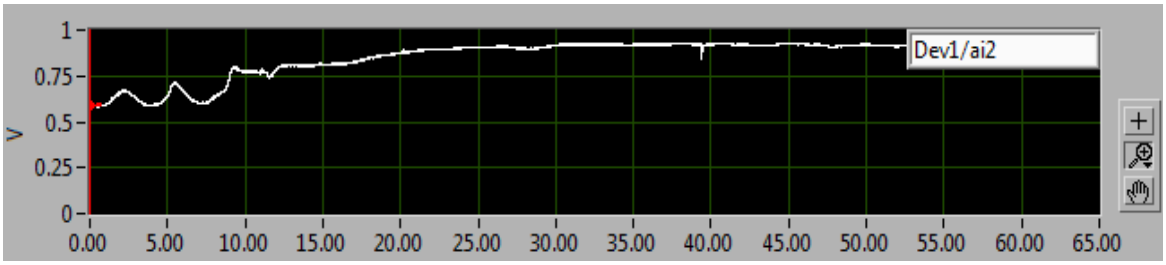


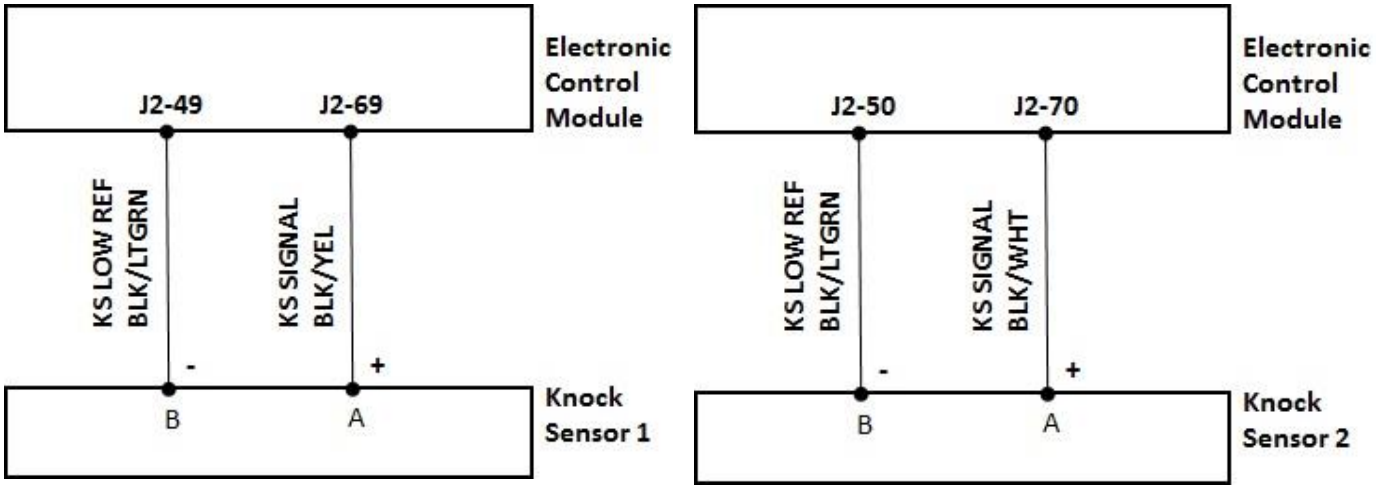
Figure 3.15.4: Non-typical Post-Catalyst O2S signal. The sensor voltage is above 0.8V indicating low amounts of oxygen in the exhaust stream. This can be cause by rich stoichiometric air/fuel ratios or poor combustion due to ignition failures

3.16 Knock Sensor Operational Test

System Overview
The air/fuel mixture within an engine combustion chamber should only be ignited by the spark plug. However, sometimes conditions within the combustion chamber cause the air/fuel mixture to be ignited by other means. When this occurs, flame fronts in the cylinder collide producing detonation, or spark knock. Long term detonation can result in mechanical damage to the engine. A Knock Sensor is a piezoelectric (crystal) device that produces a voltage when subjected to mechanical stress. When an engine experiences detonation the Knock Sensor sends a signal to the ECM. This application uses two knock sensors, one per engine bank at the rear of each cylinder head. Knock Sensor “1” is located on bank 1. Knock Sensor “2” is located on bank 2. Each knock sensor has 2 circuits; a signal circuit and a low reference circuit.
The ECM primarily uses Knock Sensor information to determine ignition timing. An engine experiencing detonation cannot operate with optimized ignition advance and the ECM will start to use less ignition advance (thus less engine power) to reduce detonation.

Diagnostic Tips
- Knock sensors will produce voltage when exposed to mechanical stress

Tools Required
- Digital Multi Meter (DMM) capable of reading AC Millivolts (mVAC)
- Knock Sensor Breakout Harness - 69000049



Test Procedure - Knock Sensor Operational Test

Step	Action	Decision
1	A. Key OFF B. Disconnect knock sensor connector C. Check knock sensor connector terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are knock sensor connector, harness, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest.

Step	Action	Decision
2	Install knock sensor breakout harness 69000049 to knock sensor only. Check resistance of Knock Sensor between: • (terminal A) and (terminal B) • (terminal A) and Ground • (terminal B) and Ground Is resistance infinite or O.L?	Yes: Go To Step 3 No: Replace Knock Sensor.

Step	Action	Decision
3	A. Set DMM to mVAC. Connect leads to signal circuit (terminal A) and low reference (terminal B) with breakout harness installed only to knock sensor. B. Start engine, leave at idle. Record mVAC. C. Raise engine speed to 1500 RPM. Record mVAC. Did the knock sensor produce mVAC voltage AND did voltage rise with engine RPM?	Yes: End Diagnostics. No: Go To Step 4

Step	Action	Decision
4	Remove knock sensor from engine. Inspect for: • Knock sensor was fully secured to engine (torqued and does not rotate) • Factory fastener securing knock sensor on both sides • Corrosion or debris between engine and knock sensor • Damaged knock sensor Were any issues found?	Yes: Repair and retest. No: Replace suspect Knock Sensor.

3.17 MAP Sensor Operational Test

System Overview
The Manifold Absolute Pressure (MAP) Sensor is located in the top rear of the intake manifold. The sensor reads pressure in the intake manifold and reports the value to the ECM. The ECM calculates load on the engine based mainly on this value. An engine at idle in park or neutral will have a high intake manifold vacuum reading, and a low MAP pressure reading in PowerLink. This indicates low load on the engine. As load on the engine increases intake manifold vacuum will decrease, and MAP pressure will rise in PowerLink. A Key ON engine OFF reading of the MAP sensor should be very close to barometric pressure. Barometric pressure is greatly influenced by altitude. The higher the altitude, the lower the barometric pressure.

Diagnostic Tips
- Any intake air leak after the throttle body will have an effect on the MAP sensor accuracy.
- Misfires will create a rise in MAP pressure.
- A MAP sensor that is reading incorrect pressure will create drivability concerns.

Tools Required – 6.0L Gasoline
- PSI PowerLink
- 10mm socket

NOTE: The below section will instruct the technician to back-probe the MAP Sensor Connector. When back-probing any connector, use the thinnest possibly probes, to minimize deformation of the weather pack seal in the back of the connector. Before back-probing the connector, coat back-probe in dielectric grease. This will help the probe be inserted into the connector, and will better seal the connector when the probe is removed. When inserting the probe, make sure the probe is parallel to the wire, and gently push the probe between the weather pack seal and the wire. DO NOT use excessive force, and stop pushing if probe bottoms out in the connector. Failure to follow these guidelines may result in a damaged connector.

Test Procedure - MAP Sensor Operational Test

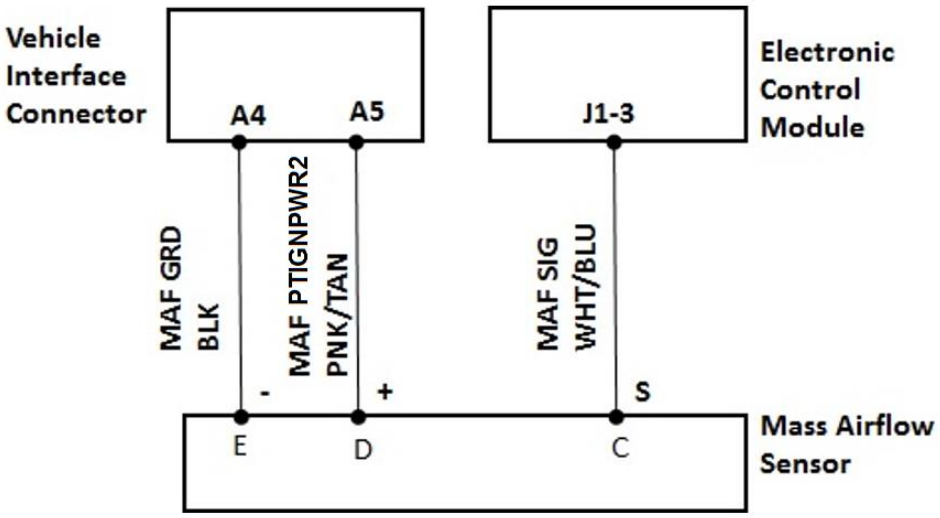
Step	Action	Decision
1	A. Key OFF B. Disconnect MAP Connector C. Check MAP Connector for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are MAP connector, harness, and terminals clean and undamaged?	Yes: Re-connect sensor. Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest.

Step	Action	Decision
2	If PowerLink is available: Key ON, Check and record MAP Pressure and Barometric Pressure values. If PowerLink is not available: A. Key OFF Fully Install MAP Connector at MAP sensor. B. Carefully insert back-probes (terminal A) and (terminal B) of the MAP Connector and place DMM leads against back-probes. Set meter to DC Volts. C. Key ON. Record voltage of MAP sensor. NOTE: If OVER 1000ft above sea level, voltage will be lower due to barometric pressure changes. Is MAP Pressure and Barometric Pressure ± 0.5 PSI OR Voltage above 4.5 volts?	Yes: Go To Step 3 No: Verify elevation. If effect of elevation is in question, compare to other vehicles in shop. Replace MAP sensor if values are drastically different.

Step	Action	Decision
3	Start vehicle, allow to idle for approximately 3 minutes. With the vehicle in neutral, parking brake engaged, and vehicle accessories off (lights, air conditioning, air compressor, etc) Record MAP sensor pressure via PowerLink or measure voltage between (terminal A) and (terminal B) if PowerLink is not available Is MAP value between 3.0 - 4.5 psi OR voltage between 0.7 - 1.0V?	Yes: End Diagnostics. No: Verify elevation. If effect of elevation is in question, compare to other vehicles in shop. Replace MAP sensor if values are drastically different.

3.18 MAF Sensor Operational Test

Overview
The mass air flow (MAF) sensor provides a variable signal to the engine control module (ECM) based on the amount of air that is moving through the sensor to the engine. The MAF sensor is supplied battery voltage by the PTIGN2 fuse. The ECM supplies 5 V to the MAF sensor on the signal circuit. The MAF sensor uses the voltage to produce a frequency signal to the ECM.



Tools Required
- PSI PowerLink
- Digital Multimeter (DMM)
- Breakout Harness ZTSE4960
- OEM Recommended Leak Locator Kit

Diagnostic Tips
- Disconnecting the MAF sensor does not generate a MAF sensor code only IAT
- MAF sensors are sensitive to debris
- Only clean a MAF sensor with approved cleaning solution

Test Procedure – MAF Sensor Operational Test

Step	Action	Decision
1	A. Key OFF B. Disconnect MAF Connector C. Check MAF Connector for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are MAF connector, harness, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest.

Step	Action	Decision
2	A. Key OFF B. Remove the MAF sensor from the air filter box C. Check MAF sensor for: damaged or missing MAF elements, O-ring, IAT sensing element, or dirt and debris clogging the sensor. Are the MAF sensor elements and O-ring present and undamaged? Are they free of debris? **Note:** Only use approved MAF sensor cleaning fluid. Never use general cleaning fluid or brake cleaner to clean a MAF sensor.	Yes: Reinstall MAF and Go To Step 3 No: If damaged replace MAF sensor. If dirty use appropriate MAF sensor cleaning fluid, reinstall and retest.

Step	Action	Decision
3	With the Key OFF, install the MAF sensor breakout harness (ZTSE4960) between the MAF sensor and the engine wiring harness. Measure resistance between the MAF sensor ground (terminal E) and chassis ground. Is resistance greater than 10 ohms?	Yes: See SPN 132 for further diagnostics. No: Go To Step 4

Step	Action	Decision
4	With the Key ON, measure voltage between the MAF sensor ground circuit (terminal E) and the MAF voltage supply circuit (PTIGNPWR2) (terminal D) Is voltage equal to B+ ± 0.5V?	Yes: Go To Step 5 No: See SPN 132 for further diagnostics.

Step	Action	Decision
5	With the Key OFF, disconnect the MAF sensor. With the Key ON, measure voltage between the MAF signal circuit (terminal C) and ground Is voltage between 4.8 and 5.2V?	Yes: Go To Step 6 No: See SPN 132 for further diagnostics.

Step	Action	Decision
6	With the Key OFF, reconnect the MAF sensor. With the Key ON, measure DC Hertz (Hz) between the MAF signal circuit (terminal C) and ground. Start the engine and allow RPM to stabilize at idle speed (750 ± 70 RPM) Is reading between 2.3 and 2.9 kHz?	Yes: End Diagnostics. No: Go To Step 7

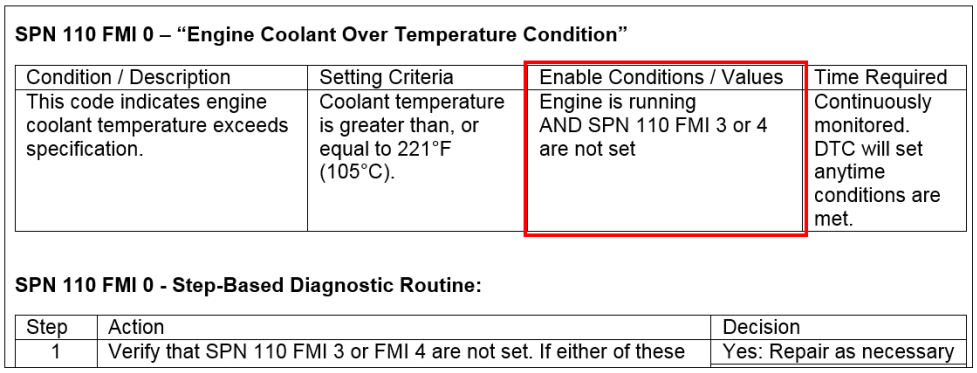
Step	Action	Decision
7	Perform section **3.7 Engine Intake and Exhaust Leaks** Were any issues found?	Yes: Repair leak and retest. No: Replace MAF sensor and retest.

04 SPN/FMI Numbers, Sub-sections, Module Numbers, Descriptions

DTC INFORMATION

Type A requires one drive cycle to turn on MIL
Type B requires two drive cycles to turn on MIL
Type C is non-emissions related no MIL lamp, Type C will illuminate the amber or stop lamp.

It is recommended the technician review the enabling conditions for each specific SPN FMI number when diagnosing an SPN FMI. The enabling conditions are found at the top of each step based diagnostic routine, please see below for an example.



SPN 110 FMI 0 – "Engine Coolant Over Temperature Condition"

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code indicates engine coolant temperature exceeds specification.	Coolant temperature is greater than, or equal to 221°F (105°C).	Engine is running AND SPN 110 FMI 3 or 4 are not set	Continuously monitored. DTC will set anytime conditions are met.

SPN 110 FMI 0 - Step-Based Diagnostic Routine:

Step	Action	Decision
1	Verify that SPN 110 FMI 3 or FMI 4 are not set. If either of these	Yes: Repair as necessary

SPN/FMI Number Matrix

SPN	FMI	Sub-Section	Module Number	PSI PowerLink Condition Description
29	3	Accelerator Pedal Position (APP) Sensor	05	Pedal Position Sensor/Switch "E" Circuit High Input
29	4	Accelerator Pedal Position (APP) Sensor	05	Pedal Position Sensor/Switch "E" Circuit Low Input
51	2	Throttle Position (TP) Sensor	34	Throttle Position Sensor/Switch "A" / "B" Voltage Correlation
51	3	Throttle Position (TP) Sensor	34	Throttle Position Sensor/Switch "A" Circuit High
51	4	Throttle Position (TP) Sensor	34	Throttle Position Sensor/Switch "A" Circuit Low
51	7	Throttle Position (TP) Sensor	34	Throttle Position Sensor/Switch "A" Circuit Range/Performance
51	19	Throttle Position (TP) Sensor	34	Invalid Data Received from Throttle Body Module
91	2	Accelerator Pedal Position (APP) Sensor	05	Throttle/Pedal Position Sensor/Switch "D"/"E" Voltage Correlation
91	3	Accelerator Pedal Position (APP) Sensor	05	Pedal Position Sensor/Switch "D" Circuit High Input
91	4	Accelerator Pedal Position (APP) Sensor	05	Pedal Position Sensor/Switch "D" Circuit Low Input

96	2	Fuel Level Sensor	20	Fuel Level Sensor “A” Circuit Intermittent
96	3	Fuel Level Sensor	20	Fuel Level Sensor "A" Circuit High
96	4	Fuel Level Sensor	20	Fuel Level Sensor "A" Circuit Low
96	7	Fuel Level Sensor	20	Fuel Level Sensor “A” Circuit Range/Performance
100	1	Engine Oil Pressure (EOP) Sensor	17	Engine Oil Pressure Too Low
100	3	Engine Oil Pressure (EOP) Sensor	17	Engine Oil Pressure Sensor/Switch "A" High
100	4	Engine Oil Pressure (EOP) Sensor	17	Engine Oil Pressure Sensor/Switch "A" Low
110	0	Engine Coolant Temperature (ECT)	14	Engine Coolant Over Temperature Condition
110	2	Engine Coolant Temperature (ECT)	14	Engine Coolant Temperature High Rationality
110	3	Engine Coolant Temperature (ECT)	14	Engine Coolant Temperature Circuit High
110	4	Engine Coolant Temperature (ECT)	14	Engine Coolant Temperature Circuit Low
110	7	Engine Coolant Temperature (ECT)	14	Coolant Thermostat (Coolant Temperature Below Thermostat Regulating Temperature)
110	15	Engine Coolant Temperature (ECT)	14	Engine Coolant Temperature High Startup
110	18	Engine Coolant Temperature (ECT)	14	Coolant Temperature Relapsed Below Diagnostic Monitoring Temperature
110	31	Engine Coolant Temperature (ECT)	14	Engine Coolant Temperature Stuck
111	1	Engine Coolant Level Sensor	15	Engine Coolant Level Low
111	3	Engine Coolant Level Sensor	15	Engine Coolant Level Sensor/Switch Circuit High
111	4	Engine Coolant Level Sensor	15	Engine Coolant Level Sensor/Switch Circuit Low
132	0	Mass Airflow (MAF) Sensor	30	Mass Air Flow Circuit High Input
132	1	Mass Airflow (MAF) Sensor	30	Mass Air Flow Circuit Low Input
132	2	Mass Airflow (MAF) Sensor	30	Mass Air Flow Circuit Range/Performance
132	20	Mass Airflow (MAF) Sensor	30	Throttle Actuator Control Range/Performance
168	0	Ignition Voltage	26	System Voltage High
168	1	Ignition Voltage	26	System Voltage Low

172	3	Intake Air Temperature (IAT) Sensor	27	Intake Air Temperature Sensor 1 Circuit High
172	4	Intake Air Temperature (IAT) Sensor	27	Intake Air Temperature Sensor 1 Circuit Low
172	10	Intake Air Temperature (IAT) Sensor	27	Intake Air Temperature Sensor 1 Circuit Range/Performance Bank 1
172	20	Intake Air Temperature (IAT) Sensor	27	Intake Air Temperature Sensor 1 – High Rationality
172	21	Intake Air Temperature (IAT) Sensor	27	Intake Air Temperature Sensor 1 – Low Rationality
172	31	Intake Air Temperature (IAT) Sensor	27	Intake Air Temperature Sensor Stuck
175	0	Engine Oil Temperature (EOT) Sensor	18	Engine Oil Over Temperature
175	2	Engine Oil Temperature (EOT) Sensor	18	Engine Oil Temperature Sensor “A” Range/Performance at Startup
175	2	Engine Oil Temperature (EOT) Sensor	18	Engine Oil Temperature Sensor “A” Range/Performance
175	3	Engine Oil Temperature (EOT) Sensor	18	Engine Oil Temperature Sensor High
175	4	Engine Oil Temperature (EOT) Sensor	18	Engine Oil Temperature Sensor Low
188	16	Idle Control	37	Idle Control System RPM – Higher than Expected
188	18	Idle Control	37	Idle Control System RPM – Lower than Expected
191	5	Vehicle Speed Sensor	38	Vehicle Speed Sensor “A” Circuit
251	2	ECM	12	ECM/PCM Engine Off Timer Performance
518	2	Torque Calculation	35	Internal Control Module Torque Calculation Performance
588	13	ECM	12	Engine Serial Number Not Programmed or Incompatible
629	2	ECM	12	Internal Control Module Torque Calculation Performance
629	12	ECM	12	ECM/PCM Processor
629	14	Accelerator Pedal Position (APP) Sensor	05	ECM/PCM Processor (APP Sensor Correlation)
629	31	ECM	12	ECM/PCM Processor
630	13	RAM/ROM	31	Control Module Performance
636	2	Crankshaft Position (CKP) Sensor	10	Crankshaft Position Sensor "A" Circuit Range/Performance

636	4	Crankshaft Position (CKP) Sensor	10	Crankshaft Position Sensor "A" Circuit
639	5	CAN Communication	39	High Speed CAN Communication Bus
639	8	CAN Communication	39	Vehicle Communications Bus A Performance
651	3	Fuel Injectors	16	Cylinder 1 Injector Circuit High
651	4	Fuel Injectors	16	Cylinder 1 Injector Circuit Low
651	5	Cylinder #1 Fuel Injector	16	Injector Circuit/Open - Cylinder 1
652	3	Fuel Injectors	16	Cylinder 2 Injector Circuit High
652	4	Fuel Injectors	16	Cylinder 2 Injector Circuit Low
652	5	Fuel Injectors	16	Injector Circuit/Open - Cylinder 2
653	3	Fuel Injectors	16	Cylinder 3 Injector Circuit High
653	4	Fuel Injectors	16	Cylinder 3 Injector Circuit Low
653	5	Fuel Injectors	16	Injector Circuit/Open - Cylinder 3
654	3	Fuel Injectors	16	Cylinder 4 Injector Circuit High
654	4	Fuel Injectors	16	Cylinder 4 Injector Circuit Low
654	5	Fuel Injectors	16	Injector Circuit/Open - Cylinder 4
655	3	Fuel Injectors	16	Cylinder 5 Injector Circuit High
655	4	Fuel Injectors	16	Cylinder 5 Injector Circuit Low
655	5	Fuel Injectors	16	Injector Circuit/Open - Cylinder 5
656	3	Fuel Injectors	16	Cylinder 6 Injector Circuit High
656	4	Fuel Injectors	16	Cylinder 6 Injector Circuit Low
656	5	Fuel Injectors	16	Injector Circuit/Open - Cylinder 6
657	3	Fuel Injectors	16	Cylinder 7 Injector Circuit High
657	4	Fuel Injectors	16	Cylinder 7 Injector Circuit Low
657	5	Fuel Injectors	16	Injector Circuit/Open - Cylinder 7
658	3	Fuel Injectors	16	Cylinder 8 Injector Circuit High
658	4	Fuel Injectors	16	Cylinder 8 Injector Circuit Low
658	5	Fuel Injectors	16	Injector Circuit/Open - Cylinder 8
677	3	Starter Relay	40	Starter Relay “A” Circuit Low
677	4	Starter Relay	40	Starter Relay “A” Circuit High
677	5	Starter Relay	40	Starter Relay “A” Circuit
723	5	Camshaft Position (CAM) Sensor	07	Camshaft Position Sensor "A" Circuit
723	7	Camshaft Position (CAM) Sensor	07	Camshaft Position Sensor "A" Circuit Range/Performance
876	3	A/C Clutch Relay	41	A/C Clutch Relay Control Circuit Low
876	4	A/C Clutch Relay	41	A/C Clutch Relay Control Circuit High

876	5	A/C Clutch Relay	41	A/C Clutch Relay Control Circuit
876	6	A/C Clutch Relay	41	A/C Clutch 2 Relay Control Circuit
876	16	A/C Clutch Relay	41	A/C Clutch 2 Relay Control Circuit Low
876	18	A/C Clutch Relay	41	A/C Clutch 2 Relay Control Circuit High
1045	2	Brake Switch	06	Brake Switch “A” / “B” Correlation
1045	7	Brake Switch	06	Brake Switch "A" Circuit
1109	0	Throttle Actuator Control	32	Throttle Actuator Control System - Forced Idle
1109	15	Throttle Actuator Control	32	Throttle Actuator Control System - Forced Limited Power
1109	16	Throttle Actuator Control	32	Throttle Actuator Control System - Forced Limited RPM
1110	31	Throttle Actuator Control	32	Throttle Actuator Control System - Forced Engine Shutdown
1268	3	Ignition Coils	25	Ignition Coil "A" Primary Control Circuit High
1268	4	Ignition Coils	25	Ignition Coil "A" Primary Control Circuit Low
1268	5	Ignition Coils	25	Ignition Coil "A" Primary Control Circuit Open
1269	3	Ignition Coils	25	Ignition Coil "D" Primary Control Circuit High
1269	4	Ignition Coils	25	Ignition Coil "D" Primary Control Circuit Low
1269	5	Ignition Coils	25	Ignition Coil "D" Primary Control Circuit Open
1270	3	Ignition Coils	25	Ignition Coil "H" Primary Control Circuit High
1270	4	Ignition Coils	25	Ignition Coil "H" Primary Control Circuit Low
1270	5	Ignition Coils	25	Ignition Coil "H" Primary Control Circuit Open
1271	3	Ignition Coils	25	Ignition Coil "G" Primary Control Circuit High
1271	4	Ignition Coils	25	Ignition Coil "G" Primary Control Circuit Low
1271	5	Ignition Coils	25	Ignition Coil "G" Primary Control Circuit Open
1272	3	Ignition Coils	25	Ignition Coil "F" Primary Control Circuit High
1272	4	Ignition Coils	25	Ignition Coil "F" Primary Control Circuit Low
1272	5	Ignition Coils	25	Ignition Coil "F" Primary Control Circuit Open
1273	3	Ignition Coils	25	Ignition Coil "E" Primary Control Circuit High
1273	4	Ignition Coils	25	Ignition Coil "E" Primary Control Circuit Low
1273	5	Ignition Coils	25	Ignition Coil "E" Primary Control Circuit Open
1274	3	Ignition Coils	25	Ignition Coil "C" Primary Control Circuit High
1274	4	Ignition Coils	25	Ignition Coil "C" Primary Control Circuit Low
1274	5	Ignition Coils	25	Ignition Coil "C" Primary Control Circuit Open
1275	3	Ignition Coils	25	Ignition Coil "B" Primary Control Circuit High
1275	4	Ignition Coils	25	Ignition Coil "B" Primary Control Circuit Low
1275	5	Ignition Coils	25	Ignition Coil "B" Primary Control Circuit Open
1322	31	Cylinder Misfire	36	Random/Multiple Cylinder Misfire Detected

1323	31	Cylinder Misfire	36	Cylinder 1 Misfire Detected
1324	31	Cylinder Misfire	36	Cylinder 2 Misfire Detected
1325	31	Cylinder Misfire	36	Cylinder 3 Misfire Detected
1326	31	Cylinder Misfire	36	Cylinder 4 Misfire Detected
1327	31	Cylinder Misfire	36	Cylinder 5 Misfire Detected
1328	31	Cylinder Misfire	36	Cylinder 6 Misfire Detected
1329	31	Cylinder Misfire	36	Cylinder 7 Misfire Detected
1330	31	Cylinder Misfire	36	Cylinder 8 Misfire Detected
1347	3	Fuel Pump	21	Fuel Pump 1 Circuit Short High
1347	4	Fuel Pump	21	Fuel Pump 1 Circuit Short Low
1347	5	Fuel Pump	21	Fuel Pump 1 Circuit Open
1352	3	Knock Sensor	28	Knock Sensor 1 Circuit High
1352	4	Knock Sensor	28	Knock Sensor 1 Circuit Low
1352	5	Knock Sensor	28	Knock Sensor 1 Circuit
1353	3	Knock Sensor	28	Knock Sensor 2 Circuit High
1353	4	Knock Sensor	28	Knock Sensor 2 Circuit Low
1353	5	Knock Sensor	28	Knock Sensor 2 Circuit
1485	3	ECM Power Relay Control	11	ECM Power Relay Control Circuit High
1485	4	ECM Power Relay Control	11	ECM Power Relay Control Circuit Low
1485	5	ECM Power Relay Control	11	ECM Power Relay Control Circuit Open
1634	13	ECM	12	Internal Control Module Memory Checksum Error (Cal Mismatch)
2003	8	CAN Communication	39	Lost Communication with TCM
2003	19	CAN Communication	39	Invalid Data Received from TCM
2007	8	CAN Communication	39	Lost Communication with PTO Control Module
2011	2	CAN Communication	39	ABS Rough Road Rationality
2011	19	CAN Communication	39	Invalid Data Received from Anti-Lock Brake System (ABS) Control Module
2033	8	CAN Communication	39	Lost Communication with Body Control Module
2609	3	A/C Refrigerant Pressure Sensor	42	A/C Refrigerant Pressure Sensor “A” Circuit High
2609	4	A/C Refrigerant Pressure Sensor	42	A/C Refrigerant Pressure Sensor “A” Circuit Low
2609	16	A/C Refrigerant Pressure Sensor	42	A/C Refrigerant Pressure Sensor 2 “A” Circuit High
2609	18	A/C Refrigerant Pressure Sensor	42	A/C Refrigerant Pressure Sensor 2 “A” Circuit Low
2634	15	System Voltage	43	System Voltage High – Main Relay
2634	17	System Voltage	43	System Voltage Low – Main Relay
3050	18	Catalyst Banks	09	Bank 1 Catalyst System Efficiency Below Threshold
3051	18	Catalyst Banks	09	Bank 2 Catalyst System Efficiency Below Threshold

3052	5	Rough Road Sensor	47	Rough Road Sensor Not Detected
3053	1	EVAP System Purge Control Valve	44	EVAP System Large Leak Detected (Large Leak)
3053	2	EVAP System Purge Control Valve	44	EVAP System Incorrect Purge Flow
3217	0	O2 Sensor	23	Bank 1 Sensor 1 O2 Sensor Signal Stuck Rich
3217	1	O2 Sensor	23	Bank 1 Sensor 1 O2 Sensor Signal Stuck Lean
3217	3	O2 Sensor	23	Bank 1 Sensor 1 O2 Sensor Circuit High Voltage
3217	4	O2 Sensor	23	Bank 1 Sensor 1 O2 Sensor Circuit Low Voltage
3217	5	O2 Sensor	23	Bank 1 Sensor 1 O2 Sensor Circuit No Activity Detected
3222	1	O2 Sensor	24	HO2S Heater Control Circuit Bank 1 Sensor 1
3222	3	O2 Sensor	24	Bank 1 Sensor 1 HO2S Heater Control Circuit High
3222	4	O2 Sensor	24	Bank 1 Sensor 1 HO2S Heater Control Circuit Low
3222	5	O2 Sensor	24	Bank 1 Sensor 1 HO2S Heater Control Circuit Open
3222	10	O2 Sensor	23	O2 Sensor Circuit range/Performance Bank 1 Sensor 1
3227	0	O2 Sensor	23	Bank 1 Sensor 2 O2 Sensor Signal Stuck Rich
3227	1	O2 Sensor	23	Bank 1 Sensor 2 O2 Sensor Signal Stuck Lean
3227	3	O2 Sensor	23	Bank 1 Sensor 2 O2 Sensor Circuit High Voltage
3227	4	O2 Sensor	23	Bank 1 Sensor 2 O2 Sensor Circuit Low Voltage
3227	5	O2 Sensor	23	Bank 1 Sensor 2 O2 Sensor Circuit No Activity Detected
3227	10	O2 Sensor	23	Bank 1 Sensor 2 O2 Sensor Circuit Range/Performance
3227	16	Fuel Trim	22	Bank 1 Post Catalyst Fuel Trim System Too Lean
3227	18	Fuel Trim	22	Bank 1 Post Catalyst Fuel Trim System Too Rich
3232	1	Heated O2 Sensor Circuit	24	HO2S Heater Control Circuit Bank 1 Sensor 2
3232	3	Heated O2 Sensor Circuit	24	Bank1 Sensor 2 HO2S Heater Control Circuit High
3232	4	Heated O2 Sensor Circuit	24	Bank 1 Sensor 2 HO2S Heater Control Circuit Low
3232	5	Heated O2 Sensor Circuit	24	Bank 1 Sensor 2 HO2S Heater Control Circuit Open
3256	0	O2 Sensor	23	Bank 2 Sensor 1 O2 Sensor Signal Stuck Rich
3256	1	O2 Sensor	23	Bank 2 Sensor 1 O2 Sensor Signal Stuck Lean
3256	3	O2 Sensor	23	Bank 2 Sensor 1 O2 Sensor Circuit High Voltage
3256	4	O2 Sensor	23	Bank 2 Sensor 1 O2 Sensor Circuit Low Voltage
3256	5	O2 Sensor	23	Bank 2 Sensor 1 O2 Sensor Circuit No Activity Detected
3262	1	Heated O2 Sensor Circuit	24	HO2S Heater Control Circuit bank 2 Sensor 1
3262	3	Heated O2 Sensor Circuit	24	Bank 2 Sensor 1 HO2S Heater Control Circuit High

3262	4	Heated O2 Sensor Circuit	24	Bank 2 Sensor 1 HO2S Heater Control Circuit Low
3262	5	Heated O2 Sensor Circuit	24	Bank 2 Sensor 1 HO2S Heater Control Circuit Open
3262	10	O2 Sensor	23	O2 Sensor Circuit Range/Performance Bank 2 Sensor 1
3266	0	O2 Sensor	23	Bank 2 Sensor 2 O2 Sensor Signal Stuck Rich
3266	1	O2 Sensor	23	Bank 2 Sensor 2 O2 Sensor Signal Stuck Lean
3266	3	O2 Sensor	23	Bank 2 Sensor 2 O2 Sensor Circuit High Voltage
3266	4	O2 Sensor	23	Bank 2 Sensor 2 O2 Sensor Circuit Low Voltage
3266	5	O2 Sensor	23	Bank 2 Sensor 2 O2 Sensor Circuit No Activity Detected
3266	10	O2 Sensor	23	Bank 2 Sensor 2 O2 Sensor Circuit Range/Performance
3266	16	Catalyst Banks	09	Bank 2 Post Catalyst Fuel Trim System Too Lean
3266	18	Catalyst Banks	09	Bank 2 Post catalyst Fuel Trim System Too Rich
3271	1	Heated O2 Sensor Circuit	24	HO2S Heater Control Circuit Bank 2 Sensor 2
3272	3	Heated O2 Sensor Circuit	24	Bank 2 Sensor 2 HO2S Heater Control Circuit High
3272	4	Heated O2 Sensor Circuit	24	Bank 2Sensor 2 HO2S Heater Control Circuit Low
3272	5	Heated O2 Sensor Circuit	24	Bank 2 Sensor 2 HO2S Heater Control Circuit Open
3301	2	ECM	12	ECM/PCM Engine On Timer Performance
3306	2	Camshaft Variable Timing	08	“A” Camshaft Profile Control Performance/Stuck Off Bank 1
3306	7	Camshaft Variable Timing	08	Crankshaft Position/Camshaft Position Correlation Bank 1 Sensor A
3306	10	Camshaft Variable Timing	08	“A” Camshaft Position Slow Response Bank 1
3464	2	Throttle Actuator Control	32	Throttle Actuator Control Performance
3464	7	Throttle Actuator Control	32	Throttle Closed Position Performance
3509	31	Sensor Reference Voltage	13	Sensor Reference Voltage "A" Circuit
3510	31	Sensor Reference Voltage	13	Sensor Reference Voltage "B" Circuit
3563	3	Manifold Absolute Pressure (MAP) Sensor	29	Manifold Absolute Pressure Circuit High Input
3563	4	Manifold Absolute Pressure (MAP) Sensor	29	Manifold Absolute Pressure Circuit Low Input
3563	7	Manifold Absolute Pressure (MAP) Sensor	29	Manifold Absolute Pressure Stuck at Startup
3563	7	Manifold Absolute Pressure (MAP) Sensor	29	Manifold Absolute Pressure Stuck

3563	10	Manifold Absolute Pressure (MAP) Sensor	29	Manifold Absolute Pressure/Barometric Pressure Sensor Circuit Intermittent
3563	20	Manifold Absolute Pressure (MAP) Sensor	29	Manifold Absolute Pressure/Mass Air Flow – Throttle Position Correlation at Higher Load
3563	21	Manifold Absolute Pressure (MAP) Sensor	29	Manifold Absolute Pressure/Mass Air Flow – Throttle Position Correlation at Idle
3673	3	Throttle Position Sensor	34	Throttle Position Sensor/Switch "B" Circuit High
3673	4	Throttle Position Sensor	34	Throttle Position Sensor/Switch "B" Circuit Low
3673	7	Throttle Position Sensor	34	Throttle Position Sensor/Switch "B" Circuit Range/Performance
4203	13	Crankshaft Position Sensor	10	Crankshaft Position System Variation Not Learned
4237	15	Fuel Trim	22	Bank 1 System Too Lean at Idle
4237	16	Fuel Trim	22	Bank 1 System Too Lean
4237	17	Fuel Trim	22	Bank 1 System Too Rich at Idle
4237	18	Fuel Trim	22	Bank 1 System Too Rich
4239	15	Fuel Trim	22	Bank 2 System Too Lean at Idle
4239	16	Fuel Trim	22	Bank 2 System Too Lean
4239	17	Fuel Trim	22	Bank 2 System Too Rich at Idle
4239	18	Fuel Trim	22	Bank 2 System Too Rich
4240	10	O2 Sensor	22	O2 Sensor Circuit Slow Response Bank 1 Sensor 1
4241	10	O2 Sensor	22	O2 Sensor Circuit Slow Response Bank 2 Sensor 1
5077	31	Engine Protection	19	Engine Protection Mode
5323	7	Engine Coolant Temperature (ECT)	14	Insufficient Coolant Temperature for Closed Loop Operation
5358	15	Fuel Trim	22	Cylinder 1 - Fuel Trim at Min Limit
5358	17	Fuel Trim	22	Cylinder 1 - Fuel Trim at Max Limit
5359	15	Fuel Trim	22	Cylinder 2 - Fuel Trim at Min Limit
5359	17	Fuel Trim	22	Cylinder 2 - Fuel Trim at Max Limit
5360	15	Fuel Trim	22	Cylinder 3 - Fuel Trim at Min Limit
5360	17	Fuel Trim	22	Cylinder 3 - Fuel Trim at Max Limit
5361	15	Fuel Trim	22	Cylinder 4 - Fuel Trim at Min Limit
5361	17	Fuel Trim	22	Cylinder 4 - Fuel Trim at Max Limit
5362	15	Fuel Trim	22	Cylinder 5 - Fuel Trim at Min Limit
5362	17	Fuel Trim	22	Cylinder 5 - Fuel Trim at Max Limit
5363	15	Fuel Trim	22	Cylinder 6 - Fuel Trim at Min Limit
5363	17	Fuel Trim	22	Cylinder 6 - Fuel Trim at Max Limit
5364	15	Fuel Trim	22	Cylinder 7 - Fuel Trim at Min Limit
5364	17	Fuel Trim	22	Cylinder 7 - Fuel Trim at Max Limit
5365	15	Fuel Trim	22	Cylinder 8 - Fuel Trim at Min Limit
5365	17	Fuel Trim	22	Cylinder 8 - Fuel Trim at Max Limit

6336	3	Camshaft Variable Timing	08	“A” Camshaft Position Actuator Control Circuit High Bank 1
6336	4	Camshaft Variable Timing	08	“A” Camshaft Position Actuator Control Circuit Low Bank 1
6336	5	Camshaft Variable Timing	08	“A” Camshaft Position Actuator Control Circuit Open Bank 1
6336	7	Camshaft Variable Timing	08	“A” Camshaft Profile Control Stuck Bank 1
7355	2	ECM	12	Engine Timing Advance Error
7833	3	EVAP System Vent Control Valve	45	EVAP System Vent Control Circuit Shorted High
7833	4	EVAP System Vent Control Valve	45	EVAP System Vent Control Circuit Shorted Low
7833	5	EVAP System Vent Control Valve	45	EVAP System Vent Control Circuit Open
7833	7	EVAP System Vent Control Valve	45	EVAP System Vent Valve Stuck Closed
7834	3	EVAP System Purge Control Valve	45	EVAP System Purge Control Valve “A” Circuit High
7834	4	EVAP System Purge Control Valve	45	EVAP System Purge Control Valve “A” Circuit Low
7834	5	EVAP System Purge Control Valve	44	EVAP System Purge Control Valve “A” Circuit Open
7835	0	EVAP System Pressure Sensor/Switch	46	EVAP System Pressure Sensor/Switch Circuit Intermittent
7835	3	EVAP System Pressure Sensor/Switch	46	EVAP System Pressure Sensor/Switch Circuit High
7835	4	EVAP System Pressure Sensor/Switch	46	EVAP System Pressure Sensor/Switch Circuit Low
7835	7	EVAP System Pressure Sensor/Switch	46	EVAP System Pressure Sensor/Switch Circuit Range/Performance Stuck
7835	20	EVAP System Pressure Sensor/Switch	46	EVAP System Pressure Sensor/Switch Circuit Range/Performance High
7835	21	EVAP System Pressure Sensor/Switch	46	EVAP System Pressure Sensor/Switch Circuit Range/Performance Low

05 Accelerator Pedal Position (APP) Sensor

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
29	3	Pedal Position Sensor/Switch "E" Circuit High Input	• Malfunctioning APP sensor • Intermittent open in APP sensor wiring harness • Intermittent open within the APP sensor connector • Open ground circuit through the ECM	A	MIL
29	4	Pedal Position Sensor/Switch "E" Circuit Low Input	• Malfunctioning APP sensor • Intermittent short in APP sensor wiring harness • Intermittent short within APP sensor connector • No reference voltage from ECM	A	MIL
91	2	Throttle/Pedal Position Sensor/Switch "D"/"E" Voltage Correlation	• Intermittent open or short in APP sensor wiring harness • Intermittent open or short within APP sensor connector • Defective or damaged APP sensor • Defective ECM	A	MIL
91	3	Pedal Position Sensor/Switch "D" Circuit High Input	• Malfunctioning APP sensor • Intermittent open in the APP sensor wiring harness • Intermittent open within APP sensor connector • Open ground circuit through ECM	A	MIL
91	4	Pedal Position Sensor/Switch "D" Circuit Low Input	• Malfunctioning APP sensor • Intermittent short in APP sensor wiring harness • Intermittent short within APP sensor connector • No reference voltage from ECM • Bent pins or spread terminals	A	MIL
629	14	ECM/PCM Processor – Analog to Digital APP Input Correlation	• Intermittent open or short in APP sensor wiring harness • Intermittent open or short within APP sensor connector • Defective or damaged APP • Defective ECM	A	MIL



Overview

The Electronic Throttle Control (ETC) system consists of the Electronic Control Module (ECM), Throttle Body, Accelerator Pedal Position (APP) sensors (1 and 2), and Throttle Position Sensors (1 and 2). The throttle body housing contains the actuator, throttle plate, and throttle position (TP) sensor. When the driver depresses the accelerator pedal, the APP sensor sends a signal to the ECM regarding the amount of torque requested by the driver. The ECM sends a signal to the throttle actuator to move the throttle plate using an electric motor. The TP sensor monitors the position of the throttle plates and sends a signal to the ECM regarding their current position. The throttle actuator, APP, and TP sensor must all stay synchronized for the ECM to control engine torque demand.

The Accelerator Pedal Position (APP) sensor is a potentiometer whose movement correlates to pedal position. There are two APP sensors. One sensor indicates the full range of the accelerator pedal position and the other indicates half of the pedal position. APP1 and APP2 must maintain correlation between them for the system to operate correctly, or SPN 91, FMI 2 will become active.

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)
- 3 Amp Fused Jumper Wire
- Accelerator Pedal Breakout Harness ZTSE4485A

Diagnostic Tips:

- SPN 3509/3510 FMI 31 is for the reference voltage circuit “A/B”, these 5V references are shared internally in the ECM by the following:
    - APP1/APP2
    - Camshaft Position Sensor
    - Crankshaft Position Sensor
    - Engine Coolant Level Sensor
    - Fuel Supply Pressure Sensor
    - Manifold Absolute Pressure Sensor
    - Engine Oil Pressure
    - Engine Throttle Position 1/2
- Short to ground or power in one of the circuits above will affect all of the circuits.

To 6.0L Gasoline Setting Criteria

- SPN 29 FMI 3 - Pedal Position Sensor/Switch “E” Circuit High Input
- SPN 29 FMI 4 - Pedal Position Sensor/Switch “E” Circuit Low Input
- SPN 91 FMI 2 - Throttle/Pedal Position Sensor/Switch “D”/”E” Voltage Correlation
- SPN 91 FMI 3 - Pedal Position Sensor/Switch “D” Circuit High Input
- SPN 91 FMI 4 - Pedal Position Sensor/Switch “D” Circuit Low Input
- SPN 629 FMI 14 - ECM/PCM Processor – Analog to Digital APP Input Correlation

Associated Faults

SPN	FMI	Description
636	4	Crankshaft Position Sensor “A” Circuit
1109	15	Throttle Actuator Control System – Forced Limited Power
3510	31	Sensor Reference Voltage “B” Circuit
3563	4	Manifold Absolute Pressure Circuit Low Input

Step-Based Diagnostic Routine - SPN 29 FMI 3, SPN 29 FMI 4

Step	Action	Decision
1	Using PowerLink, check SPNs. Are any of the associated fault codes active other than 1109 FMI 15?	Yes: Complete SPN 3510 FMI 31 diagnostics, repair faults, clear DTC's and retest.
		No: Go To Step 2

Step	Action	Decision
2	A. Key OFF B. Disconnect Vehicle Interface Connector (VIC) C. Disconnect ECM J1 connector D. Check Accelerator Pedal Connector, VIC, and ECM J1 connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Are the connectors, harness, and terminals clean and undamaged?	Yes: Go To Step 3 No: Repair connector, harness, or terminal damage. After repairs are complete, retest for DTC.

Step	Action	Decision
3	A. Key OFF B. Disconnect VIC C. Disconnect ECM J1 connector Measure resistance between ECM side of VIC (terminal A2) and ECM J1-2. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance between VIC (terminal A2) and ECM J1-2. No: Go To Step 4

Step	Action	Decision
4	A. Key OFF B. Disconnect VIC C. Disconnect ECM J1 connector Measure resistance between ECM side of VIC (terminal A2) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground between VIC (terminal A2) and ECM J1-2. No: Go To Step 5

Step	Action	Decision
5	A. Key OFF B. VIC connected C. Disconnect ECM J1 connector D. Disconnect Accelerator Pedal Connector Key ON, measure voltage between ECM J1-2 and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage between VIC (terminal A2) and ECM J1-2, if no short is found between VIC (terminal A2) and ECM J1-2, Go To Step 12 No: Go To Step 6

Step	Action	Decision
6	A. Key OFF B. Disconnect VIC C. Disconnect ECM J1 connector Measure resistance between ECM side of VIC (terminal A3) and ECM J1-16. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance between VIC (terminal A3) and ECM J1-16. No: Go To Step 7

Step	Action	Decision
7	A. Key OFF B. Disconnect VIC C. Disconnect ECM J1 connector Measure resistance between ECM side of VIC (terminal A2) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground between VIC (terminal A3) and ECM J1-16. No: Go To Step 8

Step	Action	Decision
8	A. Key OFF B. VIC connected C. Disconnect ECM J1 connector D. Disconnect Accelerator Pedal Connector Measure voltage between ECM J1-16 and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage between VIC (terminal A3) and ECM J1-16, if no short is found between VIC (terminal A3) and ECM J1-16, Go To Step 12 No: Go To Step 9

Step	Action	Decision
9	A. Key OFF B. Disconnect VIC C. Disconnect ECM J1 connector Measure resistance between ECM side of VIC (terminal A1) and ECM J1-30. Is resistance greater than 5 ohms?	Yes: Repair open or short to ground between VIC (terminal A1) and ECM J1-30. No: Go To Step 10

Step	Action	Decision
10	A. Key OFF B. Disconnect VIC C. Disconnect ECM J1 connector Measure resistance between ECM side of VIC (terminal A1) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground between VIC (terminal A1) and ECM J1-30. No: Go To Step 11

Step	Action	Decision
11	A. Key OFF B. VIC connected C. Disconnect ECM J1 connector D. Disconnect Accelerator Pedal Connector Measure voltage between ECM J1-30 and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage between VIC (terminal A1) and ECM J1-30, if no short is found between VIC (terminal A1) and ECM J1-30, Go To Step 12 No: Go To Step 12

Step	Action	Decision
12	See OEM Diagnostics. After completing OEM Diagnostics, has the fault been repaired?	Yes: End Diagnostics No: Replace ECM and retest.

Associated Faults

SPN	FMI	Description
54	4	Throttle Position Sensor/Switch "A" Circuit Low
94	4	Fuel Supply Pressure Sensor Circuit Short Low
100	1	Engine Oil Pressure Too Low
100	4	Engine Oil Pressure Sensor/Switch "A" Low
111	4	Engine Coolant Level Sensor/Switch Circuit Low
723	4	Camshaft Position Sensor “A” Circuit
1109	15	Throttle Actuator Control System – Forced Limited Power
3509	31	Sensor Reference Voltage “A” Circuit
3673	4	Throttle Position Sensor/Switch "B" Circuit Low

Step-Based Diagnostic Routine: SPN 91 FMI 3, 4

Step	Action	Decision
1	Using PowerLink, check SPNs. Are any of the associated fault codes active other than 1109 FMI 15?	Yes: Complete SPN 3509 FMI 31, repair faults, clear DTC’s, and retest. No: Go To Step 2

Step	Action	Decision
2	A. Key OFF B. Disconnect Accelerator Pedal Connector C. Disconnect Vehicle Interface Connector (VIC) D. Disconnect ECM J1 connector E. Check Accelerator Pedal Connector, VIC, and ECM J1 connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Are the Accelerator Pedal connector, harness, and terminals clean and undamaged?	Yes: Go To Step 3 No: Repair connector, harness, or terminal damage. After repairs are complete, retest for DTC.

Step	Action	Decision
3	A. Key OFF B. Disconnect VIC C. Disconnect ECM J1 connector Measure resistance between ECM side of VIC (terminal B4) and ECM J1-10. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance between VIC (terminal B4) and ECM J1-10. No: Go To Step 4

Step	Action	Decision
4	A. Key OFF B. Disconnect VIC C. Disconnect ECM J1 connector Measure resistance between ECM side of VIC (terminal B4) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground between VIC (terminal B4) and ECM J1-10. No: Go To Step 5

Step	Action	Decision
5	A. Key OFF B. VIC connected C. Disconnect ECM J1 connector D. Disconnect Accelerator Pedal Connector Measure voltage between ECM J1-10 and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage between VIC (terminal B4) and ECM J1-10, if no short is found between VIC (terminal B4) and ECM J1-10, Go To Step 12 No: Go To Step 6

Step	Action	Decision
6	A. Key OFF B. Disconnect VIC C. Disconnect ECM J1 connector Measure resistance between ECM side of VIC (terminal B5) and ECM J1-24. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance between VIC (terminal B5) and ECM J1-24. No: Go To Step 7

Step	Action	Decision
7	A. Key OFF B. Disconnect VIC C. Disconnect ECM J1 connector Measure resistance between ECM side of VIC (terminal B5) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground between VIC (terminal B5) and ECM J1-24. No: Go To Step 8

Step	Action	Decision
8	A. Key OFF B. VIC connected C. Disconnect ECM J1 connector D. Disconnect Accelerator Pedal Connector Measure voltage between ECM J1-30 and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage between VIC (terminal B5) and ECM J1-24, if no short is found between VIC (terminal B5) and ECM J1-24, Go To Step 12 No: Go To Step 9

Step	Action	Decision
9	A. Key OFF B. Disconnect VIC C. Disconnect ECM J1 connector Measure resistance between ECM side of VIC (terminal B3) and ECM J1-38. Is resistance greater than 5 ohms?	Yes: Repair open or short to ground between VIC (terminal B3) and ECM J1-38. No: Go To Step 10

Step	Action	Decision
10	A. Key OFF B. Disconnect VIC C. Disconnect ECM J1 connector Measure resistance between ECM side of VIC (terminal B3) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground between VIC (terminal B3) and ECM J1-38. No: Go To Step 11

Step	Action	Decision
11	A. Key OFF B. VIC connected C. Disconnect ECM J1 connector D. Disconnect Accelerator Pedal Connector Measure voltage between ECM J1-38 and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage between VIC (terminal B3) and ECM J1-38, if no short is found between VIC (terminal B3) and ECM J1-38, Go To Step 12 No: Go To Step 12

Step	Action	Decision
12	See OEM Diagnostics. After completing OEM Diagnostics, has the fault been repaired?	Yes: End Diagnostics No: Go To Step 5

Step-Based Diagnostic Routine: SPN 91 FMI 2, SPN 629 FMI 14

Step	Action	Decision
1	A. Key OFF B. Disconnect Accelerator Pedal Connector. C. Check Accelerator Pedal Connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Are the Accelerator Pedal connector, harness, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest for DTC.

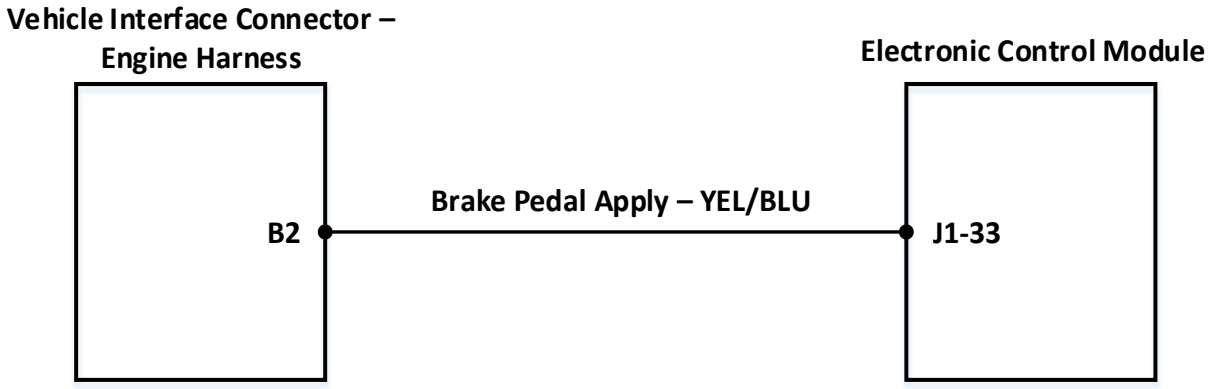
Step	Action	Decision
2	A. Key OFF B. Disconnect Vehicle Interface Connector (VIC). C. Check Vehicle Interface Connector (VIC) for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Are the Vehicle Interface Connector (VIC), harness, and terminals clean and undamaged?	Yes: Reconnect VIC, Go To Step 3 No: Repair connector, harness, or terminal damage. After repairs are complete, retest for DTC.

Step	Action	Decision
3	A. Key OFF B. Disconnect Vehicle Interface Connector (VIC). Measure resistance between VIC (terminal A2) and VIC (terminal B4). Is resistance less than 2500 ohms?	Yes: Repair APP1 signal circuit short to APP2 signal circuit and retest. No: Go To Step 4

Step	Action	Decision
4	See OEM Diagnostics. After completing OEM Diagnostics is fault repaired?	Yes: End Diagnostics. No: Replace ECM and retest.

06 Brake Switch

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
1045	2	Brake Switch "A"/"B" Correlation	• Malfunctioning Brake Switch • Misadjusted Brake Switch • Brake Switch Harness is open or shorted • Poor electrical connection	C	AMBER
1045	7	Brake Switch “A” Circuit	• Malfunctioning Brake Switch • Misadjusted Brake Switch • Brake Switch Harness is open or shorted • Poor electrical connection	C	AMBER



Overview

The brake lamps receive power from the Vehicle Power Center through the red ECU VBATT wire. There is also a fuse before the brake lamp switch itself. When the brakes are applied, power is allowed to flow to the brake lamps and then chassis ground. The ECM monitors brake pedal application by sensing voltage drop on the Brake Pedal Apply wire at J1-33.

Diagnosis of the sensor includes:

- Visual inspection of the electrical connections
- Checking the ECM and brake lamp fuses
- Checking for battery voltage on the power circuit
- Checking for continuity through the ground circuits

Tools Required

- PSI PowerLink
- Digital Multimeter

To 6.0L Gasoline Setting Criteria

- SPN 1045 FMI 2 – Brake Switch “A”/”B” Correlation
- SPN 1045 FMI 7 – Brake Switch “A” Circuit

Step-Based Diagnostic Routine: SPN 1045 FMI 2, 7

Step	Action	Decision
1	A. Key OFF B. Disconnect Vehicle Interface Connector (VIC) C. Disconnect ECM J1 connector D. Check VIC and ECM J1 connector terminals for; loose, bent or broken pins; or broken connector housing. Are VIC or ECM J1 harnesses, terminals and connectors clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest for DTC.

Step	Action	Decision
2	A. Key OFF B. Disconnect VIC C. Disconnect ECM J1 connector Measure resistance between ECM side of VIC (terminal B2) and ECM J1-33. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance between VIC (terminal B2) and ECM J1-33. No: Go To Step 3

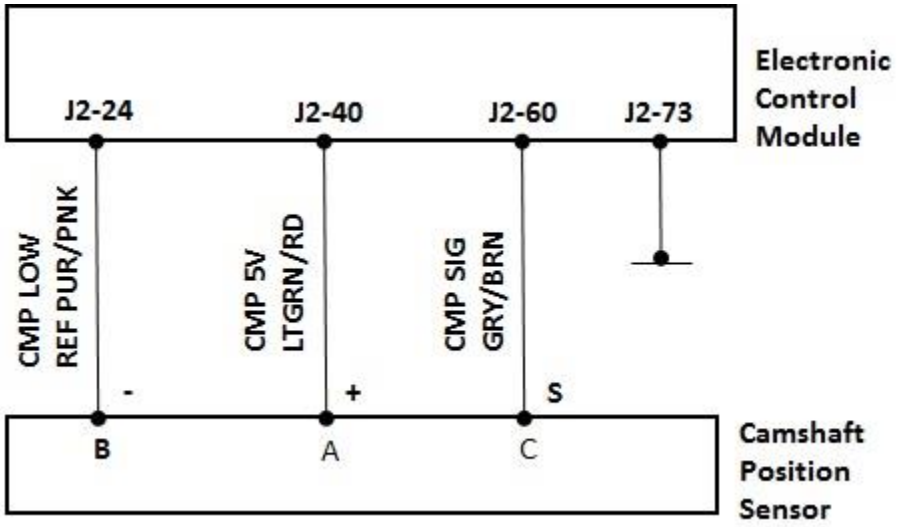
Step	Action	Decision
3	A. Key OFF B. Disconnect VIC C. Disconnect ECM J1 connector Measure resistance between ECM side of VIC (terminal B2) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground between VIC (terminal B2) and ECM J1-33. No: Go To Step 4

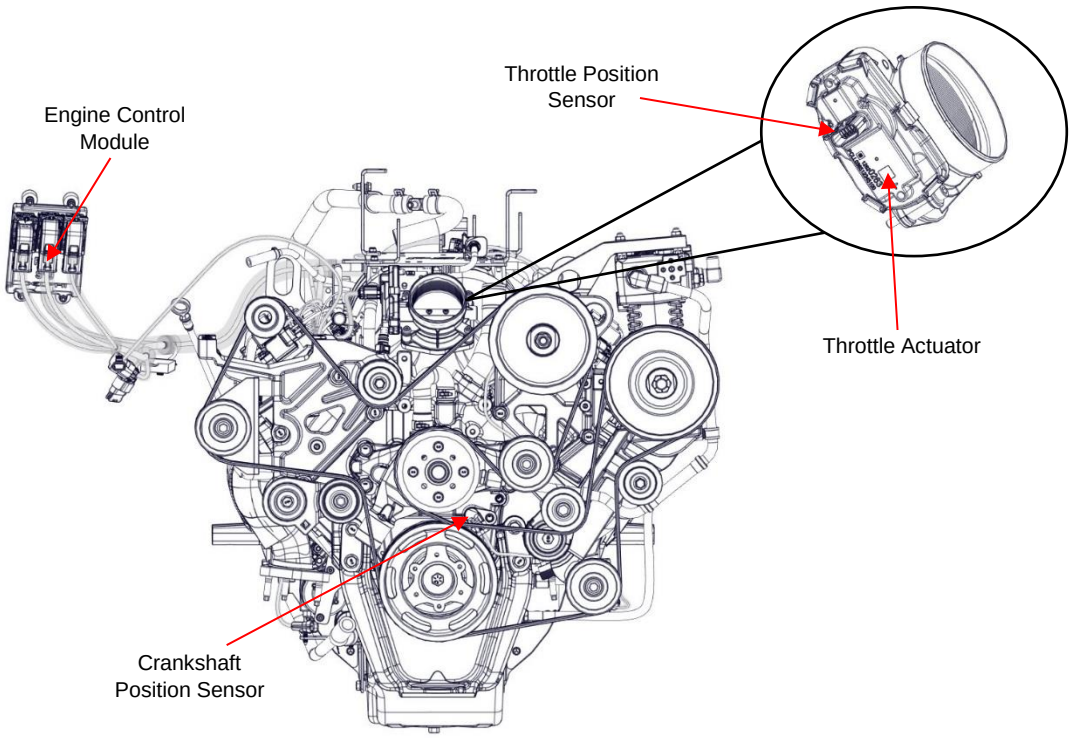
Step	Action	Decision
4	A. Key OFF B. VIC installed C. Disconnect ECM J1 connector Key ON, measure voltage between ECM side of VIC (terminal B2) and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage between VIC (terminal B2) and ECM J1-33, if no short is found between VIC (terminal B3) and ECM J1-38, Go To Step 12 No: Go To Step 5

Step	Action	Decision
5	See OEM Diagnostics. After completing OEM Diagnostics, has the fault been repaired?	Yes: End Diagnostics No: Replace ECM and Retest.

07 Camshaft Position (CMP) Sensor

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
723	2	Camshaft Position Sensor "A" Circuit Range/ Performance	• Malfunctioning sensor • Missing or damaged tone ring • Debris interfering with the sensor plate.	A	NONE
723	4	Camshaft Position Sensor "A" Circuit	• Open or ground in signal circuit • Open or ground in 5V supply circuit • Open in low reference circuit • Malfunctioning sensor • No 5V supply from the ECM • Debris blocking the sensor plate	A	NONE





Overview

The Camshaft Position (CMP) Sensor is a Hall-effect device with 3 circuits. The three circuits include a 5-volt supply (terminal A), a signal return (terminal C), and low reference (terminal B). Mechanically, a 1x gear is attached to the camshaft. As the camshaft turns, the tooth on the gear passes the CMP sensor. The CMP signal is normally high (5 volts) and pulled low to 0 volts each time the tooth on the wheel passes the sensor.

Diagnosis of the CMP sensor includes:

- Ensuring that a 5V supply voltage is supplied to the sensor from the ECM
    - The 5V supply is shared with the coolant level, and oil pressure
    - A short to ground or a short to low reference circuit in any of these circuits will cause all associated sensors to read incorrectly
- Ensuring continuity on the ground circuit
- Verifying that all wiring harness circuits, connectors, and pins are firmly attached and not causing intermittent electrical issues
- Ensuring that the camshaft gear is clean and free of damage
- Ensuring that the sensor is free of debris near the gear and installed correctly

Tools Required – 6.0L Gasoline

- PSI PowerLink
- Digital Multimeter (DMM)

To 6.0L Gasoline Setting Criteria

- SPN 723 FMI 5 – Camshaft Position Sensor “A” Circuit Range/Performance
- SPN 723 FMI 7 – Camshaft Position Sensor “A” Circuit

Associated Faults

SPN	FMI	Description
54	4	Throttle Position Sensor/Switch "A" Circuit Low
94	4	Fuel Supply Pressure Sensor Circuit Short Low
100	1	Engine Oil Pressure Too Low
100	4	Engine Oil Pressure Sensor/Switch "A" Low
111	4	Engine Coolant Level Sensor/Switch Circuit Low
723	4	Camshaft Position Sensor “A” Circuit
1109	15	Throttle Actuator Control System – Forced Limited Power
3509	31	Sensor Reference Voltage “A” Circuit
3673	4	Throttle Position Sensor/Switch "B" Circuit Low

NOTE: The below section will instruct the technician to back-probe the Camshaft Position Sensor Connector. When back-probing any connector, use the thinnest possibly probes, to minimize deformation of the weather pack seal in the back of the connector. Before back-probing the connector, coat back-probe in dielectric grease. This will help the probe be inserted into the connector, and will better seal the connector when the probe is removed. When inserting the probe, make sure the probe is parallel to the wire, and gently push the probe between the weather pack seal and the wire. DO NOT use excessive force, and stop pushing if probe bottoms out in the connector. Failure to follow these guidelines may result in a damaged connector.

Step-Based Diagnostic Routine: SPN 723 FMI 2, 4

Step	Action	Decision
1	Using PowerLink, check the ECM for active or inactive associated fault codes. Are any of the associated fault codes present other than 1109 FMI 15 (active or inactive)?	Yes: Complete SPN 3509 FMI 31, repair faults, clear DTC's, and retest. No: Go To Step 2

Step	Action	Decision
2	A. Key OFF B. Visually confirm the Camshaft Position Sensor is fully seated to the block, secure, and undamaged. C. Disconnect Camshaft Position Sensor. D. Check Camshaft Position Sensor Connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Are the Camshaft Position Sensor, harness, and terminals clean and undamaged? Is the sensor fully seated and secured?	Yes: Go To Step 3 No: Repair connector, harness, or terminal damage. If the sensor is not fully seated remove and inspect, if damaged replace it, if undamaged reinstall. After repairs are complete, retest for DTC.

Step	Action	Decision
3	With the Key OFF, fully install Camshaft Position Sensor Connector. Carefully insert back-probes to (terminal A) and (terminal B), and place DMM leads against back-probes. Key ON and measure voltage between (terminal A) and (terminal B). Is the voltage between 4.5 and 5.5 volts?	No Higher: Repair short to power in the 5V reference circuit Yes: Go To Step 8 No Lower: Go To Step 4

Step	Action	Decision
4	With the Key ON, measure voltage between (terminal A) and Chassis/Engine ground. Is the voltage between 4.5 and 5.5 volts?	Yes: Repair open or high resistance in the low reference circuit No: Go To Step 5

Step	Action	Decision
5	With the Key OFF, measure resistance between (terminal A) and (terminal B). Is the resistance less than 1000 Ohms?	Yes: Go To Step 6 No: Go To Step 7

Step	Action	Decision
6	With the Key OFF, disconnect the camshaft position sensor measure resistance between (terminal A) and (terminal B). Is the resistance less than 1000 Ohms?	Yes: Repair short between 5V reference and low reference circuit or ground No: Replace camshaft position sensor.

Step	Action	Decision
7	A. With the Key OFF B. ECM connector J2 disconnected C. Camshaft Position Sensor Disconnected Measure resistance from ECM J2-40 to (terminal A) on the camshaft position sensor. Is the resistance less than 5 Ohms?	Yes: Retest condition. Test for 5V reference at the other sensors, if present repair open or short in the camshaft position sensor circuit. No: Repair open or high resistance in the 5V reference circuit.

Step	Action	Decision
8	With the back-probes installed, but Camshaft Position Sensor Connector disconnected from the camshaft position sensor. Key ON and measure voltage between (terminal C) and (terminal B). Is the voltage between 4.5 and 5.5 volts?	No Higher: Repair short to power in the camshaft signal circuit Yes: Go To Step 13 No Lower: Go To Step 9

Step	Action	Decision
9	With the Key ON, and the camshaft position sensor disconnected. Measure voltage between (terminal C) and Chassis/Engine ground. Is the voltage between 4.5 and 5.5 volts?	Yes: Repair open or high resistance in low reference circuit No: Go To Step 10

Step	Action	Decision
10	With the Key OFF, and the camshaft position sensor disconnected, measure resistance between (terminal C) and (terminal B). Is the resistance less than 2000 Ohms?	Yes: Repair short between cam signal and low reference circuit or ground No: Go To Step 11

Step	Action	Decision
11	A. With the Key OFF B. ECM connector J2 disconnected C. Camshaft Position Sensor Disconnected Measure resistance from ECM J2-60 to (terminal C) on the camshaft position sensor. Is the resistance less than 5 Ohms?	Yes: Go To Step 12 No: Repair open or high resistance in the cam signal circuit.

Step	Action	Decision
12	With the Key OFF, reinstall ECM connector J2, fully install back-probes into (terminal C) and (terminal B) with Camshaft Position Sensor Connector installed onto Camshaft Position Sensor and measure resistance between (terminal C) and (terminal B). Is the resistance less than 2000 Ohms?	Yes: Replace camshaft position sensor No: Inspect J2 connector for push back terminals or damaged/bent pins on the ECM and connector. If no issues are found replace the ECM.

Step	Action	Decision
13	With the Key OFF, and the camshaft position sensor disconnected measure resistance between (terminal A) and (terminal C). Is the resistance less than 2000 Ohms?	Yes: Repair short between camshaft signal and 5V reference circuit No: Replace camshaft position sensor and retest.

08 Camshaft Variable Timing

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
3306	2	"A" Camshaft Profile Control Performance/ Stuck Off	• Low engine oil level • Contaminated engine oil • Failed Camshaft phaser • Failed Oil Control Solenoid	B	MIL
3306	7	Crankshaft Position/ Camshaft Position Correlation	• Incorrectly installed Camshaft Position Sensor • Incorrectly installed Crankshaft Position Sensor • Failed timing chain tensioner • Incorrectly installed timing chain • Worn or loose timing chain components • Incorrect timing	B	MIL
3306	10	"A" Camshaft Position Slow Response	• Low engine oil level • Contaminated engine oil • Failed Camshaft phaser • Failed Oil Control Solenoid	B	MIL
6336	3	Variable Camshaft Oil Control Solenoid Short to Battery	• Malfunctioning Oil Control Solenoid • Intermittent short in the Oil Control Solenoid wiring harness • Intermittent short within the Oil Control Solenoid connector • Oil Control Solenoid circuit shorted to battery	A	MIL
6336	4	Variable Camshaft Oil Control Solenoid Short to Ground	• Malfunctioning Oil Control Solenoid • Intermittent short in the Oil Control Solenoid wiring harness • Intermittent short within the Oil Control Solenoid connector • Oil Control Solenoid circuit shorted to ground	A	MIL
6336	5	Variable Camshaft Oil Control Solenoid Open	• Malfunctioning Oil Control Solenoid • Intermittent open in the Oil Control Solenoid wiring harness • Intermittent open within the Oil Control Solenoid connector • Oil Control Solenoid circuit open	A	MIL

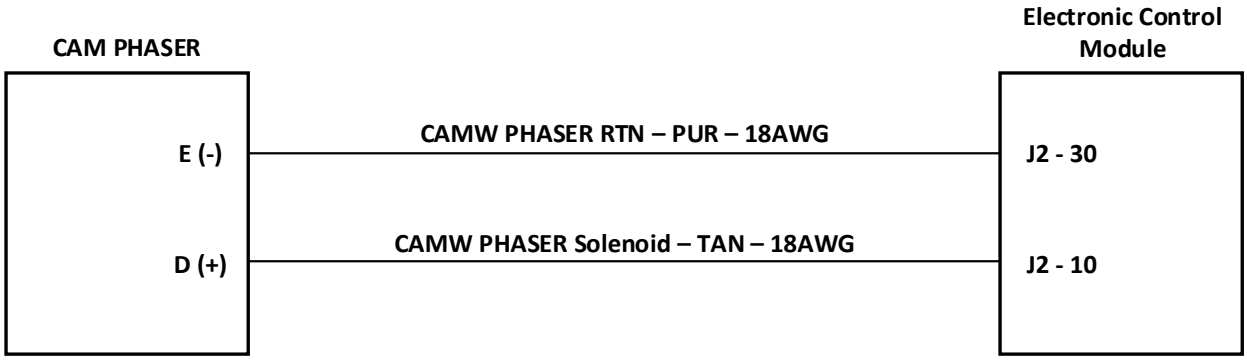
6336	7	“A” Camshaft Profile Control Stuck	• Low engine oil level • Contaminated engine oil • Failed Camshaft phaser • Failed Oil Control Solenoid	B	MIL

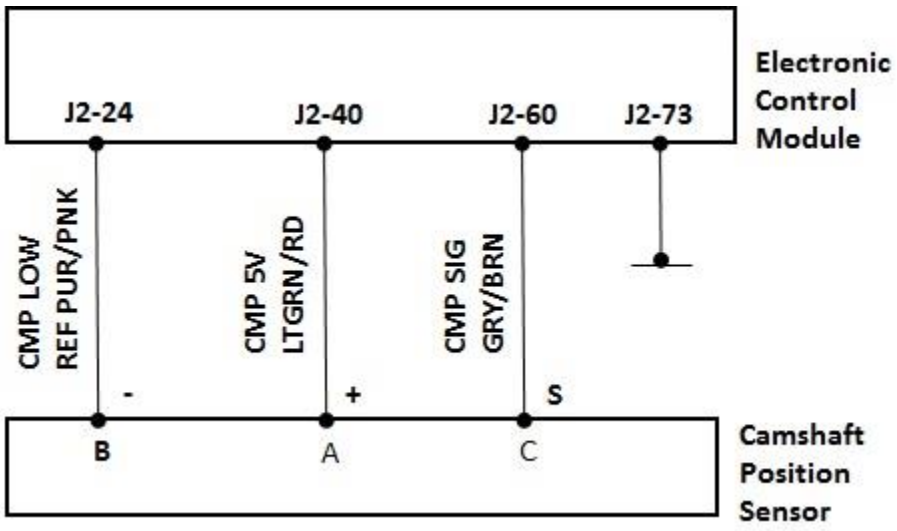
Overview

Variable Camshaft timing is used to increase performance and decrease harmful engine emissions. The change in camshaft timing, and speed of change, is observed and compared to desired camshaft timing. If the camshaft phaser is detected to be seized or does not change camshaft timing as expected, engine performance will be affected and a DTC will set. Camshaft phaser response speed is monitored and compared to a threshold based on oil temperature and requested desired rate. If response speed is outside of the allowable threshold, a DTC will set.

In order for the camshaft phaser to function correctly, the oil control valve feeding the phaser must be functioning correctly as well. Small particles in the engine oil may cause the oil control valve to bind or get stuck at certain spool positions. A test is used to detect a stuck valve spool. A cleaning function is used to try and free the spool, if unsuccessful, a DTC will set.

Camshaft controlled systems must be able to diagnose a one-tooth miss between the camshaft and crankshaft. May factors can affect the potential for false fault codes, such as natural variation of tooth offsets with temperature, RPM, and the cumulation of mechanical and electrical tolerances. To prevent false failures, two sets of thresholds are used, wider thresholds are used when outside of a temperature band, and tighter thresholds are used inside the temperature band.





Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)
- Test Light

To 6.0L Gasoline Setting Criteria

- SPN 3306 FMI 2 – “A” Camshaft Profile Control Performance/Stuck Off Bank 1
- SPN 3306 FMI 7 – Crankshaft Position/Camshaft Position Correlation Bank 1 Sensor A
- SPN 3306 FMI 10 – “A” Camshaft Position Slow Response Bank 1
- SPN 6336 FMI 3 – “A” Camshaft Position Actuator Control Circuit High Bank 1
- SPN 6336 FMI 4 – “A” Camshaft Position Actuator Control Circuit Low Bank 1
- SPN 6336 FMI 5 – “A” Camshaft Position Actuator Control Circuit Open Bank 1
- SPN 6336 FMI 7 – “A” Camshaft Position Control Stuck On Bank 1

Step-Based Diagnostic Routine – Variable Camshaft Oil Control Solenoid

Step	Action	Decision
1	Using PSI PowerLink, determine any other SPNs are active. Are any associated fault codes present?	Yes: See associated SPN diagnostics. Repair as necessary, clear SPNs and release to customer to monitor concern. No: Go To Step 2

Step	Action	Decision
2	A. Key OFF B. Visually confirm Variable Camshaft Oil Control Solenoid is fully seated to timing cover, secure, and undamaged. C. Disconnect Variable Camshaft Oil Control Solenoid. D. Check Variable Camshaft Oil Control Solenoid Connector and Jumper Harness terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Are Variable Camshaft Oil Control Solenoid and Jumper, harness, and terminals clean and undamaged? Is sensor fully seated and secure?	Yes: Go To Step 3 No: Repair connector, harness, or terminal damage. If sensor is not fully seated remove and inspect, if damaged replace it, if undamaged reinstall. After repairs are complete, release to customer to monitor.

Step	Action	Decision
3	A. Key OFF B. Disconnect Variable Camshaft Oil Control Solenoid Jumper Harness Measure resistance between terminal E on the ECM side of the jumper harness connector and chassis ground. Is resistance less than 5 ohms?	Yes: Go To Step 4 No: Repair open or high resistance in camshaft position sensor low reference circuit.

Step	Action	Decision
4	A. Key OFF B. Variable Camshaft Oil Control Solenoid Jumper Harness disconnected C. ECM J2 connector disconnected Key ON, measure voltage between terminal D on the ECM side of the jumper harness connector and chassis ground. Is voltage greater than 1V?	Yes: Repair Short to voltage between Variable Camshaft Oil Control Solenoid Jumper Harness and ECM J2-10. No: Go To Step 5

Step	Action	Decision
5	A. Key OFF B. Variable Camshaft Oil Control Solenoid Jumper Harness disconnected Measure resistance between terminal D on the Camshaft Position Sensor/ Variable Camshaft Oil Control Solenoid side of the jumper harness connector and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair Short to ground between Variable Camshaft Oil Control Solenoid jumper harness connector terminal D and Variable Camshaft Oil Control Solenoid. No: Go To Step 6

Step	Action	Decision
6	A. Key OFF B. Variable Camshaft Oil Control Solenoid Jumper Harness disconnected Measure resistance between terminal D and terminal E on the Camshaft Position Sensor/ Variable Camshaft Oil Control Solenoid side of the jumper harness connector. Is resistance between 5 and 9 ohms?	Yes: Go To Step 10 No, Lower: Go To Step 7 No, Higher: Go To Step 8

Step	Action	Decision
7	A. Key OFF B. Variable Camshaft Oil Control Solenoid Jumper Harness disconnected from engine harness and Variable Camshaft Oil Control Solenoid Measure resistance between terminal D and terminal E on the Camshaft Position Sensor/ Variable Camshaft Oil Control Solenoid side of the jumper harness connector. Is less than infinite resistance present?	Yes: Repair Short between Variable Camshaft Oil Control Solenoid harness control circuit and low reference circuit. No: Replace Variable Camshaft Oil Control Solenoid.

Step	Action	Decision
8	A. Key OFF B. Variable Camshaft Oil Control Solenoid Jumper Harness disconnected from engine harness and Variable Camshaft Oil Control Solenoid Measure resistance between terminal D on the Variable Camshaft Oil Control Solenoid end and terminal D on the engine harness side of the Camshaft Position Sensor/ Variable Camshaft Oil Control Solenoid. Is resistance less than 2 ohms?	Yes: Go To Step 9 No: Repair open or high resistance on Variable Camshaft Oil Control Solenoid control circuit of the jumper harness.

Step	Action	Decision
9	A. Key OFF B. Variable Camshaft Oil Control Solenoid Jumper Harness disconnected from engine harness and Variable Camshaft Oil Control Solenoid Measure resistance between terminal D on the Variable Camshaft Oil Control Solenoid end and terminal D on the engine harness side of the Camshaft Position Sensor/ Variable Camshaft Oil Control Solenoid. Is resistance less than 2 ohms?	Yes: Replace Variable Camshaft Oil Control Solenoid. No: Repair open or high resistance on Variable Camshaft Oil Control Solenoid control circuit of the jumper harness.

Step	Action	Decision
10	A. Key OFF B. Variable Camshaft Oil Control Solenoid Jumper Harness disconnected from engine harness and Variable Camshaft Oil Control Solenoid Measure resistance between each terminal on the Variable Camshaft Oil Control Solenoid and the Variable Camshaft Oil Control Solenoid. Is less than infinite resistance present?	Yes: Replace Variable Camshaft Oil Control Solenoid. No: Go To Step 11

Step	Action	Decision
11	A. Key OFF B. Remove Variable Camshaft Oil Control Solenoid from engine C. Install a 20A fused jumper wire between the control circuit of the Variable Camshaft Oil Control Solenoid and battery positive **NOTE:** The Variable Camshaft Oil Control Solenoid pintle should be facing down for this test. Do not allow electrical current to flow through the Variable Camshaft Oil Control Solenoid for greater than 2 seconds at a time. Momentarily install a jumper wire between Variable Camshaft Oil Control Solenoid low reference terminal and ground. Does the Variable Camshaft Oil Control Solenoid pintle extend then the circuit is completed?	Yes: See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section. No: Replace Variable Camshaft Oil Control Solenoid.

Step-Based Diagnostic Routine – SPN 3306 FMI 7

Step	Action	Decision
1	Using PSI PowerLink, determine any other SPNs are active. Are any associated fault codes present?	Yes: See associated SPN diagnostics. Repair as necessary, clear SPNs and release to customer to monitor concern. No: Go To Step 2

Step	Action	Decision
2	A. Key OFF B. Visually confirm Camshaft Position Sensor and Camshaft Position Sensor are fully seated to block, secure, and undamaged. C. Disconnect Crankshaft Position Sensor and Camshaft Position Sensor. D. Check Crankshaft Position Sensor and Camshaft Position Sensor Connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Are Crankshaft Position Sensor, Camshaft Position Sensor, harness, and terminals clean and undamaged? Are sensors fully seated and secure?	Yes: Go To Step 3 No: Repair connector, harness, or terminal damage. If sensor is not fully seated remove and inspect, if damaged replace it, if undamaged reinstall. After repairs are complete, release to customer to monitor.

Step	Action	Decision
3	A. Key OFF B. Inspect for proper Camshaft and Crankshaft timing. Camshaft Sprocket timing mark should be at the 6 o'clock position while the Crankshaft Sprocket is at the 12 o'clock position. C. Inspect timing chain for binding or wear. Inspect the Camshaft and Crankshaft sprockets for worn, damaged, or chipped teeth. D. Inspect for a damaged key way on the Crankshaft and Crankshaft Sprocket. E. Inspect for worn Oil Pump Drive Splines. F. Inspect Timing Chain Tensioner for a damaged or broken tension spring, and excessive wear or scoring on the chain guide surface. Were any of the above problems found? **NOTE:** Detailed inspection procedures can be found in the Service Manual.	Yes: Repair or replace failed component as outlined in the service manual. No: Reassemble and retest.

Step-Based Diagnostic Routine –SPN 6336 FMI 7 & SPN 3306 FMI 10

Step	Action	Decision
1	Using PSI PowerLink, determine any other SPNs are active. Are any associated fault codes present?	Yes: See associated SPN diagnostics. Repair as necessary, clear SPNs and release to customer to monitor concern. No: Go To Step 2

Step	Action	Decision
2	Perform Section **2.6.3 Low Engine Oil Pressure**. Where any problems found regarding engine oil level, quality, or pressure? **NOTE:** Engine oil level, pressure and quality are critical to the correct operation of the variable camshaft timing system. Verifying the engine has the correct oil viscosity, oil level, and pressure must be done before completing the rest of the diagnostics.	Yes: Repair engine as outlined in section **2.6.3 Low Engine Oil Pressure.** No: Go To Step 3

Step	Action	Decision
3	A. Key OFF B. Disconnect Variable Camshaft Oil Control Solenoid Jumper Harness Measure resistance between terminal E on the ECM side of the jumper harness connector and chassis ground. Is resistance less than 5 ohms?	Yes: Go To Step 4 No: Repair open or high resistance in camshaft position sensor low reference circuit.

Step	Action	Decision
4	A. Key OFF B. Variable Camshaft Oil Control Solenoid Jumper Harness disconnected C. ECM J2 connector disconnected Key ON, measure voltage between terminal D on the ECM side of the jumper harness connector and chassis ground. Is voltage greater than 1V?	Yes: Repair Short to voltage between Variable Camshaft Oil Control Solenoid Jumper Harness and ECM J2-10. No: Go To Step 5

Step	Action	Decision
5	A. Key OFF B. Variable Camshaft Oil Control Solenoid Jumper Harness disconnected Measure resistance between terminal D on the Camshaft Position Sensor/ Variable Camshaft Oil Control Solenoid side of the jumper harness connector and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair Short to ground between Variable Camshaft Oil Control Solenoid jumper harness connector terminal D and Variable Camshaft Oil Control Solenoid. No: Go To Step 6

Step	Action	Decision
6	A. Key OFF B. Variable Camshaft Oil Control Solenoid Jumper Harness disconnected Measure resistance between terminal D and terminal E on the Camshaft Position Sensor/ Variable Camshaft Oil Control Solenoid side of the jumper harness connector. Is resistance between 5 and 9 ohms?	Yes: Go To Step 10 No, Lower: Go To Step 7 No, Higher: Go To Step 8

Step	Action	Decision
7	A. Key OFF B. Variable Camshaft Oil Control Solenoid Jumper Harness disconnected from engine harness and Variable Camshaft Oil Control Solenoid Measure resistance between terminal D and terminal E on the Camshaft Position Sensor/ Variable Camshaft Oil Control Solenoid side of the jumper harness connector. Is less than infinite resistance present?	Yes: Repair Short between Variable Camshaft Oil Control Solenoid harness control circuit and low reference circuit. No: Replace Variable Camshaft Oil Control Solenoid.

Step	Action	Decision
8	A. Key OFF B. Variable Camshaft Oil Control Solenoid Jumper Harness disconnected from engine harness and Variable Camshaft Oil Control Solenoid Measure resistance between terminal D on the Variable Camshaft Oil Control Solenoid end and terminal D on the engine harness side of the Camshaft Position Sensor/ Variable Camshaft Oil Control Solenoid. Is resistance less than 2 ohms?	Yes: Go To Step 9 No: Repair open or high resistance on Variable Camshaft Oil Control Solenoid control circuit of the jumper harness.

Step	Action	Decision
9	A. Key OFF B. Variable Camshaft Oil Control Solenoid Jumper Harness disconnected from engine harness and Variable Camshaft Oil Control Solenoid Measure resistance between terminal D on the Variable Camshaft Oil Control Solenoid end and terminal D on the engine harness side of the Camshaft Position Sensor/ Variable Camshaft Oil Control Solenoid. Is resistance less than 2 ohms?	Yes: Replace Variable Camshaft Oil Control Solenoid. No: Repair open or high resistance on Variable Camshaft Oil Control Solenoid control circuit of the jumper harness.

Step	Action	Decision
10	A. Key OFF B. Variable Camshaft Oil Control Solenoid Jumper Harness disconnected from engine harness and Variable Camshaft Oil Control Solenoid Measure resistance between each terminal on the Variable Camshaft Oil Control Solenoid and the Variable Camshaft Oil Control Solenoid. Is less than infinite resistance present?	Yes: Replace Variable Camshaft Oil Control Solenoid. No: Go To Step 11

Step	Action	Decision
11	Refer to Engine Service manual and perform Camshaft Position Actuator Magnet (Solenoid) Cleaning and Inspection and Camshaft Position Actuator Solenoid Valve Inspection. Were any problems found?	Yes: Repair engine based on service manual recommendations. No: Go To Step 12

Step	Action	Decision
12	A. Key OFF B. Remove Variable Camshaft Oil Control Solenoid from engine C. Install a 20A fused jumper wire between the control circuit of the Variable Camshaft Oil Control Solenoid and battery positive **NOTE:** The Variable Camshaft Oil Control Solenoid pintle should be facing down for this test. Do not allow electrical current to flow through the Variable Camshaft Oil Control Solenoid for greater than 2 seconds at a time. Momentarily install a jumper wire between Variable Camshaft Oil Control Solenoid low reference terminal and ground. Does the Variable Camshaft Oil Control Solenoid pintle extend then the circuit is completed?	Yes: See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section. No: Replace Variable Camshaft Oil Control Solenoid.

09 Catalyst Banks

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
3050	18	Bank 1 Catalyst System Efficiency Below Threshold	• Exhaust system leak • Incomplete cylinder combustion • Contaminated fuel • Malfunctioning O2 Sensor or associated circuits • Aging O2 Sensor / Slow O2 response • Long term misfire allowing unburned fuel into the catalyst • Leaking fuel injector • Aging or failed catalyst	A	MIL
3051	18	Bank 2 Catalyst System Efficiency Below Threshold	• Exhaust system leak • Incomplete cylinder combustion • Contaminated fuel • Malfunctioning O2 Sensor or associated circuits • Aging O2 Sensor / Slow O2 response • Long term misfire allowing unburned fuel into the catalyst • Leaking fuel injector • Aging or failed catalyst	A	MIL

Overview

The PSI 6.0L Gasoline Engine utilizes two three-way catalytic converters, one for each bank. The purpose of the catalysts are to store oxygen and then use stored oxygen to convert harmful combustion by-products (CO and NOx) and fuel (Hydrocarbons) to less harmful compounds (N_2, O_2, H_2O, CO_2). As a catalyst ages, the storing capacity and conversion of these gases/fuels becomes less efficient and results in higher emissions output of the engine. To detect the catalysts efficiency the ECM uses oxygen content before and after the catalyst because oxygen is stored and used in the conversion process by the catalyst.

$$Carbon\ Monoxide\ (CO) + Oxygen\ (O_2) \rightarrow Carbon\ Dioxide\ (CO_2)$$
$$Hydrocarbons\ (HC) + Oxygen\ (O_2) \rightarrow Water\ (H_2O) and\ Carbon\ Dioxide\ (CO_2)$$
$$Nitrogen\ Oxides\ (NO_x) \rightarrow Nitrogen\ (N_2)\ and\ Oxygen\ (O_2)$$

By observing the downstream O2 Sensor signal, the deterioration of the catalyst can be detected. At idle the engine cycles between rich and lean air/fuel ratios. This causes the pre-catalyst O2 sensor to fluctuate between 0.01V (Lean Fueling - High O2 Content) and 0.9V (Rich Fueling – Low O2 Content) see *Figure 1 below. This exhaust mixture then passes through the catalytic converter which induces a chemical reaction storing and converting the oxygen content of the exhaust. The post-catalyst oxygen sensor signal will remain stable in the low oxygen voltage range (typically higher than 0.5V) with minor fluctuations as the engine cycles between rich and lean air/fuel ratios see *Figure 2 below. As a catalyst ages, it loses the ability to store oxygen and convert the engine by-products efficiently and the post-catalyst oxygen sensor will begin to fluctuate similar to the pre-catalyst oxygen sensor. A catalyst that has lost all storing

and converting capabilities will generate a nearly identical pattern on the pre and post catalyst oxygen sensors.

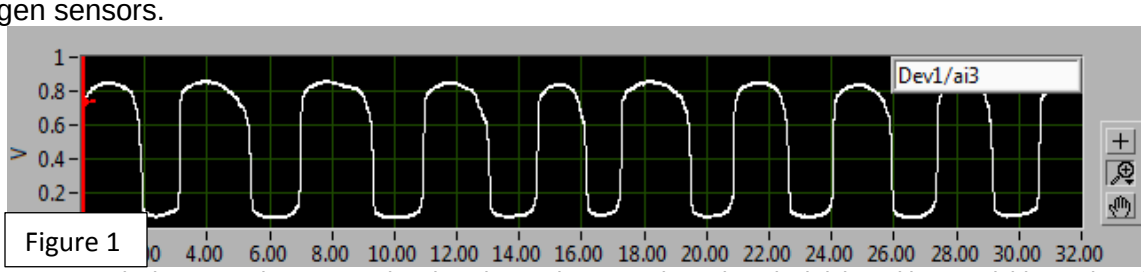


Figure 1: Typical Pre-Catalyst HO2S signal as the engine goes through typical rich and lean stoichiometric ratios

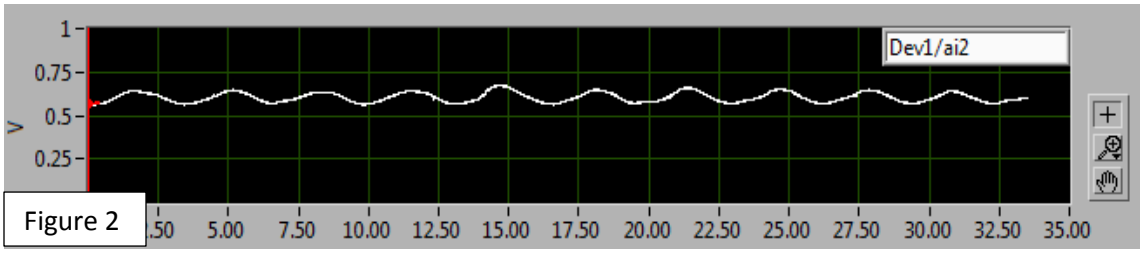


Figure 2: Typical Post-Catalyst HO2S signal. Minor fluctuations follow standard engine stoichiometric ratios but remains above 0.5V due to low oxygen content caused by the catalyst storing and converting oxygen.

NOTE: O2 sensors age and become less efficient over time. This can cause false SPNs if a new post-catalyst sensor is combined with an aged or biased pre-catalyst O2 Sensor. Check vehicle repair history and if this fault has set after recently replacing the post-catalyst O2 Sensor, the pre-catalyst sensor may also need to be replaced. This, however, does not mean both sensors should always be replaced together.

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)
- Automotive Lab Scope (If Available)
- OEM Recommended Leak Locator Kit
- Compressed Air and Soapy Water
- Power / Hand Tools for Removing Exhaust Components
- O2 Sensor Breakout harness 69000046
- Oxygen Sensor Socket 88750B

To 6.0L Gasoline Setting Criteria

- SPN 3050 FMI 18 – Bank 1 Catalyst System Efficiency Below Threshold
- SPN 3051 FMI 18 – Bank 2 Catalyst System Efficiency Below Threshold

Associated Fault Codes

SPN	FMI	Description
3217	3	Bank 1 Sensor 1 O2 Sensor Circuit High Voltage
3217	4	Bank 1 Sensor 1 O2 Sensor Circuit Low Voltage
3217	5	Bank 1 Sensor 1 O2 Sensor Circuit No Activity Detected
3227	3	Bank 1 Sensor 2 O2 Sensor Circuit High Voltage
3227	4	Bank 1 Sensor 2 O2 Sensor Circuit Low Voltage
3227	5	Bank 1 Sensor 2 O2 Sensor Circuit No Activity Detected
3256	3	Bank 2 Sensor 1 O2 Sensor Circuit High Voltage
3256	4	Bank 2 Sensor 1 O2 Sensor Circuit Low Voltage
3256	5	Bank 2 Sensor 1 O2 Sensor Circuit No Activity Detected
3266	3	Bank 2 Sensor 2 O2 Sensor Circuit High Voltage
3266	4	Bank 2 Sensor 2 O2 Sensor Circuit Low Voltage
3266	5	Bank 2 Sensor 2 O2 Sensor Circuit No Activity Detected
4237	15	Bank 1 System Too Lean at Idle
4237	16	Bank 1 System Too Lean
4237	17	Bank 1 System Too Rich at Idle
4237	18	Bank 1 System Too Rich
4239	15	Bank 2 System Too Lean at Idle
4239	16	Bank 2 System Too Lean
4239	17	Bank 2 System Too Rich at Idle
4239	18	Bank 2 System Too Rich

Step-Based Diagnostic Routine: SPN 3050, 3051 FMI 18

Step	Action	Decision
1	Using PSI PowerLink, determine any other SPNs are active. Are any associated fault codes present?	Yes: See associated SPN diagnostics. Repair as necessary, clear SPNs and release to customer to monitor concern. No: Go To Step 2

Step	Action	Decision
2	On exhaust bank in question, perform following for both HO2S. A. Key OFF B. Visually confirm catalyst is present and canister is undamaged C. Visually confirm both HO2S are fully seated in exhaust, secure, and undamaged. D. Disconnect HO2S. E. Check HO2S sensor connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Are O2 sensors, harnesses, and terminals clean and undamaged? Are sensors fully seated and secure?	Yes: Go To Step 3 No: Repair connector, harness, or terminal damage. If sensor is not fully seated remove and inspect, if damaged replace it, if undamaged reinstall. After repairs are complete, release to customer to monitor.

Step	Action	Decision
3	Visually inspect for gaps between exhaust sealing surfaces. Audible test, listen for exhaust leaks. Check for exhaust leaks by spraying soapy water on exhaust joints while vehicle is in PARK and idling. Nothing found, see **3.7 Engine Intake and Exhaust Leaks** in Symptom Based Diagnostic Section. Smoke test exhaust for leaks. Are there any exhaust leaks?	Yes: Repair leaks, clear SPNs, release to the customer to monitor. No: Go To Step 4

Step	Action	Decision
4	On exhaust bank in question, perform following for both HO2S. With the Key OFF, install O2 Sensor Breakout harness 69000046 onto suspected HO2S harness connector and sensor. Measure resistance between low reference circuit (terminal A) and engine/chassis ground. Is resistance less than 10 ohms both sensors?	Yes: Go To Step 5 No: See SPN 3217, 3227, 3256, 3266 to diagnose questionable HO2S circuit.

Step	Action	Decision
5	On exhaust bank in question, perform following for both HO2S. With the Key ON, measure voltage on HO2S signal circuit (terminal B) and low reference circuit (terminal A). Is 1.6 – 2.1V present on both sensors?	Yes: Go To Step 6 No: See SPN 3217, 3227, 3256, 3266 to diagnose the questionable HO2S circuit.

Step	Action	Decision
6	Verify Pre-catalyst oxygen sensor is operating properly. Note: The HO2S signal depends on oxygen content in the exhaust. Therefore, analyzing the HO2S signal requires logical understanding of what the sensor is doing and may require a bank to bank comparison. If using a DMM, understand that the DMM has limited capabilities and sampling rates. If the DMM has a high-resolution feature, enable it. It is preferred to use an automotive lab scope when available. With the Key OFF, install breakout harness on pre-catalyst HO2S. Then perform the following: A. Warm engine to operating temperature ECT 150F+ B. Clear fault codes C. Monitor sensor voltage between (terminal B) and (terminal A) on HO2S breakout harness D. In PowerLink under Status Indicators find “Engine Exhaust Gas Oxygen Sensor Closed Loop Operation, Bank 1&2.” E. Start Engine and Idle Once in Closed Loop operation sensor voltage should cycle between 0.01 – 1V, rising and falling every 1-3 seconds. ***Figure 1** Does sensor output voltage cycle smoothly between 0.01 – 1V?	Yes: Go To Step 7 No – Outputs stable or erratic voltage between 0.02-1V: ***Figure 2** Replace HO2S sensor and retest. If voltage remains unchanged, Go To Step 8. No – Outputs positive voltage greater than 1V: See SPN 3217, 3227, 3256, 3266 diagnostics. No – Outputs (stable or erratic) voltage less than 0.2V: Replace HO2S and retest. If signal remains unchanged, Go To Step 8.

Step	Action	Decision
7	Verify Post-catalyst oxygen sensor is operating properly. Note: HO2S signal depends on oxygen content in the exhaust. Therefore, analyzing HO2S signals require logical understanding of what the sensor is doing and may require a bank to bank comparison. If using a DMM, understand that the DMM has limited capabilities and sampling rates. If the DMM has a high-resolution feature, enable it. It is preferred to use an automotive lab scope when available. With the Key OFF, install breakout harness on post-catalyst HO2S. Then perform the following: A. Warm engine to operating temperature ECT 150F+ B. Clear fault codes C. Monitor sensor voltage between (terminal B) and (terminal A) on HO2S breakout harness D. In PowerLink under Status Indicators find "Engine Exhaust Gas Oxygen Sensor Closed Loop Operation, Bank 1&2." E. Start Engine and Idle Once in Closed Loop operation sensor voltage should remain stable between 0.5 – 0.8V indicating the catalyst is converting remaining fuel vapors and oxygen to heat. ***Figure 3** Does sensor output voltage remain between 0.5 – 0.8V? Note: The more ineffective the catalytic converter, the more the post-catalyst HO2S will resemble the pre-catalyst HO2S.	Yes: Go To Step 8 No – Outputs alternating voltage between 0.01-1V (Similar to pre-cat or erratic) ***Figure 1 & 2**: Replace HO2S and retest. If signal remains unchanged replace catalytic converter and re-evaluate. No – Outputs stable positive voltage greater than 0.8V ***Figure 4**: Go To Step 8. No – Low voltage (< 0.5V): Replace HO2S and retest. If signal remains unchanged, Go To Step 8.

Step	Action	Decision
8	Perform following: A. Remove pre-catalyst HO2S and use a bore scope to inspect catalyst brick for plugging, cracks or melting. B. Disconnect catalytic converter outlet and inspect for a broken brick. C. Remove muffler and attempt to shake any pieces of catalyst material out of muffler. Was any damage to catalyst found during inspection, or did pieces of catalyst come out of muffler?	Yes: Replace catalytic converter. Ensure that all exhaust hangers are in place and secure. Clear faults and retest. No: Reassemble and Go To Step 9

Step	Action	Decision
9	Using PowerLink, Evaluate Fuel Trims, Refer to Section **3.4 Evaluating Fuel Trims** with PowerLink in the Symptom Based Diagnostic Section. Were any issues found while evaluating fuel trims?	Yes: Repair issue, clear fault code and release to customer to monitor concern. No: Replace catalytic converter. Ensure that all exhaust hangers are in place and secure. Clear faults and retest.

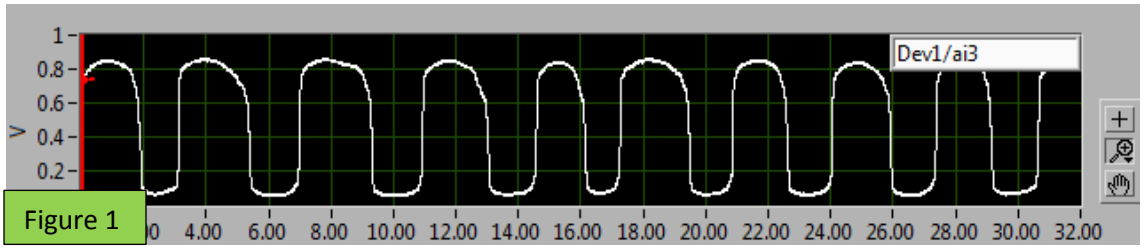


Figure 1: Typical Pre-Catalyst HO2S signal as the engine goes through typical rich and lean stoichiometric ratios

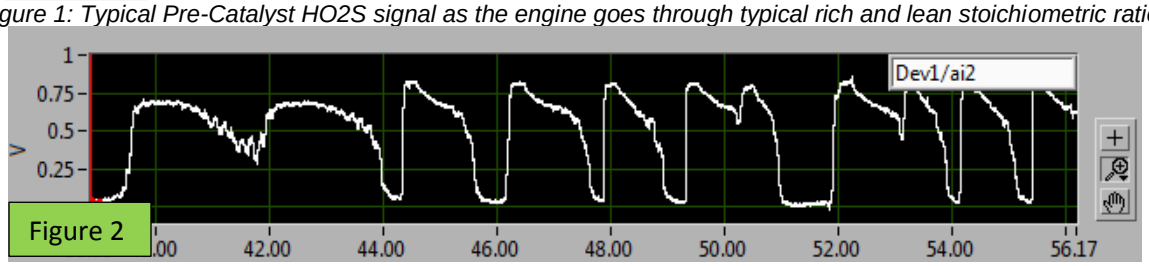


Figure 2: Erratic Pre-Catalyst HO2S signal due to engine performance and combustion concerns

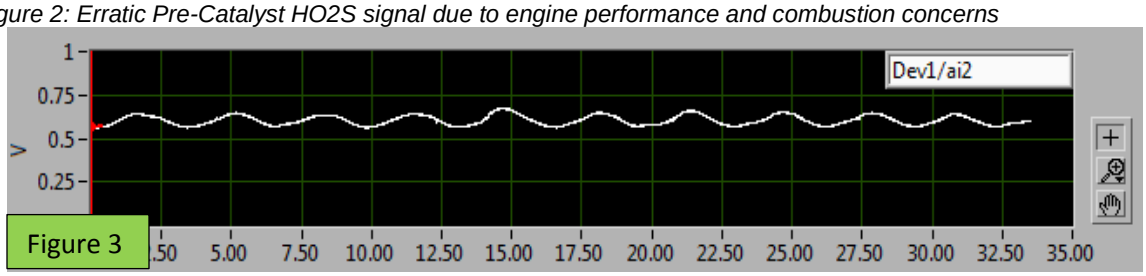


Figure 3: Typical Post-Catalyst HO2S signal. Minor fluctuations follow standard engine stoichiometric ratios but remains above 0.5V due to low oxygen content caused by the catalyst storing and converting oxygen.

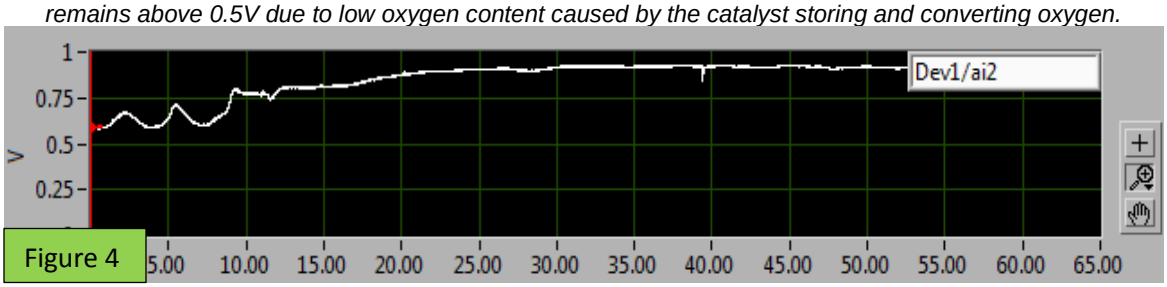
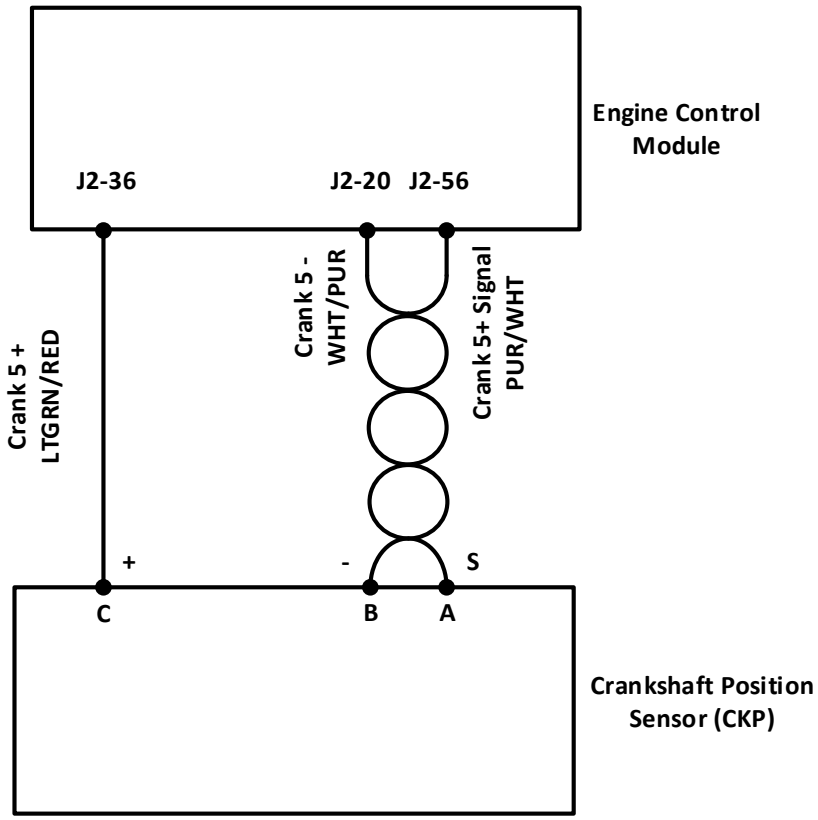


Figure 4 Non-typical Post-Catalyst HO2S signal. The sensor voltage is above 0.8V indicating low amounts of oxygen in the exhaust stream. This can be cause by rich stoichiometric air/fuel ratios or poor combustion due to ignition failures

10 Crankshaft Position (CKP) Sensor

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
636	2	Crankshaft Position Sensor "A" Circuit Range/Performance	• Malfunctioning CKP sensor • Intermittent open or short in the CKP sensor wiring harness • Intermittent open or short within the CKP sensor connector • Missing or damaged tone ring teeth • Debris on the sensor or tone ring.	A	MIL
636	4	Crankshaft Position Sensor "A" Circuit	• Open or short to ground in signal circuit “A” • Open or short to ground in reference circuit “C” • Open in ground circuit “B” • Malfunctioning CKP sensor • Open common ground circuit through the ECM • No reference voltage from the ECM • Debris on the sensor or tone ring • Sensor not connected	A	MIL
4203	13	Crankshaft Position (CKP) System Variation Not Learned	• Worn crankshaft main bearings • Debris between the CKP sensor and the reluctor wheel • A damaged reluctor wheel • Excessive crankshaft runout • A damaged crankshaft • Electromagnetic interference (EMI) in the signal circuit of the CKP sensor	C	NONE



Overview

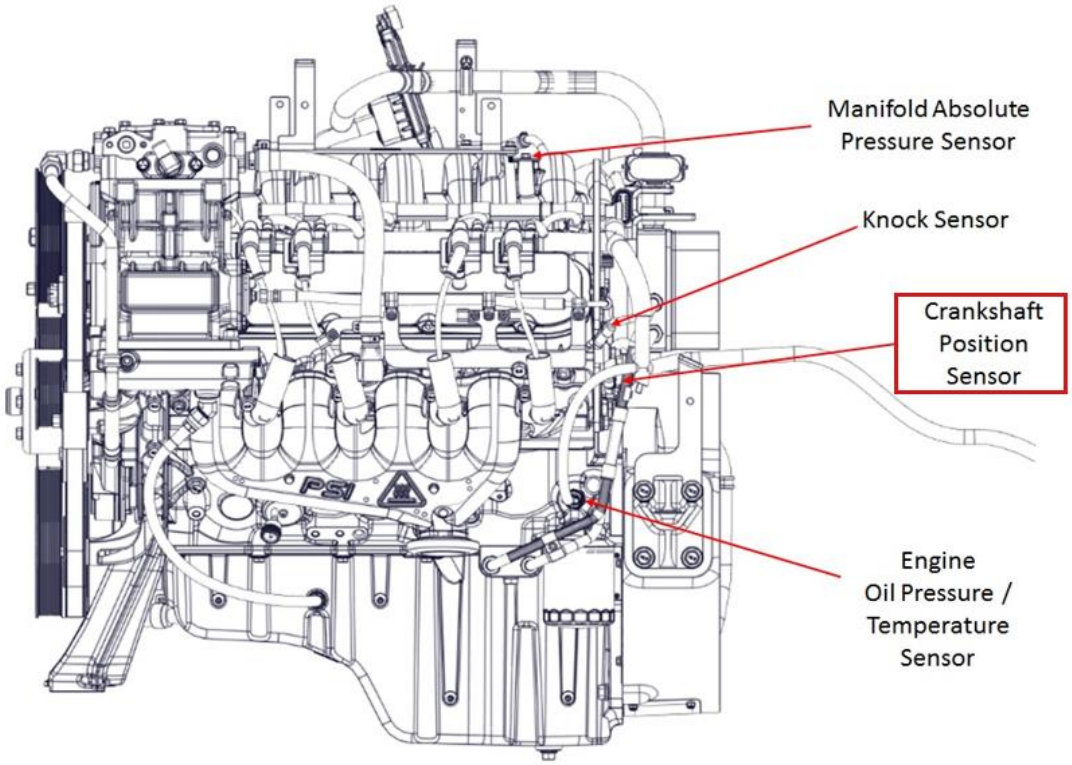
The Crankshaft Position (CKP) Sensor is a Hall-effect device with 3 circuits. The three circuits include a 5V supply (terminal C), a signal circuit (terminal A), and a low reference (terminal B). Mechanically, a 58x crankshaft wheel is attached to the crankshaft. As the crankshaft turns the teeth on the wheel pass the CKP sensor. The CKP signal is normally high (5 volts) and pulled low to 0 volts each time a tooth on the wheel passes the sensor.

Diagnosis of the CKP sensor includes:

- Ensuring that a 5V supply is sent to the sensor from the ECM
- Ensuring continuity on the ground circuit
- Verifying that all wiring harness circuits, connectors, and pins are firmly attached and not causing intermittent electrical issues
- Ensuring that the crankshaft wheel is clean and free of damage
- Ensuring that the sensor is free of debris near the tone ring

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)
- Breakout Harness 69000050



Associated Faults

SPN	FMI	Description
636	4	Crankshaft Position Sensor “A” Circuit
1109	15	Throttle Actuator Control System – Forced Limited Power
3510	31	Sensor Reference Voltage “B” Circuit
3563	4	Manifold Absolute Pressure Circuit Low Input

To 6.0L Gasoline Setting Criteria

- SPN 636 FMI 2 – Crankshaft Position Sensor “A” Circuit Range/Performance
- SPN 636 FMI 4 – Crankshaft Position Sensor “A” Circuit
- SPN 4203 FMI 13 – Crankshaft Position (CKP) System Variation Not Learned

Step-Based Diagnostic Routine - CKP Sensor SPN 636 FMI 2 and 4

Step	Action	Decision
1	Using PowerLink, check the ECM for active or inactive associated fault codes. Are any of the associated fault codes present other than 1109 FMI 15 (active or inactive)?	Yes: Complete SPN 3510 FMI 31, repair faults, clear DTC's, and retest. No: Go To Step 2

Step	Action	Decision
2	A. Key OFF B. Visually confirm Crankshaft Position Sensor is fully seated to block, secure, and undamaged. C. Disconnect Crankshaft Position Sensor. D. Check Crankshaft Position Sensor Connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Are Crankshaft Position Sensor, harness, and terminals clean and undamaged? Is sensor fully seated and secure? Note: Crankshaft position sensor has vertical play in it even bolt in place but loose. Making sure sensor is fully seated may require loosening bolt, pushing sensor down, and then retightening bolt.	Yes: Go To Step 3 No: Repair connector, harness, or terminal damage. If sensor is not fully seated remove and inspect, if damaged replace it, if undamaged reinstall. After repairs are complete, retest for DTC.

Step	Action	Decision
3	Key OFF, install breakout harness 69000050. Key ON, measure voltage between (terminal C) and (terminal B). Is voltage between 4.5 and 5.5 volts?	No Higher: Repair short to power in 5V reference circuit. Yes: Go To Step 8 No Lower: Go To Step 4

Step	Action	Decision
4	Key ON, measure voltage between (terminal C) and Chassis/Engine ground. Is voltage between 4.5 and 5.5 volts?	Yes: Repair open or high resistance in low reference circuit. No: Go To Step 5

Step	Action	Decision
5	Key OFF, measure resistance between (terminal C) and (terminal B). Is resistance less than 1000 Ohms?	Yes: Go To Step 6 No: Go To Step 7

Step	Action	Decision
6	Key OFF, disconnect crankshaft position sensor measure resistance between (terminal C) and (terminal B). Is resistance less than 1000 Ohms?	Yes: Repair short between 5V reference and low reference circuit or ground. No: Replace crankshaft position sensor.

Step	Action	Decision
7	A. Key OFF B. ECM connector J2 disconnected C. Crankshaft Position Sensor Disconnected Measure resistance from ECM J2-36 to (terminal C) on crankshaft position sensor. Is resistance less than 5 Ohms?	Yes: Inspect J2 connector for push back terminals or damaged/bent pins on ECM and connector. If no issues are found replace ECM. No: Repair open or high resistance in 5V reference circuit.

Step	Action	Decision
8	With breakout harness 69000050 installed but disconnected from crankshaft position sensor. Key ON and measure voltage between (terminal A) and (terminal B). Is voltage between 4.5 and 5.5 volts?	No Higher: Repair short to power in crankshaft signal circuit. Yes: Go To Step 13 No Lower: Go To Step 9

Step	Action	Decision
9	Key ON, and crankshaft position sensor disconnected. Measure voltage between (terminal A) and Chassis/Engine ground. Is voltage between 4.5 and 5.5 volts?	Yes: Repair open or high resistance in low reference circuit. No: Go To Step 10

Step	Action	Decision
10	Key OFF, and crankshaft position sensor disconnected. Measure resistance between (terminal A) and (terminal B). Is resistance less than 2500 Ohms?	Yes: Repair short between crank signal and low reference circuit or ground. No: Go To Step 11

Step	Action	Decision
11	A. Key OFF B. ECM connector J2 disconnected C. Crankshaft Position Sensor Disconnected Measure resistance from ECM J2-56 to (terminal A) on crankshaft position sensor. Is resistance less than 5 Ohms?	Yes: Go To Step 12 No: Repair open or high resistance in crank signal circuit.

Step	Action	Decision
12	Key OFF, reinstall ECM connector J2, fully install breakout harness 69000050 measure resistance between (terminal A) and (terminal B). Is resistance less than 2500 Ohms?	Yes: Replace crankshaft position sensor. No: Inspect J2 connector for push back terminals or damaged/bent pins on ECM and connector. If no issues are found replace ECM.

Step	Action	Decision
13	With Key OFF, disconnect crankshaft position sensor and measure resistance between (terminal A) and (terminal C). Is resistance less than 2500 Ohms?	Yes: Repair short between crankshaft signal and 5V reference circuit. No: Replace crankshaft position sensor and retest.

Step-Based Diagnostic Routine – CKP Sensor SPN 4203 FMI 13

Step	Action	Decision
1	Did you perform the Diagnostic System Check – Vehicle?	Yes: Go To Step 2 No: Go to Diagnostic System Check – Vehicle.

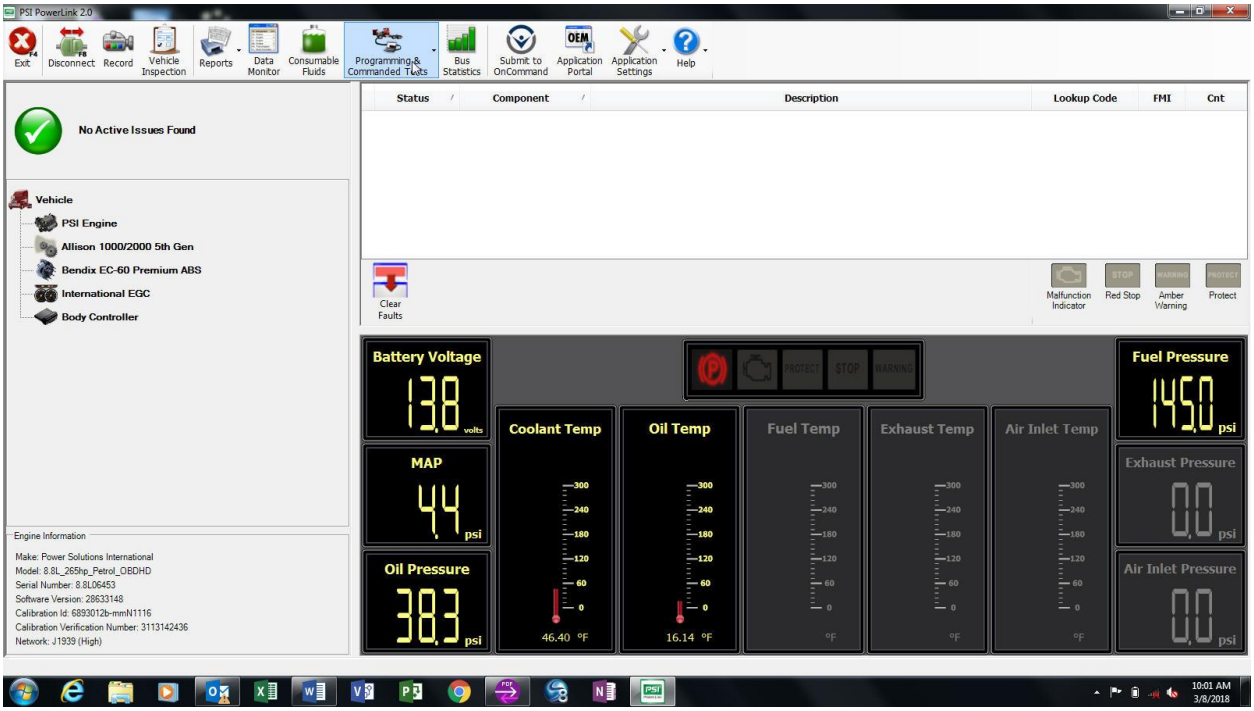
Step	Action	Decision
2	Perform the Crankshaft Position (CKP) System Variation Learn Procedure. Refer to the CKP System Variation Learn Procedure. See below images for reference using PowerLink to perform learn procedure. Does the scan tool display “learned” this ignition?	Yes: Go To Step 4 No: Go To Step 3

Step	Action	Decision
3	Inspect for the following conditions: • Worn crankshaft main bearings • Debris between the CKP sensor and the reluctor wheel • A damaged reluctor wheel • Excessive crankshaft runout • A damaged crankshaft • Electromagnetic interference (EMI) in the signal circuit of the CKP sensor • The ignition switch is in the ON position until the battery has insufficient system voltage. • A powertrain control module (PCM) power disconnect with the ignition ON that may have erased the stored value and set the DTC. Did you complete the inspection?	Yes: Go To Step 4 No: Complete inspection, go to Step 4

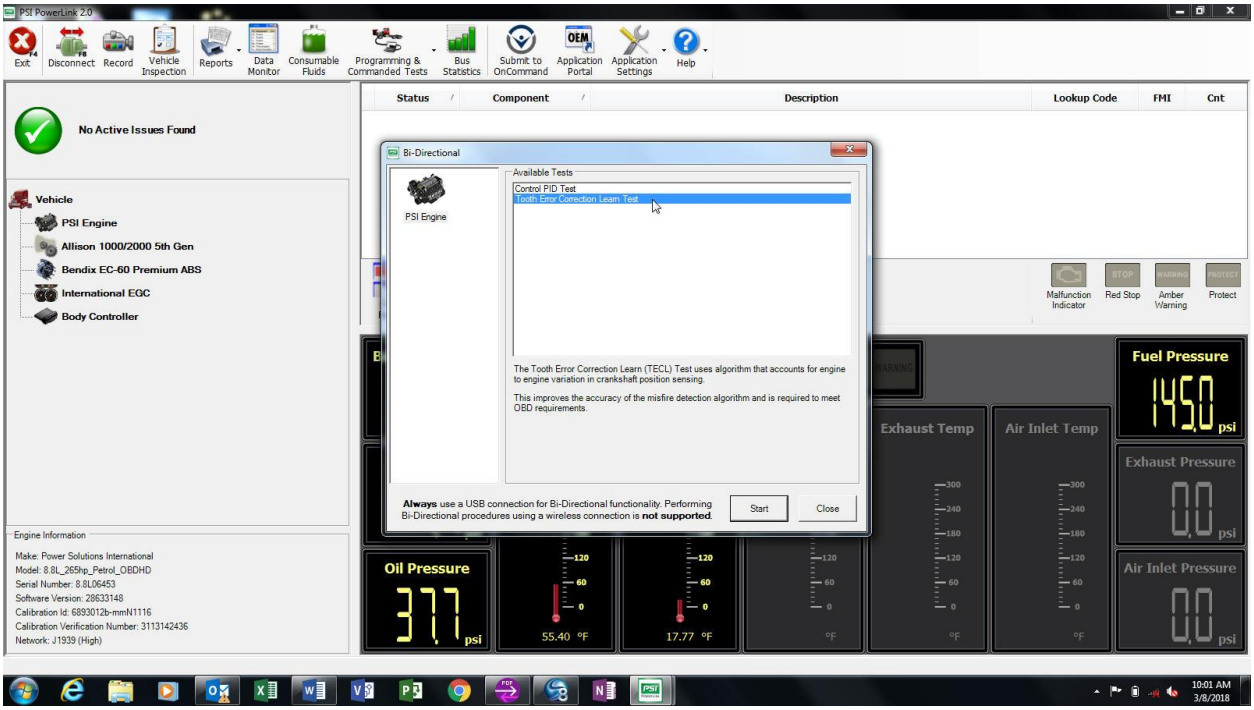
Step	Action	Decision
4	A. Clear the DTCs with a scan tool B. Turn OFF the ignition for 30 seconds. C. Start the engine. D. Operate the vehicle within the Conditions for Running the DTC, as specified in the supporting text. Did the DTC fail this ignition?	Yes: Go To Step 2 No: Go To Step 5

Step	Action	Decision
5	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	Yes: Go To Diagnostic Trouble Code (DTC) List – Vehicle.
		No: System OK.

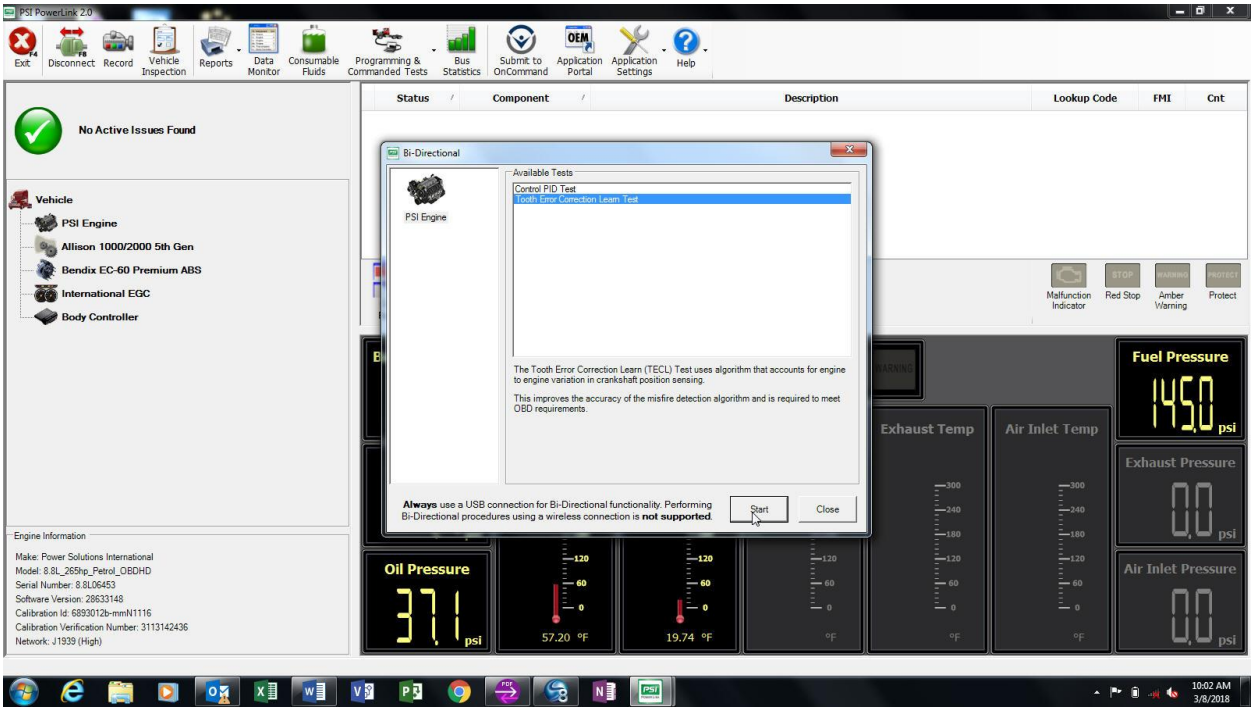
Crankshaft Position (CKP) System Variation Learn Procedure



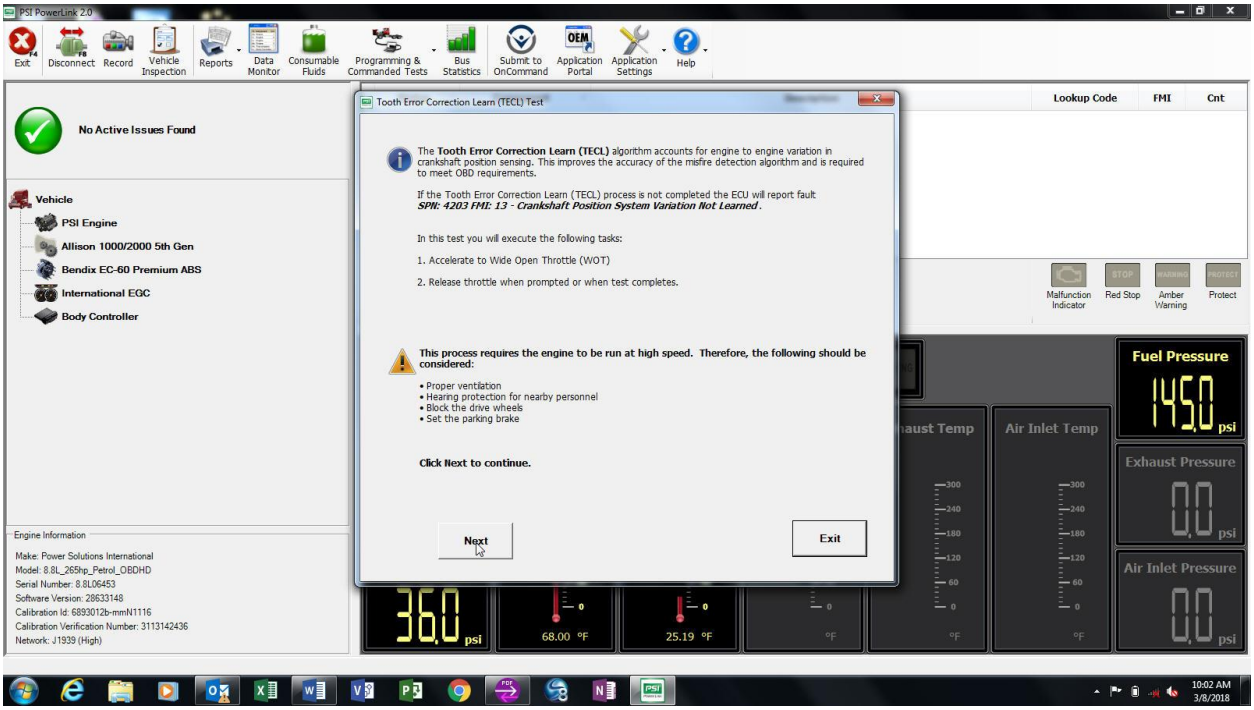
Step 1 - Connect PowerLink to vehicle, connect to vehicle ECM, select "Programming & Commanded Tests"



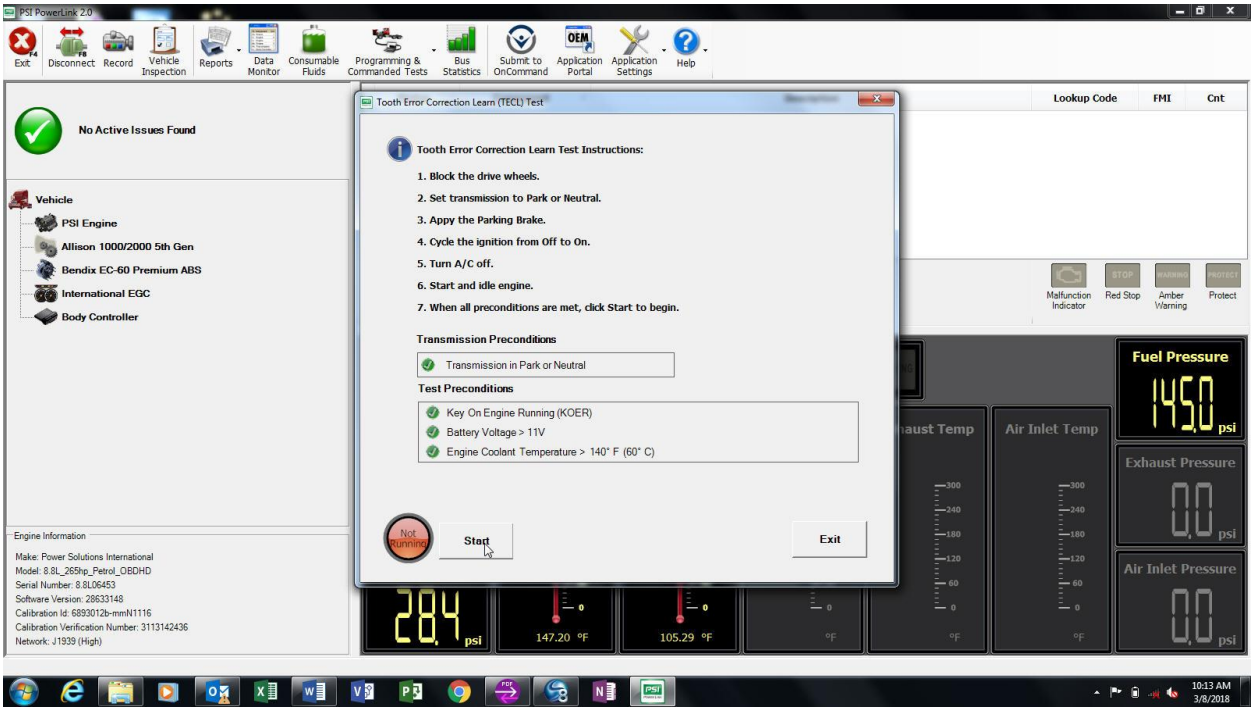
Step 2 - Select "Tooth Error Correction Learn Test"



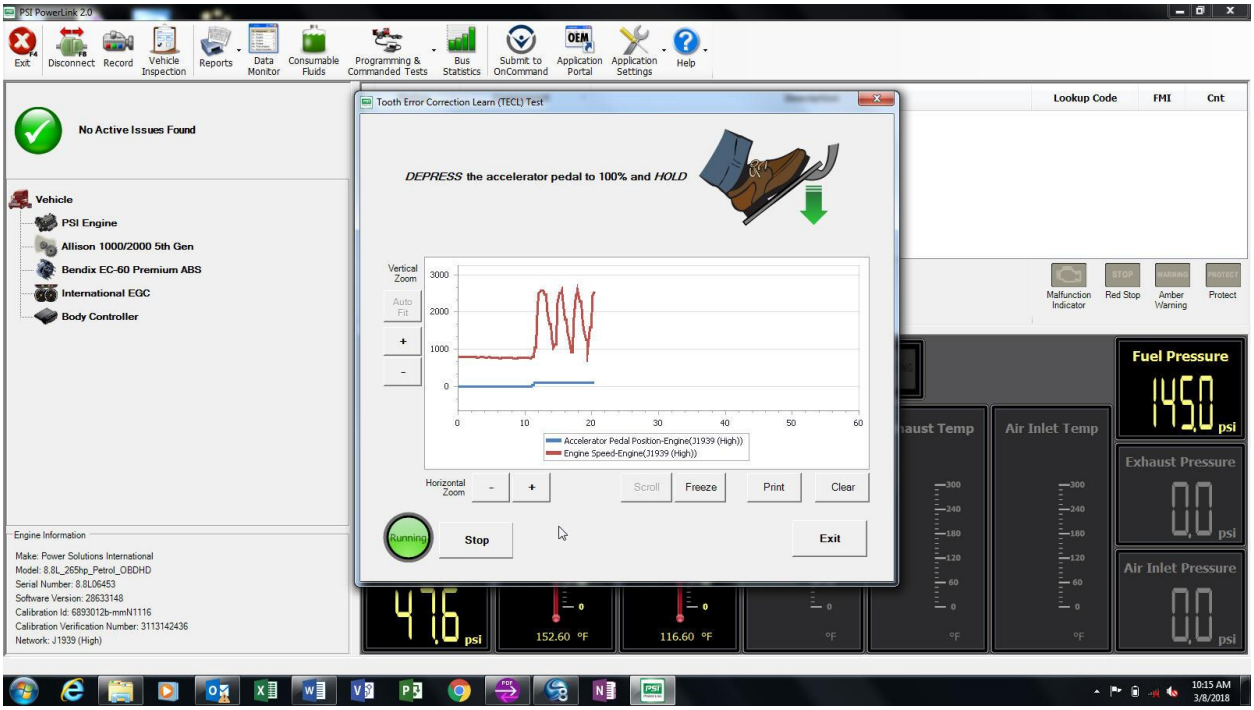
Step 3 - Select "Start"



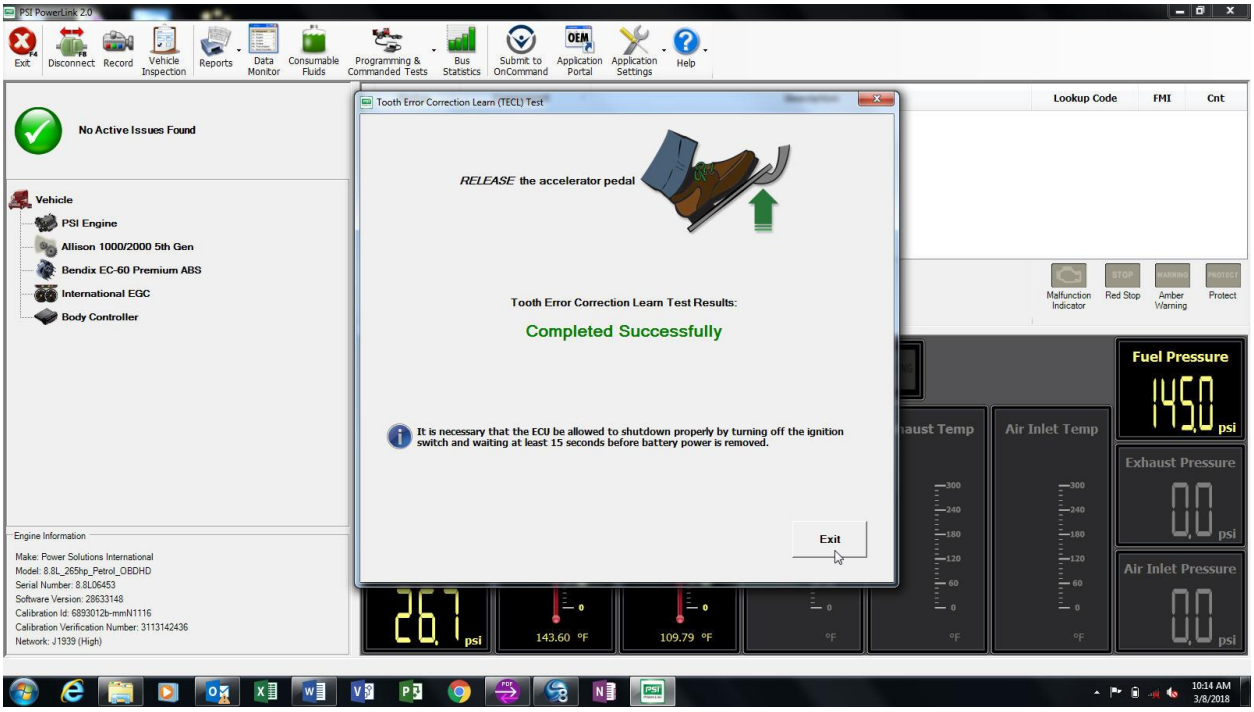
Step 4 - After reading the information regarding the warnings and description of test, select "Next"



Step 5 - Perform the instructions provided, and once the preconditions are met, select "Start"



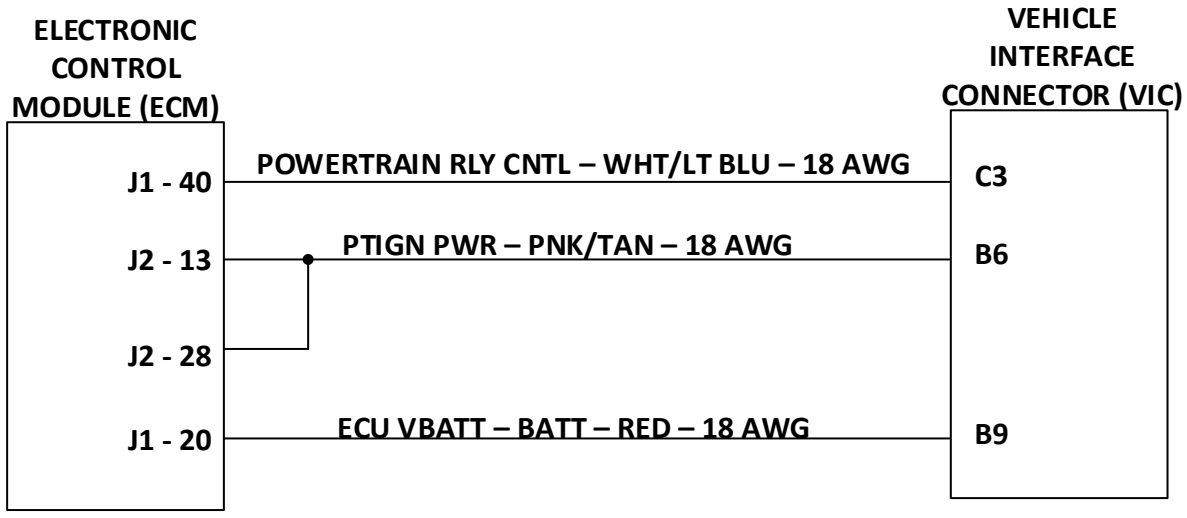
Step 6 - Perform Learn Test



Step 7 - Crankshaft Position (CKP) System Variation Learn Procedure completed

11 Powertrain Relay Control (ECM Power Relay)

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
1485	3	ECM Power Relay Control Circuit High	• Malfunctioning Relay • Short to voltage • Loose or intermittent connection	A	MIL
1485	4	ECM Power Relay Control Circuit Low	• Battery / Charging System • Short to ground in wiring • Battery • Malfunctioning relay • Loose electrical connection • ECM fuse	A	MIL
1485	5	ECM Power Relay Control Circuit Open	• Loose electrical connection • Malfunctioning Relay • ECM fuse • Open in wiring	A	MIL



Overview

The fault code description for SPN 1485 names specifically “ECM Power Relay” but this fault code refers to the “Powertrain Relay” in the Vehicle Power Center, refer to OEM manuals for location.

The Powertrain Relay provides battery voltage to the fused circuits; PTIGN PWR 1, PTIGN PWR 2, INJ PWR 1, and INJ PWR 2 circuits through the Vehicle Interface Connector (VIC). The Powertrain relay is provided battery power at all times and is commanded closed by ECM which grounds the relay. The relay is located within the Vehicle Power Center and the ECM control circuit is located at ECM (J1-40). The grounding circuit passes through the Vehicle Interface Connector (VIC) at (terminal C3) to the relay. The ECM receives power directly from the battery through the same circuit as the coil (terminal 86) on the Powertrain Relay. This runs through the 10 amp ECM Fuse also located in the Vehicle Power Center.

Tools Required

- PSI PowerLink
- Digital Multimeter
- Relay Breakout Harness 69000090

To 6.0L Gasoline Setting Criteria

- SPN 1485 FMI 3 – ECM Power Control Relay Control Circuit High
- SPN 1485 FMI 4 – ECM Power Control Relay Control Circuit Low
- SPN 1485 FMI 5 – ECM Power Control Relay Control Circuit Open

Step-Based Diagnostic Routine: SPN 1485 FMI 3

Step	Action	Decision
1	A. Key OFF B. Disconnect Powertrain Relay C. Check Powertrain Relay terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are Powertrain Relay connectors, harness, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest for fault.

Step	Action	Decision
2	A. Key OFF B. ECM Connector J1 disconnected C. VIC connected D. Powertrain Relay removed Key ON, measure voltage between ECM Connector J1-40 and chassis ground. Is voltage less than 1V?	Yes: Go To Step 3 No: Repair short to voltage between ECM Connector J1-40 and VIC (terminal C3), if no short is found between ECM J1-40 and VIC (terminal C3), Go To Step 3

Step	Action	Decision
3	Go See OEM Diagnostics. After OEM diagnostics have been completed, has the fault been corrected?	Yes: End Diagnostics. No: See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section.

Step-Based Diagnostic Routine: SPN 1485 FMI 4, 5

Step	Action	Decision
1	A. Key OFF B. Disconnect Powertrain Relay and Vehicle Interface Connectors (VIC) C. Check Powertrain Relay and Vehicle Interface Connector (VIC) terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are Powertrain Relay and Vehicle Interface Connectors (VIC), harnesses, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest.

Step	Action	Decision
2	A. Key OFF B. ECM Connector J1 removed C. VIC disconnected Key OFF, measure resistance between ECM Connector J1-40 and VIC (terminal C3). Is resistance less than 5 ohms?	Yes: Go To Step 3 No: Repair open or high resistance between ECM Connector J1-40 and VIC (terminal C3)

Step	Action	Decision
3	A. Key OFF B. ECM Connector J1 removed C. VIC disconnected Key OFF, measure resistance between VIC terminal C3 and chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 4 No: Repair short to ground between ECM Connector J1-40 and VIC (terminal C3)

Step	Action	Decision
4	A. Key OFF B. ECM Connector J1 removed C. Powertrain Relay removed Key OFF, measure voltage between ECM Connector J1-40 and chassis ground. Is voltage 1V or less?	Yes: Go To Step 5 No: Repair short to voltage between ECM Connector J1-40 and VIC (terminal C3) , if no short is found between VIC (terminal C3) and ECM J1-40, Go To Step 7

Step	Action	Decision
5	A. Key OFF B. ECM Connector J1 removed C. VIC disconnected Key OFF, measure resistance between VIC (terminal B9) and ECM Connector J1-20. Is resistance less than 5 ohms?	Yes: Go To Step 6 No: Repair open or high resistance between ECM Connector J1-20 and VIC (terminal B9)

Step	Action	Decision
6	A. Key OFF B. ECM Connector J1 removed C. VIC disconnected Key OFF, measure resistance between VIC (terminal B9) and chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 7 No: Repair short to ground between VIC (terminal B9) and ECM Connector J1-20.

Step	Action	Decision
7	Go See OEM Diagnostics. After OEM diagnostics have been completed, has the fault been corrected?	Yes: End Diagnostics No: Go To Step 8

Step	Action	Decision
8	See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section. After **1.3 Intermittent Fault Code Diagnostics** has been completed, has the fault been corrected?	Yes: End diagnostics No: Replace ECM and retest.

12 Engine Control Module (ECM)

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
251	2	ECM/PCM Engine On Timer Performance	• Faulty ECM/PCM	A	MIL
588	13	Engine Serial Number Not Programmed or Incompatible	• Incorrect serial number programmed into system • No serial number entered into system	A	MIL
629	2	Internal Control Module Torque Calculation Performance	• ECM Failure	A	MIL
629	12	ECM Processor	• ECM Failure	C	STOP
629	31	ECM Processor	• ECM Failure	C	STOP
1634	13	Internal Control Module Memory Checksum Error – System Software Verification Mismatch	• Incorrect calibration uploaded to CPU	A	MIL
3301	2	ECM/PCM Engine On Timer Performance	• Faulty ECM/PCM	A	MIL
7355	2	Engine Timing Advance Error	• Faulty ECM	B	MIL

Overview

The Engine Control Module (ECM) continuously monitors internal circuitry within the module. SPN 629 codes will be set whenever the ECM detects and internal module failure.

SPN 251 FMI 2 and SPN 3301 FMI 2:

The Engine Run Test Diagnostic monitors the ability of the Low Power Counter (LPC) to correctly measure the engine run time. Erroneous counter operation will result in wrong engine run times, which in turn is used by many subsystems to determine operating conditions and also make diagnostic decisions.

This code detects inaccuracy of the LPC by comparing the elapsed start/end time of the LPC during a reference time period defined by a timer within the controller's main processor.

SPN 588 FMI 13:

The Engine Identification Number, or serial number, is programmed into the ECM during engine assembly. CAN diagnostics checks to ensure the that the Engine Identification Number was programmed into the ECM. If the Engine Identification Number was not programmed during engine assembly, then a fault code will set. This diagnostic uses the same enable criteria as the

rest of the CAN diagnostics, but it also adds a required minimum ignition on time. No default actions are taken if this fault is set.

SPN 1634 FMI 13:

The diagnostic is designed to prevent incorrect calibration and software combinations in production applications. The software version must be consistent with the calibration.

The test will run once every key cycle.

The calibration ID is compared to the calibration ID provided in the software, and if the two do not match, the diagnostic is said to have failed and is reported to the diagnostic manager. Else if they do match, the diagnostic is said to have passed and is reported to the diagnostic manger.

SPN 7355 FMI 2:

Spark timing is used to control engine combustion, as well as other emissions-related and drivability functions. One such function is to enhance the "*light-off*" timing of the catalytic converter. During cold starts, spark timing is retarded to promote heat generation in the exhaust, and speeds the catalytic converter's ability to convert emissions (*HC, CO, and NOx*). When the engine is warmed up, the spark timing is returned to its more advanced control to maximize engine torque and horsepower.

Regulations require that any cold start emission control strategy be monitored for failure. Errors in achieving the converter light-off commanded spark timing can cause an increase in vehicle emissions, and therefore must be diagnosed.

The spark timing diagnostic monitors the commanded spark timing and the actual spark timing measured by the hardware. The difference between these two values (spark timing error) is compared to a calibration table (*one for advance and one for retard*) where the interpolated calibration is dependent on engine speed. If this difference meets or exceeds this calibration, the sample fails. If enough of these samples fail in a calibrated sample time, the diagnostic fails.

Table 1: Engine Speed RPM vs. Spark Timing Error (Advance)

Engine Speed (RPM)	Spark Timing Error (deg. crank)
0	9
400	9
500	9
600	9
700	9
800	9
900	9
1000	9
1500	9
2000	9
2500	9
3000	9

Table 2: Engine Speed RPM vs. Spark Timing Error (Retard)

Engine Speed (RPM)	Spark Timing Error (deg. crank)
0	9
400	9
500	9
600	9
700	9
800	9
900	9
1000	9
1500	9
2000	9
2500	9
3000	9

Tools Required

- PSI PowerLink
-

To 6.0L Gasoline Setting Criteria

- SPN 251 FMI 2 – ECM/PCM Engine On Timer Performance
- SPN 588 FMI 13 – Engine Serial Number Not Programmed or Incompatible
- SPN 629 FMI 2 – Internal Control Module Torque Calculation Performance
- SPN 629 FMI 12 – ECM Processor
- SPN 629 FMI 12 – ECM Processor – ETC
- SPN 629 FMI 12 – ECM Processor – Internal Communication
- SPN 629 FMI 12 – ECM Processor – Main Processor
- SPN 629 FMI 12 – ECM Processor – Checking Processor
- SPN 629 FMI 12 – ECM Processor – CPU
- SPN 629 FMI 12 – ECM Processor – Sequencing
- SPN 629 FMI 31 – ECM Processor
- SPN 1634 FMI 13 Internal Control Module Memory Checksum Error – System Software Verification Mismatch
- SPN 3301 FMI 2 – ECM/PCM Engine On Timer Performance
- SPN 7355 FMI 2 – Engine Timing Advance Error

Step-Based Diagnostic Routine

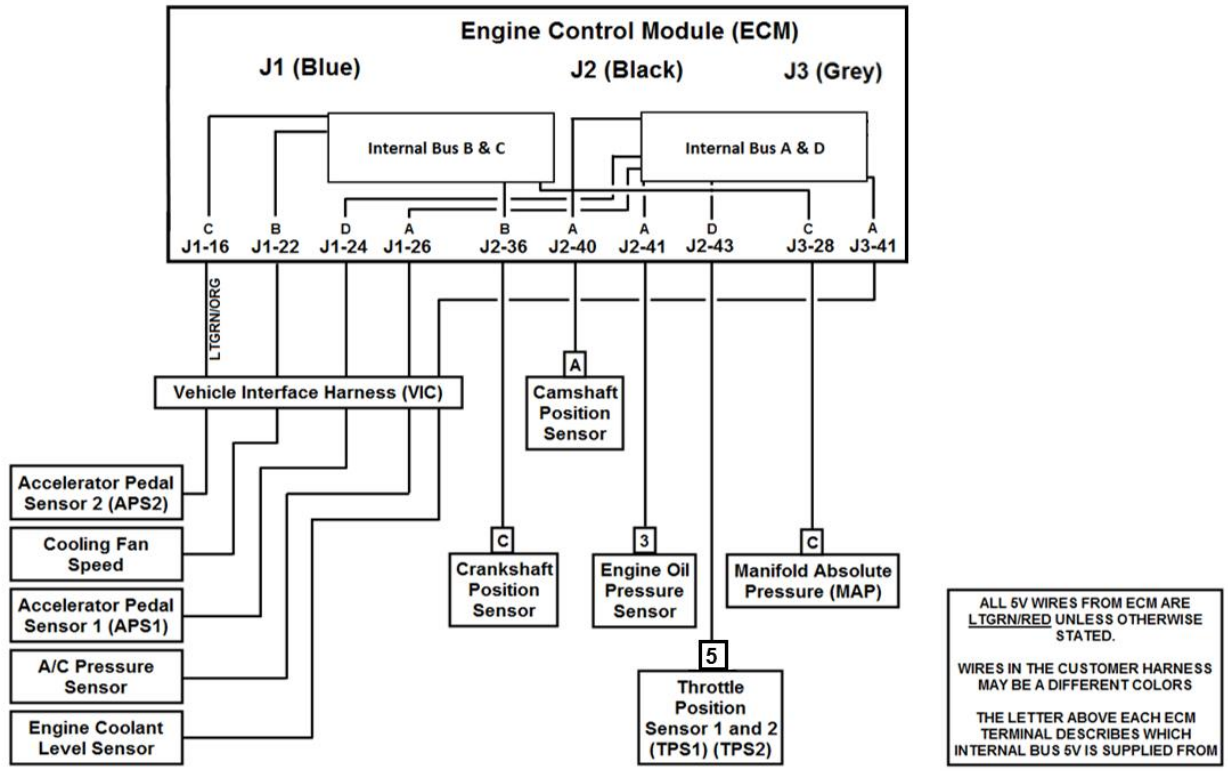
Step	Action	Decision
1	Using PowerLink, check for active SPNs. Diagnose and repair all other fault codes besides: • SPN 251 FMI 2 • SPN 588 FMI 13 • SPN 629 FMI 2, 12 or 31 • SPN 1634 FMI 13 • SPN 3301 FMI 2 • SPN 7355 FMI 2 Clear DTC's and retest. Are any of the above fault codes still present/active?	Yes: Replace ECM and retest. No: End Diagnostics.

13 Sensor Reference Voltage A/B

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
3509	31	Sensor Reference Voltage "A" Circuit	• Open, ground, or short to voltage in any 5V reference supply circuit on the A circuit group	A	MIL
3510	31	Sensor Reference Voltage "B" Circuit	• Open, ground, or short to voltage in any 5V reference supply circuit on the B circuit group	A	MIL

Overview

The Engine Control Module (ECM) provides 5V reference to multiple sensors on the engine and fuel system. There are two internal busses within the ECM for distributing the 5V reference, bus A and bus B. If voltage on either bus is higher or lower than expected, SPN 3509 FMI 31 (“A”) or SPN 3510 FMI 31 (“B”) fault will be set. Sensor reference faults may also be associated with a specific sensor fault. Diagnose the 5V reference circuit fault first. For example: if code SPN 3510 FMI 31 sets along with SPN 636 FMI 2 (Crankshaft Position Sensor "A" Circuit Range/Performance), diagnose the 5V reference circuit first for SPN 3510 FMI 31. Sensor reference voltage “A” and “B” are not linked together internally within the ECM. When a concern occurs on a reference circuit, the ECM may shut functions down to internally protect itself.



Sensor Reference “A” Supplied Sensors:

- A/C Pressure Sensor (if factory installed)
- Fan Speed (if equipped)
- Camshaft Position Sensor
- Engine Coolant Level Sensor
- Engine Oil Pressure Sensor
- Fuel Supply Pressure Sensor
- Fuel Rail Pressure Sensor (CNG and Gasoline only)
- Accelerator Pedal Position “1” Sensor

Sensor Reference “B” Supplied Sensors:

- Crankshaft Position Sensor
- Accelerator Pedal Position “2” Sensor
- Manifold Absolute Pressure Sensor

Possible Causes:

- Short to ground or battery voltage on the 5 volt reference circuit.
- A malfunctioning sensor in the associated 5 volt reference circuit.
- Short to voltage or ground on the signal circuit

Tools Required – 6.0L Gasoline

- PSI PowerLink
- Digital Multimeter (DMM)
- Breakout harness:
    - Accelerator Pedal ZTSE4485A,
    - Throttle body 69000052.

To 6.0L Gasoline Setting Criteria

- SPN 3509 FMI 31 – Sensor Reference Voltage “A” Circuit
- SPN 3510 FMI 31 – Sensor Reference Voltage “B” Circuit

NOTE: The below section will instruct the technician to back-probe sensor connectors. When back-probing any connector, use the thinnest possibly probes, to minimize deformation of the weather pack seal in the back of the connector. Before back-probing the connector, coat back-probe in dielectric grease. This will help the probe be inserted into the connector, and will better seal the connector when the probe is removed. When inserting the probe, make sure the probe is parallel to the wire, and gently push the probe between the weather pack seal and the wire. DO NOT use excessive force, and stop pushing if probe bottoms out in the connector. Failure to follow these guidelines may result in a damaged connector.

Step-Based Diagnostic Routine: SPN 3509 FMI 31

Step	Action	Decision
1	Using PowerLink, check SPNs. Is SPN 3509 FMI 31 active?	Yes: Go To Step 2 No: If inactive, diagnose and repair all other active fault codes first. Then clear DTCs and retest.

Step	Action	Decision
2	Key OFF, Carefully insert back-probes into Engine Oil Pressure Sensor Connector. Key ON, Measure voltage between 5V reference terminal 3 and chassis ground. Is voltage less than 4.8V, between 4.8 and 5.2V, or greater than 5.2V?	Greater than 5.2V: Go To Step 3 Between: Go To Step 6 Less than 4.8V: Go To Step 4

Step	Action	Decision
3	Key OFF, disconnect ECM J1, J2, and J3 connectors. Fully Install the corresponding breakout harness to the following sensors, or insert back-probes if breakout harnesses are unavailable: • A/C Pressure Sensor (if factory installed) • Fan Speed (if equipped) • Camshaft Position Sensor • Engine Coolant Level Sensor • Fuel Tank Pressure Sensor • Accelerator Pedal Position “1” Sensor - ZTSE4485A Key ON, measure voltage between 5 volt reference circuit and chassis ground at each sensor. Is voltage greater than 5.2V on any of the tested circuits?	Yes: Repair short to voltage in 5V reference circuit. No: Go To Step 6

Step	Action	Decision
4	Key OFF, disconnect ECM J1, J2, and J3 connectors. Fully Install the corresponding breakout harness to the following sensors, or insert back-probes if breakout harnesses are unavailable: • A/C Pressure Sensor (if factory installed) • Fan Speed (if equipped) • Camshaft Position Sensor • Engine Coolant Level Sensor • Fuel Tank Pressure Sensor • Accelerator Pedal Position “1” Sensor Measure resistance between 5V reference circuit and chassis ground at each sensor. Is resistance less than 1000 ohms at any sensor?	Yes: Repair short to ground in corresponding 5V reference circuit. No: Go To Step 5

Step	Action	Decision
5	Measure resistance between 5V reference from the sensor connector to ECM J1, J2, or J3 connector for each sensor as follows: • A/C Pressure Sensor J1-26 • Fan Speed J1-22 (if equipped) • Camshaft Position Sensor J2-40 • Engine Oil Pressure Sensor J2-41 • Engine Coolant Level Sensor J3-41 • Fuel Tank Pressure Sensor J3-43 • Accelerator Pedal Position “1” Sensor J1-24 NOTE: An open in a 5 volt reference circuit will set an associated fault. If an associated fault for a circuit listed above is active use the diagnostic steps for the active SPN. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in 5V reference circuit. No: Go To Step 6

Step	Action	Decision
6	Record and clear fault codes. Key ON, wiggle test engine harness. If fault returns replace engine wiring harness and retest. Is SPN 3509 FMI 31 still active?	Yes: Replace ECM Note: Prior to replacing ECM please verify that all diagnostics have been completed accurately. No: End Diagnostic.

Step-Based Diagnostic Routine: SPN 3510 FMI 31

Step	Action	Decision
1	Using PowerLink, check SPNs. Is SPN 3510 FMI 31 active?	Yes: Go To Step 2 No: If inactive, diagnose and repair all other active fault codes first. Then clear DTCs and retest.

Step	Action	Decision
2	Key OFF, Carefully insert back-probe to Manifold Absolute Pressure Sensor Connector (terminal B). Key ON, measure voltage between 5V reference (terminal B) and chassis ground. Is voltage less than 4.8V, between 4.8 and 5.2V, greater than 5.2V?	Greater than 5.2V: Go To Step 3 Between: Go To Step 6 Less than 4.8V: Go To Step 4

Step	Action	Decision
3	Key OFF, disconnect ECM J1, J2, and J3 connectors. Fully Install the corresponding breakout harness to the following sensors, or insert back-probes if breakout harnesses are unavailable: • Crankshaft Position Sensor • Accelerator Pedal Position “2” Sensor – ZTSE4485A • Manifold Absolute Pressure Sensor Key ON. Measure voltage between 5V reference and chassis ground at each sensor. Is greater than 5.2V found on any of the reference circuits?	Yes: Repair short to voltage in 5V reference circuit. No: Go To Step 6

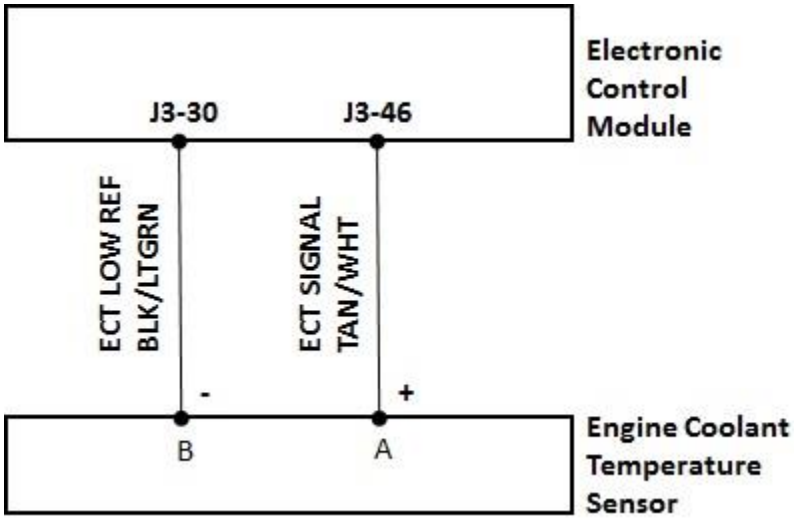
Step	Action	Decision
4	Key OFF, disconnect ECM J1, J2, and J3 connectors. Fully Install the corresponding breakout harness to the following sensors, or insert back-probes if breakout harnesses are unavailable: • Crankshaft Position Sensor • Accelerator Pedal Position “2” Sensor • Manifold Absolute Pressure Sensor Measure resistance between 5V reference circuit and chassis ground at each sensor. Is resistance less than 1000 ohms at any sensor?	Yes: Repair short to ground in the 5V reference circuit. No: Go To Step 5

Step	Action	Decision
5	Measure resistance between 5V reference from the sensor connector to ECM J1, J2, or J3 connector for each sensor as follows: • Accelerator Pedal Position “2” Sensor J1-16 • Crankshaft Position Sensor J2-36 • Manifold Absolute Pressure Sensor J3-28 NOTE: An open in a 5 volt reference circuit will set an associated fault. If an associated fault for a circuit listed above is active use the diagnostic steps for the active SPN. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in the 5V reference circuit. No: Record and clear fault codes. Key ON, wiggle test engine harness. If fault returns inspect harness for damage or rubbed through wires. Replace wiring harness.

Step	Action	Decision
6	Record and clear fault codes. Key ON, wiggle test engine harness. If fault returns replace engine wiring harness and retest. Is SPN 3510 FMI 31 still active?	Yes: Replace ECM Note: Prior to replacing ECM please verify that all diagnostics have been completed accurately. No: End Diagnostic.

14 Engine Coolant Temperature (ECT) Sensor

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
110	0	Engine Coolant Over Temperature Condition	• Engine cooling system failure • Malfunctioning sensor	C	AMBER
110	2	Engine Coolant Temperature High Rationality	• High resistance in ECT 1 circuit • High resistance in SIG GNG circuit • Failed ECT 1 sensor	A	MIL
110	3	Engine Coolant Temperature Circuit High	• Signal circuit open or short to voltage • Open low reference circuit • Malfunctioning sensor	A	MIL
110	4	Engine Coolant Temperature Circuit Low	• Signal circuit short to ground • Low reference circuit open or shorted to ground • Loose electrical connector or pin • Malfunctioning sensor	A	MIL
110	7	Coolant Thermostat (Coolant Temperature Below Thermostat Regulating Temperature)	• Stuck open, missing or incorrect thermostat • Low coolant level • Malfunctioning ECT sensor	B	MIL
110	15	Engine Coolant Temperature High Startup	• Skewed high ECT sensor • Signal circuit shorted to voltage • High resistance in EOT sensor signal circuit • High resistance in IAT sensor signal circuit	A	MIL
110	18	Coolant Temperature Relapsed Below Diagnostic Monitoring Temperature	• Thermostat Stuck Open • Engine Fan Stuck On • Low Coolant Level • ECT Signal Circuit Short to Ground • Malfunctioning ECT sensor	B	MIL
110	31	Engine Coolant Temperature Sensor Stuck	• Loose electrical connector or pin • Malfunctioning sensor	A	MIL
5323	7	Insufficient Coolant Temperature for Closed Loop Operation	• Signal circuit shorted to ground • Low reference circuit open or shorted to ground • Intermittent or poor connection • Malfunctioning sensor	A	MIL



Overview

The Engine Coolant Temperature (ECT) sensor measures the temperature of the engine coolant. The reading from this sensor is interpreted by the ECM to influence parameters such as fuel injection and ignition timing. The ECT signal determines when the cooling fan switches on and off. The ECT sensor has 2 circuits; a signal and a low reference return. A 5-volt signal is supplied to the signal circuit (terminal A) by pin J3-46 of the ECM. The low reference return circuit (terminal B) is at pin J3-30 of the ECM. The return voltage is measured to determine the engine coolant temperature. The ECT sensor is a negative temperature coefficient sensor meaning that the internal resistance decreases as the coolant temperature rises. A return voltage closer to 5 volts indicates the coolant is hot, and a voltage closer to zero indicates the coolant is cold.

SPN 110 FMI 0 – When this fault is set it may be accompanied by buzzers or audible indicators. Engine will derate torque when temperature exceeds 226°F (106°C). Engine Protection Mode SPN 5083 will also be set in tandem with this DTC.

Issues related to the ECT sensor may cause any of the following conditions:

- Reduced fuel economy
- Decreased engine performance
- Hard start

Diagnosis of the sensor includes:

- Verifying resistance of the ECT sensor.
- Verifying that the ECM is properly receiving a signal
- Ensuring that 5-volts are supplied on the signal circuit from the ECM
- Measuring resistance on the signal and low reference circuits
- Verifying that all wiring harness circuits and connectors are firmly attached
- Verifying that all pins are properly secured in the connectors and are providing adequate pressure to make an electrical connection.

Tools Required – 6.0L Gasoline

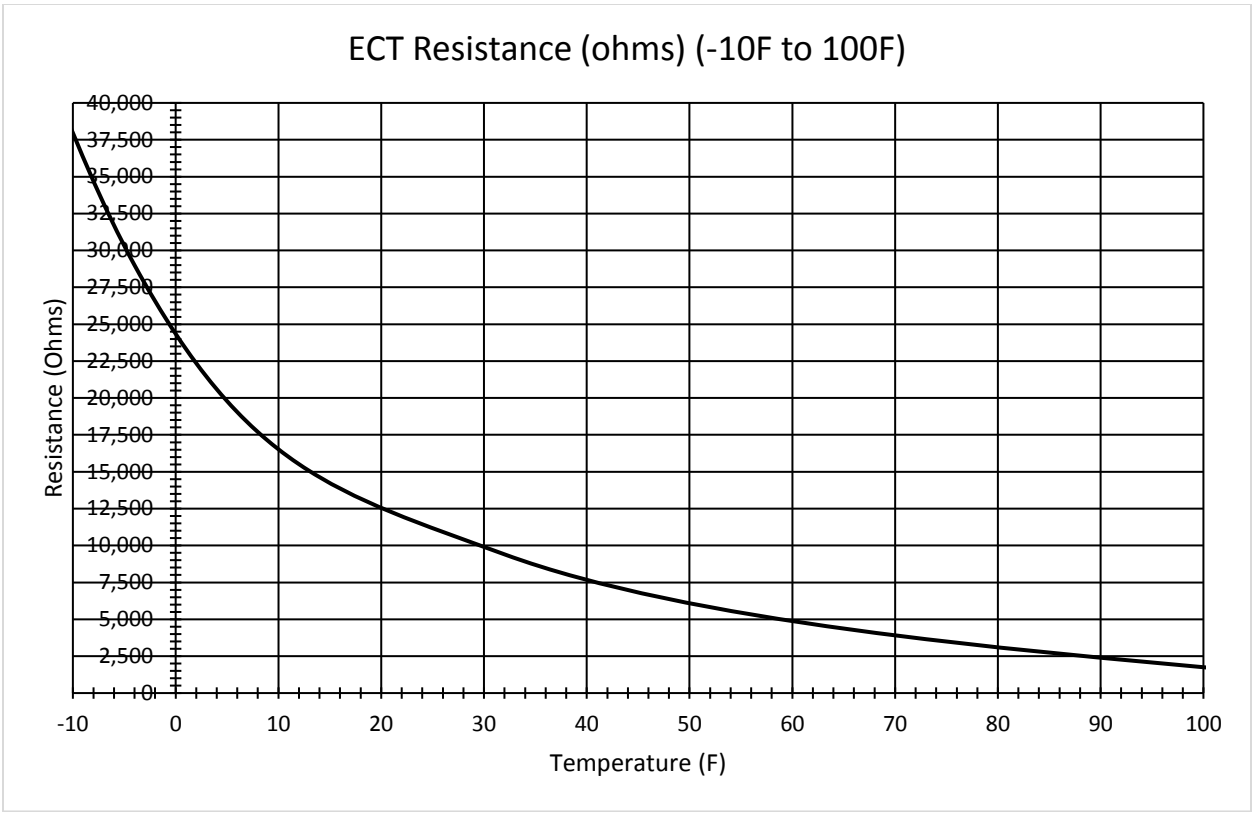
- PSI PowerLink
- Digital Multimeter (DMM)
- Infra-Red (IR) Temperature Gun

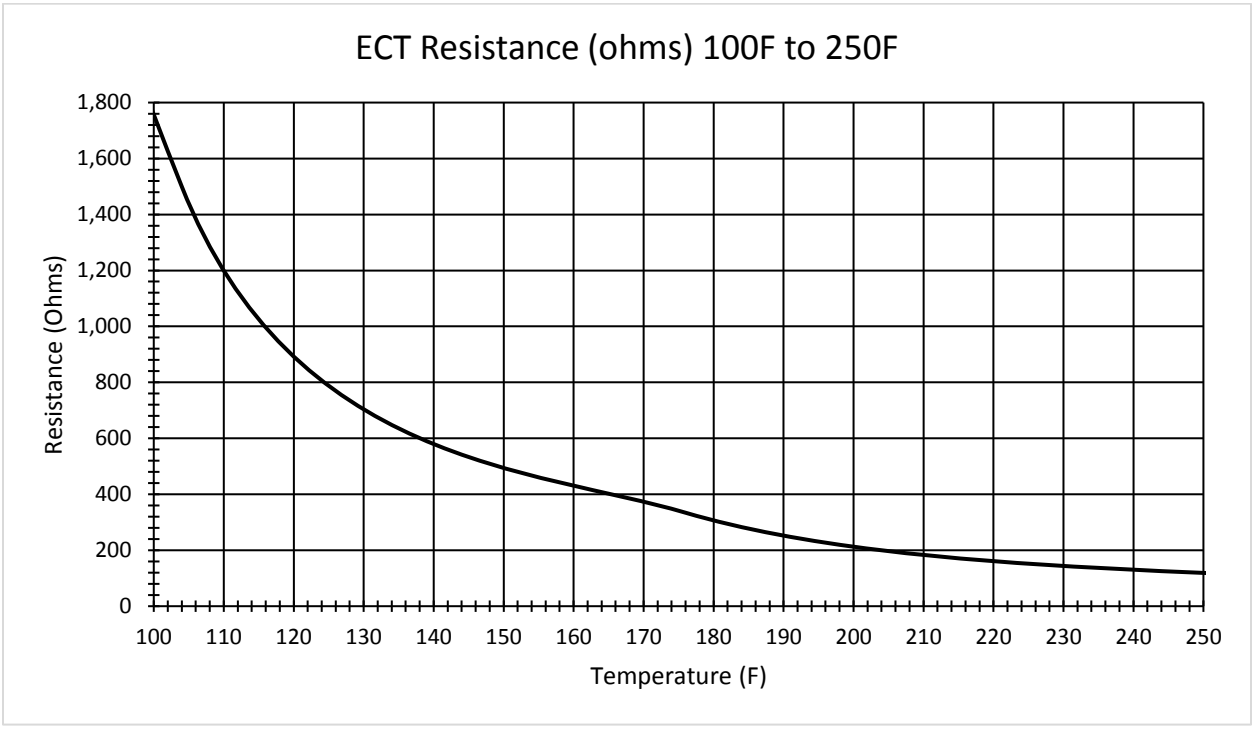
To 6.0L Gasoline Setting Criteria

- SPN 110 FMI 0 – Engine Coolant Over Temperature Condition
- SPN 110 FMI 2 – Engine Coolant Temperature High Rationality
- SPN 110 FMI 3 – Engine Coolant Temperature Circuit High
- SPN 110 FMI 4 – Engine Coolant Temperature Circuit Low
- SPN 110 FMI 7 – Coolant Thermostat (Coolant Temperature Below Thermostat Regulating Temperature)
- SPN 110 FMI 15 – Engine coolant Temperature High Startup
- SPN 110 FMI 18 – Coolant Temperature Relapsed Below Diagnostic Monitoring Temperature
- SPN 110 FMI 31 – Engine Coolant Temperature Sensor Stuck
- SPN 5323 FMI 7 – Insufficient Coolant Temperature For Closed Loop Operation

Sensor Resistance Table

Temperature	Resistance (ohms)
-40°F (-40°C)	101K Ω
-4°F (-20°C)	29K Ω
32°F (0°C)	9.4K Ω
104°F (40°C)	1.5K Ω
176°F (80°C)	334 Ω
302°F (150°C)	47.5 Ω


ECT Resistance (ohms) (-10F to 100F)
Resistance (Ohms)
40,000
37,500
35,000
32,500
30,000
27,500
25,000
22,500
20,000
17,500
15,000
12,500
10,000
7,500
5,000
2,500
0
-10
0
10
20
30
40
50
60
70
80
90
100
Temperature (F)


ECT Resistance (ohms) 100F to 250F
Resistance (Ohms)
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
Temperature (F)

Step-Based Diagnostic Routine SPN 110 FMI 0, 2, 7, 15, 18, SPN 5323 FMI 7

Step	Action	Decision
1	Verify SPN 110 FMI 3, FMI 4, FMI 31 or SPN 3510 FMI 31 are not set. If any of these DTC's are set, follow corresponding diagnostic steps first. Are any of the DTC's set?	Yes: Repair and retest. No: Go To Step 2

Step	Action	Decision
2	Was cooling system serviced recently that could have caused overheat during deaeration period?	Yes: Retest for engine over heat. No: Go To Step 3

Step	Action	Decision
3	Perform section **1.2.8 Coolant Level and Quality Inspection** in the Symptom Based Diagnostic section. Were any issues found?	Yes: Repair and retest. No: Go To Step 4

Step	Action	Decision
4	If the engine is cold soaked (at ambient temperature) perform test A. If engine has been warmed up above ambient temperature complete test B. Test A • With engine cold soaked • Key OFF • Measure resistance between (terminal A) and B with vehicle harness disconnected. Test B • Run engine until engine stabilizes at operating temperature. • Key OFF • Within 2 minutes of engine shut-down, measure resistance between (terminal A) and B with vehicle harness disconnected. Temperature can be verified with an IR temperature gun on the ECT sensor. Refer to the Sensor Resistance Table and chart for specification. Are the ECT sensor and IR temperature gun readings within 10°F (-12.2 °C) or each other?	Yes: Go To Step 5 No: Replace ECT sensor. Clear DTCs and retest.

Step	Action	Decision
5	• With ECT less than 120°F (49°C) • Start the engine and idle. • Monitor engine coolant temperature in PowerLink. • Using an IR (Infra-Red) temperature gun, verify upper radiator hose remains cool until the thermostat opens at approximately 190°F (88°C). Does the upper radiator hose stay cool until approximately 190°F (88°C) ECT?	Yes: Go To Step 6 No, Hose Warms With ECT: Thermostat stuck open, replace thermostat and retest. No, Hose Stays Cool With ECT 190°F (88°C)+ : Thermostat stuck closed or radiator internally plugged, repair and retest.

Step	Action	Decision
6	Verify engine cooling fan operation by letting the vehicle continue to idle. It may be necessary to close the hood and increase engine speed to 1,200 RPM. Does the mechanical cooling fan clutch engage at approximately 221°F (105°C)? OR Do electric engine cooling fans (if equipped) turn ON prior to engine temperature reaching 221°F (105°C)? NOTE: The fan will become noticeably loud during clutch engagement.	Yes: Go To Step 7 Mechanical Fan, No: Replace fan clutch and retest. Electric Fan, No: See OEM Diagnostics.

Step	Action	Decision
7	Key OFF, Carefully insert back-probe into Engine Coolant Temp (ECT) Connector (terminal A) and (terminal B). Measure resistance between low reference (terminal B) and chassis ground. Is resistance less than 10 ohms?	Yes: Go To Step 9 No: Go To Step 8

Step	Action	Decision
8	Key OFF, disconnect ECM connector J3. Measure resistance between low reference (terminal B) and ECM J3-30. Is resistance less than 10 ohms?	Yes: Inspect for intermittent connections or rubbed through wires in low reference circuit. No: Repair open or high resistance in low reference circuit.

Step	Action	Decision
9	Key ON, Measure voltage between signal circuit (terminal A) and chassis ground. Is voltage less than, equal to, or greater than 5V?	Equal to: Reassemble and retest for concern, if concern persists, go to step 10.
		Less than: Go To Step 10
		Greater than: Repair short to voltage in signal circuit.

Step	Action	Decision
10	Key OFF, disconnect ECM connector J3. Measure resistance between signal circuit (terminal A) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground in signal circuit.
		No: Go To Step 11

Step	Action	Decision
11	Key OFF, with ECM connector J3 disconnected measure resistance between signal circuit (terminal A) and ECM J3-46. Is resistance less than 10 ohms?	Yes: See SPN 3510 FMI 31
		No: Repair open or high resistance in signal circuit.

Step-Based Diagnostic Routine: SPN 110 FMI 3, 4, 31

Step	Action	Decision
1	• Key OFF, • Measure resistance between (terminal A) and (terminal B) with vehicle harness disconnected. Temperature can be verified with an IR temperature gun on the engine block at the ECT sensor. Refer to the Sensor Resistance Table for specification. Is ECT sensor within specification?	Yes: Ensure there are no air pockets in the cooling system. If OK, Go To Step 2. No: Replace ECT sensor. Clear DTCs and retest.

Step	Action	Decision
2	Key OFF, Carefully insert back-probes into ECT Connector (terminal A) and (terminal B). Measure resistance between low reference (terminal B) and chassis ground. Is resistance less than 10 ohms?	Yes: Go To Step 3 No: Go To Step 6

Step	Action	Decision
3	Key ON, Measure voltage between signal circuit (terminal A) and chassis ground. Is voltage less than, equal to, or greater than 5V?	Equal to: Go To Step 6 Less than: Go To Step 4 Greater than: Repair short to voltage in signal circuit

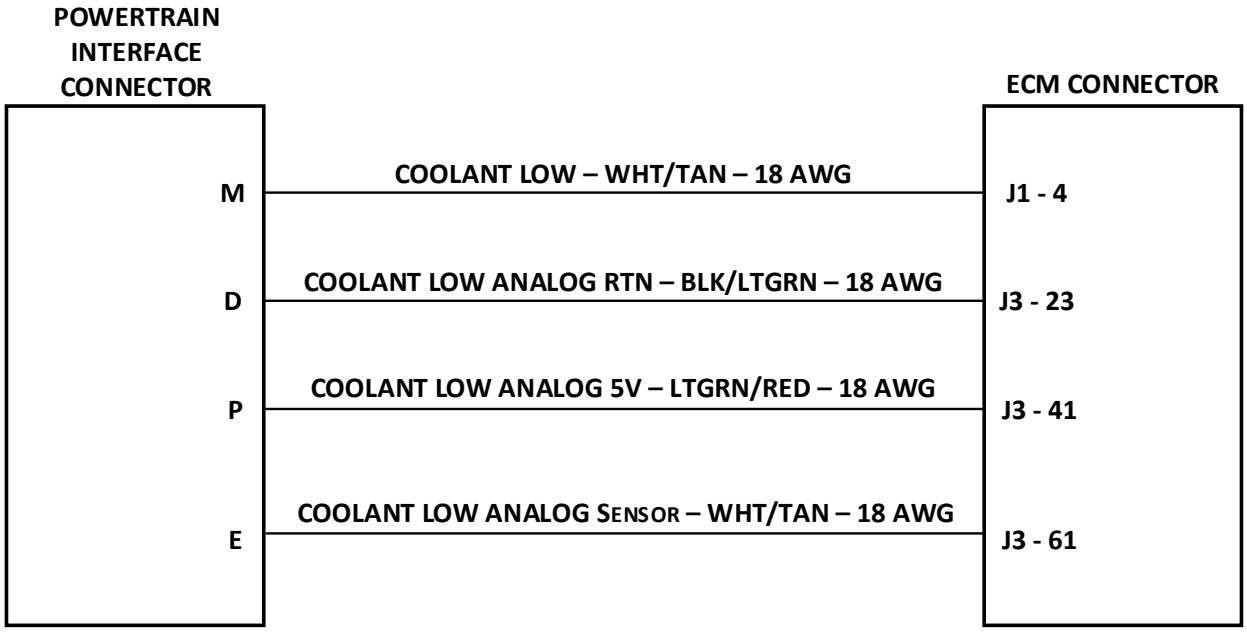
Step	Action	Decision
4	Key OFF, disconnect ECM connector J3. Measure resistance between signal circuit (terminal A) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground in signal circuit No: Go To Step 5

Step	Action	Decision
5	Key OFF, with ECM connector J3 disconnected measure resistance between signal circuit (terminal A) and ECM J3-46. Is resistance less than 10 ohms?	Yes: Inspect for intermittent connections or rubbed through wires in signal circuit. No: Repair open in signal circuit.

Step	Action	Decision
6	Key OFF, disconnect ECM connector J3. Measure resistance between low reference (terminal B) and ECM J3-30. Is resistance less than 10 ohms?	Yes: Inspect for intermittent connections or rubbed through wires in low reference circuit. No: Repair open in low reference circuit

15 Engine Coolant Level (ECL) Sensor

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
111	1	Engine Coolant Level Low	• Low engine coolant level • Low reference circuit open or high resistance • 5V reference circuit open or high resistance • Signal circuit shorted to ground • 5V reference circuit shorted to ground • Malfunctioning sensor	C	AMBER
111	3	Engine Coolant Level Sensor / Switch Circuit High	• 5V reference shorted to voltage • Signal circuit shorted to voltage • Malfunctioning sensor	C	AMBER
111	4	Engine Coolant Level Sensor / Switch Circuit Low	• Low engine coolant level • Low reference circuit open or high resistance • 5V reference circuit open or high resistance • Signal circuit shorted to ground • Malfunctioning sensor	C	AMBER



Overview

The Engine Coolant Level (ECL) monitoring system has three main components. These components consist of the Engine Coolant Level Sensor (ECLS), Coolant Level Module (ECLM), and the ECM. The ECLS is a two wire switch which lowers in resistance when immersed in coolant. The ECLM reduces the amount of electrical flow through the ECLS to minimize electrical charge in the cooling system and galvanic corrosion. The ECM monitors the return signal from the ECLM for High/Low conditions as well as the 5V reference. The ECLS is located in the coolant surge tank. The ECLM is located on the engine wiring harness near the ECM.

SPN 111 FMI 1 – The low coolant lamp will illuminate or a text message will appear on the driver information screen. This may also be accompanied by buzzers or audible indicators. Lamp will turn OFF if coolant level is above threshold for a period of time

SPN 111 FMI 3 - Amber Warning Lamp is illuminated. Low coolant level indicator is disabled. If the condition is corrected, the amber lamp will clear on a key cycle or with a code clear on PSI PowerLink.

SPN 111 FMI 4 - Amber Warning Lamp is illuminated. Low coolant level indicator is disabled. If the condition is corrected, the amber lamp will clear on a key cycle or with a code clear on PSI PowerLink.

Diagnosis of the sensor includes:

- Coolant has acceptable quality
- Coolant level and module connectors are in good condition
- Coolant level module has 5v reference and ground
- Coolant level module is not internally passing voltage
- Coolant level sensor resistance is in specification
- Verifying that the ECM is properly receiving a signal
- Ensuring that 5-volts are supplied on the signal circuit from the ECM
- Ensuring continuity on the low reference circuit
- Verifying that all wiring harness circuits and connectors are firmly attached
- Verifying that all pins are properly secured in the connectors and are providing adequate pressure to make an electrical connection.

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)

To 6.0L Gasoline Setting Criteria

- SPN 111 FMI 1 – Engine Coolant Level Low
- SPN 111 FMI 3 – Engine Coolant Level Sensor/Switch Circuit High
- SPN 111 FMI 4 – Engine Coolant Level Sensor/Switch Circuit Low

Associated Fault Codes

SPN	FMI	Description
94	4	Fuel Supply Pressure Sensor Circuit Short Low
100	1	Engine Oil Pressure Too Low
100	4	Engine Oil Pressure Sensor/Switch "A" Low
111	4	Engine Coolant Level Sensor/Switch Circuit Low
723	4	Camshaft Position Sensor “A” Circuit
1109	15	Throttle Actuator Control System – Forced Limited Power
3509	31	Sensor Reference Voltage “A” Circuit

Step-Based Diagnostic Routine: SPN 111 FMI 1, 3, 4

Step	Action	Decision
1	Using PowerLink, verify ECM has the most current calibration version installed. Is the ECM calibration up to date?	Yes: Go To Step 2 No: Install most current calibration onto ECM.

Step	Action	Decision
2	Using PowerLink, check the ECM for active or inactive associated fault codes. Are any of the associated fault codes present other than 1109 FMI 15 (active or inactive)?	Yes: Complete SPN 3509 FMI 31, repair faults, clear DTC’s, and retest. No: Go To Step 3

Step	Action	Decision
3	Perform section **1.2.8 Coolant Level and Quality Inspection** in the Symptom Based Diagnostic Section. Were any issues found?	Yes: Diagnose and repair concern, if ECL is LOW perform **2.5.4 Engine Coolant Consumption** in the Symptom Based Diagnostic section. After repairs, if SPN 111 returns with coolant FULL. Go To Step 4. No: Go To Step 4

Step	Action	Decision
4	A. Key OFF B. Visually confirm **Engine Coolant Level Sensor (ECLS)** is fully seated in surge tank, secure, and undamaged. C. Disconnect **Engine Coolant Level Sensor (ECLS)** harness. D. Check **Engine Coolant Level Sensor (ECLS)** connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Is **Engine Coolant Level Sensor (ECLS)**, harness, terminals clean and undamaged? Is sensor fully seated and secure?	Yes: Go To Step 5 No: Repair connector, harness, or terminal damage. If sensor is not fully seated remove and inspect, if damaged replace it, if undamaged reinstall. After repairs are complete, retest for DTC.

Step	Action	Decision
5	A. Key OFF B. Visually confirm **Engine Coolant Level Module (ECLM)** is fully seated in connector, secure, and undamaged. C. Disconnect **Engine Coolant Level Module (ECLM)** harness. D. Check **Engine Coolant Level Module (ECLM)** connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Is **Engine Coolant Level Module (ECLM)**, harness, terminals clean and undamaged? Is sensor fully seated and secure?	Yes: Go To Step 6 No: Repair connector, harness, or terminal damage. If module is not fully seated remove and inspect, if damaged replace it, if undamaged reinstall. After repairs are complete, retest for DTC.

Step	Action	Decision
6	Key OFF, disconnect **ECLM** from connector. Key ON, measure voltage between **ECLM** harness (terminal A) and **ECLM** harness (terminal D). Is voltage between 4.8V to 5.2V?	Yes: Go To Step 9 No: Go To Step 7

Step	Action	Decision
7	Key OFF, disconnect **ECLM** from connector. Key ON, measure voltage between **ECLM** harness (terminal A) and engine/chassis ground. Is voltage between 4.8V to 5.2V?	Yes: Repair open or high resistance in Coolant Low Analog RTN between module connector and ECM. No: Go To Step 8

Step	Action	Decision
8	Key OFF, disconnect **ECLM** from connector. Disconnect ECM J3 Connector. Measure resistance between **ECLM** harness (terminal A) and ECM J3-41. Is resistance less than 5 ohms?	Yes: Perform SPN 3509 FMI 31 diagnostics. No: Repair open or high resistance in Coolant Low Analog 5V.

Step	Action	Decision
9	Key OFF, with **ECLM** connected and **ECLS** disconnected. Key ON, measure voltage between **ECLS** harness (terminal A) and engine/chassis ground. Is voltage less than 0.25V?	Yes: Go To Step 10 No: Replace Engine Coolant Level Module and retest

Step	Action	Decision
10	Key OFF, with **ECLM** connected and **ECLS** disconnected. Key ON, measure voltage between **ECLS** harness (terminal B) and engine/chassis ground. Is voltage less than 0.25V?	Yes: Go To Step 11 No: Replace Engine Coolant Level Module and retest

Step	Action	Decision
11	A. Key OFF B. Drain coolant below **ECLS** C. Removed **ECLS** and dry Inspect surge tank adaptor and threads for damage or cracks. On **ECLS**, measure resistance between sensor (terminal A) and sensor tip. Is resistance between 64.6K – 71.4K ohms?	Yes: Go To Step 12 No: Replace Engine Coolant Level Sensor and retest.

Step	Action	Decision
12	On **ECLS**, measure resistance between sensor (terminal A) and sensor (terminal B). Submerge sensor tip in coolant while monitoring resistance. With the sensor out of coolant is resistance between 199.5K – 220.5K ohms? With the sensor in coolant, does resistance drop?	Yes: Go To Step 13 No: Replace Engine Coolant Level Sensor and retest.

Step	Action	Decision
13	Key OFF, with **ECLM** connected and **ECLS** disconnected. Measure resistance between **ECLS** harness (terminal A) and engine/chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 15 No: Go To Step 14

Step	Action	Decision
14	Key OFF, with **ECLM** and **ECLS** disconnected. Measure resistance between **ECLS** harness (terminal A) and engine/chassis ground. Is resistance greater than 1000 ohms?	Yes: Replace Engine Coolant Level Module and retest No: Repair Coolant Low AN short to ground, then retest.

Step	Action	Decision
15	Key OFF, with **ECLM** and **ECLS** disconnected. Measure resistance between **ECLM** harness (terminal C) and engine/chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 16 No: Repair Coolant Low Analog Sensor circuit short to ground, then retest.

Step	Action	Decision
16	Key OFF, with **ECLM** connected and **ECLS** disconnected. Measure resistance between **ECLS** harness (terminal B) and engine/chassis ground. Is resistance less than 5 ohms?	Yes: Go To Step 18 No: Go To Step 17

Step	Action	Decision
17	Key OFF, with **ECLM** and **ECLS** disconnected. Measure resistance between **ECLS** harness (terminal B) and **ECLM** harness (terminal E). Is resistance less than 5 ohms?	Yes: Replace Engine Coolant Level Module and retest. No: Repair open or high resistance in Coolant Low AN RTN, then retest.

Step	Action	Decision
18	Key OFF, with **ECLM** and **ECLS** disconnected. Measure resistance between **ECLS** harness (terminal A) and **ECLM** harness (terminal B). Is resistance less than 5 ohms?	Yes: Go To Step 19 No: Repair open or high resistance in Coolant Low AN, then retest.

Step	Action	Decision
19	Key OFF, disconnect **ECLM** from connector. Disconnect ECM J3 Connector. Measure resistance between **ECLM** harness (terminal C) and ECM J3-61. Is resistance less than 10 ohms?	Yes: Go To Step 20 No: Repair open or high resistance in Coolant Low Analog Sensor circuit.

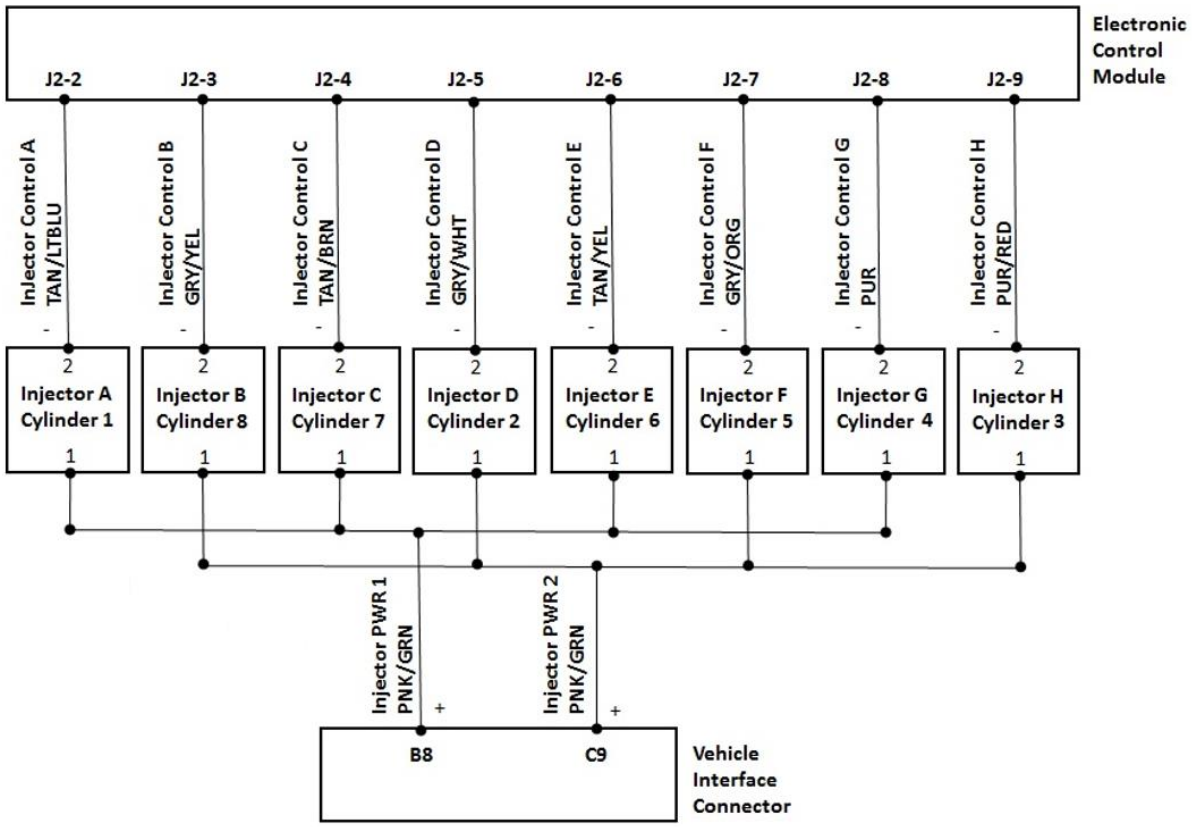
Step	Action	Decision
20	A. Reassemble cooling system B. Fill surge tank with approved coolant above **ECLS** C. Key ON D. Clear fault codes Did SPN 111 become ACTIVE?	Yes: Go To Step 21 No: End diagnostics.

Step	Action	Decision
21	Replace coolant surge tank. Key ON, clear fault codes. Did SPN 111 become ACTIVE?	Yes: Replace ECM and retest. No: End diagnostics.

16 Fuel Injectors

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
651	3	Cylinder 1 Injector Circuit High	• Short to power in the circuit wiring • Malfunctioning fuel injector	A	MIL
651	4	Cylinder 1 Injector Circuit Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Malfunctioning fuel injector	A	MIL
651	5	Cylinder 1 Injector Circuit/Open	• Open in the circuit wiring • Loose electrical connector or pin • Malfunctioning fuel injector	A	MIL
652	3	Cylinder 2 Injector Circuit High	• Short to power in the circuit wiring • Malfunctioning fuel injector	A	MIL
652	4	Cylinder 2 Injector Circuit Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Malfunctioning fuel injector	A	MIL
652	5	Cylinder 2 Injector Circuit/Open	• Open in the circuit wiring • Loose electrical connector or pin • Malfunctioning fuel injector	A	MIL
653	3	Cylinder 3 Injector Circuit High	• Short to power in the circuit wiring • Malfunctioning fuel injector	A	MIL
653	4	Cylinder 3 Injector Circuit Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Malfunctioning fuel injector	A	MIL
653	5	Cylinder 3 Injector Circuit/Open	• Open in the circuit wiring • Loose electrical connector or pin • Malfunctioning fuel injector	A	MIL
654	3	Cylinder Injector Circuit High	• Short to power in the circuit wiring • Malfunctioning fuel injector	A	MIL
654	4	Cylinder 4 Injector Circuit Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Malfunctioning fuel injector	A	MIL
654	5	Cylinder 4 Injector Circuit/Open	• Open in the circuit wiring • Loose electrical connector or pin • Malfunctioning fuel injector	A	MIL
655	3	Cylinder 5 Injector Circuit High	• Short to power in the circuit wiring • Malfunctioning fuel injector	A	MIL
655	4	Cylinder 5 Injector Circuit Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Malfunctioning fuel injector	A	MIL
655	5	Cylinder 5 Injector Circuit/Open	• Open in the circuit wiring • Loose electrical connector or pin • Malfunctioning fuel injector	A	MIL
656	3	Cylinder 6 Injector Circuit High	• Short to power in the circuit wiring • Malfunctioning fuel injector	A	MIL

656	4	Cylinder 6 Injector Circuit Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Malfunctioning fuel injector	A	MIL
656	5	Cylinder 6 Injector Circuit/Open	• Open in the circuit wiring • Loose electrical connector or pin • Malfunctioning fuel injector	A	MIL
657	3	Cylinder 7 Injector Circuit High	• Short to power in the circuit wiring • Malfunctioning fuel injector	A	MIL
657	4	Cylinder 7 Injector Circuit Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Malfunctioning fuel injector	A	MIL
657	5	Cylinder 7 Injector Circuit/Open	• Open in the circuit wiring • Loose electrical connector or pin • Malfunctioning fuel injector	A	MIL
658	3	Cylinder 8 Injector Circuit High	• Short to power in the circuit wiring • Malfunctioning fuel injector	A	MIL
658	4	Cylinder 8 Injector Circuit Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Malfunctioning fuel injector	A	MIL
658	5	Cylinder 8 Injector Circuit/Open	• Open in the circuit wiring • Loose electrical connector or pin • Malfunctioning fuel injector	A	MIL



Overview

The fuel injector delivers fuel to the cylinder in the same sequence as the ignition firing order. Delivery of fuel to the cylinder is relative to intake valve timing so that fuel can be delivered at the same time air is filling the cylinder during the intake stroke. The amount of fuel delivered is determined by the Engine Control Module (ECM) and controlled by pulse-width modulation. The fuel injectors in this application are controlled via ground-side switching within the ECM. Therefore, each injector has an individual ground circuit that connects to the ECM at J2, pins 2 through 9. Power is supplied from the vehicle interface connector through the engine harness with each bank of fuel injectors sharing a common power supply (Injector PWR 1 and Injector PWR 2).

Diagnosis of the fuel injectors includes:

- Verifying that the fuel injectors have power
- Verifying that the ECM is properly controlling the ground-side
- Ensuring that the injector solenoid is operating
- Checking for opens, grounds, or shorts within the wiring harness
- Verifying that all wiring harness circuits and connectors are firmly attached
- Verifying that all pins are properly secured in the connectors and are providing adequate pressure to make an electrical connection.

NOTE: Fuel injectors have mechanical components that may wear and can become plugged. If a fuel injector passes all electrical tests, then the most likely issue is mechanical failure of the injector.

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)
- Noid Light J-34730-2C
- Breakout Harness ZTSE4831

Diagnostic Tips

- Injector resistance changes with engine temperature.
- This vehicle has fuel filters in three different locations (not all are serviceable). However, iron oxide and other tar-like impurities will build up over time and may eventually cause an injector to fail. Keep this in mind if the fuel filters have not been changed regularly, the fuel system has been contaminated, or the fuel injectors have seen a long service life.

To 6.0L Gasoline Setting Criteria

- SPN 651 FMI 3 – Cylinder 1 Injector Circuit High
- SPN 651 FMI 4 – Cylinder 1 Injector Circuit Low
- SPN 651 FMI 5 – Cylinder 1 Injector Circuit/Open
- SPN 652 FMI 3 – Cylinder 2 Injector Circuit High
- SPN 652 FMI 4 – Cylinder 2 Injector Circuit Low
- SPN 652 FMI 5 – Cylinder 2 Injector Circuit/Open
- SPN 653 FMI 3 – Cylinder 3 Injector Circuit High
- SPN 653 FMI 4 – Cylinder 3 Injector Circuit Low
- SPN 653 FMI 5 – Cylinder 3 Injector Circuit/Open
- SPN 654 FMI 3 – Cylinder 4 Injector Circuit High
- SPN 654 FMI 4 – Cylinder 4 Injector Circuit Low
- SPN 654 FMI 5 – Cylinder 4 Injector Circuit/Open
- SPN 655 FMI 3 – Cylinder 5 Injector Circuit High
- SPN 655 FMI 4 – Cylinder 5 Injector Circuit Low
- SPN 655 FMI 5 – Cylinder 5 Injector Circuit/Open
- SPN 656 FMI 3 – Cylinder 6 Injector Circuit High
- SPN 656 FMI 4 – Cylinder 6 Injector Circuit Low
- SPN 656 FMI 5 – Cylinder 6 Injector Circuit/Open
- SPN 657 FMI 3 – Cylinder 7 Injector Circuit High
- SPN 657 FMI 4 – Cylinder 7 Injector Circuit Low
- SPN 657 FMI 5 – Cylinder 7 Injector Circuit/Open
- SPN 658 FMI 3 – Cylinder 8 Injector Circuit High
- SPN 658 FMI 4 – Cylinder 8 Injector Circuit Low
- SPN 658 FMI 5 – Cylinder 8 Injector Circuit/Open

Step-Based Diagnostic Routine (All Injector Circuit SPN/FMI)

Step	Action	Decision
1	A. Key OFF B. Disconnect Fuel Injector Harness Connector. C. Check Fuel Injector Harness Connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Are Fuel Injector connector, harness, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest for DTC.

Step	Action	Decision
2	Key OFF, Install fuel injector breakout harness ZTSE4831. Key ON, using a DMM check for B+ at injector connector (terminal 1). Is B+ present with Key ON?	Yes: Go To Step 6 No: Go To Step 3

Step	Action	Decision
3	Check fuel injector fuses in Vehicle Power Center. There are 2 fuses, one for each power circuit supplying each injector bank. Is the fuse open for the injector being tested?	Yes: Go To Step 4 No: Go To Step 5

Step	Action	Decision
4	Key OFF, measure resistance between the fuel injector connector (terminal 1) and ground. Is resistance greater than 1000 ohms?	Yes: Test all other fuel injectors on this bank for short to ground. Replace fuse. No: Go To Step 13 Repair short to ground in fuel injector power circuit. Replace fuse.

Step	Action	Decision
5	Key OFF, measure resistance from Injector PWR fuse to fuel injector connector (terminal 1). Is resistance greater than 5 ohms?	Yes: Go To Step 6 No: Verify fuse is not open. Check for power at fuse.

Step	Action	Decision
6	Key OFF, measure resistance from fuel injector connector (terminal 1) to VIC (terminal B8 for injectors A, C, E and G or terminal C9 for injectors B, D, F, and H). Is resistance greater than 5 ohms?	Yes: Repair the open/high resistance in the circuit between fuel injector (terminal 1) and appropriate VIC terminal. No: Go To Step 14

Step	Action	Decision
7	Connect a noid light (J-34730-2C) to fuel injector connector. Crank engine and verify noid light flashes. Does the noid light flash?	Yes: Go To Step 11 No: Go To Step 7

Step	Action	Decision
8	Noid light did not flash while engine was cranking. Was noid light on continuously?	Yes: Go To Step 8 No: Go To Step 9

Step	Action	Decision
9	Key OFF, disconnect ECM connector J2. Measure resistance between fuel injector connector (terminal 2) and ground. Is resistance greater than 1000 ohms?	Yes: Return to Step 1 No: Repair short to ground in fuel injector control circuit.

Step	Action	Decision
10	Key OFF, disconnect ECM connector J2. Key ON, measure voltage between fuel injector connector (terminal 2) and ground. Is voltage greater than 1V?	Yes: Repair short to voltage in fuel injector control circuit. No: Go To Step 10

Step	Action	Decision
11	Key OFF, measure resistance on fuel injector control wire from ECM J2 to fuel injector connector (terminal 2). Is resistance greater than 5 ohms?	Yes: Repair open / high resistance in fuel injector control circuit. No: See **1.3 Intermittent Fault Code Diagnostics**.

Step	Action	Decision
12	Key OFF disconnect fuel injector connector. Measure fuel injector resistance across injector (terminal 1) and (terminal 2). Is resistance between 12 and 17 ohms?	Yes: Go To Step 12 No: Replace fuel injector.

Step	Action	Decision
13	Key OFF, measure resistance between the fuel injector connector (terminal 1) and ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 14 No: Repair short to ground in fuel injector power circuit. Replace fuse.

Step	Action	Decision
14	Go See OEM Diagnostics. After OEM diagnostics have been completed, has the fault been corrected?	Yes: End Diagnostics. No: See **1.3 Intermittent Fault Code Diagnostics**.

Step	Action	Decision
12	Measure resistance between (terminal 1) of the fuel injector and the fuel injector housing screw. Measure resistance between (terminal 2) of the fuel injector and the fuel injector housing screw. Is resistance greater than 1000 ohms on both?	Yes: Return to Step 1 No: Replace fuel injector.

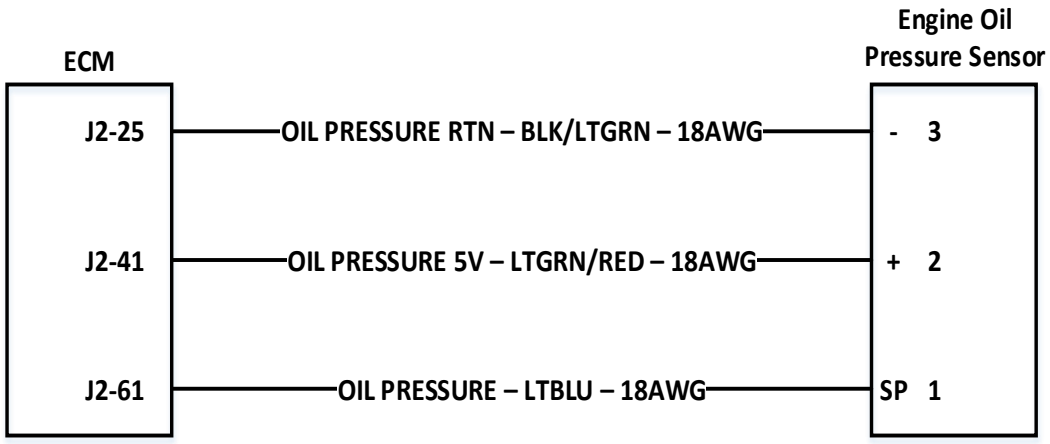
17 Engine Oil Pressure (EOP) Sensor

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
100	1	Engine Oil Pressure Too Low	• Engine Oil • Base Engine Issue • Malfunctioning sensor	C	AMBER
100	3	Engine Oil Pressure Sensor/Switch "A" High	• Signal circuit shorted to power • Malfunctioning sensor	C	AMBER
100	4	Engine Oil Pressure Sensor/Switch "A" Low	• Signal circuit short to ground • Reference circuit open or shorted to ground • Loose electrical connector or pin • Malfunctioning sensor	C	AMBER

Overview

The Engine Oil Pressure Sensor is a transducer that generates a signal as a function of the pressure applied to it. The Engine Oil Pressure and Engine Oil Temperature Sensors are combined into one unit on this vehicle. The Engine Oil Pressure Sensor has 3 circuits; a 5-volt supply (terminal 3), low reference which is shared with the Engine Oil Temperature Sensor (terminal 1), and signal (terminal 2). The signal circuit for the Engine Oil Temperature is (terminal 4).

SPN 100 FMI 1 – When this fault is set it may be accompanied by buzzers, audible indicators, and/or a message in the driver information center. Engine will derate torque when oil pressure is below a critical threshold. Engine Protection Mode SPN 5082 will also be set in tandem with this DTC.



6.0L Gasoline Engine Oil Pressure Sensor

6.0L GASOLINE OIL PRESSURE TABLE

Minimum Oil Pressure (Hot)	1000 RPM	2000 RPM	3000 RPM
	152 kPa (22 psi)	207 kPa (30 psi)	228 kPa (33 psi)

Diagnosis of the Engine Oil Pressure sensor includes:

- Verifying that the ECM is properly receiving a signal
- Ensuring that a 5-volt supply voltage is supplied to the sensor from the ECM
- Checking for continuity on the low reference circuit
- Verifying that all wiring harness circuits and connectors are firmly attached
- Verifying that all pins are properly secured in the connectors and are providing adequate pressure to make an electrical connection.

Tools Required – 6.0L Gasoline

- PSI PowerLink
- Digital Multi-Meter (DMM)
- 3 Amp Fused Jumper Wire
- Oil Pressure Test Fitting EN-21867-16
- Pressure Test Kit EN-21867

To 6.0L Gasoline Setting Criteria

- SPN 100 FMI 1 – Engine Oil Pressure Too Low
- SPN 100 FMI 3 – Engine Oil Pressure Sensor/Switch “A” High
- SPN 100 FMI 4 – Engine Oil Pressure Sensor/Switch “A” Low

Associated Faults

SPN	FMI	Description
54	4	Throttle Position Sensor/Switch "A" Circuit Low
94	4	Fuel Supply Pressure Sensor Circuit Short Low
100	1	Engine Oil Pressure Too Low
100	4	Engine Oil Pressure Sensor/Switch "A" Low
111	4	Engine Coolant Level Sensor/Switch Circuit Low
723	4	Camshaft Position Sensor “A” Circuit
1109	15	Throttle Actuator Control System – Forced Limited Power
3509	31	Sensor Reference Voltage “A” Circuit
3673	4	Throttle Position Sensor/Switch "B" Circuit Low

NOTE: The below section will instruct the technician to back-probe the Engine Oil Pressure Sensor Connector. When back-probing any connector, use the thinnest possibly probes, to minimize deformation of the weather pack seal in the back of the connector. Before back-probing the connector, coat back-probe in dielectric grease. This will help the probe be inserted into the connector, and will better seal the connector when the probe is removed. When inserting the probe, make sure the probe is parallel to the wire, and gently push the probe between the weather pack seal and the wire. DO NOT use excessive force, and stop pushing if probe bottoms out in the connector. Failure to follow these guidelines may result in a damaged connector.

Step-Based Diagnostic Routine: SPN 100 FMI 1

Step	Action	Decision
1	Using PowerLink, check the ECM for active or inactive associated fault codes. Are any of the associated fault codes present (active or inactive)? Note: Please review the setting condition for the fault codes, some require the engine running for a short period of time to become active.	Yes: Complete SPN 3509 FMI 31, repair faults, clear DTC's, and retest. No: Go To Step 2

Step	Action	Decision
2	Verify engine oil level is full and the oil is in good condition. Refer to Section **1.2.7 Oil Level and Quality Inspection.** Is the oil level full and in good condition?	Yes: Go To Step 3 No: Correct as needed.

Step	Action	Decision
3	Verify the correct oil filter is installed. Is the correct oil filter installed?	Yes: Go To Step 4 No: Replace oil filter.

Step	Action	Decision
4	Install oil pressure test fitting (EN-21867-16) and manual gauge. Run engine at operating temperature. Record oil pressure readings from manual gauge at 1000 RPM and 2000 RPM. NOTE: If engine is not able to reach operating temperature, run engine under customer concern conditions. Is oil pressure greater than the minimum specifications at stated engine RPMs? (see above RPM/Pressure table)	Yes: Go To Step 5 No: Go To Step 3 of Section **2.6.3 Low Engine Oil Pressure.**

Step	Action	Decision
5	With the Key OFF, Carefully insert back-probes into Oil Pressure Sensor Connector. Measure resistance between low reference circuit (terminal 3) and chassis ground. Is resistance greater than 10 ohms?	Yes: Go To Step 6 No: Go To Step 7

Step	Action	Decision
6	With the Key OFF Disconnect ECM connector J2. Measure resistance across low reference circuit (terminal 3) and ECM connector J2-25. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in low reference circuit. No: Inspect for intermittent connections or rubbed through wires in low reference circuit.

Step	Action	Decision
7	With the Key ON, measure voltage between 5V supply circuit (terminal 2) and chassis ground. Is voltage less than, between, or greater than 4.8 and 5.2V?	Less than 4.8V: Go To Step 8 Between: Go To Step 11 Greater than 5.2V: Go To Step 10

Step	Action	Decision
8	With the Key OFF, disconnect ECM connector J2. Measure resistance between 5V supply circuit (terminal 2) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground in 5V supply circuit. No: Go To Step 9

Step	Action	Decision
9	Measure resistance between 5V supply circuit (terminal 2) to ECM connector J2-41. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in 5V supply circuit. No: Inspect for intermittent connections or rubbed through wires in 5v circuit.

Step	Action	Decision
10	With the Key OFF, disconnect ECM connector J2. With the Key ON, measure voltage between 5V supply circuit (terminal 2) and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage in 5V supply circuit. No: Inspect for intermittent connections or rubbed through wires in 5v circuit.

Step	Action	Decision
11	With the Key ON engine OFF. Using PSI PowerLink, check engine oil pressure value. Is the value less than 1 psi?	Yes: Go To Step 13 No: Go To Step 12

Step	Action	Decision
12	With the Key OFF, disconnect ECM connector J2. With the Key ON, measure voltage between signal circuit (terminal 1) and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage in signal circuit. No: Inspect for intermittent connections or rubbed through wires in signal circuit.

Step	Action	Decision
13	With the Key OFF, install a 3 amp fused jumper wire between signal circuit (terminal 1) and 5V supply circuit (terminal 2). With the Key ON, Using PSI PowerLink, check engine oil pressure value. Is the parameter greater than 110 psi?	Yes: Replace the engine oil pressure sensor. No: Go To Step 14

Step	Action	Decision
14	With the Key OFF, remove the fused jumper wire. Disconnect ECM connector J2, measure resistance between signal circuit (terminal 1) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair the short to ground in the signal circuit. No: Go To Step 15

Step	Action	Decision
15	Measure resistance between signal circuit (terminal 1) and ECM connector J2-61. Is resistance greater than 5 ohms?	Yes: Repair the open or high resistance in the signal circuit. No: Inspect for intermittent connections or rubbed through wires in signal circuit.

Associated Faults – SPN 100 FMI 3, SPN 100 FMI 4

SPN	FMI	Description
54	4	Throttle Position Sensor/Switch "A" Circuit Low
94	4	Fuel Supply Pressure Sensor Circuit Short Low
100	1	Engine Oil Pressure Too Low
100	4	Engine Oil Pressure Sensor/Switch "A" Low
111	4	Engine Coolant Level Sensor/Switch Circuit Low
723	4	Camshaft Position Sensor “A” Circuit
1109	15	Throttle Actuator Control System – Forced Limited Power
3509	31	Sensor Reference Voltage “A” Circuit
3673	4	Throttle Position Sensor/Switch "B" Circuit Low

Step-Based Diagnostic Routine: SPN 100 FMI 3 and SPN 100 FMI 4

Step	Action	Decision
1	Using PowerLink, check the ECM for active or inactive associated fault codes. Are any of the associated fault codes present (active or inactive)? Note: Please review the setting condition for the fault codes, some require the engine running for a short period of time to become active.	Yes: Complete SPN 3509 FMI 31, repair faults, clear DTC’s, and retest. No: Go To Step 2

Step	Action	Decision
2	Key OFF, Carefully insert back-probes into Oil Pressure Sensor Connector. Measure resistance between low reference circuit (terminal 3) and chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 3 No: Go To Step 4

Step	Action	Decision
3	With the Key OFF, Disconnect ECM connector J2. Measure resistance between low reference circuit (terminal 3) and ECM connector J2-25. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in low reference circuit. No: Inspect for intermittent connections or rubbed through wires.

Step	Action	Decision
4	With the Key ON, measure voltage between 5V supply circuit (terminal 2) and chassis ground. Is voltage less than, greater than, or between 4.8 and 5.2V?	Less than 4.8V: Go To Step 5 Greater than 5.2V: Go To Step 7 Between: Go To Step 8

Step	Action	Decision
5	With the Key OFF, disconnect ECM connector J2. Measure resistance between the 5V supply circuit (terminal 2) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground in 5V supply circuit. No: Go To Step 6

Step	Action	Decision
6	With the Key OFF, Disconnect ECM connector J2. Measure resistance between 5V supply circuit (terminal 2) to ECM connector J2-41 Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in 5V supply circuit. No: Inspect for intermittent connections or rubbed through wires.

Step	Action	Decision
7	With the Key OFF, disconnect ECM connector J2. With the Key ON, measure voltage between 5V supply circuit (terminal 2) and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage in 5V supply circuit. No: Inspect for intermittent connections or rubbed through wires.

Step	Action	Decision
8	With the Key ON engine OFF. Using PSI PowerLink, check engine oil pressure value. Is the value less than 1 psi?	Yes: Go To Step 10 No: Go To Step 9

Step	Action	Decision
9	With the Key OFF, disconnect ECM connector J2. With the Key ON, measure voltage between signal circuit (terminal 1) and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage in signal circuit. No: Inspect for intermittent connections or rubbed through wires in signal circuit.

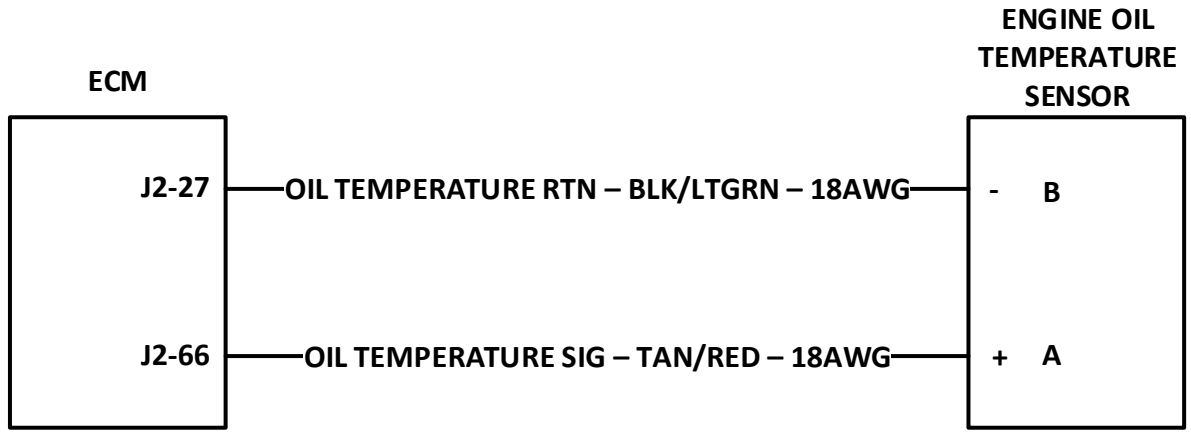
Step	Action	Decision
10	With the Key OFF, install a 3 amp fused jumper wire between signal circuit (terminal 1) and 5V supply circuit (terminal 2). With the Key ON, Using PSI PowerLink, check engine oil pressure value Is the value greater than 110 psi?	Yes: Replace engine oil pressure sensor. No: Go To Step 11

Step	Action	Decision
11	With the Key OFF, remove the fused jumper wire Disconnect ECM connector J2, measure resistance between signal circuit (terminal 1) and chassis ground Is resistance less than 1000 ohms?	Yes: Repair short to ground or high resistance in signal circuit. No: Go To Step 12

Step	Action	Decision
12	With the Key OFF, disconnect ECM connector J2. Measure resistance between signal circuit (terminal 1) and ECM connector J2-61 Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in signal circuit. No: Inspect for intermittent connections or rubbed through wires.

18 Engine Oil Temperature (EOT) Sensor

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
175	0	Engine Oil Over Temperature	• Engine cooling system failure • Malfunctioning sensor	C	AMBER
175	2	Engine Oil Temperature Sensor “A” Range/ Performance	• Malfunctioning EOT sensor • High resistance in EOT 1 circuit • High Resistance in SIG GND circuit • Short in EOT 1 circuit • Short in SIG GND circuit	A	MIL
175	3	Engine Oil Temperature Circuit High	• Signal circuit open or short to voltage • Open low reference circuit • Malfunctioning sensor	A	MIL
175	4	Engine Oil Temperature Circuit Low	• Signal circuit short to ground • Low reference circuit open or shorted to ground • Loose electrical connector or pin • Malfunctioning sensor	A	MIL



6.0L Gasoline Engine Oil Temperature Sensor

Overview

The Engine Oil Temperature sensor is combined with the Engine Oil Pressure sensor. The temperature sensor has two circuits; a signal (terminal 4) and a low reference (terminal 1). The signal circuit has 5 volts supplied to it, as temperature changes the resistance in the sensor changes. The ECM monitors voltage on the signal wire to provide a temperature reading.
SPN 175 FMI 0 – When this fault is set it may be accompanied by buzzers or audible indicators.

Diagnosis of the sensor includes:

- Verifying that the ECM is properly receiving a signal
- Ensuring that 5-volts are supplied on the signal circuit from the ECM
- Checking for continuity on the low reference circuit
- Verifying that all wiring harness circuits and connectors are firmly attached
- Verifying that all pins are properly secured in the connectors and are providing adequate pressure to make an electrical connection.

Tools Required – 6.0L Gasoline

- PSI PowerLink
- Digital Multimeter (DMM)

To 6.0L Gasoline Setting Criteria

- SPN 175 FMI 0 – Engine Oil Over Temperature
- SPN 175 FMI 2 – Engine Oil Temperature Sensor “A” Startup Rationality
- SPN 175 FMI 2 – Engine Oil Temperature Sensor “A” Warmed Up Rationality
- SPN 175 FMI 3 – Engine Oil Temperature Circuit High
- SPN 175 FMI 4 – Engine Oil Temperature Circuit Low

Sensor Resistance Table

Temperature	Resistance (ohms)
-40°F (-40°C)	339K Ω
-4°F (-20°C)	97.6K Ω
32°F (0°C)	32.75K Ω
68°F (20°C)	12.5K Ω
104°F (40°C)	5.3K Ω
176°F (80°C)	1.2k Ω
248°F (120°C)	397 Ω

NOTE: The below section will instruct the technician to back-probe the Engine Oil Temperature Sensor Connector. When back-probing any connector, use the thinnest possibly probes, to minimize deformation of the weather pack seal in the back of the connector. Before back-probing the connector, coat back-probe in dielectric grease. This will help the probe be inserted into the connector, and will better seal the connector when the probe is removed. When inserting the probe, make sure the probe is parallel to the wire, and gently push the probe between the weather pack seal and the wire. DO NOT use excessive force, and stop pushing if probe bottoms out in the connector. Failure to follow these guidelines may result in a damaged connector.

Step-Based Diagnostic Routine: SPN 175 FMI 0

Step	Action	Decision
1	Verify engine oil level is full and oil is in good condition. Is the engine oil level full and in good condition?	Yes: Go To Step 2 No: Correct as needed.

Step	Action	Decision
2	Verify the correct engine oil filter is installed. Is the correct engine oil filter installed?	Yes: Go To Step 3 No: Replace engine oil filter.

Step	Action	Decision
3	Inspect the engine oil cooler and lines for damage, kinks, and debris. Is the engine oil cooler and lines free of damage and obstruction?	Yes: Go To Step 4 No: Repair as needed.

Step	Action	Decision
4	A. Key OFF B. Disconnect oil temperature/pressure connector C. Check oil temperature/pressure connector terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are oil temperature/pressure 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 DTC.

Step	Action	Decision
5	With the Key OFF, Carefully insert back-probes into Engine Oil Temperature Connector. Measure resistance between low reference (terminal B) and chassis ground. Is resistance less than 10 ohms?	Yes: Go To Step 6 No: Go To Step 8

Step	Action	Decision
6	With the Key ON, measure voltage between signal circuit (terminal A) and chassis ground. Is voltage less than, equal to, or greater than 5V?	Less than: Go To Step 7 Equal to: Go To Step 9 Greater than: Repair short to voltage in signal circuit.

Step	Action	Decision
7	With the Key OFF, disconnect ECM connector J2. Measure resistance between signal circuit (terminal A) to ECM connector (J2-66). Is resistance less than 5 ohms?	Yes: Inspect for intermittent connections or rubbed through wires in signal circuit. No: Repair the open or high resistance in the signal circuit.

Step	Action	Decision
8	With the Key OFF, Disconnect ECM connector J2. Measure resistance between low reference circuit (terminal B) and ECM connector (J2-25). Is resistance less than 5 ohms?	Yes: Inspect for intermittent connections or rubbed through wires in low reference circuit. No: Repair open or high resistance in low reference circuit.

Step	Action	Decision
9	With the Key OFF, Disconnect breakout harness from vehicle harness. Measure resistance between signal (terminal A) and low reference (terminal A). Refer to the Sensor Resistance Table for specification. Is the sensor within specification?	Yes: Inspect for intermittent connections or rubbed through wires in low reference circuit. No: Replace sensor. Clear DTCs and retest the system.

Step-Based Diagnostic Routine: SPN 175 FMI 2, 3, 4

Step	Action	Decision
1	A. Key OFF B. Disconnect oil temperature connector C. Check oil temperature connector terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are oil temperature/pressure connector, harness, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest for DTC.

Step	Action	Decision
2	With the Key OFF, Carefully insert back-probes into Engine Oil Temperature Connector. Measure resistance between low reference (terminal B) and chassis ground. Is resistance less than 10 ohms?	Yes: Go To Step 3 No: Go To Step 5

Step	Action	Decision
3	With the Key ON, measure voltage between signal circuit (terminal A) and chassis ground. Is voltage less than, equal to, or greater than 5V?	Less than: Go To Step 4 Equal to: Go To Step 6 Greater than: Repair the short to voltage in the signal circuit.

Step	Action	Decision
4	With the Key OFF, disconnect ECM connector J2. Measure resistance between signal circuit (terminal A) to ECM connector (J2-66). Is resistance less than 5 ohms?	Yes: Go To Step 7 No: Repair the open or high resistance in the signal circuit.

Step	Action	Decision
5	With the Key OFF, Disconnect ECM connector J2. Measure resistance between low reference circuit (terminal B) and ECM connector (J2-25). Is resistance less than 5 ohms?	Yes: Go To Step 8 No: Repair the open or high resistance in the low reference circuit.

Step	Action	Decision
6	With the Key OFF, Disconnect breakout harness from vehicle harness. Measure resistance between signal (terminal A) and low reference (terminal B). Refer to the Sensor Resistance Table for specification. Is the sensor within specification?	Yes: Inspect for intermittent connections or rubbed through wires. No: Replace the sensor, clear DTCs and retest the system.

Step	Action	Decision
7	With the Key OFF, disconnect ECM connector J2. Measure resistance between signal circuit (terminal A) to chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground in signal circuit. No: Inspect for intermittent connections or rubbed through wires.

Step	Action	Decision
8	With the Key OFF, disconnect ECM connector J2. Measure resistance between signal circuit (terminal B) to chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground in signal circuit. No: Inspect for intermittent connections or rubbed through wires.

19 Engine Protection Mode

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
5077	31	Throttle Actuator Control System – Engine Protection Mode	• Check for other DTCs	C	STOP

Overview

This fault is caused by major issues such as low engine oil pressure, high oil temperature, low coolant level, and high coolant temperature.
This fault is only active when the root cause faults are active. Although these faults are continuously monitored every 1,000ms, the ignition must be turned off for at least 3.5 seconds and all root cause faults corrected in order for these faults to clear on the next ignition cycle. When this fault is set a Red (Stop Engine) Warning Lamp is illuminated and reduced engine torque is active. Audible buzzers may be present because of the stop engine lamp.

Diagnosis includes:

- Correct all root cause DTCs that are set
  - SPN 100 FMI 1 – Engine Oil Pressure Too Low
  - SPN 110 FMI 0 – Engine Coolant Over Temperature Condition
  - SPN 111 FMI 1 – Engine Coolant Level Low
  - SPN 175 FMI 0 – Engine Oil Over Temperature
- Verifying that all wiring harness circuits and connectors are firmly attached for the engine oil pressure and temperature sensor, engine coolant temperature sensor and engine coolant level sensor.
- Checking for damaged or pinched wires, moist or corroded terminals, loose, bent or broken pins, or broken connector housing.

Tools Required

- PSI PowerLink

To 6.0L Gasoline Setting Criteria

- SPN 5077 FMI 31 – Throttle actuator Control system – Engine Protection Mode

Step-Based Diagnostic Routine: SPN 5077 FMI 31

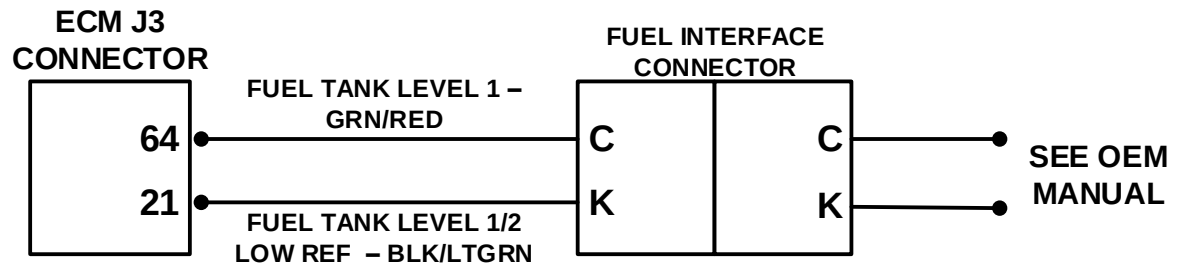
Step	Action	Decision
1	• Verifying that all wiring harness circuits and connectors are firmly attached for the engine oil pressure and temperature sensor, engine coolant temperature sensor and engine coolant level sensor. • Checking for damaged or pinched wires, moist or corroded terminals, loose, bent or broken pins, or broken connector housing. Are engine oil pressure, engine coolant temperature sensor, engine coolant level sensor connectors, harness, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness or terminal damage. After repairs are complete, clear codes and retest.

Step	Action	Decision
2	Cycle Key ON. Retrieve all DTCs using PowerLink. Were any other fault codes present/active other than SPN 5077-31?	Yes: Diagnose and repair all other fault codes aside from SPN 5077. After repair cycle key twice and retest. No: Clear fault, cycle key twice. Retest.

20 Fuel Level Sensor

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
38	2	Fuel Level Sensor "B" Circuit Intermittent	• Malfunctioning sensor • Intermittent poor connection • Damaged sending unit/sensor	B	NONE
38	3	Fuel Level Sensor "B" Circuit High	• Sending Unit Assembly circuit shorted to power • Malfunctioning sensor	B	NONE
38	4	Fuel Level Sensor "B" Circuit Low	• Sending Unit Assembly signal circuit short to ground • Sending Unit Assembly return	B	NONE
38	7	Fuel Level Sensor "B" Circuit Range / Performance	• Malfunctioning sensor • Intermittent poor connection • Damaged sending unit/sensor	B	NONE
96	2	Fuel Level Sensor "A" Circuit Intermittent	• Malfunctioning sensor • Intermittent poor connection • Damaged sending unit/sensor	B	MIL
96	3	Fuel Level Sensor "A" Circuit High	• Sending Unit Assembly circuit shorted to power • Sending Unit Assembly circuit open • Malfunctioning sensor	B	MIL
96	4	Fuel Level Sensor "A" Circuit Low	• Sending Unit Assembly signal circuit short to ground • Sending Unit Assembly low reference circuit open or shorted to ground • Loose electrical connector or pin • Malfunctioning sensor	B	MIL
96	7	Fuel Level Sensor "A" Circuit Range / Performance	• Malfunctioning sensor • Intermittent poor connection • Damaged sending unit/sensor	B	MIL

Gasoline Fuel Level Sensor Circuit:



****Note:** The gasoline fuel level sensor and wiring is specific to the chassis/vehicle manufacturer. See OEM manuals for further details on wiring after the Fuel Interface Connector.

Float Level	Resistance (ohms)
	Min
Empty Tank	250
Full Tank	40

Gasoline Overview

For gasoline units, the fuel level sensor, sending unit and associated fuel tank components are installed by the chassis/vehicle manufacturer. Diagnostics in this procedure for gasoline engines will involve troubleshooting from the ECM up to the Fuel System Interface connector; beyond this the OEM service manual from the chassis/vehicle manufacturer will need to be referenced.

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)
- Fuel Level Sensor Breakout Harness 690000181

To 6.0L Gasoline Setting Criteria

- SPN 96 FMI 2 – Fuel Level Sensor “A” Circuit Intermittent
- SPN 96 FMI 3 – Fuel Level Sensor “A” Circuit High
- SPN 96 FMI 4 – Fuel Level Sensor “A” Circuit Low
- SPN 96 FMI 7 – Fuel Level Sensor “A” Circuit Range/Performance

Gasoline Step-Based Diagnostic Routine – Fuel Level Sensor

Step	Action	Decision
1	A. Key OFF B. Disconnect Fuel Interface Connector. C. Check Fuel Interface Connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Are Sending Unit Assembly connector, harness, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest for DTC.

Step	Action	Decision
2	With Key ON, disconnect Fuel Interface Connector, measure voltage from (terminal C) to (terminal K) on Fuel Interface Connector. Is voltage less than, equal to, or greater than 5V?	Equal to: See OEM Diagnostics. Less than: Go To Step 3 Greater than: Repair short to voltage in signal circuit.

Step	Action	Decision
3	With Key OFF, ECM connected, Fuel Interface Connector disconnected, measure resistance from (terminal K) on Fuel Interface Connector to ground. Is resistance less than 10 ohms?	Yes: Go To Step 4 No: Repair high resistance or open in low reference circuit.

Step	Action	Decision
4	With Key OFF, disconnect J3 connector at ECM, disconnect Fuel Interface Connector, and measure resistance from (terminal C) to (terminal K) on Fuel Interface Connector. Is resistance greater than 1000 ohms?	Yes: Go To Step 5 No: Repair short between low/high reference circuits.

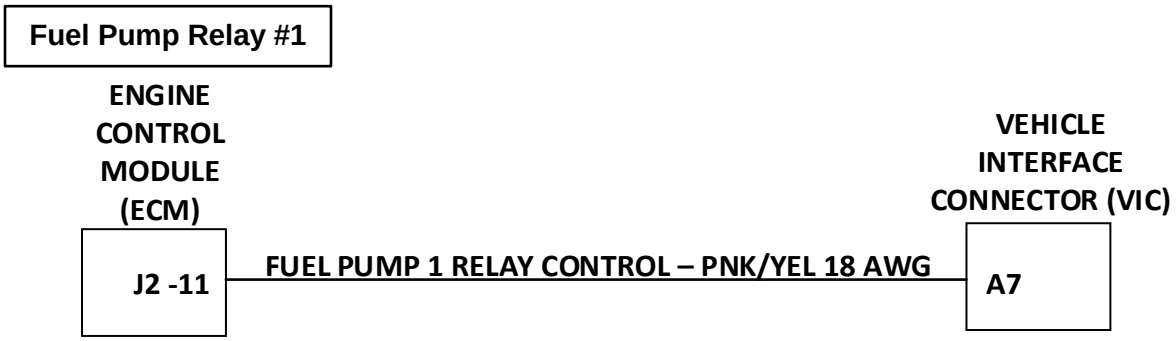
Step	Action	Decision
5	With Key OFF, disconnect J3 connector at ECM, disconnect Fuel Interface Connector, and measure resistance from (terminal C) on Fuel Interface Connector to ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 6 No: Repair short to ground in high reference circuit.

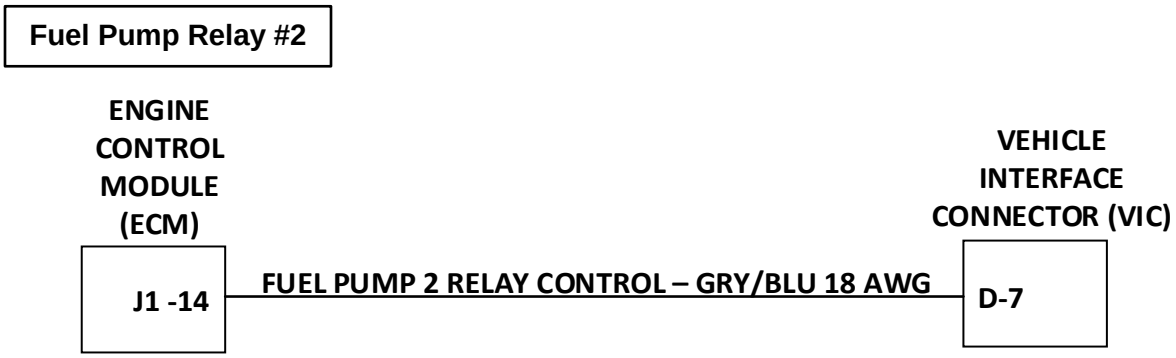
Step	Action	Decision
6	With Key OFF, disconnect J3 connector at ECM, disconnect Fuel Interface Connector, and measure resistance between (terminal 64) on ECM J3 and (terminal C) on Fuel Interface Connector. Is resistance greater than 10 ohms?	Yes: Repair open or high resistance in high reference circuit. No: Replace ECM.

21 Fuel Pump

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
1347	3	Fuel Pump 1 Circuit Short High	• Short to power in the circuit wiring • Malfunctioning pump or relay	A	MIL
1347	4	Fuel Pump 1 Circuit Short Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Malfunctioning pump or relay	A	MIL
1347	5	Fuel Pump 1 Circuit Open	• Open in the circuit wiring • Loose electrical connector or pin • Malfunctioning pump or relay	A	MIL
1348	3	Fuel Pump 2 Circuit Short High	• Short to power in the circuit wiring • Malfunctioning pump or relay	A	NONE
1348	4	Fuel Pump 2 Circuit Short Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Malfunctioning pump or relay	A	NONE
1348	5	Fuel Pump 2 Circuit Open	• Open in the circuit wiring • Loose electrical connector or pin • Malfunctioning pump or relay	A	NONE

Gasoline ECM to Fuel Pump Relay Schematics





**Note: The gasoline fuel pump and wiring is specific to the chassis/vehicle manufacturer. See OEM manuals for further details on wiring continuing from Terminal 30 on the Fuel Pump Relay.

Gasoline Overview

For gasoline units, the engine control module (ECM) enables the fuel pump relay when the ignition switch is turned ON. The control module continues to enable the fuel pump relay as long as ignition reference pulses are detected. The ECM disables the fuel pump relay if ignition reference pulses cease to be detected and the ignition remains ON.

The fuel pump and associated fuel tank components on gasoline engines are installed by the chassis/vehicle manufacturer. Diagnostics in this procedure for gasoline engines will involve troubleshooting from the ECM up to the Fuel Pump Relay; beyond this, the OEM service manual from the chassis/vehicle manufacturer will need to be referenced.

NOTE: Relays and pump motors have mechanical components that will wear over time. If the electrical wiring passes testing and inspection, it is likely that the mechanical portion of the relay or pump has failed.

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)
- 10 Amp Fused Jumper Wire

To 6.0L Gasoline Setting Criteria

- SPN 1347 FMI 3 – Fuel Pump 1 Circuit Short High
- SPN 1347 FMI 4 – Fuel Pump 1 Circuit Short Low
- SPN 1347 FMI 5 – Fuel Pump 1 Circuit Open

Step-Based Diagnostic Routine: SPN 1347 FMI 3, 4, 5

Step	Action	Decision
1	A. Key OFF B. Disconnect fuel interface connector (FIC) and fuel pump relay connector C. Check FIC and fuel pump relay connector terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are fuel pump and fuel pump relay connector, harness, and terminals clean and undamaged?	Yes: Install fuel interface connector, Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest for DTC.

Step	Action	Decision
2	A. Key OFF B. ECM Connector J2 disconnected C. VIC disconnected Key OFF, measure resistance between ECM Connector J2-11 and VIC (terminal A7). Is resistance less than 5 ohms?	Yes: Go To Step 3 No: Repair open or high resistance in circuit between ECM J2-11 and VIC (terminal A7)

Step	Action	Decision
3	A. Key OFF B. ECM Connector J2 disconnected C. VIC disconnected Key OFF, measure resistance between VIC (terminal A7) and chassis ground Is resistance greater than 1000 ohms?	Yes: Go To Step 4 No: Repair short to ground between ECM Connector J2-11 and VIC (terminal A7)

Step	Action	Decision
4	A. Key OFF B. ECM Connector J2 disconnected C. VIC connected D. Fuel Pump Relay removed Key ON, measure voltage between ECM Connector J2-11 and chassis ground. Is voltage less than 1V?	Yes: Go To Step 5 No: Repair short to voltage between ECM Connector J2-11 and VIC (terminal A7), if no short is found between ECM J2-11 and VIC (terminal A7), Go To Step 5

Step	Action	Decision
5	Go See OEM Diagnostics. After OEM diagnostics have been completed, has the fault been corrected?	Yes: End Diagnostics. No: Go To Step 6

Step	Action	Decision
6	See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section. After **1.3 Intermittent Fault Code Diagnostics** has been completed, has the fault been corrected?	Yes: End diagnostics. No: Replace ECM and retest.

Step-Based Diagnostic Routine: SPN 1348 FMI 3, 4, 5

Step	Action	Decision
1	A. Key OFF B. Disconnect fuel interface connector (FIC) and fuel pump relay connector C. Check FIC and fuel pump relay connector terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are fuel pump and fuel pump relay connector, harness, and terminals clean and undamaged?	Yes: Install fuel interface connector, Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest for DTC.

Step	Action	Decision
2	A. Key OFF B. ECM Connector J1 disconnected C. VIC disconnected Key OFF, measure resistance between ECM Connector J1-14 and VIC (terminal D7). Is resistance less than 5 ohms?	Yes: Go To Step 3 No: Repair open or high resistance in circuit between ECM J1-14 and VIC (terminal D7)

Step	Action	Decision
3	A. Key OFF B. ECM Connector J1 disconnected C. VIC disconnected Key OFF, measure resistance between VIC (terminal D7) and chassis ground Is resistance greater than 1000 ohms?	Yes: Go To Step 4 No: Repair short to ground between ECM Connector J1-14 and VIC (terminal D7)

Step	Action	Decision
4	A. Key OFF B. ECM Connector J1 disconnected C. VIC connected D. Fuel Pump Relay removed Key ON, measure voltage between ECM Connector J1-14 and chassis ground. Is voltage less than 1V?	Yes: Go To Step 5 No: Repair short to voltage between ECM Connector J1-14 and VIC (terminal D7), if no short is found between ECM J1-14 and VIC (terminal D7), Go To Step 5

Step	Action	Decision
5	Go See OEM Diagnostics. After OEM diagnostics have been completed, has the fault been corrected?	Yes: End Diagnostics. No: Go To Step 6

Step	Action	Decision
6	See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section. After **1.3 Intermittent Fault Code Diagnostics** has been completed, has the fault been corrected?	Yes: End diagnostics. No: Replace ECM and retest.

22 Fuel Trims

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
3227	16	Bank 1 Post Catalyst Fuel Trim System too Lean	• Misfire • Faulty injector(s) • Malfunctioning sensor	B	MIL
3227	18	Bank 1 Post Catalyst Fuel Trim System too Rich	• Fuel contamination • Malfunctioning MAF sensor • Saturated EVAP canister	B	MIL
3266	16	Bank 2 Post Catalyst Fuel Trim System Too Lean	• Misfire • Faulty injector(s) • Malfunctioning sensor	B	MIL
3266	18	Bank 2 Post Catalyst Fuel Trim System Too Rich	• Fuel contamination • Malfunctioning MAF sensor • Saturated EVAP canister	B	MIL
4237	15	Bank 1 System Too Lean at Idle	• Air leak in the induction system • Engine vacuum leak • Sticking, plugged, or failed fuel injector • Plugged fuel filter • Low fuel pressure • Exhaust leak at the manifold, or before pre-cat O2 Sensor • MAF sensor • MAP sensor • Incorrect, or contaminated fuel • Debris in the induction system affecting MAF • Biased O2 sensor • O-Ring not sealing on fuel line at LPDM • Ignition misfire 1. Spark plug wire 2. Spark plug 3. Ignition coil	B	MIL

4237	16	Bank 1 System Too Lean	• Air leak in the induction system • Engine vacuum leak • Sticking, plugged, or failed fuel injector • Plugged fuel filter • Low fuel pressure • Exhaust leak at the manifold, or before pre-cat O2 Sensor • MAF sensor • MAP sensor • Incorrect, or contaminated fuel • Debris in the induction system affecting MAF • Fuel delivery leak • Ignition misfire 1. Spark plug wire 2. Spark plug 3. Ignition coil	B	MIL
4237	17	Bank 1 System Too Rich at Idle	• Fuel injectors • MAF sensor • MAP sensor • Biased O2 sensor • Ignition misfire 1. Spark plug wire 2. Spark plug 3. Ignition coil • Engine mechanical issues	B	MIL
4237	18	Bank 1 System Too Rich	• Fuel injectors • MAF sensor • MAP sensor • Biased O2 sensor • Ignition misfire 1. Spark plug wire 2. Spark plug 3. Ignition coil	B	MIL

4239	15	Bank 2 System Too Lean at Idle	• Air leak in the induction system • Engine vacuum leak • Sticking, plugged, or failed fuel injector • Plugged fuel filter • Low fuel pressure • Exhaust leak at the manifold, or before pre-cat O2 Sensor • MAF sensor • MAP sensor • Incorrect, or contaminated fuel • Debris in the induction system affecting MAF • O-Ring not sealing on fuel line at LPDM • Ignition misfire 1. Spark plug wire 2. Spark plug 3. Ignition coil	B	MIL
4239	16	Bank 2 System Too Lean	• Air leak in the induction system • Engine vacuum leak • Sticking, plugged, or failed fuel injector • Plugged fuel filter • Low fuel pressure • Exhaust leak at the manifold, or before pre-cat O2 Sensor • MAF sensor • MAP sensor • Incorrect, or contaminated fuel • Debris in the induction system affecting MAF • O-Ring not sealing on fuel line at LPDM • Ignition misfire 1. Spark plug wire 2. Spark plug 3. Ignition Coil	B	MIL
4239	17	Bank 2 System Too Rich at Idle	• Leaking fuel delivery • Fuel injectors • MAF sensor • MAP sensor • Biased O2 sensor • Ignition misfire 1. Spark plug wire 2. Spark plug 3. Ignition coil • Engine mechanical issues	B	MIL

4239	18	Bank 2 System Too Rich	• Leaking fuel delivery • Fuel injectors • MAF sensor • MAP sensor • Biased O2 sensor • Ignition misfire 1. Spark plug wire 2. Spark plug 3. Ignition coil • Engine mechanical issues	B	MIL
5358	15	Cylinder 1 - Fuel Trim at Min Limit	• Fuel system components • Ignition system components • Engine mechanical issues • Vacuum and/or exhaust leak • Faulty O2 sensor	B	MIL
5358	17	Cylinder 1 - Fuel Trim at Max Limit	• Fuel contamination • Malfunctioning MAF sensor • Saturated EVAP canister • Faulty O2 sensor	B	MIL
5359	15	Cylinder 2 - Fuel Trim at Min Limit	• Fuel system components • Ignition system components • Engine mechanical issues • Vacuum and/or exhaust leak • Faulty O2 sensor	B	MIL
5359	17	Cylinder 2 - Fuel Trim at Max Limit	• Fuel contamination • Malfunctioning MAF sensor • Saturated EVAP canister • Faulty O2 sensor	B	MIL
5360	15	Cylinder 3 - Fuel Trim at Min Limit	• Fuel system components • Ignition system components • Engine mechanical issues • Vacuum and/or exhaust leak • Faulty O2 sensor	B	ML
5360	17	Cylinder 3 - Fuel Trim at Max Limit	• Fuel contamination • Malfunctioning MAF sensor • Saturated EVAP canister • Faulty O2 sensor	B	MIL
5361	15	Cylinder 4 - Fuel Trim at Min Limit	• Fuel system components • Ignition system components • Engine mechanical issues • Vacuum and/or exhaust leak • Faulty O2 sensor	B	MIL

5361	17	Cylinder 4 - Fuel Trim at Max Limit	• Fuel contamination • Malfunctioning MAF sensor • Saturated EVAP canister • Faulty O2 sensor	B	MIL
5362	15	Cylinder 5 - Fuel Trim at Min Limit	• Fuel system components • Ignition system components • Engine mechanical issues • Vacuum and/or exhaust leak • Faulty O2 sensor	B	MIL
5362	17	Cylinder 5 - Fuel Trim at Max Limit	• Fuel contamination • Malfunctioning MAF sensor • Saturated EVAP canister • Faulty O2 sensor	B	MIL
5363	15	Cylinder 6 - Fuel Trim at Min Limit	• Fuel system components • Ignition system components • Engine mechanical issues • Vacuum and/or exhaust leak • Faulty O2 sensor	B	MIL
5363	17	Cylinder 6 - Fuel Trim at Max Limit	• Fuel contamination • Malfunctioning MAF sensor • Saturated EVAP canister • Faulty O2 sensor	B	MIL
5364	15	Cylinder 7 - Fuel Trim at Min Limit	• Fuel system components • Ignition system components • Engine mechanical issues • Vacuum and/or exhaust leak • Faulty O2 sensor	B	MIL
5364	17	Cylinder 7 - Fuel Trim at Max Limit	• Fuel contamination • Malfunctioning MAF sensor • Saturated EVAP canister • Faulty O2 sensor	B	MIL
5365	17	Cylinder 8 - Fuel Trim at Max Limit	• Fuel contamination • Malfunctioning MAF sensor • Saturated EVAP canister • Faulty O2 sensor	B	MIL
5365	15	Cylinder 8 - Fuel Trim at Min Limit	• Fuel system components • Ignition system components • Engine mechanical issues • Vacuum and/or exhaust leak • Faulty O2 sensor	B	MIL

Overview

The ideal stoichiometric air/fuel (A/F) ratio for a Gasoline vehicle is 14.7:1 (by mass). When a Gasoline vehicle operates at this air/fuel ratio, the fuel burns completely resulting in the lowest amount of emissions. The best fuel economy occurs at leaner ratios and the most power is made at richer ratios. In rich conditions, the emissions output will increase. The Engine Control Module (ECM) will attempt to operate at the ideal 14.7:1 ratio. The primary input for monitoring air/fuel ratio is the O2 sensor. Lean codes are set when excessive oxygen is detected within the exhaust gas and rich codes are set when too little oxygen is detected. Bank 1 is the side of the engine that has cylinder #1 (Left-Hand Side of engine as viewed from the flywheel), bank 2 would be on the opposite side (Right-Hand Side of engine as viewed from the flywheel).

NOTE: Completely diagnose and repair all other DTCs prior to beginning diagnosis of these codes. This group of codes can be associated with drivability issues. Therefore, do not attempt to diagnose drivability related symptoms if no other DTCs are present, refer to symptom based diagnostics first. If SPN 4237 and 4239 are the only DTCs present, refer to symptom based diagnostics first.

Short Term Fuel Trim

Short Term Fuel Trim (STFT1 and STFT2) is the ECM's immediate response to adjust the air/fuel ratio. In positive corrections, fuel is added to adjust for a lean condition, while negative corrections reduce fuel in response to a rich condition. STFT corrections represent the current engine run cycle and react very quickly to O2 sensor input. For example, a large vacuum leak, would cause the ECM to immediately add positive fuel trim to balance the A/F mixture. STFT is not stored in Keep Alive Memory (KAM) after shut down and automatically resets to 0 for the next start/run cycle.

Long Term Fuel Trim

Unlike STFT, Long Term Fuel Trim (LTFT1 and LTFT2) is learned over time while in closed loop operation. It is a table stored in the KAM and also used for open loop fuel calculations (like start up and wide-open throttle). LTFT works to keep STFT within specification.

Normal Readings

A normal STFT reading will generally fluctuate between negative and positive every 1-3 seconds. With LPG applications, usually they will stay around ± 15%, but they may occasionally go up depending on the efficiency of the engine, age of the components, and other factors. A normal LTFT reading will appear to stay the same, giving a long term average of fuel added. In LPG applications, it can be as much as ± 20%. It will fluctuate much slower than STFT readings and possibly appearing static.

Diagnosing with Fuel Trims

Knowing whether a vehicle is running too rich, or too lean will help narrow down diagnosis. Fuel trims that differ greatly from one cylinder bank to the other will also provide key information. Always evaluate fuel trims at idle and at 1500 RPM.

Running too rich – High negative fuel trim corrections can be caused by MAF sensor problems, MAP/BARO sensor problems, leaking fuel injectors, aging O2 sensors and base engine issues such as low compression and incorrect camshaft timing.
Running too lean – High positive fuel corrections can be traced to MAF, MAP/BARO, aging O2 sensors, vacuum leaks, unmetered air leaks, clogged or dirty fuel injectors, fuel quality issues and fuel delivery issues.

Vacuum Leaks vs Fuel Delivery Issues

With the engine idling, look at the Short Term Fuel Trim (STFT) and Long term Fuel Trim (LTFT) values. Normal STFT range may be as high as ± 15%. If the numbers are +15% or higher for STFT and LTFT, the engine is running lean. Increase the engine RPM to 1500 and hold for 30 seconds. If the STFT drops back down to a more normal reading, it confirms the engine has a vacuum leak at idle. This is because vacuum leaks have less of a leaning effect on the fuel mixture as engine speed and load increase. If the fuel trim readings do not change much, the lean fuel condition is more likely due to a fuel delivery problem.

Positive LTFT Readings

When LTFT readings trend positive, it means the ECM is compensating for an air/fuel mixture that is becoming progressively leaner over time. Vacuum leaks, restricted fuel injectors, restrictions in the fuel delivery system, fouled spark plugs that misfire occasionally and incorrect fuel pressure are likely causes. Sensors that affect fuel strategy can also cause a lean condition such as MAP, MAF, Fuel Pressure, and O2 Sensor.

Negative LTFT Readings

When LTFT readings trend negative, it means the ECM is compensating for an air/fuel mixture that is becoming progressively richer over time. Plugged catalysts causing excessive exhaust back-pressure to build up, ignition system or fuel injectors are likely causes. Sensors that affect fuel strategy can cause a rich condition such as MAP, MAF, Fuel Pressure, and O2 Sensor. An engine that does not go into closed loop will also use more fuel, so any issue that results in the ECM thinking that the engine is still cold can cause a rich condition such as; ECT, IAT, or a stuck open thermostat.

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)
- Leak Locator
- Fuel Pressure Gauge – CH-48027
- O2 Sensor Breakout harness - 69000046

To 6.0L Gasoline Setting Criteria

- SPN 3227 FMI 16 – Bank 1 Post Catalyst Fuel Trim Too Lean
- SPN 3227 FMI 18 – Bank 1 Post Catalyst Fuel Trim Too Rich
- SPN 3266 FMI 16 – Bank 2 Post Catalyst Fuel Trim Too Lean
- SPN 3266 FMI 18 – Bank 2 Post Catalyst Fuel Trim Too Rich
- SPN 4237 FMI 15 – Bank 1 System Too Lean at Idle
- SPN 4237 FMI 16 – Bank 1 System Too Lean
- SPN 4237 FMI 17 – Bank 1 System Too Rich at Idle
- SPN 4237 FMI 18 – Bank 1 System too Rich
- SPN 4239 FMI 15 – Bank 2 System Too Lean at Idle
- SPN 4239 FMI 16 – Bank 2 System Too Lean
- SPN 4239 FMI 17 – Bank 2 System Too Rich at Idle
- SPN 4239 FMI 18 – Bank 2 System Too Rich
- SPN 5358 FMI 15 – Cylinder 1 – Fuel Trim at Min Limit
- SPN 5358 FMI 17 – Cylinder 1 – Fuel Trim at Max Limit
- SPN 5359 FMI 15 – Cylinder 2 – Fuel Trim at Min Limit
- SPN 5359 FMI 17 – Cylinder 2 – Fuel Trim at Max Limit
- SPN 5360 FMI 15 – Cylinder 3 – Fuel Trim at Min Limit
- SPN 5360 FMI 17 – Cylinder 3 – Fuel Trim at Max Limit
- SPN 5361 FMI 15 – Cylinder 4 – Fuel Trim at Min Limit
- SPN 5361 FMI 17 – Cylinder 4 – Fuel Trim at Max Limit
- SPN 5362 FMI 15 – Cylinder 5 – Fuel Trim at Min Limit
- SPN 5362 FMI 17 – Cylinder 5 – Fuel Trim at Max Limit
- SPN 5363 FMI 15 – Cylinder 6 – Fuel Trim at Min Limit
- SPN 5363 FMI 17 – Cylinder 6 – Fuel Trim at Max Limit
- SPN 5364 FMI 15 – Cylinder 7 – Fuel Trim at Min Limit
- SPN 5364 FMI 17 – Cylinder 7 – Fuel Trim at Max Limit
- SPN 5365 FMI 15 – Cylinder 8 – Fuel Trim at Min Limit
- SPN 5365 FMI 17 – Cylinder 8 – Fuel Trim at Max Limit

Evaluating Fuel Trims with PowerLink

Step	Action	Decision
1	Is a rich or lean fuel trim condition present? Reference **Section 3.4 Evaluating Fuel Trims** if the condition is unclear.	Rich: Go To **Section 3.5 Rich Fuel Trim Diagnostics**
		Lean: Go To **Section 3.6 Lean Fuel Trim Diagnostics**

23 O2 Sensor Signal Circuit (O2S)

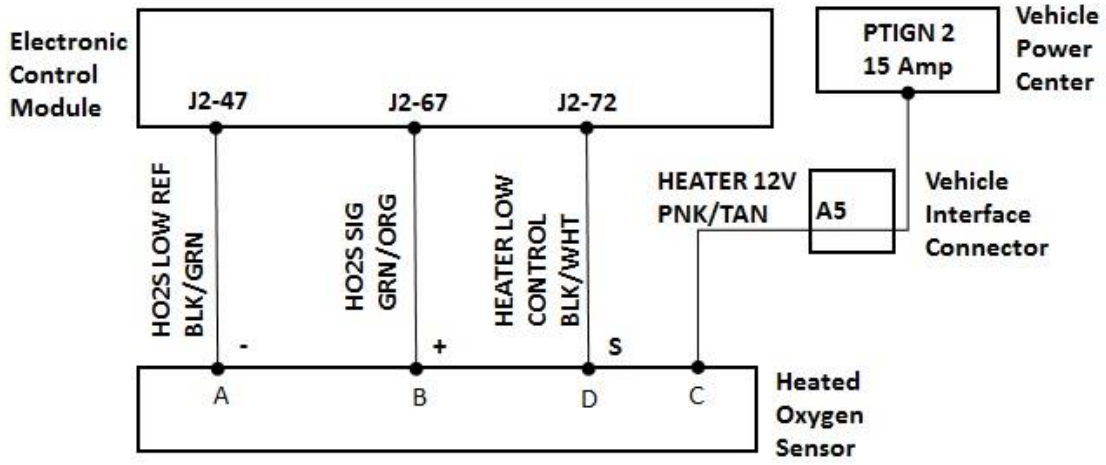
SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
3217	0	Bank 1 Sensor 1 O2 Sensor signal Stuck Rich	• Fuel injectors • MAF sensor • MAP sensor • Biased O2 sensor • Ignition misfire • Spark plug wire • Spark plug • Ignition coil • Malfunctioning sensor	B	MIL
3217	1	Bank 1 Sensor 1 O2 Sensor Signal Stuck Lean	• Fuel injectors • MAF sensor • MAP sensor • Biased O2 sensor • Ignition misfire • Spark plug wire • Spark plug • Ignition coil • Malfunctioning sensor	B	MIL
3217	3	Bank 1 Sensor 1 O2 Sensor Circuit High Voltage	• O2S signal circuit shorted to voltage • O2S low reference circuit shorted to voltage • O2S signal circuit open or high resistance • O2S low reference open or high resistance • O2S signal circuit shorted to heater control circuit • Malfunctioning sensor	A	MIL
3217	4	Bank 1 Sensor 1 O2 Sensor Circuit Low Voltage	• O2S signal circuit shorted to ground • O2S low reference shorted to ground • O2S signal circuit shorted to low reference circuit • Malfunction sensor	A	MIL
3217	5	Bank 1 Sensor 1 O2 Sensor Circuit No activity Detected	• Heater control circuit open or high resistance • O2S low reference open or high resistance • Malfunctioning sensor	A	MIL
3227	0	Bank 1 Sensor 2 O2 Sensor Signal Stuck Rich	• Fuel injectors • MAF sensor • MAP sensor • Biased O2 sensor	B	MIL

			• Ignition misfire • Spark plug wire • Spark plug • Ignition coil • Malfunctioning sensor		
3227	1	Bank 1 Sensor 2 O2 Sensor Signal Stuck Lean	• Fuel injectors • MAF sensor • MAP sensor • Biased O2 sensor • Ignition misfire • Spark plug wire • Spark plug • Ignition coil • Malfunctioning sensor	B	MIL
3227	3	Bank 1 Sensor 2 O2 Sensor Circuit High Voltage	• O2S signal circuit shorted to voltage • O2S low reference circuit shorted to voltage • O2S signal circuit open or high resistance • O2S low reference open or high resistance • O2S signal circuit shorted to heater control circuit • Malfunctioning sensor	B	MIL
3227	4	Bank 1 Sensor 2 O2 Sensor Circuit Low Voltage	• O2S signal circuit shorted to ground • O2S low reference shorted to ground • O2S signal circuit shorted to low reference circuit • Malfunction sensor	B	MIL
3227	5	Bank1 Sensor 2 O2 Sensor Circuit No activity Detected	• Heater control circuit open or high resistance • O2S low reference open or high resistance • Malfunctioning sensor	B	MIL
3222	10	O2 Sensor Circuit Range/ Performance Bank 1 Sensor 1	• Intermittent heater control circuit open or short • Intermittent poor connection • Malfunctioning sensor	B	MIL
3227	10	Bank 1 Sensor 2 O2 Sensor Circuit Range/ Performance	• Heater control circuit open or high resistance • O2S low reference open or high resistance • Malfunctioning sensor	B	MIL

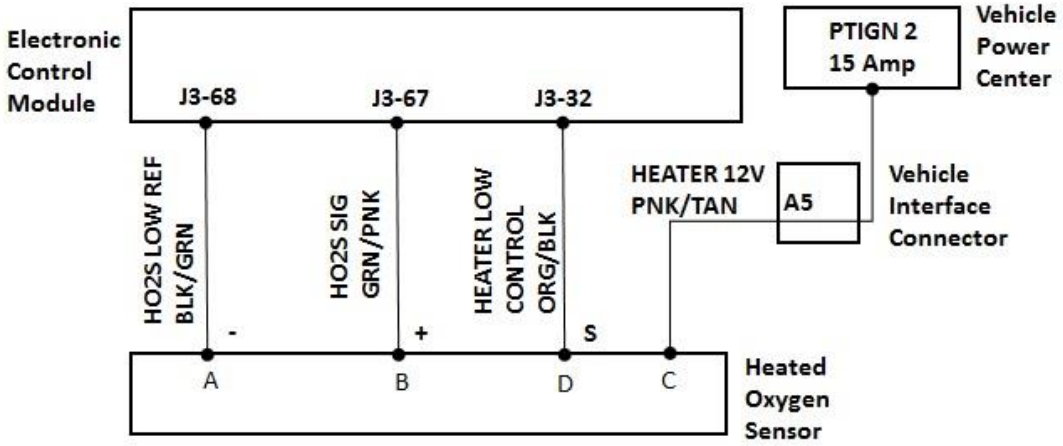
3256	0	Bank2 Sensor 1 O2 Sensor Signal Stuck Rich	• Fuel injectors • MAF sensor • MAP sensor • Biased O2 sensor • Ignition misfire • Spark plug wire • Spark plug • Ignition coil • Malfunctioning sensor	B	MIL
3256	1	Bank 2 Sensor 1 O2 Sensor Signal Stuck Lean	• Fuel injectors • MAF sensor • MAP sensor • Biased O2 sensor • Ignition misfire • Spark plug wire • Spark plug • Ignition coil • Malfunctioning sensor	B	MIL
3256	3	Bank 2 Sensor 1 O2 Sensor Circuit High Voltage	• O2S signal circuit shorted to voltage • O2S low reference circuit shorted to voltage • O2S signal circuit open or high resistance • O2S low reference open or high resistance • O2S signal circuit shorted to heater control circuit • Malfunctioning sensor	A	MIL
3256	4	Bank 2 Sensor 1 O2 Sensor Circuit Low Voltage	• O2S signal circuit shorted to ground • O2S low reference shorted to ground • O2S signal circuit shorted to low reference circuit • Malfunction sensor	A	MIL
3256	5	Bank 2 Sensor 1 O2 Sensor Circuit No activity Detected	• Heater control circuit open or high resistance • O2S low reference open or high resistance • Malfunctioning sensor	A	MIL
3262	10	O2 Sensor Circuit Range/ Performance Bank 2 Sensor 1	• Intermittent heater control circuit open or short • Intermittent poor connection • Malfunctioning sensor	B	MIL
3266	0	Bank 2 Sensor 2 O2 Sensor Signal Stuck Rich	• Fuel injectors • MAF sensor • MAP sensor • Biased O2 sensor	B	MIL

			• Ignition misfire • Spark plug wire • Spark plug • Ignition coil • Malfunctioning sensor		
3266	1	Bank 2 Sensor 2 O2 Sensor Signal Stuck Lean	• Fuel injectors • MAF sensor • MAP sensor • Biased O2 sensor • Ignition misfire • Spark plug wire • Spark plug • Ignition coil • Malfunctioning sensor	B	MIL
3266	3	Bank 2 Sensor 2 O2 Sensor Circuit High Voltage	• O2S signal circuit shorted to voltage • O2S low reference circuit shorted to voltage • O2S signal circuit open or high resistance • O2S low reference open or high resistance • O2S signal circuit shorted to heater control circuit • Malfunctioning sensor	B	MIL
3266	4	Bank 2 Sensor 2 O2 Sensor Circuit Low Voltage	• O2S signal circuit shorted to ground • O2S low reference shorted to ground • O2S signal circuit shorted to low reference circuit • Malfunction sensor	B	MIL
3266	5	Bank 2 Sensor 2 O2 Sensor Circuit No activity Detected	• Heater control circuit open or high resistance • O2S low reference open or high resistance • Malfunctioning sensor	B	MIL
3266	10	Bank 2 Sensor 2 O2 Sensor Circuit Range/ Performance	• O2S signal circuit shorted to ground • O2S low reference shorted to ground • O2S signal circuit shorted to low reference circuit • Malfunction sensor	B	MIL
4240	10	O2 Sensor Circuit Slow Response Bank 1 Sensor 1	• Malfunctioning sensor • Intermittent poor connection	A	MIL

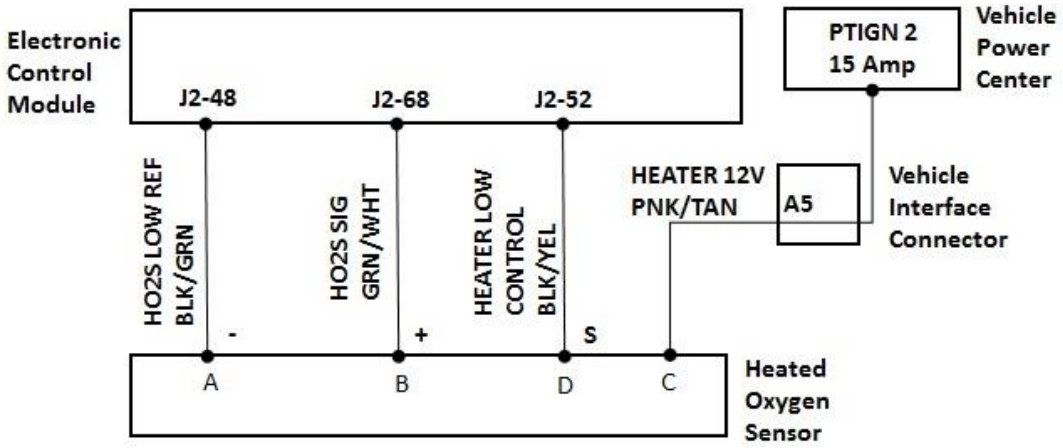
4241	10	O2 Sensor Circuit Slow Response Bank 2 Sensor 1	• Malfunctioning sensor • Intermittent poor connection	A	MIL



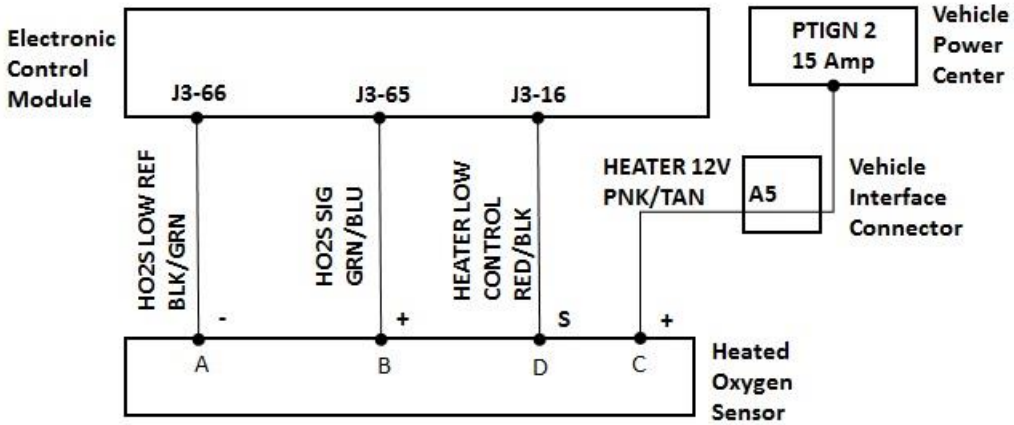
HO2S Bank 1 Sensor 1



HO2S Bank 1 Sensor 2



HO2S Bank 2 Sensor 1



HO2S Bank 2 Sensor 2

Overview

The O2 sensor (O2S) uses a ceramic and platinum probe that generates voltage based on the difference in oxygen in the exhaust gas and air external to the exhaust system. The sensor will generate around 0.9 volts when the fuel mixture is rich meaning there are lower amounts of oxygen in the exhaust. When the air/fuel mixture is lean and there are higher amounts of oxygen present in the exhaust, the sensor's output voltage will drop down around 0.1 volts. O2 sensor input is critical to the ECM for managing fuel trims when in closed loop. The ECM will command additional fuel if it perceives a lean condition from either pre-catalyst O2 sensors and reduce fuel when it perceives a rich condition from either pre-catalyst O2 sensors.

To operate, the sensor must be hot (about 600F or higher) before it will generate a reliable voltage signal. Therefore, in order to get the sensor up to operating temperature quickly, a heating element is added to the sensor assembly.
The circuits of the O2 sensor include: a low reference circuit for the O2 sensor (terminal A), a signal circuit for the O2 sensor (terminal B), a 12V (B+) circuit to power the heater element (terminal C), and a low control circuit for the ECM to control the heater element on the ground side (terminal D). The ECM uses a smart driver on the low control circuit to measure current output from the heater element. The driver will duty cycle the ground side of the heater to maintain a target current.
There is a total of four O2 sensors on this vehicle application, two located in the exhaust system for each bank with one before the catalyst and one after. The two located before the catalyst (Bank 1, Sensor 1, and Bank 2, Sensor 1) are the sensors used by the ECM to control fuel trims. The two located after the catalyst (Bank 1, Sensor 2, and Bank 2, Sensor 2) provide data to the ECM regarding catalyst efficiency. However, it is important to understand that all four O2 sensors function the same and are the same part number.

SPNs 3217, 3227, 3256, and 3266 are all related to issues with the O2 sensor and its circuits.
SPNs 3222, 3232, 3262, and 3272 are all related to issues with the heater element and its circuits.

Tools Required

- Digital Multimeter (DMM)
- PSI PowerLink
- O2 Sensor Breakout harness 69000046
- Oxygen Sensor Socket 88750B

To 6.0L Gasoline Setting Criteria

- SPN 3217 FMI 0 – Bank 1 Sensor 1 O2 Sensor Signal Stuck Rich
- SPN 3217 FMI 1 – Bank 1 Sensor 1 O2 Sensor Signal Stuck Lean
- SPN 3217 FMI 3 – Bank 1 Sensor 1 O2 Sensor Circuit High Voltage
- SPN 3217 FMI 4 – Bank 1 Sensor 1 O2 Sensor Circuit Low Voltage
- SPN 3217 FMI 5 – Bank 1 Sensor 1 O2 Sensor Circuit No Activity Detected
- SPN 3222 FMI 10 – O2 Sensor Loss of Ready Status Bank 1 Sensor 1
- SPN 3222 FMI 10 – O2 Sensor Time Ready Status Bank 1 Sensor 1
- SPN 3227 FMI 0 – Bank 1 Sensor 2 O2 Sensor Signal Stuck Rich
- SPN 3227 FMI 1 – Bank 1 Sensor 2 O2 Sensor Signal Stuck Lean
- SPN 3227 FMI 3 – Bank 1 Sensor 2 O2 Sensor Circuit High Voltage
- SPN 3227 FMI 4 – Bank 1 Sensor 2 O2 Sensor Circuit Low Voltage

- SPN 3227 FMI 5 – Bank 1 Sensor 2 O2 Sensor Circuit No Activity Detected
- SPN 3227 FMI 10 – Bank 1 Sensor 2 O2 Sensor Circuit Performance
- SPN 3227 FMI 10 – Bank 1 Sensor 2 O2 Sensor Circuit Range/Performance
- SPN 3256 FMI 0 – Bank 2 Sensor 1 O2 Sensor Signal Stuck Rich
- SPN 3256 FMI 1 – Bank 2 Sensor 1 O2 Sensor Signal Stuck Lean
- SPN 3256 FMI 3 – Bank 2 Sensor 1 O2 Sensor Circuit High Voltage
- SPN 3256 FMI 4 – Bank 2 Sensor 1 O2 Sensor Circuit Low Voltage
- SPN 3256 FMI 5 – Bank 2 Sensor 1 O2 Sensor Circuit No Activity Detected
- SPN 3262 FMI 10 – O2 Sensor Loss of Ready Status Bank 2 Sensor 1
- SPN 3262 FMI 10 – O2 Sensor Time Ready Status Bank 2 Sensor 1
- SPN 3266 FMI 0 – Bank 2 Sensor 2 O2 Sensor Signal Stuck Rich
- SPN 3266 FMI 1 – Bank 2 Sensor 2 O2 Sensor Signal Stuck Lean
- SPN 3266 FMI 3 – Bank 2 Sensor 2 O2 Sensor Circuit High Voltage
- SPN 3266 FMI 4 – Bank 2 Sensor 2 O2 Sensor Circuit Low Voltage
- SPN 3266 FMI 5 – Bank 2 Sensor 2 O2 Sensor Circuit No Activity Detected
- SPN 3266 FMI 10 – Bank 2 Sensor 2 O2 Sensor Signal Performance
- SPN 3266 FMI 10 – Bank 2 Sensor 2 O2 Sensor Circuit Range/Performance
- SPN 4240 FMI 10 – O2 Sensor Circuit Slow Response Bank 1 Sensor 1 (Rich to Lean Transition Rate)
- SPN 4240 FMI 10 – O2 Sensor Circuit Slow Response Bank 1 Sensor 1 (Lean to Rich Transition Rate)
- SPN 4240 FMI 10 – O2 Sensor Circuit Slow Response Bank 1 Sensor 1 (Number of Transitions)
- SPN 4240 FMI 10 – O2 Sensor Circuit Slow Response Bank 1 Sensor 1 (Symmetric Transition Rate)
- SPN 4240 FMI 10 – O2 Sensor Circuit Slow Response Bank 1 Sensor 1 (Rich to Lean Delay to Respond)
- SPN 4240 FMI 10 – O2 Sensor Circuit Slow Response Bank 1 Sensor 1 (Lean to Rich Delay to Respond)
- SPN 4240 FMI 10 – O2 Sensor Circuit Slow Response Bank 1 Sensor 1 (Symmetric Delay to Respond)
- SPN 4241 FMI 10 – O2 Sensor Circuit Slow Response Bank 2 Sensor 1 (Rich to Lean Transition Rate)
- SPN 4241 FMI 10 – O2 Sensor Circuit Slow Response Bank 2 Sensor 1 (Lean to Rich Transition Rate)
- SPN 4241 FMI 10 – O2 Sensor Circuit Slow Response Bank 2 Sensor 1 (Number of Transitions)
- SPN 4241 FMI 10 – O2 Sensor Circuit Slow Response Bank 2 Sensor 1 (Symmetric Transition Rate)
- SPN 4241 FMI 10 – O2 Sensor Circuit Slow Response Bank 2 Sensor 1 (Rich to Lean Delay to Respond)
- SPN 4241 FMI 10 – O2 Sensor Circuit Slow Response Bank 2 Sensor 1 (Lean to Rich Delay to Respond)
- SPN 4241 FMI 10 – O2 Sensor Circuit Slow Response Bank 2 Sensor 1 (Symmetric Delay to Respond)

Step-Based Diagnostic Routine: O2 Sensor Signal Diagnostics

Step	Action	Decision
1	A. Key OFF B. Visually confirm HO2S is fully seated in exhaust, secure, and undamaged. C. Disconnect HO2S. D. Check HO2S connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Is HO2S, harness, terminals clean and undamaged? Is sensor fully seated and secure?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. If sensor is not fully seated remove and inspect, if damaged replace it, if undamaged reinstall. After repairs are complete, retest for DTC.

Step	Action	Decision
2	Perform 1.2.6 Exhaust System Inspection and **3.7 Engine Intake and Exhaust Leaks**, from rear HO2S to the exhaust manifold in relation to the suspected engine bank, to inspect for exhaust leaks. Were any exhaust leaks found?	Yes: Repair exhaust leak, and retest. No: Go To Step 3

Step	Action	Decision
3	Key OFF, install O2 Sensor Breakout harness 69000046 onto suspect HO2S harness connector and sensor. Measure resistance between low reference circuit (terminal A) and engine/chassis ground. Is resistance less than 10 ohms?	Yes: Go To Step 5 No: Go To Step 4

Step	Action	Decision
4	Key OFF, disconnect associated ECM connector J2 or J3 (see below), inspect harness and ECM for pushed back terminals or damaged pins. Measure resistance across HO2S low reference circuit (terminal A) to associated ECM terminal. Bank 1 Sensor 1: J2-47 Bank 2 Sensor 1: J2-48 Bank 2 Sensor 2: J3-66 Bank 1 Sensor 2: J3-68 Is resistance less than 5 ohms?	Yes: Replace ECM, and retest. No: Repair open or high resistance in HO2S low reference circuit.

Step	Action	Decision
5	Key ON, measure voltage on HO2S signal circuit (terminal B) and low reference circuit (terminal A). Is 1.6 – 2.1V present?	Yes: Go To Step 7
		No Lower: Go To Step 11
		No Higher: Go To Step 6

Step	Action	Decision
6	Key OFF, disconnect HO2S from breakout harness. Key ON, measure voltage on HO2S signal circuit (terminal B) and low reference circuit (terminal A). Is 1.6 – 2.1V present?	Yes: Replace HO2S and retest.
		No: Repair short to power in HO2S Signal Circuit.

Step	Action	Decision
7	Determine which sensor is being looked at. Is sensor being diagnosed a pre-catalyst HO2S? (Bank 1 or 2 Sensor 1)	Yes Pre-Catalyst: Go To Step 8
		No Post-Catalyst: Go To Step 9

Step	Action	Decision
8	Note: This step is used to determine if the HO2S is functioning properly. The HO2S signal depends on oxygen content in the exhaust therefore analyzing the HO2S signal requires logical understanding of what the sensor is doing and may require a bank to bank comparison. If using a DMM, understand that the DMM has limited capabilities and sampling rates. If the DMM has a high resolution feature, enable it. It is preferred to use a lab scope when available. A. Warm engine to operating temperature ECT 150F+ B. Clear fault codes C. Monitor sensor voltage between (terminal B) and (terminal A) on HO2S breakout harness D. In PowerLink under Status Indicators find “Engine Exhaust Gas Oxygen Sensor Closed Loop Operation, Bank 1&2.” E. Start Engine and Idle Once in Closed Loop operation sensor voltage should cycle between 0.02 – 1V, rising and falling every 1-3 seconds. *Figure 1 Does sensor output voltage cycle smoothly between 0.01 – 1V?	Yes: See **1.3 Intermittent Fault Code Diagnostics** in Symptom Based Diagnostic section.
		No – Outputs stable or erratic voltage between 0.02-1V: *Figure 2 Replace HO2S sensor and retest. If voltage remains unchanged see Fuel Trim Diagnostics in Symptom Based Diagnostic section.
		No – Outputs positive voltage greater than 1V: Go To Step 9
		No – Outputs low voltage erratic or stable (< 0.1V): Replace HO2S and retest. If signal remains unchanged See Fuel Trim Diagnostics in Symptom Based Diagnostic section.

Step	Action	Decision
9	Note: This step is used to determine if the HO2S is functioning properly. The HO2S signal depends on oxygen content in the exhaust therefore analyzing the HO2S signal requires logical understanding of what the sensor is doing and may require a bank to bank comparison. If using a DMM, understand that the DMM has limited capabilities and sampling rates. If the DMM has a high resolution feature, enable it. It is preferred to use a lab scope when available. A. Warm engine to operating temperature ECT 150F+ B. Clear fault codes C. Monitor sensor voltage between (terminal B) and (terminal A) on HO2S breakout harness D. In PowerLink under Status Indicators find “Engine Exhaust Gas Oxygen Sensor Closed Loop Operation, Bank 1&2.” E. Start Engine and Idle Once in Closed Loop operation sensor voltage should remain stable between 0.5 – 0.8V indicating catalyst is converting remaining fuel vapors and oxygen to heat. Does sensor output voltage remain between 0.5 – 0.8V? *Figure 3 Note: The more ineffective catalytic converter, post-catalyst HO2S will resemble pre-catalyst HO2S.	Yes: See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section. No – Outputs cyclic/erratic voltage between 0.01-1V: Replace HO2S and retest. If signal remains unchanged replace catalytic converter and re-evaluate. No – Outputs stable positive voltage greater than 0.8V: *Figure 4 See Fuel Trim Diagnostics in Symptom Based Diagnostic section. No – Low voltage (< 0.5V): Replace HO2S and retest. If signal remains unchanged See Fuel Trim Diagnostics in Symptom Based Diagnostic section.

Step	Action	Decision
10	Key OFF, disconnect ECM connector J2 or J3 and HO2S from breakout harness. Bank 1 Sensor 1: J2 Bank 2 Sensor 1: J2 Bank 2 Sensor 2: J3 Bank 1 Sensor 2: J3 Key ON, measure voltage between signal circuit (terminal B) and engine/chassis ground Is voltage greater than 0.2V?	Yes: Repair short to voltage in signal circuit. No: Replace HO2S and retest.

Step	Action	Decision
11	Key OFF, measure resistance between HO2S signal circuit (terminal B) and engine/chassis ground. Is resistance less than 2500 ohms?	Yes: Go To Step 12 No: Go To Step 13

Step	Action	Decision
12	Key OFF, disconnect HO2S from breakout harness and measure resistance between HO2S signal circuit (terminal B) and engine/chassis ground. Is resistance less than 2500 ohms?	Yes: Repair short to ground in HO2S signal circuit. No: Replace HO2S sensor and retest.

Step	Action	Decision
13	Key OFF, disconnect associated ECM connector J2 or J3 (see below), inspect harness and ECM for pushed back terminals or damaged pins. Measure resistance across HO2S signal circuit (terminal B) to associated ECM terminal. Bank 1 Sensor 1: J2-67 Bank 2 Sensor 1: J2-68 Bank 2 Sensor 2: J3-65 Bank 1 Sensor 2: J3-67 Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in HO2S signal circuit. No: Replace ECM and retest.

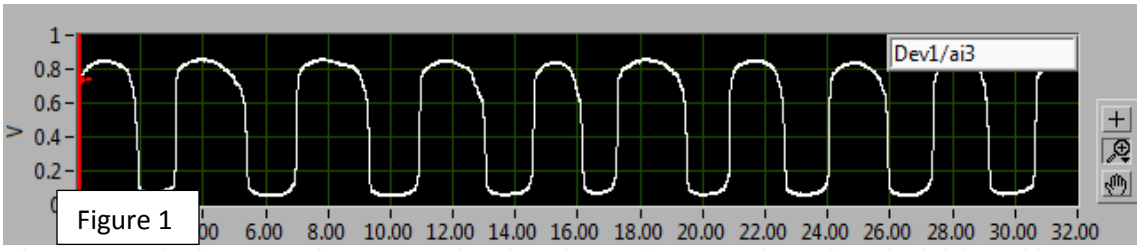


Figure 2: Typical Pre-Catalyst HO2S signal as the engine goes through typical rich and lean stoichiometric ratios

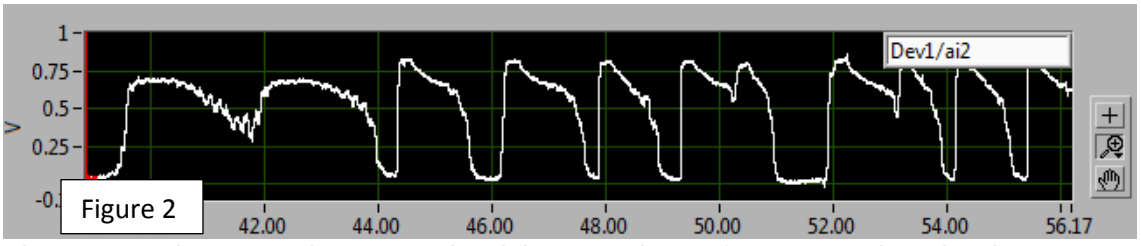


Figure 3: Erratic Pre-Catalyst HO2S signal due to engine performance and combustion concerns

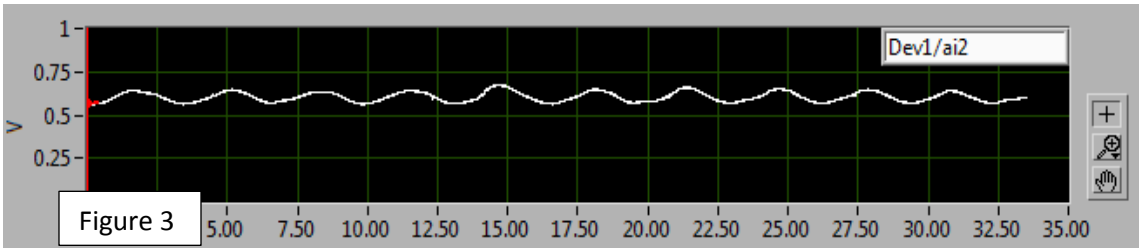


Figure 4: Typical Post-Catalyst HO2S signal. Minor fluctuations follow standard engine stoichimetric ratios but remains above 0.5V due to low oxygen content caused by the catalyst converting hydrocarbons and oxygen to heat.

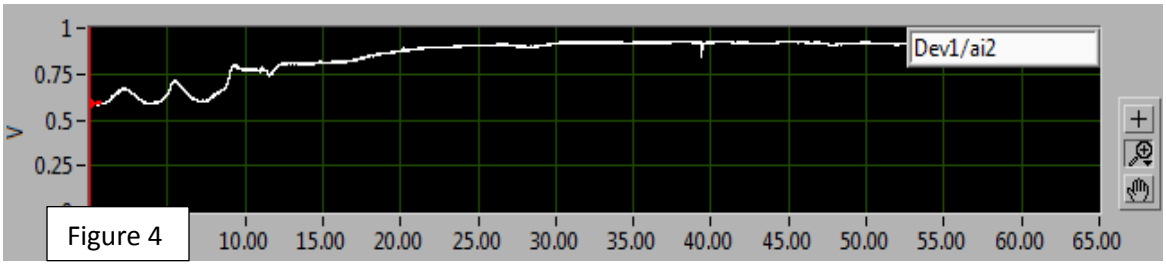
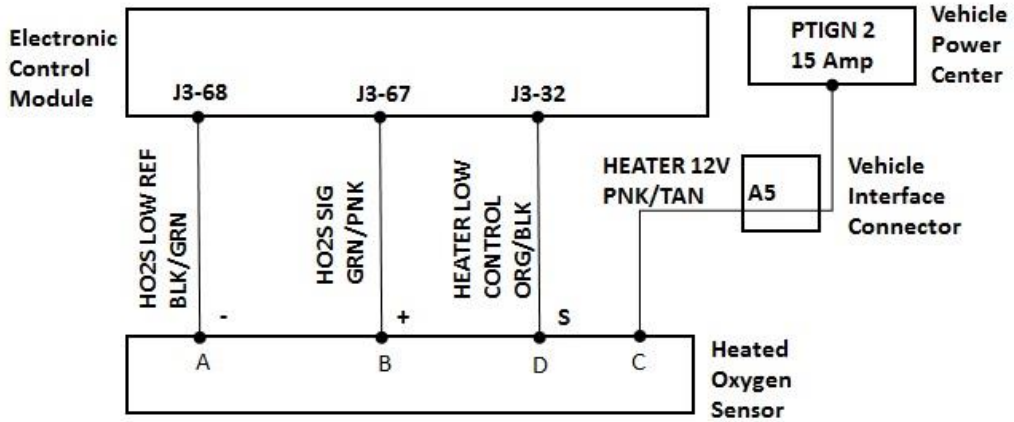


Figure 5: Non-typical Post-Catalyst HO2S signal. The sensor voltage is above 0.8V indicating low amounts of oxygen in the exhaust stream. This can be cause by rich stoichiometric air fuel ratios or poor combustion due to ignition failures

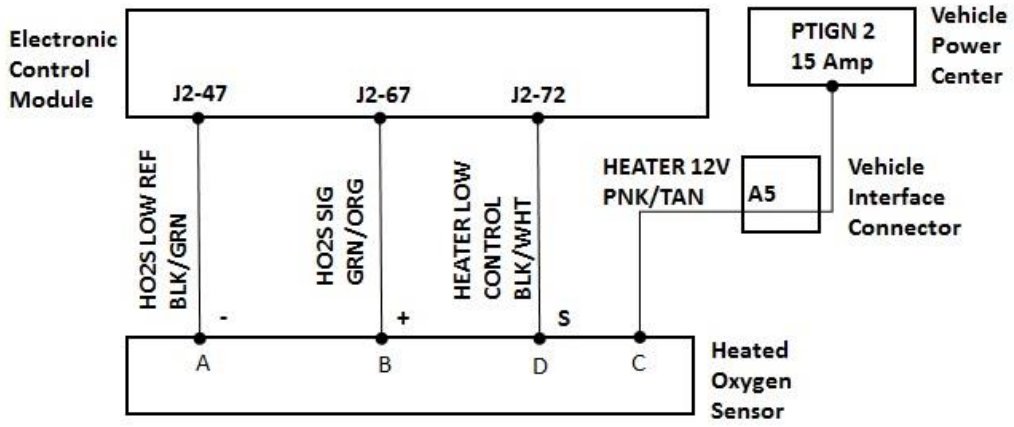
24 O2 Sensor Heater Control Circuit (O2S)

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
3222	1	HO2S Heater Control Circuit Bank 1 Sensor 1	• Heater control circuit shorted to ground or open • Heater control circuit high resistance • Malfunctioning sensor	A	MIL
3222	3	Bank1 Sensor1 O2S Heater Control Circuit High	• Heater control circuit shorted to voltage • Ground circuit open or high resistance • Malfunctioning sensor	A	MIL
3222	4	Bank1 Sensor 1 O2S Heater Control Circuit Low	• Heater control circuit shorted to ground • Heater control circuit high resistance • Malfunctioning sensor	A	MIL
3222	5	Bank1 Sensor1 O2S Heater Control Circuit Open	• Heater control circuit open • Malfunctioning sensor	A	MIL
3232	1	HO2S Heater Control Circuit Bank 1 Sensor 2	• Heater control circuit shorted to ground • Heater control circuit high resistance • Malfunctioning sensor	A	MIL
3232	3	Bank1 Sensor2 O2S Heater Control Circuit High	• Heater control circuit shorted to voltage • Ground circuit open or high resistance • Malfunctioning sensor	A	MIL
3232	4	Bank 1 Sensor 2 O2S Heater Control Circuit Low	• Heater control circuit shorted to ground • Heater control circuit high resistance • Malfunctioning sensor	A	MIL
3232	5	Bank1 Sensor2 O2S Heater Control Circuit Open	• Heater control circuit open • Malfunctioning sensor	A	MIL
3262	1	HO2S Heater Control Circuit Bank 2 Sensor 1	• Heater control circuit shorted to ground • Heater control circuit high resistance • Malfunctioning sensor	A	MIL

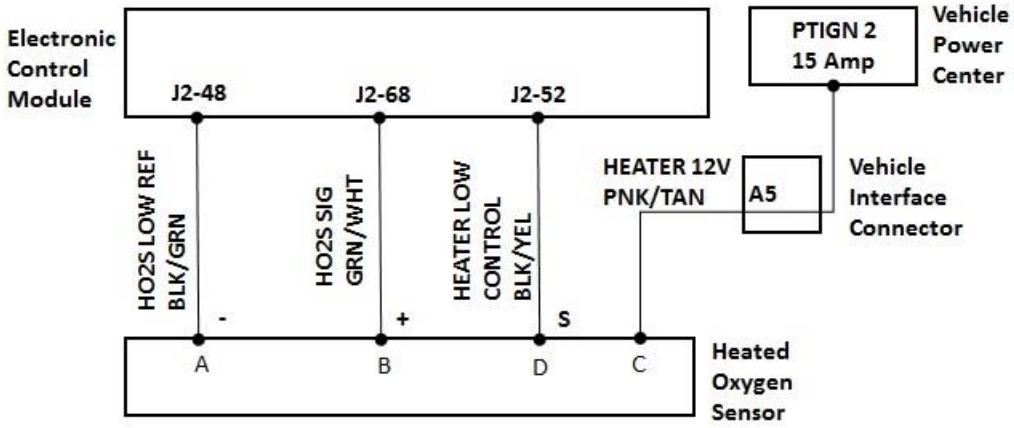
3262	3	Bank2 Sensor1 O2S Heater Control Circuit High	• Heater control circuit shorted to voltage • Ground circuit open or high resistance • Malfunctioning sensor	A	MIL
3262	4	Bank2 Sensor 1 O2S Heater Control Circuit Low	• Heater control circuit shorted to ground • Heater control circuit high resistance • Malfunctioning sensor	A	MIL
3262	5	Bank2 Sensor1 O2S Heater Control Circuit Open	• Heater control circuit open • Malfunctioning sensor	A	MIL
3271	1	HO2S Heater Control Circuit Bank 2 Sensor 2	• Heater control circuit shorted to voltage • Ground circuit open or high resistance • Malfunctioning sensor	A	MIL
3272	3	Bank2 Sensor2 O2S Heater Control Circuit High	• Heater control circuit shorted to voltage • Ground circuit open or high resistance • Malfunctioning sensor	A	MIL
3272	4	Bank2 Sensor2 O2S Heater Control Circuit Low	• Heater control circuit shorted to ground • Heater control circuit high resistance • Malfunctioning sensor	A	MIL
3272	5	Bank2 Sensor2 O2S Heater Control Circuit Open	• Heater control circuit open • Malfunctioning sensor	A	MIL



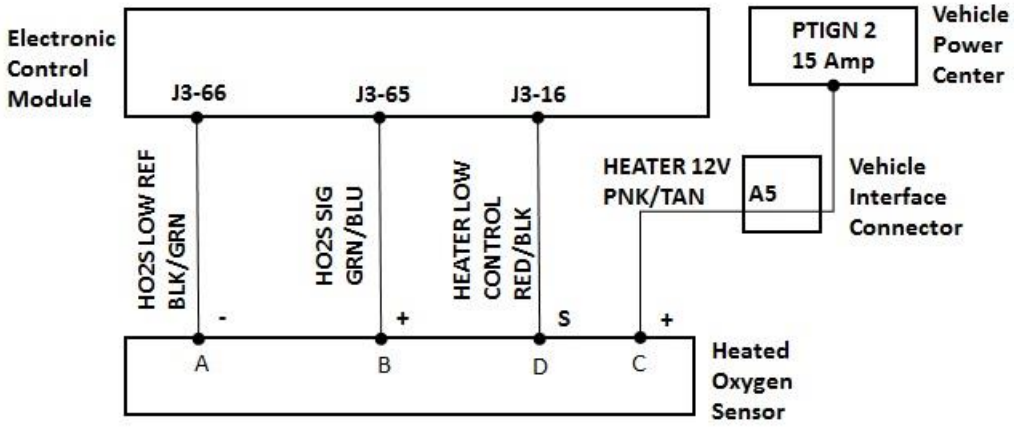
HO2S Bank 1 Sensor 2



HO2S Bank 1 Sensor 1



HO2S Bank 2 Sensor 1



HO2S Bank 2 Sensor 2

Overview

The O2 sensor (O2S) uses a ceramic and platinum probe that generates voltage based on the difference in oxygen in the exhaust gas and air external to the exhaust system. The sensor will generate around 0.9 volts when the fuel mixture is rich meaning there are lower amounts of oxygen in the exhaust. When the air/fuel mixture is lean and there are higher amounts of oxygen present in the exhaust, the sensor's output voltage will drop down around 0.1 volts. O2 sensor input is critical to the ECM for managing fuel trims when in closed loop. The ECM will command additional fuel if it perceives a lean condition from either pre-catalyst O2 sensors and reduce fuel when it perceives a rich condition from either pre-catalyst O2 sensors.

To operate, the sensor must be hot (about 600 degrees or higher) before it will generate a reliable voltage signal. Therefore, in order to get the sensor up to operating temperature quickly, a heating element is added to the sensor assembly.
The circuits of the O2 sensor include: a low reference circuit for the O2 sensor (terminal A), a signal circuit for the O2 sensor (terminal B), a 12V (B+) circuit to power the heater element (terminal C), and a low control circuit for the ECM to control the heater element on the ground side (terminal D). The ECM uses a smart driver on the low control circuit to measure current output from the heater element. The driver will duty cycle the ground side of the heater to maintain a target current.

There is a total of four O2 sensors on this vehicle application, two located with the exhaust system for each bank with one before the catalyst and one after. The two located before the catalyst (Bank 1, Sensor 1, and Bank 2, Sensor 1) are the sensors used by the ECM to control fuel trims. The two located after the catalyst (Bank 1, Sensor 2, and Bank 2, Sensor 2) provide data to the ECM regarding catalyst efficiency. However, it is important to understand that all four O2 sensors function the same and are the same part number.

SPNs 3217, 3227, 3256, and 3266 are all related to issues with the O2 sensor and its circuits. SPNs 3222, 3232, 3262, and 3272 are all related to issues with the heater element and its circuits.

Tools Required

- Digital Multimeter (DMM)
- PSI PowerLink
- 3 Amp Fused Jumper Wire
- O2 Sensor Breakout harness 69000046
- Oxygen Sensor Socket 88750B

To 6.0L Gasoline Setting Criteria

- SPN 3222 FMI 1 – HO2S Heater Control Circuit Bank 1 Sensor 1
- SPN 3222 FMI 3 – Bank 1 Sensor 1 O2S Heater Control Circuit High
- SPN 3222 FMI 4 – Bank 1 Sensor 1 O2S Heater Control Circuit Low
- SPN 3222 FMI 5 – Bank 1 Sensor 1 O2S Heater Control Circuit Open
- SPN 3232 FMI 1 – HO2S Heater Control Circuit Bank 1 Sensor 2
- SPN 3232 FMI 3 – Bank 1 Sensor 2 O2S Heater Control Circuit High
- SPN 3232 FMI 4 – Bank 1 Sensor 2 O2S Heater Control Circuit Low
- SPN 3232 FMI 5 – Bank 1 Sensor 2 O2S Heater Control Circuit Open
- SPN 3262 FMI 1 – HO2S Heater Control Circuit Bank 2 Sensor 1
- SPN 3262 FMI 3 – Bank 2 Sensor 1 O2S Heater Control Circuit High
- SPN 3262 FMI 4 – Bank 2 Sensor 1 O2S Heater Control Circuit Low
- SPN 3262 FMI 5 – Bank 2 Sensor 1 O2S Heater Control Circuit Open
- SPN 3271 FMI 1 – HO2S Heater Control Circuit Bank 2 Sensor 2
- SPN 3272 FMI 3 – Bank 2 Sensor 2 O2S Heater Control Circuit High
- SPN 3272 FMI 4 – Bank 2 Sensor 2 O2S Heater Control Circuit Low
- SPN 3272 FMI 5 – Bank 2 Sensor 2 O2S Heater Control Circuit Open

Step-Based Diagnostic Routine: O2 Sensor Heater Control Diagnostics

Step	Action	Decision
1	A. Key OFF B. Visually confirm affected HO2S(s) is/are fully seated in exhaust, secure, and undamaged. C. Disconnect HO2S. D. Check HO2S connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Is/are HO2S(s), harness, terminals clean and undamaged? Is/are sensor(s) fully seated and secure?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. If sensor is not fully seated remove and inspect, if damaged replace it, if undamaged reinstall. After repairs are complete, retest for DTC.

Step	Action	Decision
2	Key OFF, install O2 Sensor Breakout harness 69000046. Key ON, check for voltage between (terminal C) and engine/chassis ground. Is voltage equal to B+ ± 0.5V?	Yes: Go To Step 3 No: Go To Step 8

Step	Action	Decision
3	Key ON, check for voltage between (terminal D) and engine/chassis ground. Is voltage equal to B+ ± 0.5V?	Yes: Go To Step 4 No: Go To Step 6

Step	Action	Decision
4	Key OFF, disconnect HO2S from breakout harness. Key ON, check for voltage between (terminal D) and engine/chassis ground. Is voltage equal to 3.2V ± 0.5V?	No, Higher: Go To Step 5 Yes: Replace HO2S and retest. No, Lower: Repair open, short to ground, or high resistance in Heater Low Control circuit.

Step	Action	Decision
5	Key OFF, and HO2S disconnected from breakout harness. Measure resistance between (terminal C) and (terminal D). Is resistance less than 1000 ohms?	Yes: Repair short between Heater 12V Supply and Heater Low Control circuit. No: Repair short to power in Heater Low Control circuit.

Step	Action	Decision
6	Key OFF, and HO2S disconnected from breakout harness. Measure resistance between (terminal D) and engine/chassis ground. Is resistance less than 1000 ohms?	Yes: Go To Step 7 No: Replace sensor and retest.

Step	Action	Decision
7	A. Key OFF B. HO2S disconnected from breakout harness. C. VIC disconnected Measure resistance between (terminal D) and engine/chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground in Heater Low Control circuit between VIC and HO2S. No: Go To Step 14

Step	Action	Decision
8	Check PTIGN2 fuse in Vehicle Power Center. Is fuse open?	Yes: Key OFF, replace fuse. Go To Step 10 No: Go To Step 9

Step	Action	Decision
9	Inspect PTIGN2 fuse holder for damage, poor connection, or corrosion repair if necessary. Key ON, measure voltage across PTIGN2 fuse holder. Is voltage B+ ± 0.5V?	Yes: Go To Step 13 No: Go To Step 14

Step	Action	Decision
10	Key OFF, measure resistance between (terminal C) and engine/chassis ground. Is resistance less than 1000 ohms?	Yes: Go To Step 11 No: While monitoring resistance wiggle test harness and connectors testing for intermittent short to ground in PTIGN2 circuit. If an intermittent short is found repair or replace engine harness.

Step	Action	Decision
11	Key OFF, PTIGN2 supplies B+ to all Oxygen Sensor Heater Circuits, Ignition Coils 2, 3, 5, 8, and MAF/IAT sensor. Inspect all connectors, pins, and exposed wiring, for a short to ground. If damage is found repair. If no damage is found, unplug all sensors and coils, replace fuse and Key OFF, measure resistance between (terminal C) and engine/chassis ground. Is resistance less than 1000 ohms?	Yes: Replace engine harness and retest. No: Go To Step 12

Step	Action	Decision
12	Key OFF, while monitoring resistance between (terminal C) and engine/chassis ground, plug in each sensor and coil one at a time watching resistance. Does resistance drop below 1000 ohms after plugging in one of sensors or coils?	Yes: Replace sensor or coil and retest. No: Reassemble and retest for intermittent short to ground. If fuse blows again, replace engine harness and retest.

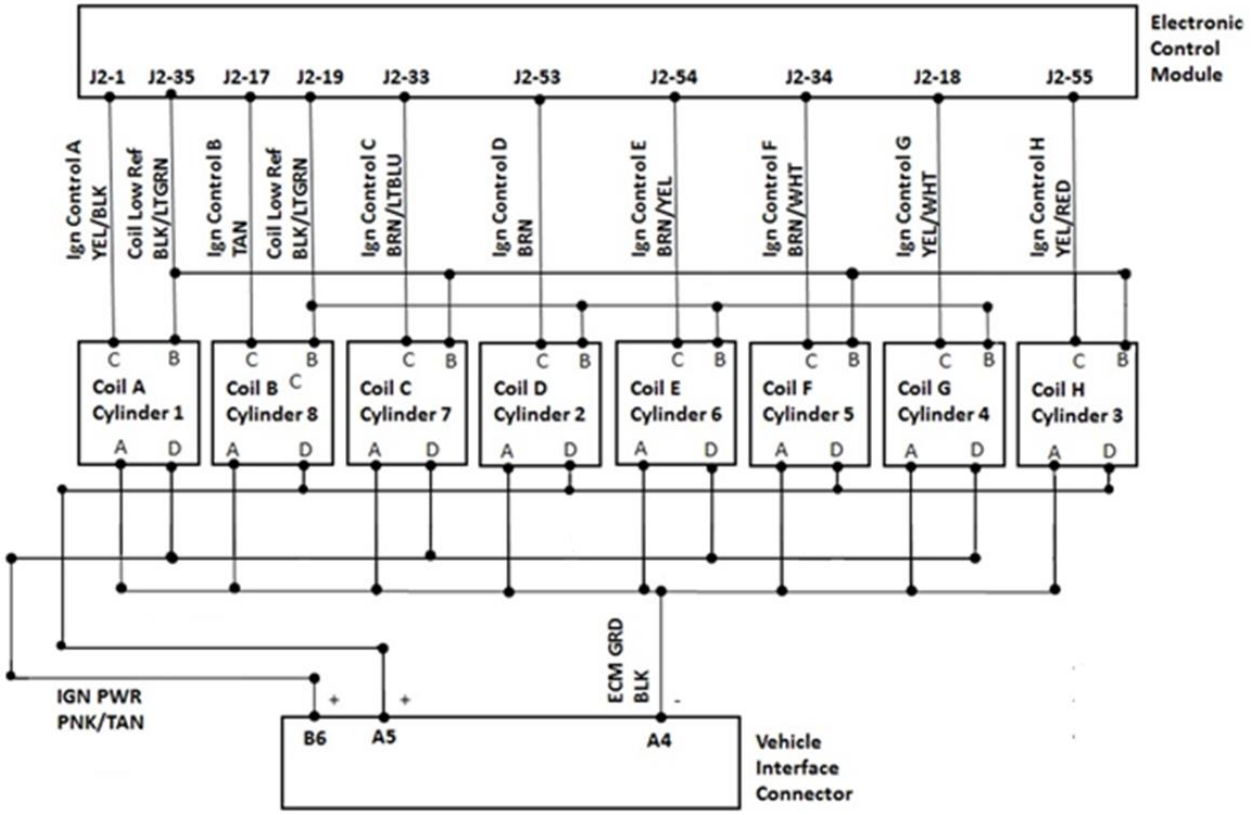
Step	Action	Decision
13	Key OFF, disconnect VIC, measure resistance between VIC (terminal A5) and HO2S connector (terminal C). Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in HO2S 12V supply circuit. No: Go To Step 14

Step	Action	Decision
16	Go See OEM Diagnostics. After OEM diagnostics have been completed, has the fault been corrected?	Yes: End Diagnostics. No: See **1.3 Intermittent Fault Code Diagnostics**.

25 Ignition Coils

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
1268	3	Ignition Coil "A" Primary Control Circuit High	• Short to power in the circuit wiring • Faulty Coil	A	MIL
1268	4	Ignition Coil "A" Primary Control Circuit Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Faulty Coil	A	MIL
1268	5	Ignition Coil "A" Primary Control Circuit Open	• Open in the circuit wiring • Loose electrical connector or pin • Faulty Coil	A	MIL
1269	3	Ignition Coil "D" Primary Control Circuit High	• Short to power in the circuit wiring • Faulty Coil	A	MIL
1269	4	Ignition Coil "D" Primary Control Circuit Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Faulty Coil	A	MIL
1269	5	Ignition Coil "D" Primary Control Circuit Open	• Open in the circuit wiring • Loose electrical connector or pin • Faulty Coil	A	MIL
1270	3	Ignition Coil "H" Primary Control Circuit High	• Short to power in the circuit wiring • Faulty Coil	A	MIL
1270	4	Ignition Coil "H" Primary Control Circuit Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Faulty Coil	A	MIL
1270	5	Ignition Coil "H" Primary Control Circuit Open	• Open in the circuit wiring • Loose electrical connector or pin • Faulty Coil	A	MIL
1271	3	Ignition Coil "G" Primary Control Circuit High	• Short to power in the circuit wiring • Faulty Coil	A	MIL
1271	4	Ignition Coil "G" Primary Control Circuit Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Faulty Coil	A	MIL
1271	5	Ignition Coil "G" Primary Control Circuit Open	• Open in the circuit wiring • Loose electrical connector or pin • Faulty Coil	A	MIL
1272	3	Ignition Coil "F" Primary Control Circuit High	• Short to power in the circuit wiring • Faulty Coil	A	MIL

1272	4	Ignition Coil "F" Primary Control Circuit Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Faulty Coil	A	MIL
1272	5	Ignition Coil "F" Primary Control Circuit Open	• Open in the circuit wiring • Loose electrical connector or pin • Faulty Coil	A	MIL
1273	3	Ignition Coil "E" Primary Control Circuit High	• Short to power in the circuit wiring • Faulty Coil	A	MIL
1273	4	Ignition Coil "E" Primary Control Circuit Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Faulty Coil	A	MIL
1273	5	Ignition Coil "E" Primary Control Circuit Open	• Open in the circuit wiring • Loose electrical connector or pin • Faulty Coil	A	MIL
1274	3	Ignition Coil "C" Primary Control Circuit High	• Short to power in the circuit wiring • Faulty Coil	A	MIL
1274	4	Ignition Coil "C" Primary Control Circuit Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Faulty Coil	A	MIL
1274	5	Ignition Coil "C" Primary Control Circuit Open	• Open in the circuit wiring • Loose electrical connector or pin • Faulty Coil	A	MIL
1275	3	Ignition Coil "B" Primary Control Circuit High	• Short to power in the circuit wiring • Faulty Coil	A	MIL
1275	4	Ignition Coil "B" Primary Control Circuit Low	• Short to ground in the circuit wiring • Loose electrical connector or pin • Faulty Coil	A	MIL
1275	5	Ignition Coil "B" Primary Control Circuit Open	• Open in the circuit wiring • Loose electrical connector or pin • Faulty Coil	A	MIL



Overview

The ignition coil delivers a spark to the cylinder in the same sequence as the ignition firing order. The ECM matches delivery of the spark with fuel delivery and intake valve timing to deliver the desire power output from the engine.

The ignition system in this application uses Coil-On-Plug technology with four circuits; 12V Ignition Power, Coil Ground, Ignition Control, and Low Reference Return. 12V Ignition Power is supplied through the Vehicle Interface Connector (VIC) after originating in the Vehicle Power Center. Ground for the coil is provided through the VIC and back to the chassis/battery ground. An igniter within the ignition coil is controlled by the ignition control circuit from the ECM and after being triggered returns low reference back to the ECM.

Diagnosis of the ignition coils includes:

- Validating the 12V Ignition Power circuit
- Validating the coil ground circuit
- Verifying that the igniter within the coil is receiving the ignition control signal
- Verifying that the igniter within the coil is returning the low reference
- Verifying that all wiring harness circuits and connectors are firmly attached
- Verifying that all pins are properly secured in the connectors and are providing adequate pressure to make an electrical connection.

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM) (ZTSE4357)
- Ignition Coil Breakout Harness 69000048

To 6.0L Gasoline Setting Criteria

- SPN 1268 FMI 3 – Ignition Coil “A” Primary Control Circuit High
- SPN 1268 FMI 4 – Ignition Coil “A” Primary Control Circuit Low
- SPN 1268 FMI 5 – Ignition Coil “A” Primary Control Circuit Open
- SPN 1269 FMI 3 – Ignition Coil “D” Primary Control Circuit High
- SPN 1269 FMI 4 – Ignition Coil “D” Primary Control Circuit Low
- SPN 1269 FMI 5 – Ignition Coil “D” Primary Control Circuit Open
- SPN 1270 FMI 3 – Ignition Coil “H” Primary Control Circuit High
- SPN 1270 FMI 4 – Ignition Coil “H” Primary Control Circuit Low
- SPN 1270 FMI 5 – Ignition Coil “H” Primary Control Circuit Open
- SPN 1271 FMI 3 – Ignition Coil “G” Primary Control Circuit High
- SPN 1271 FMI 4 – Ignition Coil “G” Primary Control Circuit Low
- SPN 1271 FMI 5 – Ignition Coil “G” Primary Control Circuit Open
- SPN 1272 FMI 3 – Ignition Coil “F” Primary Control Circuit High
- SPN 1272 FMI 4 – Ignition Coil “F” Primary Control Circuit Low
- SPN 1272 FMI 5 – Ignition Coil “F” Primary Control Circuit Open
- SPN 1273 FMI 3 – Ignition Coil “E” Primary Control Circuit High
- SPN 1273 FMI 4 – Ignition Coil “E” Primary Control Circuit Low
- SPN 1273 FMI 5 – Ignition Coil “E” Primary Control Circuit Open
- SPN 1274 FMI 3 – Ignition Coil “C” Primary Control Circuit High
- SPN 1274 FMI 4 – Ignition Coil “C” Primary Control Circuit Low
- SPN 1274 FMI 5 – Ignition Coil “C” Primary Control Circuit Open
- SPN 1275 FMI 3 – Ignition Coil “B” Primary Control Circuit High
- SPN 1275 FMI 4 – Ignition Coil “B” Primary Control Circuit Low
- SPN 1275 FMI 5 – Ignition Coil “B” Primary Control Circuit Open

Step-Based Diagnostic Routine (All Ignition Coil fault codes)

Step	Action	Decision
1	A. Key OFF B. Disconnect ignition coil connector C. Check affected ignition coil connector terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are ignition coil connector, harness, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest for fault.

Step	Action	Decision
2	With Key OFF, Install Ignition Coil breakout harness 69000048 on affected ignition coil(s). With Key ON, test for voltage between ignition power circuit (terminal D) and coil ground (terminal A). Is voltage B+ ± 0.5V?	Yes: Go To Step 9 No: Go To Step 3

Step	Action	Decision
3	With Key ON, test for voltage between ignition power circuit (terminal D) and chassis ground. Is voltage B+ ± 0.5V?	Yes: Go To Step 7 No: Go To Step 4

Step	Action	Decision
4	Check ignition coil fuses in Vehicle Power Center. There are 2 fuses, one for each power circuit supplying each group of coils (cyl 1, 4, 6, and 7 are on PTING1 fuse, and cyl 2, 3, 5, and 8 are on PTIGN2 fuse). Is fuse open for coil being tested?	Yes: Go To Step 5 No: Go To Step 6

Step	Action	Decision
5	A. Key OFF B. Ignition coil disconnected C. VIC disconnected With Key OFF, measure resistance between ignition power circuit (terminal D) and ground. Is resistance greater than 1000 Ohms?	Yes: Go To Step 16 No: Repair short to ground in ignition power circuit then replace fuse.

Step	Action	Decision
6	With Key OFF, measure resistance across entire ignition power circuit from VIC (terminal B6 if affected ignition coil is for cyl 1, 4, 6, or 7, or terminal A5 if affected ignition coil is for cyl 2, 3, 5, or 8) to ignition coil harness connector (terminal D). Is resistance greater than 5 ohms?	Yes: Repair open/high resistance in ignition power circuit. No: Go To Step 16

Step	Action	Decision
7	With Key ON, test for voltage between coil ground circuit (terminal A) and battery ground. Is voltage greater than 1V?	Yes: Repair-short to power in coil ground circuit. No: Go To Step 8

Step	Action	Decision
8	With Key OFF, measure resistance between coil ground (terminal A) and battery ground. Is resistance greater than 10 ohms?	Yes: Repair open or high resistance in coil ground circuit. No: Retest, Return to Step 2.

Step	Action	Decision
9	With engine cranking and/or running at idle speed, Use DMM (special tool ZTSE4357) to measure DC Hertz (Hz) between ignition control circuit (terminal C) and ground. NOTE: This circuit may also be tested with an inductive amp meter if it is sensitive enough to detect 3mA. Is frequency (Hz) between 3-20 Hz at idle / cranking speed?	Yes: Go To Step 14 No: Go To Step 10

Step	Action	Decision
10	With engine running / cranking, measure maximum voltage between ignition control circuit (terminal C) and battery ground. Was voltage measured less than 0.1 volts, or greater than 3.5 volts? Note: Voltage typically fluctuates between 0.1V and 0.5V at idle / cranking speed.	Greater than 3.5V: Go To Step 11 Less than 0.1V: Go To Step 12

Step	Action	Decision
11	With Key ON, measure voltage between the ignition control circuit (terminal C) and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage in ignition control circuit. No: Retest, Return to Step 2

Step	Action	Decision
12	With Key OFF, disconnect ECM connector J2 and measure resistance between ignition control circuit (terminal C) and ignition coil ground terminal A. Is resistance greater than 1000 Ohms?	Yes: Go To Step 13 No: Repair short to ground in ignition control circuit.

Step	Action	Decision
13	With Key OFF, disconnect ECM connector J2 and inspect ECM and J2 connector for damage. Measure resistance across ignition control circuit from respective (terminal A) at J2 connector (see schematic) to ignition coil harness (terminal C). Are any pins on J2 connector damaged or is resistance in circuit greater than 5 ohms?	Yes: Repair damaged pin, open, or high resistance in ignition control circuit. No: Replace ECM and retest.

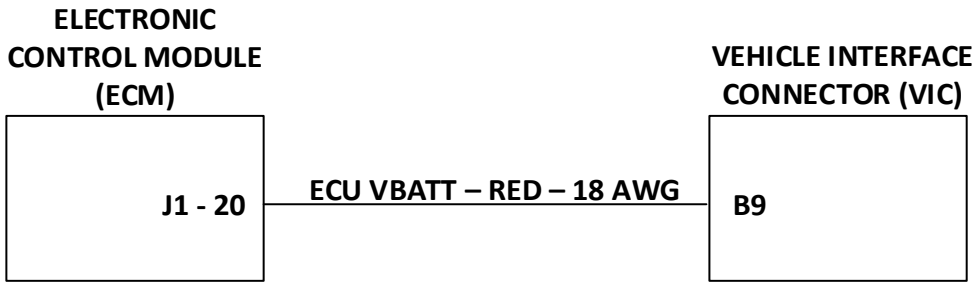
Step	Action	Decision
14	With Key OFF, disconnect ECM connector J2 With Key ON, measure voltage between low reference circuit (terminal B) and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage in low reference circuit. No: Go To Step 15

Step	Action	Decision
15	With Key OFF, disconnect ECM connector J2 and measure resistance across respective low reference circuit from J2 connector (see schematic) to ignition coil harness terminal B. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in ignition control circuit. No: Replace ignition coil.

Step	Action	Decision
16	Go See OEM Diagnostics. After OEM diagnostics have been completed, has the fault been corrected?	Yes: End Diagnostics. No: See **1.3 Intermittent Fault Code Diagnostics**.

26 Ignition Voltage

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
168	0	System Voltage High	• Incorrect settings during a jump start or charging • 12 V engine electrical system connected to 24 V chassis electrical system • Internal voltage regulator failure at full-field	B	MIL
168	1	System Voltage Low	• Loose alternator drive belt • Alternator / internal voltage regulator • Battery • Loose / corroded battery terminal connections • Loose / corroded electrical connections • Fuse	B	MIL



Overview

The ECM is provided power at all times. The ECM in this application expects system voltage to remain between 9 and 16 volts. When the ECM determines system voltage is below 9 volts or greater than 16 volts, the SPN will set.
Incorrect system voltage may cause any of the following conditions:

- No crank / slow crank
- Sluggish performance
- MIL on

Diagnosis of the system includes:

- Visual inspection of the battery and charging system
- Check ECM fuse
- Inspect alternator drive belt
- Refer to OEM procedures for battery and charging system tests

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)

Refer to the Original Equipment Manufacturer (OEM) for a list of recommended tools for testing the battery and charging system

To 6.0L Gasoline Setting Criteria

- SPN 168 FMI 0 – System Voltage High
- SPN 168 FMI 1 – System Voltage Low

Step-Based Diagnostic Routine: SPN 168 FMI 0

Step	Action	Decision
1	The engine wiring harness for this vehicle is a 12V system. If the engine was jump started from a 24V system, or the battery charger was set to 24V, this code could be set. Was the vehicle jump started or charged with a 24V system?	Yes: Clear the DTC and retest. No: Go To Step 2

Step	Action	Decision
2	Measure voltage between the 10-Amp ECU fuse within the Vehicle Power Center and battery ground. Is the voltage greater than 16V?	Yes: Go To Step 3 No: Clear the DTC and retest.

Step	Action	Decision
3	If the chassis electrical system is 24V, there will be a step-down transformer to take the 24V chassis voltage down to 12V for the engine. Does the vehicle have a step-down transformer?	Yes: Refer to OEM procedures for testing and inspecting the transformer. No: Go See OEM Diagnostics.

Step-Based Diagnostic Routine: SPN 168 FMI 1

Step	Action	Decision
1	Measure voltage at the 10-Amp ECU fuse within the Vehicle Power Center. Is the voltage less than 9V?	Yes: Go To Step 2 No: Clear DTC and retest.

Step	Action	Decision
2	Check for corroded or loose connections at the starter, alternator, and all chassis and engine grounds. Check the ECM 10-amp fuse. Was any corrosion, loose connections, or a blown fuse found? NOTE: Refer to OEM recommended service procedures for testing and inspecting the Battery and chassis electrical components.	Yes: Repair the condition, Charge batteries (if necessary) and retest. No: Go To Step 3

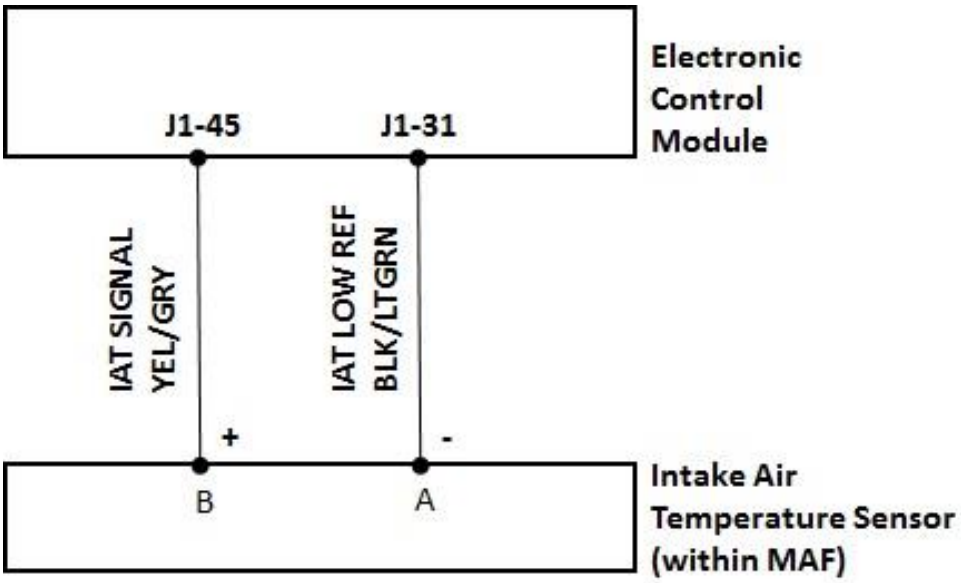
Step	Action	Decision
3	A. Key OFF B. Disconnect ECM J1 C. Disconnect VIC Measure resistance between ECM J1 (terminal 20) and VIC (terminal B9). Is resistance greater than 5 ohms?	Yes: Repair open or high resistance between ECM J1 (terminal 20) and VIC (terminal B9) No: Go To Step 4

Step	Action	Decision
4	A. Key OFF B. Disconnect ECM J1 C. Disconnect VIC Measure resistance between ECM J1 (terminal 20) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground between ECM J1 (terminal 20) and chassis ground. No: Go To Step 5

Step	Action	Decision
5	Ensure that the alternator drive belt is tight and not excessively worn. Is the alternator drive belt loose, or damaged?	Yes: Replace and/or tighten the alternator belt. No: Go See OEM Diagnostics.

27 Intake Air Temperature (IAT) Sensor

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
172	3	Intake Air Temperature Sensor 1 Circuit High	• Signal circuit open or short to voltage • Open low reference circuit • Malfunctioning sensor	A	MIL
172	4	Intake Air Temperature Sensor 1 Circuit Low	• Signal circuit short to ground • Low reference circuit open or shorted to ground • Loose electrical connector or pin • Malfunctioning sensor	A	MIL
172	10	Intake Air Temperature Sensor 1 Circuit Range/ Performance Bank 1	• Malfunctioning IAT Sensor • Intermittent or poor connection	B	MIL
172	20	Intake Air Temperature Sensor 1 – High Rationality	• Malfunctioning IAT Sensor • High resistance in signal circuit • Open in signal circuit	A	MIL
172	21	Intake Air Temperature Sensor 1 – Low Rationality	• Malfunctioning IAT Sensor • Short to voltage in signal circuit • High resistance in ECT sensor circuit	A	MIL
172	31	Intake Air Temperature Sensor Stuck	• Loose electrical connector or pin • Malfunctioning sensor	A	MIL



Overview

The Intake Air Temperature (IAT) sensor on this application is integrated with the Mass Airflow (MAF) sensor. The IAT sensor has 2 circuits; a signal and a low reference. 5-volts are supplied to the signal circuit (terminal B) by pin J1-45 of the ECM. The low reference return circuit (terminal A) is at pin J1-31 of the ECM. The IAT sensor has a positive temperature coefficient which means that as temperature rises, so does the resistance of the sensor.

A Malfunctioning IAT sensor may cause any of the following conditions:

- Hard starting when the engine is cold
- Reduced gas mileage
- Spark Knock
- Decreased engine performance

Diagnosis of the sensor includes:

- Verifying that the ECM is properly receiving a signal
- Ensuring that 5-volts are supplied on the signal circuit from the ECM
- Measuring resistance on the signal and low reference circuits
- Verifying that all wiring harness circuits and connectors are firmly attached
- Verifying that all pins are properly secured in the connectors and are providing adequate pressure to make an electrical connection.

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)
- Breakout Harness (ZTSE4960)

Sensor Resistance Table

Temperature	Resistance (ohms)
-40°F (-40°C)	101K Ω
-4°F (-20°C)	28.5K Ω
32°F (0°C)	9.4K Ω
68°F (20°C)	3.5K Ω
104°F (40°C)	1.5K Ω
176°F (80°C)	334 Ω
212°F (100°C)	133 Ω

To 6.0L Gasoline Setting Criteria

- SPN 172 FMI 3 – Intake Air Temperature Sensor 1 Circuit High
- SPN 172 FMI 4 – Intake Air Temperature Sensor 1 Circuit Low
- SPN 172 FMI 10 – Intake Air Temperature Sensor 1 Range/Performance
- SPN 172 FMI 20 – Intake Air Temperature Sensor 1 – High Rationality
- SPN 172 FMI 21 – Intake Air Temperature Sensor 1 – Low Rationality
- SPN 172 FMI 31 – Intake Air Temperature Sensor Stuck

Step-Based Diagnostic Routine: SPN 172 FMI 3, 4, 10, 20, 21, 31

Step	Action	Decision
1	A. Key OFF B. Disconnect IAT Connector C. Check IAT Connector terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are IAT connector, harness, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest.

Step	Action	Decision
2	Key OFF, disconnect IAT sensor and install breakout harness ZTSE4960 to harness connector only. Measure resistance between low reference circuit (terminal A) and ground. Is resistance less than 10 ohms?	Yes: Go To Step 3 No: Go To Step 5

Step	Action	Decision
3	Key ON, with sensor disconnected, measure voltage between signal circuit (terminal B) and low reference circuit (terminal A). Is voltage less than, equal to, or greater than 5V?	Equal to: Go To Step 6 Less than: Go To Step 4 Greater than: Repair short to voltage in signal circuit.

Step	Action	Decision
4	Key OFF, with sensor disconnected, disconnect ECM J1 connector and check for continuity across signal circuit from the ECM (J1-45) to IAT sensor (terminal B). Does signal circuit have continuity from ECM to IAT sensor?	Yes: Go To Step 7 No: Repair open or high resistance in signal circuit.

Step	Action	Decision
5	Key OFF, with sensor disconnected, disconnect ECM J1 connector and check for continuity across low reference circuit from ECM (J1-31) to IAT sensor (terminal A). Does low reference circuit have continuity from ECM to IAT sensor?	Yes: Reassemble and retest circuit for intermittent faults. No: Repair open or high resistance in low reference circuit.

Step	Action	Decision
6	Connect breakout harness ZTSE4960 to IAT sensor only and measure resistance between (terminal A) and terminal B. Refer to Sensor Resistance Table for specification. Is sensor resistance within specification?	Yes: Reassemble and retest circuit for intermittent faults. No: Replace sensor, clear DTCs and retest system.

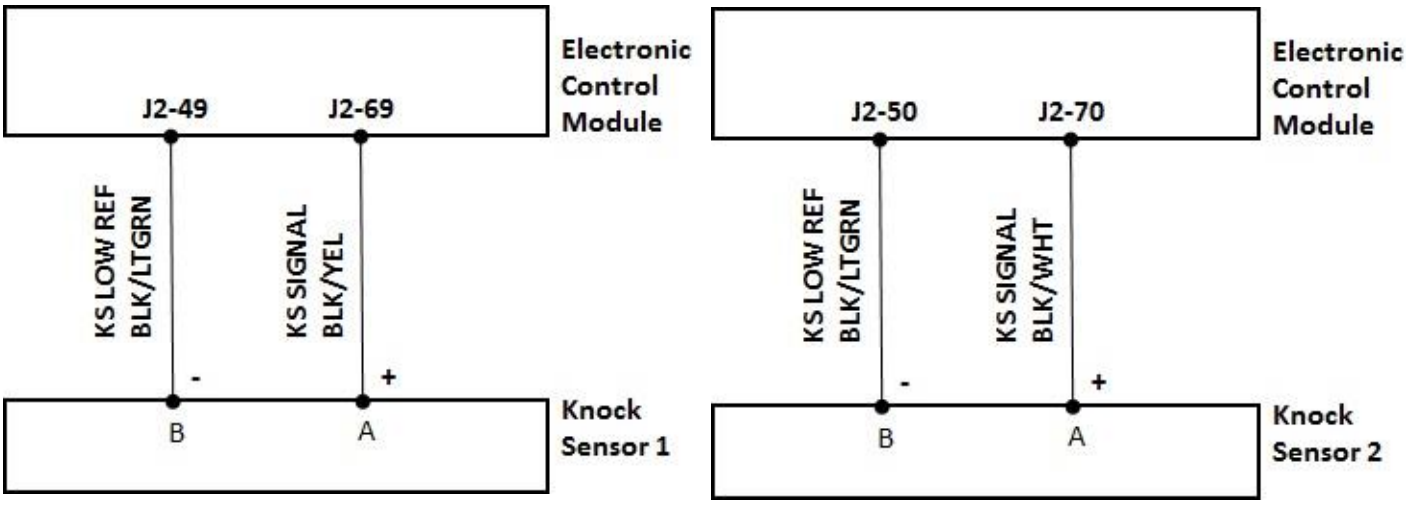
Step	Action	Decision
7	Key OFF, with ECM connector J1 and IAT sensor disconnected, measure resistance between signal circuit (terminal B) and ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground on signal circuit (terminal B). No: Go To Step 8

Step	Action	Decision
8	Key OFF, with ECM connector J1 and IAT sensor disconnected, measure resistance between signal circuit (terminal B) and low reference circuit (terminal A). Is there continuity between signal circuit (terminal B) and low reference circuit (terminal A)?	Yes: Repair short between signal circuit (terminal B) and low reference circuit (terminal A). No: Reassemble and retest circuit for intermittent faults.

28 Knock Sensor 1 and 2

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
1352	3	Knock Sensor 1 Circuit High	• Signal circuit shorted to voltage • Low reference circuit shorted to voltage • Malfunctioning sensor	A	MIL
1352	4	Knock Sensor 1 Circuit Low	• Signal circuit shorted to ground • Reference circuit open or shorted to ground • Signal circuit open, or high resistance • Reference circuit open or high resistance • Loose electrical connector or pin • Malfunctioning sensor	A	MIL
1352	5	Knock Sensor 1 Circuit	• Signal circuit shorted to ground • Reference circuit open or shorted to ground • Signal circuit open, or high resistance • Reference circuit open or high resistance • Signal circuit shorted to voltage • Low reference circuit shorted to voltage • Loose electrical connector or pin • Malfunctioning sensor	A	MIL
1353	3	Knock Sensor 2 Circuit High	• Signal circuit shorted to voltage • Low reference circuit shorted to voltage • Malfunctioning sensor	A	MIL
1353	4	Knock Sensor 2 Circuit Low	• Signal circuit shorted to ground • Reference circuit open or shorted to ground • Signal circuit open, or high resistance • Reference circuit open or high resistance • Loose electrical connector or pin • Malfunctioning sensor	A	MIL
1353	5	Knock Sensor 2 Circuit	• Signal circuit shorted to ground • Reference circuit open or shorted to ground • Signal circuit open, or high resistance • Reference circuit open or high resistance	A	MIL

			• Signal circuit shorted to voltage • Low reference circuit shorted to voltage • Loose electrical connector or pin • Malfunctioning sensor		



Overview

The air/fuel mixture within an engine combustion chamber should only be ignited by the spark plug. However, sometimes conditions within the combustion chamber cause the air/fuel mixture to be ignited by other means. When this occurs, flame fronts in the cylinder collide producing detonation, or spark knock. Long term detonation can result in mechanical damage to the engine. A Knock Sensor is a piezoelectric (crystal) device that produces a voltage when subjected to mechanical stress. When an engine experiences detonation the Knock Sensor sends a signal to the ECM. This application uses two knock sensors, one per engine bank at the rear of each cylinder head. Knock Sensor “1” is located on bank 1. Knock Sensor “2” is located on bank 2. Each knock sensor has 2 circuits; a signal circuit and a low reference circuit.
The ECM primarily uses Knock Sensor information to determine ignition timing. An engine experiencing detonation cannot operate with optimized ignition advance and the ECM will start to use less ignition advance (thus less engine power) in order to reduce detonation.

Common causes of detonation include:

- Poor fuel quality
- Using fuel with the wrong octane rating (gasoline applications)
- Factors that increase engine operating temperature

A Malfunctioning knock sensor may cause any of the following conditions:

- Decreased engine power
- Audible ping/knock sound when accelerating

Diagnosis of the sensor includes:

- Verifying that the ECM is properly receiving a signal
- Ensuring that the signal circuit has voltage from the ECM to the sensor
- Measuring resistance on the reference and signal circuits
- Verifying that all wiring harness circuits and connectors are firmly attached
- Verifying that all pins are properly secured in the connectors and are providing adequate pressure to make an electrical connection.

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)
- Knock Sensor Breakout Harness 69000049

To 6.0L Gasoline Setting Criteria

- SPN 1352 FMI 3 – Knock Sensor 1 Circuit High
- SPN 1352 FMI 4 – Knock Sensor 1 Circuit Low
- SPN 1352 FMI 5 – Knock Sensor 1 Circuit
- SPN 1353 FMI 3 – Knock Sensor 2 Circuit High
- SPN 1353 FMI 4 – Knock Sensor 2 Circuit Low
- SPN 1353 FMI 5 – Knock Sensor 2 Circuit

Step-Based Diagnostic Routine: SPN 1352 FMI 3, 4, 5

Step	Action	Decision
1	A. Key OFF B. Disconnect knock sensor connector C. Check knock sensor connector terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are knock sensor connector, harness, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest.

Step	Action	Decision
2	With the Key OFF, fully install knock sensor breakout harness 69000049. With the Key ON, measure voltage between signal circuit (terminal A) and low reference Terminal B. Is voltage less than, between, or greater than 1 to 2.5V?	Less than 1V: Go To Step 4 Between: Go To Step 10 Greater than 2.5V: Go To Step 3

Step	Action	Decision
3	With the Key OFF, measure resistance between low reference (terminal B) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground in low reference circuit. No: Go To Step 5

Step	Action	Decision
4	Disconnect ECM J2 connector, check resistance between low reference (terminal B) to ECM J2-49. Is resistance less than 5 ohms?	Yes: Go To Step 7 No: Repair open or high resistance in low reference circuit.

Step	Action	Decision
5	With the Key OFF, disconnect connector ECM J2. With the Key ON, measure voltage between signal circuit (terminal A) and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage in signal circuit. No: Go To Step 6

Step	Action	Decision
6	With ECM J2 disconnected and the Key ON, measure voltage between low reference (terminal B) and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage in low reference circuit. No: Go To Step 10

Step	Action	Decision
7	With the Key OFF, Measure resistance between signal circuit (terminal A) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair the short to ground in the signal circuit. No: Go To Step 8

Step	Action	Decision
8	Measure resistance between signal circuit (terminal A) to ECM J2-69 Is resistance less than 5 ohms?	Yes: Go To Step 9 No: Repair open or high resistance in signal circuit.

Step	Action	Decision
9	Measure resistance between signal circuit (terminal A) and low reference Terminal B. Is resistance less than 1000 ohms?	Yes: Repair short between signal and low reference circuits. No: Go To Step 10

Step	Action	Decision
10	A. Key OFF, Disconnect vehicle harness from breakout harness. B. Set DMM to mVAC. Connect leads to signal circuit (terminal A) and low reference (terminal B). C. Start engine, leave at idle. Record mVAC. D. Raise engine speed to 1500 RPM. Record mVAC. Did the knock sensor produce mVAC voltage AND did voltage rise with engine RPM?	Yes: If the knock sensor was recently replaced, re-torque fastener. Speak with vehicle operator to understand running conditions at time of failure. Perform section **3.16 Knock Sensor Operational Test** in the Symptom Based Diagnostics. No: Replace knock sensor 1. Refer to installation in engine service manual. Correct knock sensor fastener toque is critical for system function.

Step-Based Diagnostic Routine: SPN 1353 FMI 3, 4, 5

Step	Action	Decision
1	A. Key OFF B. Disconnect knock sensor connector C. Check knock sensor connector terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are knock sensor connector, harness, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest.

Step	Action	Decision
2	With the Key OFF, fully install knock sensor breakout harness 69000049. With the Key ON, measure voltage between signal circuit (terminal A) and low reference (terminal B). Is voltage less than, between, or greater than 1 to 2.5V?	Less than 1V: Go To Step 4 Between: Go To Step 10 Greater than 2.5V: Go To Step 3

Step	Action	Decision
3	With the Key OFF, measure resistance between low reference (terminal B) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground in low reference circuit. No: Go To Step 5

Step	Action	Decision
4	Disconnect ECM J2 connector, check resistance between low reference (terminal B) to ECM J2-50. Is resistance less than 5 ohms?	Yes: Go To Step 7 No: Repair open or high resistance in low reference circuit.

Step	Action	Decision
5	With the Key OFF, disconnect connector ECM J2. With the Key ON, measure voltage between signal circuit (terminal A) and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage in signal circuit. No: Go To Step 6

Step	Action	Decision
6	With ECM J2 disconnected and with the Key ON, measure voltage between low reference (terminal B) and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage in low reference circuit. No: Go To Step 10

Step	Action	Decision
7	With the Key OFF, Measure resistance between signal circuit (terminal A) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair the short to ground in the signal circuit. No: Go To Step 8

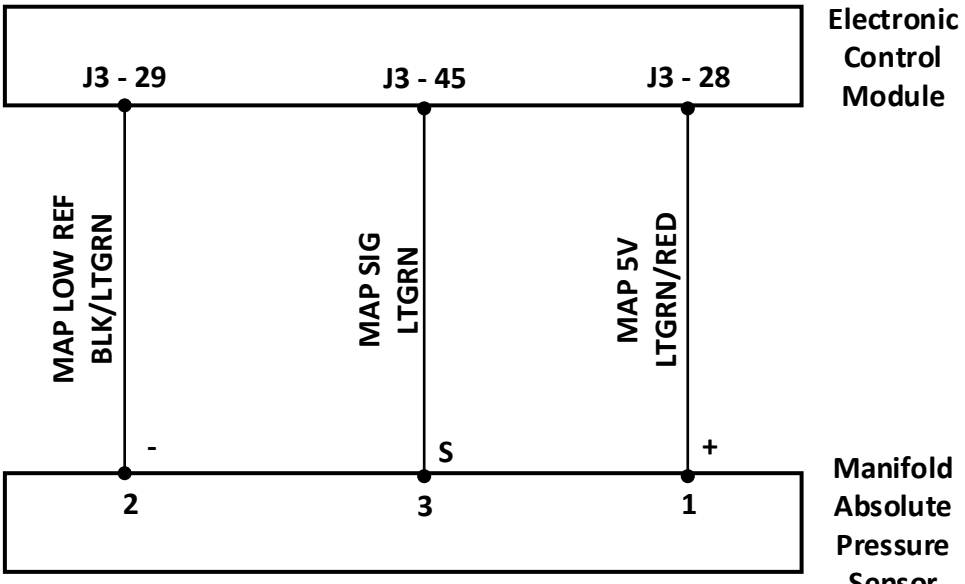
Step	Action	Decision
8	Measure resistance between signal circuit (terminal A) to ECM J2-70 Is resistance less than 5 ohms?	Yes: Go To Step 9 No: Repair open or high resistance in signal circuit.

Step	Action	Decision
9	Measure resistance between signal circuit (terminal A) and low reference (terminal B). Is resistance less than 1000 ohms?	Yes: Repair short between signal and low reference circuits. No: Go To Step 10

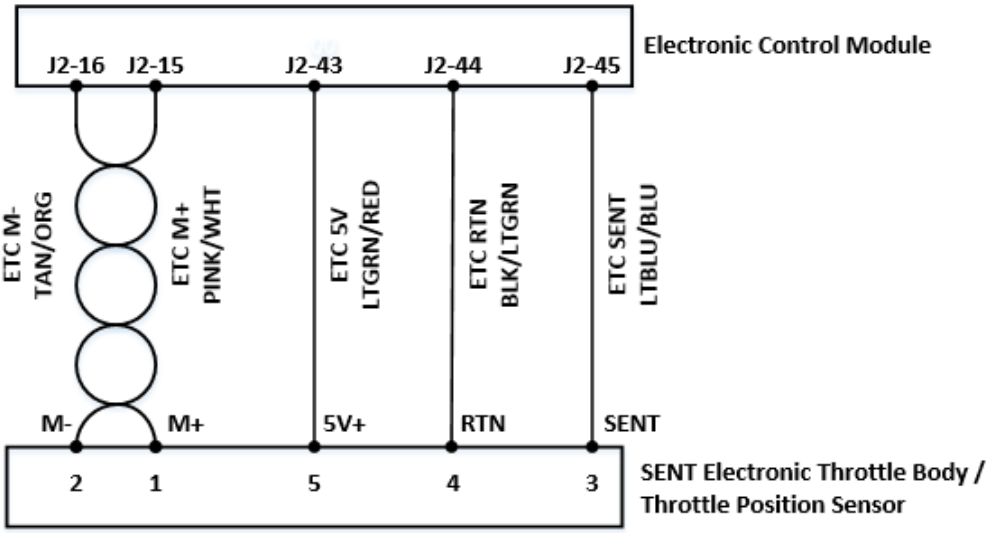
Step	Action	Decision
10	A. Key OFF, Disconnect vehicle harness from breakout harness. B. Set DMM to mVAC. Connect leads to signal circuit (terminal A) and low reference (terminal B). C. Start engine, leave at idle. Record mVAC. D. Raise engine speed to 1500 RPM. Record mVAC. Did the knock sensor produce mVAC voltage AND did voltage rise with engine RPM?	Yes: If the knock sensor was recently replaced, re-torque fastener. Speak with vehicle operator to understand running conditions at time of failure. Perform section **3.16 Knock Sensor Operational Test** in the Symptom Based Diagnostics. No: Replace knock sensor 1. Refer to installation in engine service manual. Correct knock sensor fastener toque is critical for system function.

29 Manifold Absolute Pressure (MAP) Sensor

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
3563	3	Manifold Absolute Pressure Circuit High Input	• 5V supply circuit shorted to voltage • Signal circuit shorted to voltage • Signal circuit open or high resistance • Low reference open or high resistance • Malfunctioning sensor	A	MIL
3563	4	Manifold Absolute Pressure Circuit Low Input	• 5V supply circuit shorted to ground • Signal circuit shorted to ground • 5V supply circuit open or high resistance • Signal circuit open or high resistance • Malfunctioning sensor	A	MIL
3563	7	Manifold Absolute Pressure Stuck	• Malfunctioning sensor • Intermittent poor connection • Air management system leak	B	MIL
3563	7	Manifold Absolute Pressure Stuck at Startup	• Malfunctioning sensor • Intermittent poor connection • Air management system leak	A	MIL
3563	10	MAP/BARO Pressure Sensor Circuit Intermittent	• Short to ground • Open circuit • Malfunctioning sensor	B	MIL
3563	20	Manifold Absolute Pressure/Mass Air Flow - Throttle Position Correlation at Higher Load	• Malfunctioning MAP/TPS sensor • Intermittent poor connection • Air management system leak	B	MIL
3563	21	Manifold Absolute Pressure/Mass Air Flow - Throttle Position Correlation at Idle	• Malfunctioning MAP/TPS sensor • Intermittent poor connection • Air management system leak	B	MIL



6.0L Gasoline MAP Sensor



Overview

The Manifold Absolute Pressure (MAP) sensor measures absolute (includes barometric) pressure in the intake manifold. The measurement is converted to a voltage and supplied to the ECM. The MAP sensor is the primary input for the ECM to determine engine load for ignition advance and fuel delivery strategies with corrections made by the MAF sensor reading. The MAP sensor is a three-wire pressure sensor with circuits for; 5V supply, signal, and low reference.

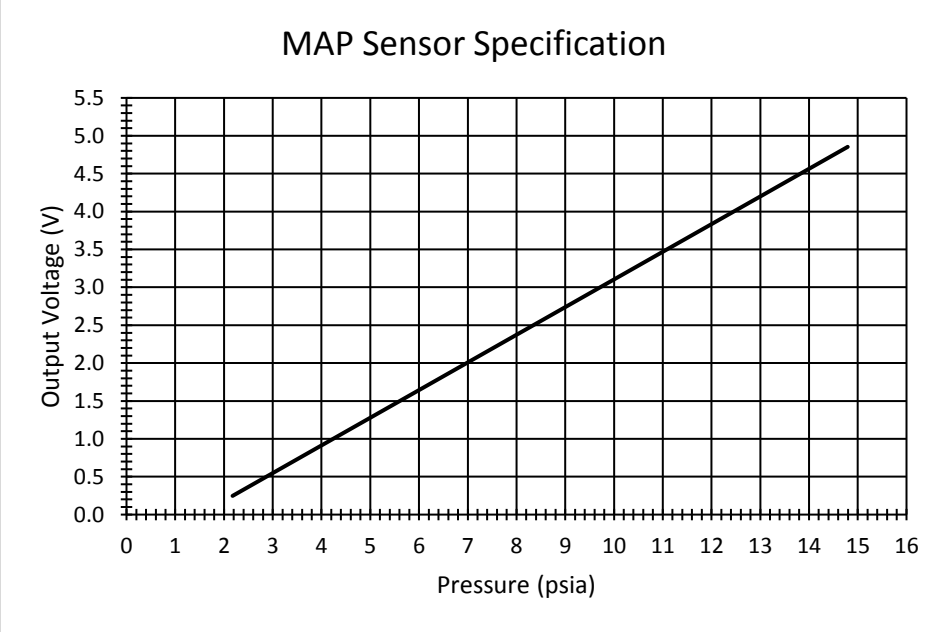
SPN 3563 FMI 20 and 21:

The Manifold Absolute Pressure / Throttle Position Sensor (MAP/TPS) Rationality Diagnostic is comprised of two tests. A deceleration test is performed to provide a robust method for detection of an altitude compensated MAP value that is too high for the deceleration condition. The power test compares the altitude compensated MAP value to both high and low limits, dependent upon throttle position and engine speed. When the MAP value is out of the threshold range, the MAP/TPS system is determined to be failed.

When the MAP/TPS Rationality Diagnostic fails, the effects may cause the fuel control subsystem to deliver an incorrect quantity of fuel. The most probable failure modes of the MAP Sensor system are a skewed MAP or TPS sensor, resulting in a poor correlation between MAP and TPS.

Tools Required – 6.0L Gasoline

- PSI PowerLink
- Digital Multimeter (DMM)
- OEM Recommended Leak Locator Kit
- 3 Amp Fused Jumper Wire
- Throttle body breakout harness 69000052



To 6.0L Gasoline Setting Criteria

- SPN 3563 FMI 3 – Manifold Absolute Pressure Circuit High Input
- SPN 3563 FMI 4 – Manifold Absolute Pressure Circuit Low Input
- SPN 3563 FMI 7 – Manifold Absolute Pressure Circuit Stuck
- SPN 3563 FMI 7 – Manifold Absolute Pressure Circuit Stuck at Startup
- SPN 3563 FMI 10 – MAP/BARO Pressure Sensor Circuit Intermittent
- SPN 3563 FMI 20 – Manifold Absolute Pressure/Mass Air Flow – Throttle Position Correlation at Higher Load
- SPN 3563 FMI 21 – Manifold Absolute Pressure/Mass Air Flow – Throttle Position Correlation at Idle

Associated Faults

SPN	FMI	Description
636	4	Crankshaft Position Sensor “A” Circuit
1109	15	Throttle Actuator Control System – Forced Limited Power
3510	31	Sensor Reference Voltage “B” Circuit
3563	4	Manifold Absolute Pressure Circuit Low Input

NOTE: The below section will instruct the technician to back-probe the MAP Sensor Connector. When back-probing any connector, use the thinnest possibly probes, to minimize deformation of the weather pack seal in the back of the connector. Before back-probing the connector, coat back-probe in dielectric grease. This will help the probe be inserted into the connector, and will better seal the connector when the probe is removed. When inserting the probe, make sure the probe is parallel to the wire, and gently push the probe between the weather pack seal and the wire. DO NOT use excessive force, and stop pushing if probe bottoms out in the connector. Failure to follow these guidelines may result in a damaged connector.

Step-Based Diagnostic Routine – SPN 3563 FMI 3, 4, 7 and 10

Step	Action	Decision
1	Using PowerLink, check the ECM for active or inactive associated fault codes. Are any of the associated fault codes present other than 1109 FMI 15 (active or inactive)?	Yes: Complete SPN 3510 FMI 31, repair faults, clear DTC's, and retest. No: Go To Step 2

Step	Action	Decision
2	A. Key OFF B. Visually confirm MAP sensor is fully seated in intake, secure, and undamaged. C. Disconnect MAP sensor harness. D. Check MAP sensor connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Is MAP sensor, harness, terminals clean and undamaged? Is sensor fully seated and secure?	Yes: Go To Step 3 No: Repair connector, harness, or terminal damage. If sensor is not fully seated remove and inspect, if damaged replace it, if undamaged reinstall. After repairs are complete, retest for DTC.

Step	Action	Decision
3	Key OFF, Carefully insert back-probes into MAP Sensor Connector. Key ON, measure voltage between 5V Supply Circuit (terminal 1) and Low Reference Circuit (terminal 2). Is voltage 4.8V to 5.2V?	Yes: Go To Step 8 No: Go To Step 4

Step	Action	Decision
4	Key ON, measure voltage between 5V Supply Circuit (terminal 1) and engine/chassis ground. Is voltage 4.8V to 5.2V?	Yes: Go To Step 6 No: Go To Step 5

Step	Action	Decision
5	Key OFF, disconnect ECM J3 connector. Inspect the connector and ECM for damaged or bent terminals and pins. Measure resistance across entire 5V Supply Circuit (terminal 1) to ECM J3-28. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in 5V Supply Circuit. No: Complete SPN 3510 FMI 31 diagnostics and retest.

Step	Action	Decision
6	Key OFF, measure resistance between Low Reference Circuit (terminal 2) and engine/chassis ground. Is resistance greater than 10 ohms?	Yes: Go To Step 7 No: Perform section **1.3 Intermittent Diagnostics** in the Symptom Based Diagnostic section.

Step	Action	Decision
7	Key OFF, disconnect ECM J3 connector. Inspect the connector and ECM for damaged or bent terminals and pins. Measure resistance across entire Low Reference Circuit (terminal 2) to ECM J3-29. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in Low Reference Circuit. No: Replace ECM and retest.

Step	Action	Decision
8	Key OFF, disconnect MAP Sensor Connector. Key ON, measure voltage between Signal Circuit (terminal 3) and Low Reference Circuit (terminal 2). Is voltage greater than 0.05V?	Yes: Repair short to voltage in Signal Circuit. No: Go To Step 9

Step	Action	Decision
9	Key OFF, disconnect MAP Sensor Connector. Measure resistance between Signal Circuit (terminal 3) and Low Reference Circuit (terminal 2). Is resistance greater than 6000 ohms?	Yes: Go To Step 10 No: Repair short to ground in Signal Circuit.

Step	Action	Decision
10	Key OFF, reconnect ECM and MAP sensor. Find current local barometric pressure (convert reading to psi if necessary, typical reading 14.7psi). Key ON, measure voltage between Signal Circuit (terminal 3) and Low Reference Circuit (terminal 2) and compare to pressure and voltage chart. Does voltage signal from sensor match pressure chart?	Yes: Go To Step 11 No: Replace MAP sensor and retest.

Step	Action	Decision
11	Key OFF, disconnect ECM J3 connector. Inspect the connector and ECM for damaged or bent terminals and pins. Measure resistance between Signal Circuit (terminal 3) and ECM J3-45. Is resistance less than 5 ohms?	Yes: Reassemble, clear fault codes and retest. If code does not return perform section **1.3 Intermittent Diagnostics** in the Symptom Based Diagnostic section. No: Repair open or high resistance in Signal Circuit.

Step-Based Diagnostic Routine – SPN 3563 FMI 20 and 21

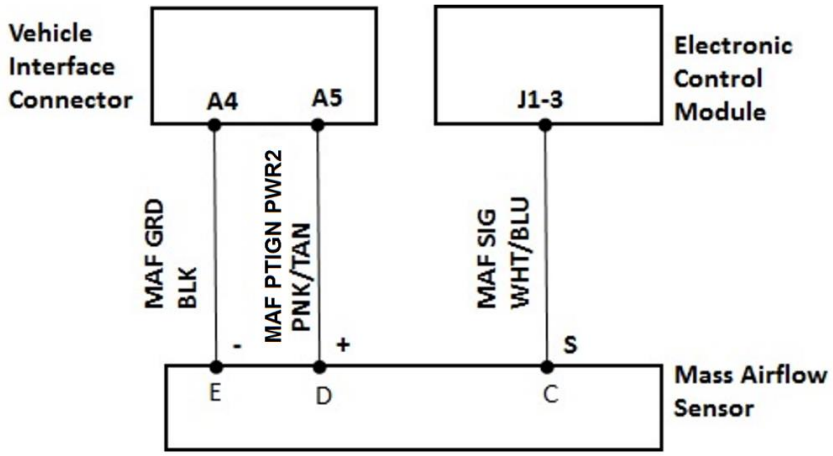
Step	Action	Decision
1	Using PowerLink, check the ECM for active or inactive associated fault codes. Are any of the associated fault codes present other than 1109 FMI 15 (active or inactive)?	Yes: Complete SPN 3510 FMI 31, repair faults, clear DTC's, and retest. No: Go To Step 2

Step	Action	Decision
2	Perform MAP Sensor diagnostics per Section 29: Manifold Absolute Pressure (MAP) Sensor (above) Did you find and correct the condition?	Yes: End Diagnostics. No: Go To Step 3

Step	Action	Decision
3	Perform the following throttle diagnostics • Section 32: Throttle Actuator Control • Section 33: Throttle Control Performance • Section 34: Throttle Position (TP) Sensor Did you find and correct the condition?	Yes: End diagnostics No: Reassemble and Reevaluate.

30 Mass Air Flow (MAF) Sensor

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
132	0	Mass Air Flow Circuit High Input	• MAF signal circuit shorted to power • Malfunctioning sensor	A	MIL
132	1	Mass Air Flow Circuit Low Input	• MAF signal circuit short to ground • MAF reference circuit open or shorted to ground • Loose electrical connector or pin • Malfunctioning sensor	A	MIL
132	2	Mass Air Flow Circuit Range/ Performance	• Malfunctioning sensor • Intermittent poor connection • Air management system leak	B	MIL
132	20	Throttle Actuator Control Range/ Performance	• Malfunctioning MAF Sensor • Malfunctioning ETC • Malfunctioning TPS • Faulty MAF, ETC, or TPS circuits	A	MIL



SPN 132 FMI 0, 1, 2 Overview

The mass air flow (MAF) sensor provides a variable signal to the engine control module (ECM) based on the amount of air that is moving through the sensor to the engine. The MAF sensor is supplied battery voltage by the PTIGN2 fuse. The ECM supplies 5 V to the MAF sensor on the signal circuit. The MAF sensor uses the voltage to produce a frequency signal to the ECM.

SPN 132 FMI 20 Overview

The engine airflow actuation diagnostic detects when the throttle is not delivering the right amount of airflow to the engine that it is supposed to. Excess airflow can cause undesired increases in engine power. The diagnostic works by comparing airflows determined by the speed/throttle method (calculation using throttle position, engine RPM, ambient air temperature,

and throttle inlet pressure), speed density calculations (based on MAP, engine RPM, and barometer), and measured airflow using the Mass Airflow sensor.

The diagnostic begins by estimating the airflow entering the intake manifold using the speed/throttle method. This is then compared to the airflow determined by the speed density method of the MAF sensor. If the error between the two values is greater than a calibrated threshold, the diagnostic is failed.

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)
- Breakout Harness ZTSE4960
- OEM Recommended Leak Locator Kit

To 6.0L Gasoline Setting Criteria

- SPN 132 FMI 0 – Mass Air Flow Circuit High Input
- SPN 132 FMI 1 – Mass Air Flow Circuit Low Input
- SPN 132 FMI 2 – Mass Air Flow Circuit Range/Performance
- SPN 132 FMI 20 – Throttle Actuator Control Range/Performance

Step-Based Diagnostic Routine – MAF Sensor

Step	Action	Decision
1	A. Key OFF B. Disconnect MAF Connector C. Check MAF Connector for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are MAF connector, harness, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest

Step	Action	Decision
2	Key OFF, install the MAF sensor breakout harness (ZTSE4960) between the MAF sensor and the engine wiring harness. Measure resistance between the MAF sensor ground (terminal E) and chassis ground. Is resistance greater than 10 ohms?	Yes: Repair open in MAF sensor ground (terminal E). No: Go To Step 3

Step	Action	Decision
3	Key ON, measure voltage between MAF sensor ground circuit (terminal E) and the MAF voltage supply circuit (PTIGNPWR2) (terminal D) Is voltage equal to B+ ± 0.5V?	Yes: Go To Step 9 No: Go To Step 4

Step	Action	Decision
4	Check PTIGN2 fuse in the Vehicle Power Center. Is the fuse open?	Yes: Go To Step 5 No: Go To Step 8

Step	Action	Decision
5	Key OFF, remove PTIGN2 fuse and measure resistance between the MAF sensor connector voltage circuit (PTIGNPWR2) (terminal D) and chassis ground Is resistance less than 1000 ohms?	Yes: Go To Step 6 No: While monitoring resistance wiggle test harness and connectors testing for intermittent short to ground in the PTIGN2 circuit. If an intermittent short is found repair or replace the harness. If no intermittent fault is found replace fuse and retest.

Step	Action	Decision
6	Key OFF, VIC disconnected and measure resistance between the MAF sensor connector voltage circuit (PTIGNPWR2) (terminal D) and chassis ground Is resistance less than 1000 ohms?	Yes: Repair short to ground in 12V Supply circuit between VIC and MAF (terminal D). No: Go To Step 19

Step	Action	Decision
7	Key OFF, PTIGN2 supplies B+ to all Oxygen Sensor Heater Circuits, Ignition Coils 2, 3, 5, 8, and the MAF/IAT sensor. Inspect all connectors, pins, and exposed wiring, for a short to ground. If damage is found repair. If no damage is found, unplug all sensors and coils, replace fuse and with the Key OFF, measure resistance between MAF voltage supply circuit (PTIGNPWR2) (terminal D) and ground. Is resistance less than 1000 ohms?	Yes: Replace engine harness and retest. No: Go To Step 8

Step	Action	Decision
8	Key OFF, while monitoring resistance between MAF voltage supply circuit (terminal D) and engine/chassis ground, plug in each sensor and coil one at a time watching the resistance Did the resistance drop below 1000 ohms after plugging in one of the sensors or coils?	Yes: Replace sensor or coil and retest. No: Reassemble and retest for intermittent short to ground. If fuse blows again, replace harness and retest.

Step	Action	Decision
9	Inspect PTIGN2 fuse holder for damage, poor connection, or corrosion repair if necessary Key ON, measure voltage between the terminals of PTIGN2 fuse holder. Is voltage B+ ± 0.5V?	Yes: Go To Step 18 No: Go To Step 19

Step	Action	Decision
10	Key OFF, disconnect MAF sensor. Key ON, measure voltage between the MAF signal circuit (terminal C) and ground Is voltage less than, between, or greater than 4.8 and 5.2V?	Less than 4.8V: Go To Step 12 Between: Go To Step 11 Greater than 5.2V: Go To Step 15

Step	Action	Decision
11	Key OFF, reconnect the MAF sensor. Key ON, measure DC Hertz (Hz) between the MAF signal circuit (terminal C) and ground. Start the engine and allow RPM to stabilize at idle speed (750 ± 70 RPM) Is reading between 2.3 and 2.9 kHz?	Yes: Reassemble and retest. No: Go To Step 16

Step	Action	Decision
12	Key OFF, disconnect ECM connector J1 and measure resistance between the signal circuit (terminal C) and chassis ground Is resistance less than 2000 ohms?	Yes: Go To Step 13 No: Go To Step 14

Step	Action	Decision
13	Key OFF, Disconnect Vehicle Interface Connector, measure resistance between MAF signal circuit (terminal C) and MAF connector ground circuit (terminal E). Is resistance greater than 5 ohms?	Yes: Repair short between MAF signal circuit (terminal C) and ground. No: Repair short between MAF signal circuit (terminal C) and MAF connector ground circuit (terminal E).

Step	Action	Decision
14	Measure resistance across the entire signal circuit from the MAF sensor connector (terminal C) to ECM J1-3 Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in signal circuit. No: Inspect for intermittent connections or rubbed through wires. Retest.

Step	Action	Decision
15	Key OFF, disconnect ECM connector J1. With the Key ON, measure voltage between the signal circuit (terminal C) and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage in signal circuit. No: Inspect for intermittent connections or rubbed through wires. Retest.

Step	Action	Decision
16	Perform section **1.2.5 Intake Air Inspection** in the Symptom Based Diagnostic section. Were any issues found during the Intake Air Inspection?	Yes: Repair the condition. Clear code, start engine and see if code returns. If so, Go To Step 17.
		No: Go To Step 17

Step	Action	Decision
17	Test the air induction system for leaks Using the OEM Recommended Leak Locator Kit perform a smoke test Was smoke observed escaping from any joint, or the intake gasket?	Yes: Repair leak. Clear code, start engine and see if code returns. If so, replace the MAF sensor.
		No: Replace MAF sensor.

Step	Action	Decision
18	A. Key OFF B. VIC disconnected C. MAF disconnected Measure resistance between VIC (terminal A5) and MAF (terminal D). Is resistance less than 5 ohms?	Yes: Go To Step 19
		No: Repair open or high resistance in MAF sensor 12V Supply circuit between MAF (terminal D) and VIC (terminal A5).

Step	Action	Decision
19	Go See OEM Diagnostics. After OEM diagnostics have been completed, has the fault been corrected?	Yes: End Diagnostics.
		No: See **1.3 Intermittent Fault Code Diagnostics**.

Step-Based Diagnostic Routine – SPN 132 FMI 20 "Throttle Actuator Control"

Step	Action	Decision
1	Perform the following throttle diagnostics • Section 32: Throttle Actuator Control • Section 33: Throttle Control Performance (SPN 3464 FMI 2) • Section 34: Throttle Position (TP) Sensor Did you find and correct the condition?	Yes: End diagnostics. No: Go to Step 2

Step	Action	Decision
2	Perform MAF Sensor diagnostics per Section 30: Mass Air Flow (MAF) Sensor Did you find and correct the condition?	Yes: End diagnostics. No: Go to Step 3

Step	Action	Decision
3	Perform MAP Sensor diagnostics per Section 29: Manifold Absolute Pressure (MAP) Sensor Did you find and correct the condition?	Yes: End diagnostics. No: Reassemble and reevaluate.

31 Random Access Memory (RAM) / Read Only Memory (ROM)

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
630	13	ECM RAM Stack Error	• ECM Failure	A	MIL STOP
630	13	ECM RAM Error	• ECM Failure	A	MIL STOP
630	13	ECM ROM Checksum Error	• ECM Failure	A	MIL STOP

Overview

The Engine Control Module (ECM) continuously monitors its own internal circuitry. SPN 630 codes will be set whenever the ECM detects internal RAM or ROM related errors.

Tools Required

- PSI PowerLink

To 6.0L Setting Criteria

- SPN 630 FMI 13 – ECM RAM Stack Error
- SPN 630 FMI 13 – ECM RAM Error
- SPN 630 FMI 13 – ECM ROM Checksum Error

Step-Based Diagnostic Routine: SPN 630 FMI 13

Step	Action	Decision
1	Using PowerLink, check for active SPNs. Diagnose and repair all other fault codes besides SPN 630 FMI 13. Clear DTC's and retest. Is SPN 630 FMI 13 still present/active?	Yes: Replace ECM and retest. No: End diagnostics.

32 Throttle Actuator Control

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
1109	0	Throttle Actuator Control System - Forced Idle	• Check for other DTCs • APP sensor unplugged • Open APS1 or APS2 signal circuit	A	MIL STOP
1109	15	Throttle Actuator Control System - Forced Limited Power	• Check for other DTCs • Open or Short in any wire in Throttle Control Circuit • Significantly large vacuum leak	A	MIL STOP
1109	16	Throttle Actuator Control System - Forced Limited RPM	• Check for other DTCs • Throttle Body unplugged • Open Throttle Control Circuit • Significantly large vacuum leak	A	MIL STOP
1110	31	Throttle Actuator Control System - Forced Engine Shutdown	• Check for other DTCs • Malfunctioning Throttle Body • Throttle plate blocked open by object • Significantly large vacuum leak	A	MIL STOP

Overview

All faults in this group are caused by major defects that affect the Engine Control Module (ECM) and control system from determining where to command the electronic throttle position. All of the faults are related to internal ECM torque calculations or sensors that effect the torque calculation. These actions may also set when the ECM detects internal memory corruptions or tampering with the calibration.

These faults are only active when the root cause faults are active. If the root cause faults are emissions related, these faults could set if there are pending faults logged. Although these faults are continuously monitored every 1,000 ms, the root cause fault must be corrected, then the ignition must be turned off for at least 5 seconds before these faults can be cleared. Please note, clearing the Throttle Actuator Control fault codes without cycling the key may result in no throttle response with no DTCs active.

Forced Idle Mode – When in this mode the engine will run with a default zero accelerator pedal position.

Forced Limited Power – When in this mode the engine will limit power by; lowering accelerator pedal position gain, lowering maximum engine torque, heavily filtering responses for higher torque, and zero accelerator pedal position when brakes applied. Fuel consumption will also be much lower.

Forced Limited RPM – When in this mode the engine will limit RPM by; disabling throttle output, torque will be controlled by cutting cylinders and retarding spark, air/fuel ratio will be set to open loop.

Forced Engine Shutdown – When in this mode the engine makes no power. The fuel injectors, fuel pump, ignition, electronic throttle control (ETC), and main relay outputs will all be turned off.

Diagnosis includes:

- Identifying and diagnosing associated DTCs:
  - 29 – Accelerator Pedal Position Sensor
  - 51 – Throttle Position Sensor
  - 91 – Accelerator Pedal Position Sensor
  - 518 – Torque Calculation
  - 629 - ECM
  - 3464 – Throttle Actuator Control
  - 3673 – Throttle Position Sensor

- Refer to Intake Air System inspection in symptom based diagnostics
- Check for large vacuum leaks – Use OEM recommended leak tester
- Verifying that all wiring harness circuits and connectors are firmly attached
- Verifying that all pins are properly secured in the connectors and are providing adequate pressure to make an electrical connection.

Tools Required

- PSI PowerLink
- Leak Locator Kit

To 6.0L Gasoline Setting Criteria

- SPN 1109 FMI 0 – Throttle Actuator Control System – Forced Idle
- SPN 1109 FMI 15 – Throttle Actuator Control System – Forced Limited Power
- SPN 1109 FMI 16 – Throttle Actuator Control System – forced Limited RPM
- SPN 1110 FMI 31 – Throttle Actuator Control system – Forced Engine Shutdown

Step-Based Diagnostic Routine: SPN 1109 FMI 0

Step	Action	Decision
1	Cycle the Key ON and Off. Key ON. Retrieve all DTCs using PowerLink. Were any other fault codes active other than SPN 1109-0?	Yes: Correct and repair all other fault codes aside from SPN 1109 and 1110. Clear all faults, cycle key twice. Retest.
		No: Go To Step 2

Step	Action	Decision
2	Verify that the APP sensor connector is plugged in fully. Inspect APP sensor connector for pulled back pins, bent pins, corroded terminals, etc. Was the APP sensor connector fully plugged in and undamaged?	Yes: Please refer to SPN 29 and 91 diagnostics.
		No: Plug in or repair APP sensor connector. Clear code, cycle key twice. Retest.

Step-Based Diagnostic Routine: SPN 1109 FMI 15, 16, SPN 1110 FMI 31

Step	Action	Decision
1	Cycle the Key ON and Off. Key ON. Retrieve all DTCs using PowerLink. Were any other fault codes active other than SPN 1109-15, 1109-16 or 1110-31?	Yes: Correct and repair all other fault codes aside from SPN 1109 and 1110. Clear all faults, cycle key twice. Retest.
		No: Go To Step 2

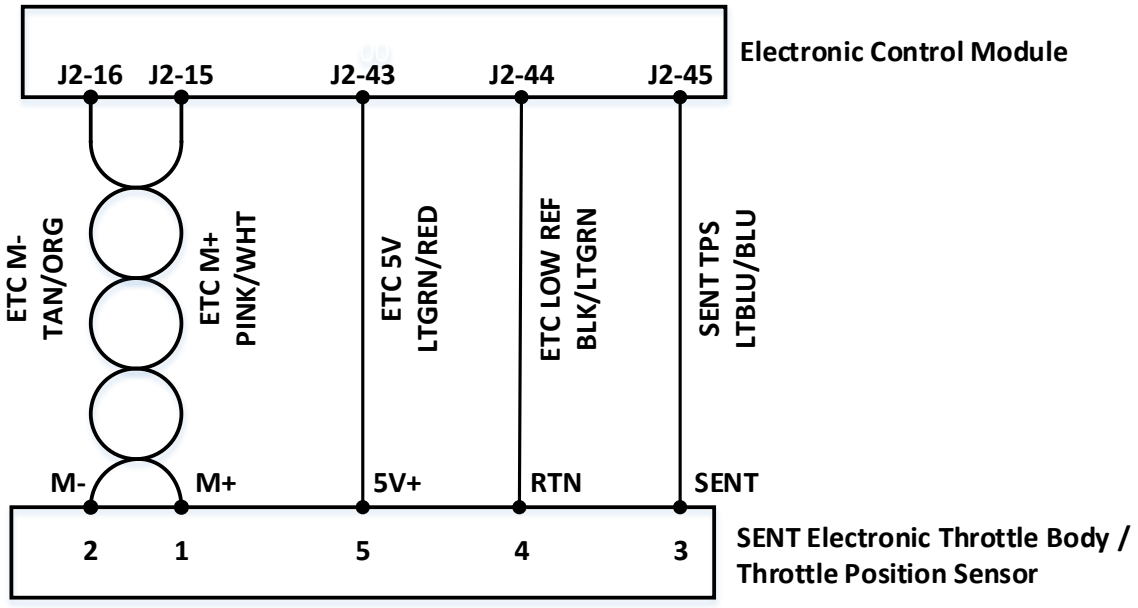
Step	Action	Decision
2	Refer to Throttle Position Diagnostics SPN 51. Were any issues found during the Throttle Actuator diagnostics?	Yes: Correct and repair throttle body faults. Clear faults, cycle key twice. Retest.
		No: Go To Step 3

Step	Action	Decision
3	Refer to APP diagnostics SPN 29 and 91. Were any issues found during the APP diagnostics?	Yes: Correct and repair APP faults. Clear faults, cycle key twice. Retest.
		No: Go To Step 4

Step	Action	Decision
4	Refer to **1.2.5 Intake Air Inspection** in the Symptom Based Diagnostic section. Were any issues found during the Intake Air Inspection?	Yes: Correct and repair Intake Air system issue. Clear faults, cycle key twice. Retest.
		No: Perform Symptom Based Diagnostics, see section **1.1 Check for DTCs and Verify Customer Concern**.

33 Throttle Actuator Control Performance

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
3464	2	Throttle Actuator Control Performance	• Electronic Throttle Control (ETC) system malfunction • Throttle actuator malfunction • Throttle plate malfunction • ECM malfunction	A	MIL
3464	2	Throttle Actuator Control Performance Steady State	• Electronic Throttle Control (ETC) system malfunction • Throttle actuator malfunction • Throttle plate malfunction • ECM malfunction	A	MIL
3464	7	Throttle Closed Position Performance	• Electrical harness is open or shorted • Poor electrical connection • Throttle plate sticking • Broken throttle return spring • ECM malfunction	C	AMBER



Overview

The Electronic Throttle Control (ETC) system consists of the Engine Control Module (ECM), Throttle Body, Accelerator Pedal Position sensors (1 and 2) and Throttle Position (TP) sensors (1 and 2). The throttle body housing contains the actuator, throttle plate, and TP sensor. When the operator depresses the accelerator pedal, the APP sensor sends a signal to the ECM regarding the amount of torque requested by the operator. The ECM sends a signal to the throttle actuator to move the throttle plate using an electric motor. The TP sensor monitors the position of the throttle plates and sends a signal to the ECM regarding their current position. The

throttle actuator, APP sensors, and TP sensors must all stay synchronized for the ECM to control engine torque demand. SPN 3464 is related to any issues with the throttle actuator motor or controls that move the motor.

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)
- Throttle Body breakout harness – 69000052

To 6.0L Gasoline Setting Criteria

- SPN 3464 FMI 2 – Throttle Actuator Control Performance
- SPN 3464 FMI 2 – Throttle Actuator Control Performance Steady State
- SPN 3464 FMI 7 – Throttle Closed Position Performance

Step-Based Diagnostic Routine: SPN 3464 FMI 2

Step	Action	Decision
1	A. Key OFF B. Visually confirm throttle body and APP sensor are both fully seated, secure and undamaged. C. Disconnect throttle body connector D. Check throttle body connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Are Throttle Body harness, connector and terminals clean and undamaged? Is connector fully seated and secure?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. If connector is not fully seated remove and inspect, if damaged replace it, if undamaged reinstall. After repairs are complete, retest for DTC.

Step	Action	Decision
2	With Key OFF, fully install breakout harness 69000052. Key ON and measure voltage between (terminal 2) and chassis ground. Is voltage between 2 - 2.4V?	No, Higher: Go To Step 3 Yes: Go To Step 8 No, Lower: Go To Step 4

Step	Action	Decision
3	A. Key OFF B. Disconnect ECM connector J2 C. Breakout harness 69000052 installed D. Throttle Body connector disconnected Measure resistance across the entire ETC Motor (-) circuit from (terminal 2) to ECM connector J2 -16. Is resistance less than 5 Ohms?	Yes: Go To Step 5 No: Repair open or high resistance in ETC Motor (-) circuit.

Step	Action	Decision
4	A. Key OFF B. Disconnect ECM connector J2 C. Breakout harness 69000052 installed D. Throttle Body connector disconnected Measure resistance across entire ETC Motor (+) circuit from (terminal 1) to ECM connector J2-15. Is resistance less than 5 Ohms?	Yes: Go To Step 5 No: Repair open or high resistance in ETC Motor (+) circuit.

Step	Action	Decision
5	A. Key OFF B. Disconnect ECM connector J2 C. Breakout harness 69000052 installed D. Throttle Body connector connected Measure resistance between ETC Motor (-) (terminal 2) and chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 6 No: Repair short to ground in the ETC Motor (-) circuit.

Step	Action	Decision
6	A. Key OFF B. Disconnect ECM connector J2 C. Breakout harness 69000052 installed D. Throttle Body connector connected Measure resistance between the ETC Motor (+) (terminal 1) and chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 7 No: Repair short to ground in the ETC Motor (+) circuit.

Step	Action	Decision
7	A. Key OFF B. Disconnect ECM connector J2 C. Breakout harness 69000052 installed D. Throttle Body connector connected With Key ON, measure voltage between ETC Motor (-) (terminal 2) and chassis ground. With Key ON, measure voltage between ETC Motor (+) (terminal 1) and chassis ground. Is voltage greater than 1V on either circuit?	Yes: Repair short to voltage in the ETC Motor (+) or (-) circuit. No: Go To Step 8

Step	Action	Decision
8	A. Key OFF B. Disconnect ECM connector J2 C. Breakout harness 69000052 installed D. Throttle Body connector disconnected Check for continuity between ETC Motor (-) (terminal 2) and ETC Motor (+) terminal 1. Does the motor circuit have continuity between ETC (-) and ETC (+)?	Yes: Repair short between ETC Motor (-) and ETC Motor (+) circuit. No: Replace throttle body and retest.

Step-Based Diagnostic Routine: SPN 3464 FMI 7

Step	Action	Decision
1	Retrieve DTCs using PowerLink. Did fault code 3464-7 set during a compression test? Note: The compression test requires the throttle plate to be secured open and kept from closing.	Yes: Clear fault code. Retest. No: Go To Step 2

Step	Action	Decision
2	Are any of the following SPN's active/inactive; 51, 3509, 3510, 3673?	Yes: Correct and Repair all other fault codes aside from SPN 3464-7 first. Clear all faults and retest. No: Go To Step 3

Step	Action	Decision
3	A. Key OFF B. Visually confirm throttle body and APP sensor are both fully seated, secure and undamaged. C. Disconnect throttle body connector D. Check throttle body connector terminals for: damaged or pinched wires, moist or corroded terminals; loose, bent or broken pins; or broken connector housing. Are Throttle Body harness, connector and terminals clean and undamaged? Is connector fully seated and secure?	Yes: Go To Step 4 No: Repair connector, harness, or terminal damage. If connector is not fully seated remove and inspect, if damaged replace it, if undamaged reinstall. After repairs are complete, retest for DTC.

Step	Action	Decision
4	With Key OFF, fully install breakout harness 69000052. Key ON and measure voltage between (terminal 2) and chassis ground. Is voltage between 2 - 2.4V?	No, Higher: Go To Step 5 Yes: Go To Step 9 No, Lower: Go To Step 6

Step	Action	Decision
5	A. Key OFF B. Disconnect ECM connector J2 C. Breakout harness 69000052 installed D. Throttle Body connector disconnected. Measure resistance across the entire ETC Motor (-) circuit from (terminal 2) to ECM connector J2 -16. Is resistance less than 5 Ohms?	Yes: Go To Step 7 No: Repair open or high resistance in ETC Motor (-) circuit.

Step	Action	Decision
6	A. Key OFF B. Disconnect ECM connector J2 C. Breakout harness 69000052 installed D. Throttle Body connector disconnected Measure resistance across entire ETC Motor (+) circuit from (terminal 1) to ECM connector J2-15. Is resistance less than 5 Ohms?	Yes: Go To Step 7 No: Repair open or high resistance in ETC Motor (+) circuit.

Step	Action	Decision
7	A. With Key OFF B. Disconnect ECM connector J2 C. Breakout harness 69000052 installed D. Throttle Body connector connected Measure resistance between the ETC Motor (-) (terminal 2) and chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 8 No: Repair short to ground in the ETC Motor (-) circuit.

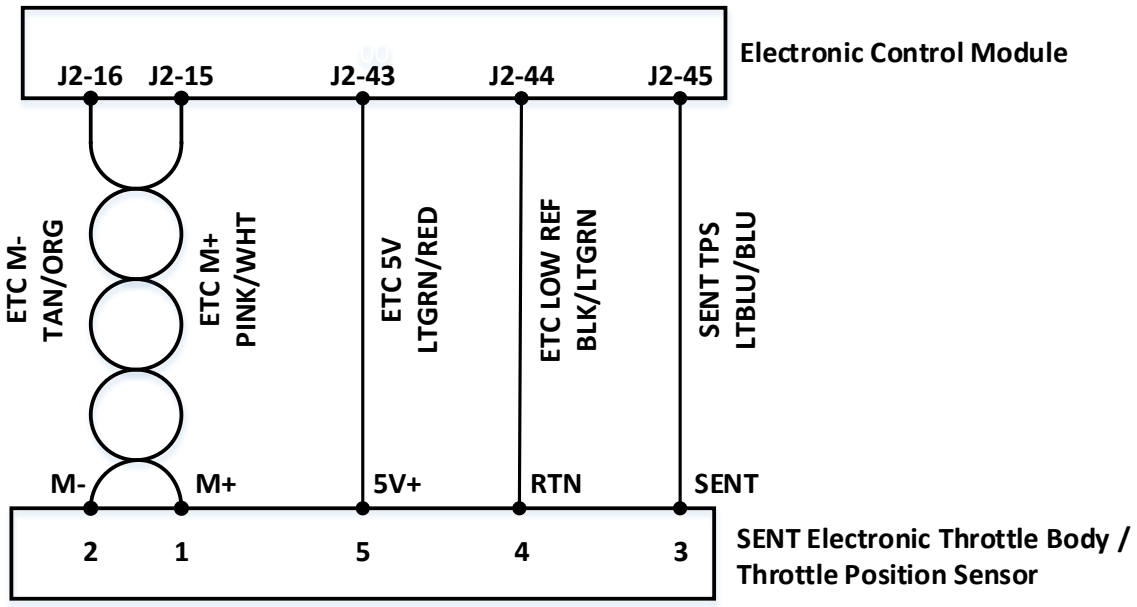
Step	Action	Decision
8	A. With Key OFF B. Disconnect ECM connector J2 C. Breakout harness 69000052 installed D. Throttle Body connector connected Measure resistance between the ETC Motor (+) (terminal 1) and chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 9 No: Repair short to ground in the ETC Motor (+) circuit.

Step	Action	Decision
9	A. Key OFF B. Disconnect ECM connector J2 C. Breakout harness 69000052 installed D. Throttle Body connector disconnected Check for continuity between ETC Motor (-) (terminal 2) and ETC Motor (+) terminal 1. Does the motor circuit have continuity between ETC (-) and ETC (+)?	Yes: Repair short between ETC Motor (-) and ETC Motor (+) circuit. No: Replace throttle body and retest.

34 Throttle Position (TP) Sensor

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
51	2	Throttle Position Sensor/Switch "A" / "B" Voltage Correlation	• Intermittent open or short in the TP sensor wiring harness • Intermittent open or short within the TP sensor connector • Malfunctioning TP sensor • Defective ECM	A	MIL
51	3	Throttle Position Sensor/Switch "A" Circuit High	• Malfunctioning TP sensor • Intermittent open in the TP sensor wiring harness • Intermittent open within the TP sensor connector • Open ground circuit through the ECM	A	MIL
51	4	Throttle Position Sensor/Switch "A" Circuit Low	• Malfunctioning TP sensor • Intermittent short in the TP sensor wiring harness • Intermittent short within the TP sensor connector • No reference voltage from the ECM	A	MIL
51	7	Throttle Position Sensor/Switch "A" Circuit Range/Performance	• Intermittent open or short in the TP sensor wiring harness • Intermittent open or short within the TP sensor connector • Malfunctioning TP sensor • Defective ECM	A	MIL
51	19	Invalid Data Received From Throttle Body Module	• Malfunctioning sensor • Intermittent poor connection • Damaged sending unit/sensor	A	MIL
3673	3	Throttle Position Sensor/Switch "B" Circuit High	• Malfunctioning TP sensor • Intermittent open in the TP sensor wiring harness • Intermittent open within the TP sensor connector • Open ground circuit through the ECM	A	MIL
3673	4	Throttle Position Sensor/Switch "B" Circuit Low	• Malfunctioning TP sensor • Intermittent short in the TP sensor wiring harness • Intermittent short within the TP sensor connector • No reference voltage from the ECM	A	MIL

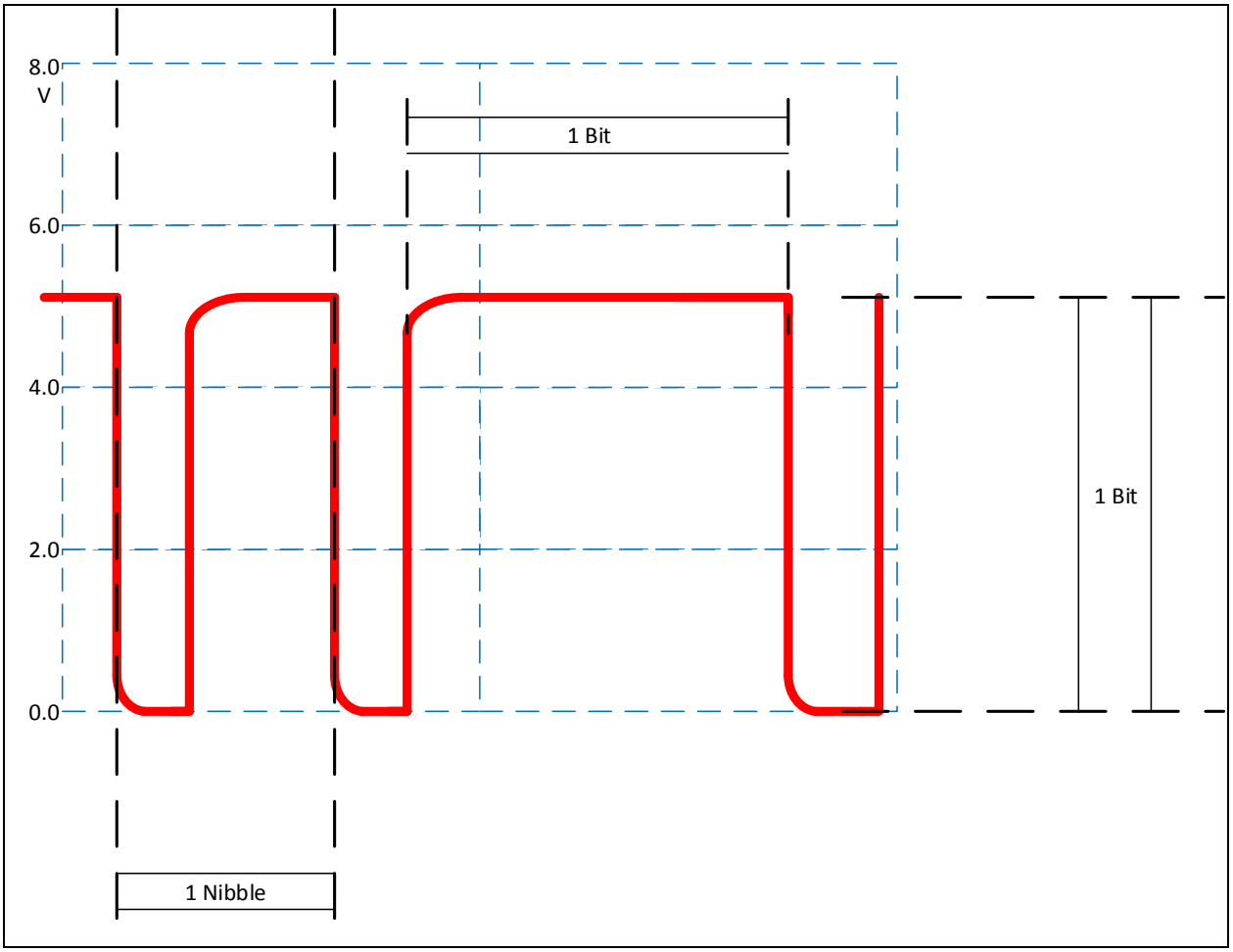
3673	7	Throttle Position Sensor/Switch "B" Circuit Range/Performance	• Intermittent open or short in the TP sensor wiring harness • Intermittent open or short within the TP sensor connector • Malfunctioning TP sensor • Defective ECM	A	MIL



Overview

The Electronic Throttle Control (ETC) system consists of the Engine Control Module (ECM), Throttle Body, Accelerator Pedal Position sensors (APP1 and APP2) and Throttle Position Sensors (TPS1 and TPS2). The throttle body assembly contains the actuator motor, throttle plate, and throttle position sensors. When the driver depresses the accelerator pedal, the APP sensors send a signal to the ECM regarding the amount of torque requested by the driver. The ECM sends a signal to the throttle actuator to move the throttle plate using an electric motor. The TP sensors monitor the position of the throttle plate and send a signal to the ECM regarding their current position. The throttle actuator, APP, and TP sensors must all stay synchronized for the ECM to control engine torque demand. TP sensor input also effects air flow calculations and transmission shift strategy.

The throttle body uses a new serial communication interface, SENT J2716. SENT (Single Edge Nibble Transmission) interface is a communication protocol used for sensors to communicate data to a controller. SENT communication is only transmitted one way, from the throttle body to the ECM. The throttle body communicates raw 12 bit values for TPS 1 and TPS 2, along with status bits. The signal sent from the throttle body resembles a pulse width modulated signal, example in figure below. When the ECM receives the SENT signal, the messages are decoded and used to determine proper throttle position. If the messages received from the throttle body are lost or an error message is received fault code SPN 51 FMI 19 will set.



Example of SENT signal outlining nibbles and bits.

Diagnosis of the TP sensor includes:

- Ensuring that a 5-volt reference voltage is supplied to the sensor from the ECM
- Ensuring continuity on the low reference circuit
- Ensuring that the signal wire is providing voltage back to the ECM
- Verifying that all wiring harness circuits, connectors, and pins are firmly attached and not causing intermittent electrical issues

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)
- 3 Amp Fused Jumper Wire
- Throttle body breakout harness 69000052

To 6.0L Gasoline Setting Criteria

- SPN 51 FMI 2 – Throttle Position Sensor/Switch “A”/”B” Voltage Correlation
- SPN 51 FMI 3 – Throttle Position Sensor/Switch “A” Circuit High
- SPN 51 FMI 4 – Throttle Position Sensor/Switch “A” Circuit Low
- SPN 51 FMI 7 – Throttle Position Sensor/Switch “A” Circuit Range/Performance
- SPN 51 FMI 19 – Invalid Data Received From Throttle Body Module
- SPN 3673 FMI 3 – Throttle Position Sensor/Switch “B” Circuit High
- SPN 3673 FMI 4 – Throttle Position Sensor/Switch “A” Circuit Low

Associated Faults

SPN	FMI	Description
54	4	Throttle Position Sensor/Switch "A" Circuit Low
94	4	Fuel Supply Pressure Sensor Circuit Short Low
100	1	Engine Oil Pressure Too Low
100	4	Engine Oil Pressure Sensor/Switch "A" Low
111	4	Engine Coolant Level Sensor/Switch Circuit Low
723	4	Camshaft Position Sensor “A” Circuit
1109	15	Throttle Actuator Control System – Forced Limited Power
3509	31	Sensor Reference Voltage “A” Circuit

Step-Based Diagnostic Routine – All Throttle Position Sensor Faults

Step	Action	Decision
1	Using Powerlink, check the ECM for active or inactive associated fault codes. Are any of the associated fault codes present other than 1109 FMI 15 (active or inactive)?	Yes: Complete SPN 3509 FMI 31, repair faults, clear DTC's, and retest. No: Go To Step 2

Step	Action	Decision
2	A. Key OFF B. Disconnect throttle assembly connector. C. Check throttle assembly Connector terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are throttle assembly connector, harness, and terminals clean and undamaged?	Yes: Go To Step 3 No: Repair connector, harness, or terminal damage. After repairs are complete, retest for DTC.

Step	Action	Decision
3	With the Key OFF, fully install throttle position breakout harness 69000052. Measure resistance between (terminal 4) and chassis ground. Is resistance greater than 130 ohms?	Yes: Go To Step 4 No: Go To Step 5

Step	Action	Decision
4	Disconnect ECM connector J2. Measure resistance between low reference (terminal 4) to ECM J2-44. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in low reference circuit. No: Inspect for intermittent connections or rubbed through wires in low reference circuit.

Step	Action	Decision
5	With the Key ON, check voltage between 5V supply Terminal 5 and chassis ground. Is voltage less than, greater than, or between 4.8 and 5.2V?	Greater than 5.2V: Go To Step 8 Between: Go To Step 9 Less than 4.8V: Go To Step 6

Step	Action	Decision
6	With the Key OFF, disconnect ECM connector J2. Measure resistance between the 5V supply Terminal 5 and chassis ground Is resistance less than 1000 ohms?	Yes: Repair short to ground in 5V supply circuit. No: Go To Step 7

Step	Action	Decision
7	Measure resistance between 5V supply Terminal 5 to ECM J2-43 Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in 5V supply circuit. No: Inspect for intermittent connections or rubbed through wires in 5V supply circuit.

Step	Action	Decision
8	With the Key OFF, disconnect ECM connector J2. With the Key ON, check voltage between 5V supply Terminal 5 and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage in 5V supply circuit. No: Inspect for intermittent connections or rubbed through wires in 5V supply circuit.

Step	Action	Decision
9	With the Key ON, wait 5 seconds. Check voltage between SENT Terminal 3 and low reference Terminal 4. Is voltage less than, greater than, or between 1.4 and 1.6V?	Greater than 1.6V: Go To Step 10 Between: Go To Step 12 Less than 1.4V: Go To Step 11

Step	Action	Decision
10	With the Key OFF, disconnect ECM connector J2. With the Key ON, measure voltage between SENT signal Terminal 3 and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage in signal circuit. No: Inspect for intermittent connections or rubbed through wires in signal circuit.

Step	Action	Decision
11	With the Key OFF, Disconnect ECM connector J2. Measure resistance between SENT signal circuit Terminal 3 and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground in signal circuit. No: Go To Step 12

Step	Action	Decision
12	Measure resistance between SENT signal circuit Terminal 3 and ECM connector J2-45 Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in signal circuit. No: Replace Throttle Body.

35 Torque Calculation

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
518	2	Engine Torque Control Rationality Steady State	• Significant engine vacuum leak • ECM failure • APP fault • Throttle Body fault	A	MIL
518	2	Engine Torque Control Rationality	• Significant engine vacuum leak • ECM failure • APP fault • Throttle Body fault	A	MIL

Overview

The Engine Control Module (ECM) adjusts requested engine torque based on conditions such as desired idling speed and parasitic loading, or by user inputs such as accelerator pedal positions. Using outputs from the sensors and actuators the ECM estimates the actual torque being produced.

Tools Required

- PSI PowerLink
- Leak Locator Kit

To 6.0L Gasoline Setting Criteria

- SPN 518 FMI 2 – Engine Torque Control Rationality Steady State
- SPN 518 FMI 2 – Engine Torque Control Rationality

Step-Based Diagnostic Routine: SPN 518 FMI 2

Step	Action	Decision
1	Cycle Key ON. Retrieve all DTCs using PowerLink. Were any other fault codes present/active other than SPN 518-2?	Yes: Diagnose and repair all other fault codes aside from SPN 518. After repair cycle key twice and retest.
		No: Go To Step 2

Step	Action	Decision
2	Perform section **3.7 Engine Intake and Exhaust Leaks** in the Symptom Based Diagnostic Section. Were any air induction leaks found?	Yes: Repair leaks, clear faults, cycle key twice. Retest.
		No: Go To Step 3

Step	Action	Decision
3	Refer to Throttle Position Diagnostics SPN 51. Were any issues found during the Throttle Actuator diagnostics?	Yes: Diagnose and repair throttle body faults. Clear faults, cycle key twice. Retest.
		No: Go To Step 4

Step	Action	Decision
4	Refer to APP diagnostics SPN 29 and 91. Were any issues found during the APP diagnostics?	Yes: Diagnose and repair APP faults. Clear faults, cycle key twice. Retest.
		No: Replace ECM

36 Cylinder Misfire

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp

1322	31	Random/Multiple Cylinder Misfire Detected	• Ignition System Concerns
			  ○ Ignition Coil
			  ○ Spark Plug Wire
			  ○ Spark Plug
			• Injector Concerns
			• Intake Vacuum Leaks
			• Intake Restrictions
			• Contaminated Fuel
				B	MIL

1323	31	Cylinder 1 Misfire Detected	• Ignition System Concerns
			  ○ Ignition Coil
			  ○ Spark Plug Wire
			  ○ Spark Plug
			• Injector Concerns
			• Intake Vacuum Leaks
			• Intake Restrictions
			• Contaminated Fuel
				B	MIL

1324	31	Cylinder 2 Misfire Detected	• Ignition System Concerns
			  ○ Ignition Coil
			  ○ Spark Plug Wire
			  ○ Spark Plug
			• Injector Concerns
			• Intake Vacuum Leaks
			• Intake Restrictions
			• Contaminated Fuel
				B	MIL

1325	31	Cylinder 3 Misfire Detected	• Ignition System Concerns
			  ○ Ignition Coil
			  ○ Spark Plug Wire
			  ○ Spark Plug
			• Injector Concerns
			• Intake Vacuum Leaks
			• Intake Restrictions
			• Contaminated Fuel
				B	MIL

1326	31	Cylinder 4 Misfire Detected	• Ignition System Concerns
			  ○ Ignition Coil
			  ○ Spark Plug Wire
			  ○ Spark Plug
			• Injector Concerns
			• Intake Vacuum Leaks
			• Intake Restrictions
			• Contaminated Fuel
				B	MIL

1327	31	Cylinder 5 Misfire Detected	• Ignition System Concerns
			  ○ Ignition Coil
			  ○ Spark Plug Wire
			  ○ Spark Plug
			• Injector Concerns
			• Intake Vacuum Leaks
			• Intake Restrictions
			• Contaminated Fuel
				B	MIL

1328	31	Cylinder 6 Misfire Detected	• Ignition System Concerns
			  ○ Ignition Coil
			  ○ Spark Plug Wire
			  ○ Spark Plug
			• Injector Concerns
			• Intake Vacuum Leaks
			• Intake Restrictions
			• Contaminated Fuel
				B	MIL

1329	31	Cylinder 7 Misfire Detected	• Ignition System Concerns
			  ○ Ignition Coil
			  ○ Spark Plug Wire
			  ○ Spark Plug
			• Injector Concerns
			• Intake Vacuum Leaks
			• Intake Restrictions
			• Contaminated Fuel
				B	MIL

1330	31	Cylinder 8 Misfire Detected	• Ignition System Concerns
			  ○ Ignition Coil
			  ○ Spark Plug Wire
			  ○ Spark Plug
			• Injector Concerns
			• Intake Vacuum Leaks
			• Intake Restrictions
			• Contaminated Fuel
				B	MIL

Overview

The misfire detection system makes use of the crank and cam position sensors to determine engine synchronization (*which cylinder is currently firing*). It also uses the crank sensor to determine crankshaft acceleration/deceleration rates which is the basis for misfire determination. A MIL is illuminated when emissions exceeds 1.5 x standard. A blinking MIL is illuminated when misfire is severe enough to result in catalyst damage.

The Misfire Diagnostic can set multiple fault codes depending on the failure mode. For instance, if the vehicle has multiple-cylinder misfire (*opposing pair, non-opposing pair or random*), the code SPN 1322 will be set. If the Misfire Diagnostic can determine that a particular cylinder has most of the misfire (> 90%), then a specific cylinder SPN P13YX (X = 1,2,3,4,5,6,7,8, Y=2,3) will be set. If opposing cylinder pair or non-opposing cylinder pair is detected by the Opposing Cylinder or Adjacent Cylinder MISF logic, then 3 faults could be set (SPN 1322, SPN13YX / SPN13YX where x and y are the two opposing or non-opposing misfiring cylinders among 1,2,3,4,5,6,7,8).

Diagnostic Tips

- To avoid catalyst damage always disconnect a fuel injector when manually inducing a misfire.
- If a code is set when manually inducing a misfire that cylinder must be re-tested after clearing active and inactive codes.
- Using a heat gun to verify a suspected misfire can be helpful.
- Using Oxygen sensor or fuel trim data can help determine what bank the misfire is occurring on for intermittent misfires.

Tools Required

- PSI PowerLink

To 6.0L Gasoline Setting Criteria

- SPN 1322 FMI 31 – Random/Multiple Cylinder Misfire Detected
- SPN 1323 FMI 31 – Cylinder 1 Misfire Detected
- SPN 1324 FMI 31 – Cylinder 2 Misfire Detected
- SPN 1325 FMI 31 – Cylinder 3 Misfire Detected
- SPN 1326 FMI 31 – Cylinder 4 Misfire Detected
- SPN 1327 FMI 31 – Cylinder 5 Misfire Detected
- SPN 1328 FMI 31 – Cylinder 6 Misfire Detected
- SPN 1329 FMI 31 – Cylinder 7 Misfire Detected
- SPN 1330 FMI 31 – Cylinder 8 Misfire Detected

Step-Based Diagnostic Routine - Misfire

Step	Action	Decision
1	Using PowerLink, check the ECM for active or inactive misfire SPN's: 1322, 1323, 1324, 1325, 1326, 1327, 1328, 1329, 1330. Are any of these SPN's present and active? **NOTE: For pending faults, review costumer concern and driving conditions associated with the pending fault. Replicate concern conditions. Once the concern has been duplicated, or the fault still shows as pending, perform diagnostic procedure starting at step 2.**	Yes: Go To Step 2 NOTE: If active codes are cylinder specific, perform all following Inspections and Diagnostics for the cylinder(s) in question and also where appropriate. No: Review customer concern and condition of complaint. Replicate concern conditions. If no issues found, End Diagnostics.

Step	Action	Decision
2	Perform the following Visual Inspection Sections: **1.2.1 Fuel Level and System Inspection** **1.2.2 Batteries and Electrical System Inspection** **1.2.3 Ignition System Inspection** **1.2.4 Component Connection Inspection** **1.2.5 Intake Air Inspection** **1.2.6 Exhaust System Inspection** **1.2.7 Oil Level and Quality Inspection** Were any issues found?	Yes: Repair and retest. No: Go To Step 3

Step	Action	Decision
3	Perform section **3.14 Electronic Ignition System Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 4

Step	Action	Decision
4	Perform section **3.9 Fuel Supply System Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 5

Step	Action	Decision
5	Perform section **3.4 Evaluating Fuel Trims** Were any issues found?	Yes: Go To Step 6. Perform remaining tests only on bank found to have a Rich or Lean condition. No: Go To Step 6. Perform Tests on ALL cylinders.

Step	Action	Decision
6	Perform section **3.15 Oxygen Sensor (O2S) Operational Test** Were any issues found?	Yes: Repair and retest. No: Go To Step 7

Step	Action	Decision
7	Perform section **3.2 Cylinder Power Balance Test** Was one or more cylinders found to have a misfire?	Yes: Go To Step 8. Perform remaining tests on cylinder(s) found to have a misfire. No: Go To Step 8. Perform Tests on ALL cylinders.

Step	Action	Decision
8	Perform section **3.10 Fuel Injector Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 9

Step	Action	Decision
9	Perform section **3.7 Engine Intake and Exhaust Leaks** Were any issues found?	Yes: Repair and retest. No: Go To Step 10

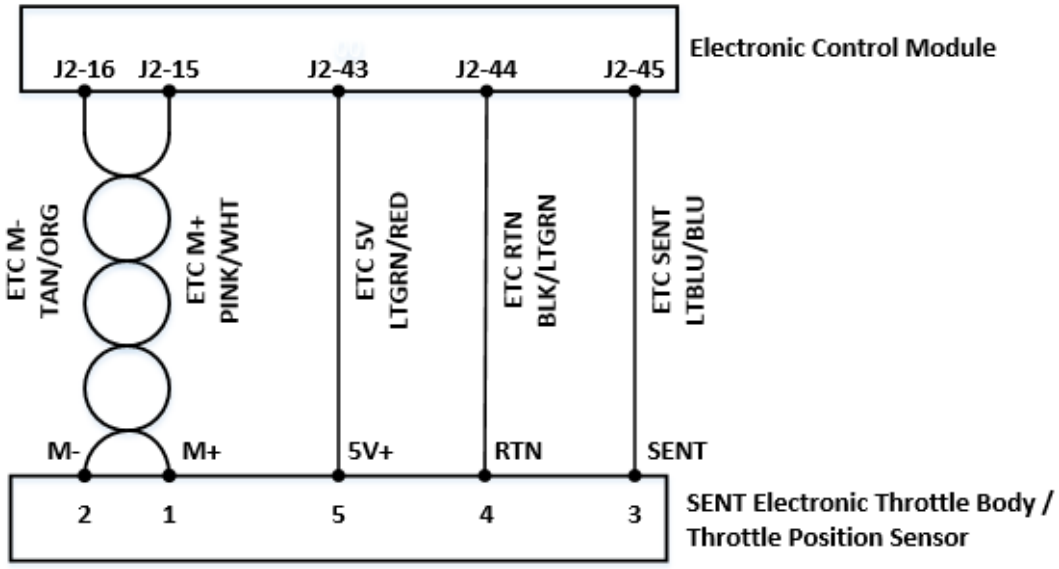
Step	Action	Decision
10	Perform section **3.1 Base Engine Diagnostics** Were any issues found?	Yes: Repair and retest. No: Go To Step 11

Step	Action	Decision
11	Perform section **3.12 Testing for Contaminated Fuel** Were any issues found?	Yes: Repair and retest. No: Go To Step 12

Step	Action	Decision
12	Perform section **3.17 MAP Sensor Operational Test** Were any issues found?	Yes: Repair and retest. No: Reassemble and reevaluate.

37 Idle Control

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
188	16	Idle Control System RPM - Higher Than Expected	• Vacuum leaks • Excessive deposits in the throttle body • A faulty positive crankcase ventilation system • Energy draining load on the engine, such as ones caused by transmission conditions	B	MIL
188	18	Idle Control System RPM - Lower Than Expected	• Vacuum leaks • Excessive deposits in the throttle body • A faulty positive crankcase ventilation system • Energy draining load on the engine, such as ones caused by transmission conditions	B	MIL



Overview

The Idle Speed Diagnostic detects malfunctions of the idle air control system by monitoring the difference between the desired idle engine speed and the actual idle engine speed. Malfunctions are reported to the OBD II Diagnostic Manager if the idle speed is more than 200 RPM above or 100 RPM below desired idle speed continuously for a calibrated length of time, per regulations.

Tools Required

- PSI PowerLink
- Vacuum Gauge
- Infrared Heat Gun

To 6.0L Gasoline Setting Criteria

- SPN 188 FMI 16 – Idle Control System RPM – Higher Than Expected
- SPN 188 FMI 18 – Idle Control System RPM – Lower Than Expected

Step-Based Diagnostic Routine: SPN 188 FMI 16, 18

Step	Action	Decision
1	A. Start the engine. B. Actuate the gas pedal and use Powerlink to observe the actual vs commanded engine RPM. Does the engine speed correspond, within 100 RPM, with each command?	Yes: Refer to Diagnosis by Symptom. No: Go To Step 2

Step	Action	Decision
2	Is the engine RPM 100 RPM more than the desired RPM?	Yes: Go To Step 3 No: Go To Step 4

Step	Action	Decision
3	Inspect for the following conditions: • Vacuum leaks • Excessive deposits in the throttle body • A faulty positive crankcase ventilation system Did you complete the repair?	Yes: Go To Step 5 No: Perform Section **33 Throttle Actuator Control** and **34 Throttle Actuator Control Performance**, then go to Step 6.

Step	Action	Decision
4	Inspect for energy draining load on the engine, such as ones caused by transmission conditions. Did you find and correct the condition?	Yes: Go To Step 5 No: Perform Section **33 Throttle Actuator Control** and **34 Throttle Actuator Control Performance**, then go to Step 6.

Step	Action	Decision
5	A. Clear the DTCs with a scan tool. B. Turn OFF the ignition for 30 seconds. C. Start the engine. D. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records. Did the DTC fail this ignition?	Yes: Go To Step 1 No: Go To Step 6

Step	Action	Decision
6	Observed the Capture Info with Powerlink. Are there any DTCs that have not been diagnosed?	Yes: Go to Diagnostic Trouble Code (DTC) List – Vehicle.
		No: System OK.

38 Vehicle Speed Sensor

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
191	5	Vehicle Speed Sensor “A” Circuit No Signal – Power Test	• Short to ground • Open circuit • Damaged or misaligned speed sensor • Faulty PCM	B	MIL
191	5	Vehicle Speed Sensor “A” Circuit No Signal – Deceleration Test	• Short to ground • Open circuit • Damaged or misaligned speed sensor • Faulty PCM	B	MIL

Overview

The ECM receives a TOS (Transmission output shaft RPM) signal by way of a CAN message from the TCM (Transmission control module). It uses this TOS signal to compute a vehicle speed. If X out of Y CAN messages are missing or have invalid data (As indicated by the TCM) a fault is set. However, if the TCM CAN data is received by the ECM and is deemed valid by the TCM, several rationality checks are run by the ECM:

Vehicle Speed Sensor Power Diagnostic
The Vehicle Speed Sensor Power Diagnostic monitors the Vehicle Speed as interpreted from the TOS (Transmission Output Shaft) sensor CAN data, but only when a set of conditions are present that are indicative of a vehicle moving condition. These conditions are those that are experienced ONLY when the vehicle is actually moving. When the conditions exist for the vehicle to be moving quickly and the Vehicle Speed Sensor is indicating a speed below a value, a failure condition is detected and flagged. X out of Y counters are then used to finally set the fault.

Vehicle Speed Sensor Deceleration Diagnostic
The Vehicle Speed Sensor Deceleration Diagnostic looks at the TCM CAN TOS speed message, but only during a set of conditions that are indicative of a vehicle in a deceleration mode. When such conditions exist and the Vehicle Speed Sensor is indicating a road speed below a value, a failure condition is detected and flagged. X out of Y counters are then used to finally set the fault.

Tools Required

- PSI PowerLink

To 6.0L Gasoline Setting Criteria

- SPN 191 FMI 5 – Vehicle Speed Sensor “A” Circuit No Signal – Power Test
- SPN 191 FMI 5 – Vehicle Speed Sensor “A” Circuit No Signal – Deceleration Test

Step-Based Diagnostic Routine: SPN 191 FMI 5

Step	Action	Decision
1	Using PowerLink, check for active SPNs. Diagnose and repair all other fault codes besides SPN 191 FMI 5. Clear DTC's and retest. Is SPN 191 FMI 5 still present/active?	Yes: See OEM Diagnostics. No: End Diagnostic.

39 CAN Communication

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
639	5	High Speed CAN Communication Bus	• Malfunctioning ECM • Open CAN circuit • CAN circuit short to ground • Open ECM ground circuit • Faulty connector	B	MIL
639	8	Vehicle Communication Bus A Performance	• Malfunctioning ECM • Open CAN circuit • CAN circuit short to ground • Open ECM ground circuit • Faulty connector	B	MIL
2003	8	Lost Communication with TCM	• Malfunctioning TCM • Open CAN circuit between TCM and ECM • CAN circuit short to ground • Open TCM ground circuit • Faulty connector	B	MIL
2003	19	Invalid Data Received From TCM	• Malfunctioning TCM • Open CAN circuit between TCM and ECM • CAN circuit short to ground • Open TCM ground circuit • Faulty connector	B	MIL
2007	8	Lost Communication with PTO Control Module	• Malfunctioning PTO control module • Open CAN circuit between PTO control module and ECM • CAN circuit short to ground • Open PTO control module ground circuit • Faulty connector	C	NONE
2011	2	ABS Rough Road Message Rationality	• Malfunctioning ABS Module • Open CAN circuit between ABS module and ECM • CAN circuit short to ground • Open ABS module ground circuit • Faulty connector	C	AMBER
2011	19	ABS Rough Road Message Invalid	• Malfunctioning ABS Module • Open CAN circuit between ABS module and ECM • CAN circuit short to ground • Open ABS module ground circuit • Faulty connector	C	AMBER

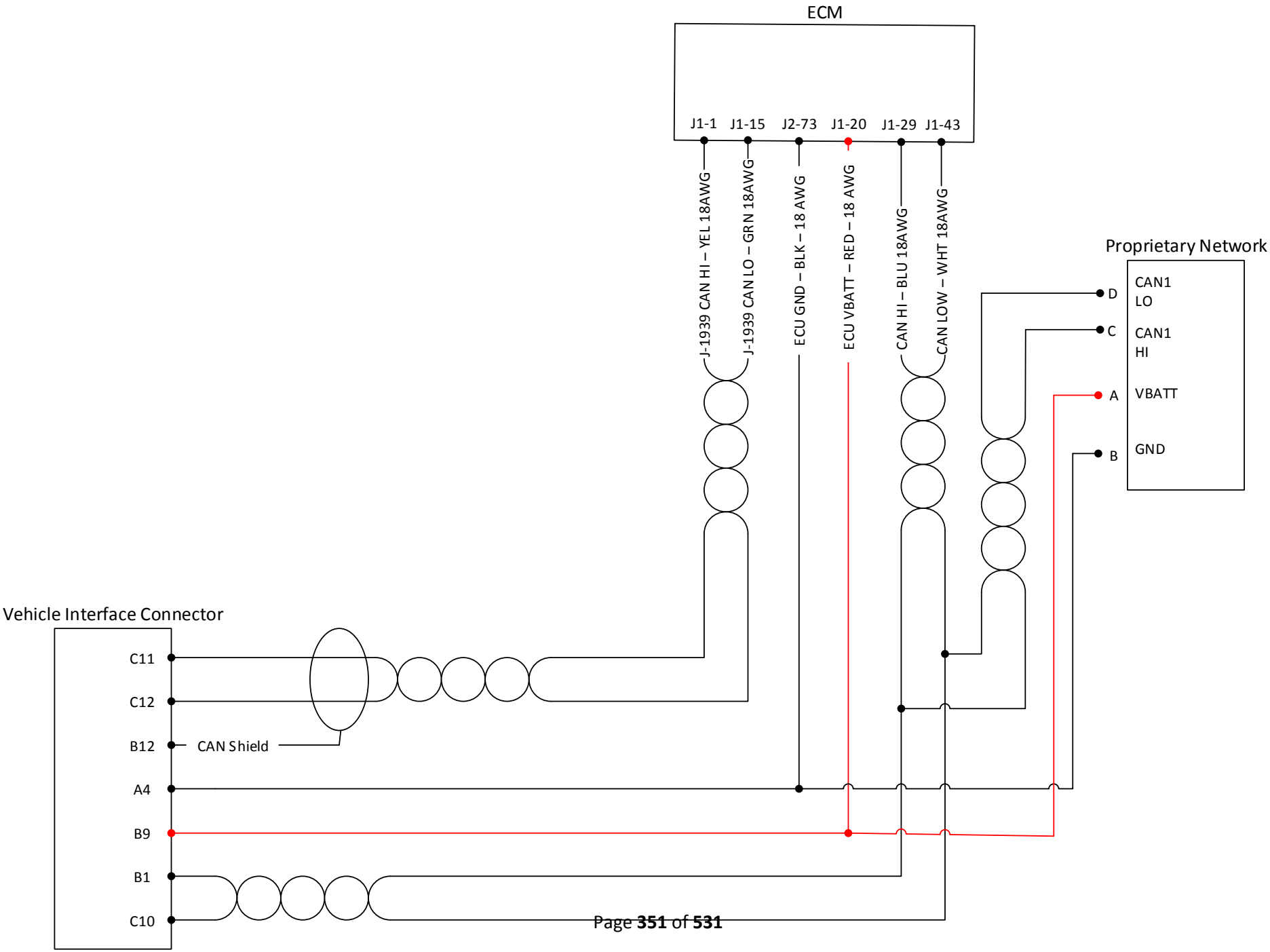
2011	19	Invalid Data Received From Anti-Lock Brake System (ABS) Control Module	• Malfunctioning ABS Module • Open CAN circuit between ABS module and ECM • CAN circuit short to ground • Open ABS module ground circuit • Faulty connector	B	MIL
2033	8	Lost Communication with Body Control Module	• Malfunctioning BCM • Open CAN circuit between BCM and ECM • CAN circuit short to ground • Open BCM ground circuit • Faulty connector	C	NONE

Overview

CAN diagnostics detect failures in communication between the ECM and all other modules that are link via the CAN bus. Two different diagnostics are used. One being a continuous diagnostic the monitors for failures across the entire CAN bus. If it is detected that no messages to the ECM are received for a calibrated time, the diagnostic is recorded as failed, and a fault code will set. The second type of diagnostic is a continuous diagnostic that detects a specific CAN module communication failure. If no communication messages are received from a specific module for a calibrated time, the diagnostic fails and a fault code specific to the module being communicated with will set.

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)


ECM
J1-1
J1-15
J2-73
J1-20
J1-29
J1-43
J-1939 CAN HI – YEL 18AWG
J-1939 CAN LO – GRN 18AWG
ECU GND – BLK – 18 AWG
ECU VBATT – RED – 18 AWG
CAN HI – BLU 18AWG
CAN LOW – WHT 18AWG
Proprietary Network
D
CAN1 LO
C
CAN1 HI
A
VBATT
B
GND
Vehicle Interface Connector
C11
C12
B12
CAN Shield
A4
B9
B1
C10

To 6.0L Gasoline Setting Criteria

- SPN 639 FMI 5 – High Speed CAN Communication Bus
- SPN 639 FMI 8 – Vehicle Communication Bus A Performance
- SPN 2003 FMI 8 – Lost Communication With TCM
- SPN 2003 FMI 19 – Invalid Data Received From TCM – Alive
- SPN 2003 FMI 19 – Invalid Data Received From TCM – Checksum
- SPN 2007 FMI 8 – Lost Communication With PTO Control Module
- SPN 2011 FMI 2 – ABS Rough Road Message Rationality
- SPN 2011 FMI 19 – ABS Rough Road Message Invalid
- SPN 2011 FMI 19 – Invalid Data Received From Anti-Lock Brake System (ABS) Control Module – Alive
- SPN 2011 FMI 19 – Invalid Data Received From Anti-Lock Brake System (ABS) Control Module – Checksum
- SPN 2033 FMI 8 – Lost Communication With Body Control Module

Step-Based Diagnostic Routine: CAN Diagnostics

Step	Action	Decision
1	Using PowerLink, check SPN's. Correct and repair all other fault codes. Are one or more of the following SPN's present? SPN 639 FMI 5, and/or 8 SPN 2003 FMI 8 and/or 19 SPN 2007 FMI 8 SPN 2011 FMI 19 SPN 2033 FMI 8	Yes: Go to Step 2 No: End Diagnostics.

Step	Action	Decision
2	Key OFF, disconnect ECM J1 and J2 connectors. Check ECM connector and terminals for: damaged or pinched wires, moist or corroded terminals, loose, bent or broken pins, or broken connector housing. Are ECM connectors, harness, and terminals clean and undamaged?	Yes: Go to step 3 No: Repair connector(s), harness, or terminal damage. After repairs are complete, retest.

Step	Action	Decision
3	Key OFF, disconnect Vehicle Interface Connector (VIC). Check VIC connector and terminals for: damaged or pinched wires, moist or corroded terminals, loose, bent, or broken pins, or broken connector housing. Is the VIC connector, harness, and terminals clean and undamaged?	Yes: Go to step 4 No: Repair connector(s), harness, or terminal damage. After repairs are complete, retest.

Step	Action	Decision
4	Key OFF, VIC and ECM J2 connectors installed, disconnect ECM connector J1 and measure voltage between terminal 20 and chassis ground. Is voltage being measured at J1-20 equal to battery positive voltage ± 0.5V?	Yes: Go to Step 5 No: Go to step 6

Step	Action	Decision
5	Key OFF, ECM J1 installed, disconnect ECM connector J2 and check resistance between terminal 73 and chassis ground. Is resistance greater than 10 ohms?	Yes: Repair open or high resistance in ECM ground circuit. No: Go to step 8

Step	Action	Decision
6	Key OFF, check 10 amp ECU fuse in the Vehicle Power Center. Is the 10 amp ECU fuse blown?	Yes: Repair short in ECU power circuit. After repairs are complete, retest.
		No: Go to step 7

Step	Action	Decision
7	Key OFF, disconnect VIC and check for voltage at terminal B9 on the Vehicle Power Center side. Is voltage being measured at B9 equal to battery positive voltage ± 0.5V?	Yes: Go to step 8
		No: Repair open or short in ECU power circuit. After repairs are complete, retest.

Step	Action	Decision
8	Key OFF, disconnect VIC and ECM connector J1. Measure resistance between ECM side VIC terminal C11 and J1 connector terminal 1. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in CAN HI circuit.
		No: Go to step 9

Step	Action	Decision
9	Key OFF, disconnect VIC and ECM connector J1. Measure resistance between ECM side VIC terminal C12 and J1 connector terminal 15. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in CAN LO circuit.
		No: Go to step 10

Step	Action	Decision
10	Key OFF, disconnect VIC and ECM connector J1. Measure resistance between J1 connector terminals 1 and 15. Is resistance less than 1000 ohms?	Yes: Repair short between CAN HI and CAN LO circuits.
		No: Go to step 11

Step	Action	Decision
11	Key OFF, disconnect VIC and ECM connector J1. Measure resistance between J1 connector terminal 1 and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground on CAN HI circuit.
		No: Go to step 12

Step	Action	Decision
12	Key OFF, disconnect VIC and ECM connector J1. Measure resistance between J1 connector terminal 15 and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground on CAN LO circuit. No: Go to step 13

Step	Action	Decision
13	Key OFF, ECM J1 connector installed, disconnect VIC. Key ON, measure voltage between ECM side VIC terminal C11 and chassis ground. Is measured voltage 7.5 V ± 0.5 V?	Yes: Go to step 14 No, Higher: Repair short to power on CAN HI circuit. No, Lower: Repair short to 5V power, or ground.

Step	Action	Decision
14	Key OFF, ECM J1 connector installed, disconnect VIC. Key ON, measure voltage between ECM side VIC terminal C12 and chassis ground. Is measured voltage 7.5V ± 0.5 V?	Yes: Go to step 15 No, Higher: Repair short to power on CAN LO circuit. No, Lower: Repair short to 5V power or ground.

Step	Action	Decision
15	Go see OEM diagnostics. After OEM diagnostics have been completed, has the fault been corrected?	Yes: End Diagnostics. No: Replace ECM.

40 Starter Relay

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
677	3	Starter Relay “A” Circuit High	• Malfunctioning Relay • Short to voltage • Loose or intermittent connection • Open ground circuit	C	AMBER
677	4	Starter Relay “A” Circuit Low	• Malfunctioning Relay • Short to ground • Loose or intermittent connection • Starter relay fuse	C	AMBER
677	5	Starter Relay “A” Circuit	• Malfunctioning Relay • loose or intermittent connection • Starter relay fuse • Open in wiring	C	AMBER



Overview

The ECM drives the Starter Motor Relay by completing the ground circuit. Using the driver circuit shown above, circuit issues are detected as follows:

When the driver is on (*Relay activated*) the Test Point would be expected to read ground. If instead voltage is read at the Test Point there is a short to voltage fault condition.

When the driver is off (*Relay deactivated*) the Test Point would be expected to read supply voltage. If instead a ground is read at the Test Point there is a short to ground or open circuit fault condition.

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)
- Relay Breakout harness 69000090

To 6.0L Gasoline Setting Criteria

- SPN 677 FMI 3 – Starter Relay “A” Circuit High
- SPN 677 FMI 4 – Starter Relay “A” Circuit Low
- SPN 677 FMI 5 – Starter Relay “A” Circuit

Step-Based Diagnostic Routine: SPN 677 FMI 3, 4, 5

Step	Action	Decision
1	A. Key OFF B. Disconnect Starter Relay and Vehicle Interface Connectors (VIC) C. Check Starter Relay and Vehicle Interface Connector (VIC) terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are Starter Relay and Vehicle Interface Connectors (VIC), harnesses, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest.

Step	Action	Decision
2	A. Key OFF B. ECM Connector J3 disconnected C. VIC disconnected Key OFF, measure resistance between ECM Connector J3-12 and VIC (terminal C8). Is resistance less than 5 ohms?	Yes: Go To Step 3 No: Repair open or high resistance between ECM Connector J3-12 and VIC (terminal C8)

Step	Action	Decision
3	A. Key OFF B. ECM Connector J3 disconnected C. VIC disconnected Key OFF, measure resistance between VIC (terminal C8) and chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 4 No: Repair short to ground between ECM Connector J3-12 and VIC (terminal C8)

Step	Action	Decision
4	A. Key OFF B. ECM Connector J3 disconnected C. VIC connected D. Starter Relay removed Key ON, measure voltage between ECM Connector J3-12 and chassis ground. Is voltage less than 1V?	Yes: Go To Step 5 No: Repair short to voltage between ECM Connector J3-12 and VIC (terminal C8), if no short is found between ECM J3-12 and VIC (terminal C8), Go To Step 6

Step	Action	Decision
5	Go See OEM Diagnostics. After OEM diagnostics have been completed, has the fault been corrected?	Yes: End Diagnostics. No: Go To Step 6

Step	Action	Decision
6	See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section. After **1.3 Intermittent Fault Code Diagnostics** has been completed, has the fault been corrected?	Yes: End diagnostics. No: Replace ECM and retest.

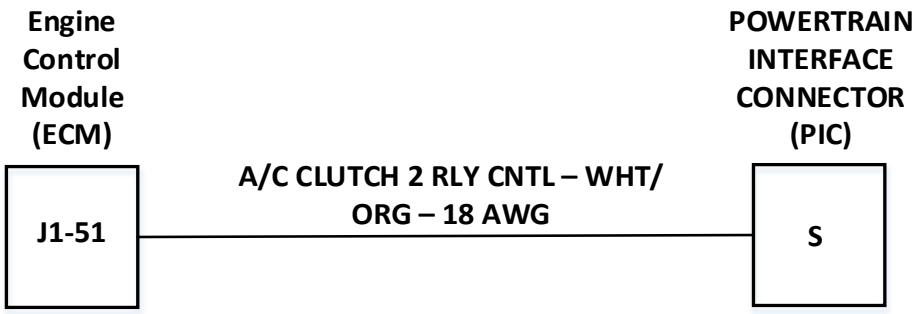
41 A/C Clutch Relay

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
876	3	A/C Clutch Rely Control Circuit High	• Malfunctioning Relay • Loose or intermittent connection • Short to voltage • Open ground circuit	C	AMBER
876	4	A/C Clutch Relay Control Circuit Low	• Malfunctioning Relay • Loose or intermittent connection • Short to ground • A/C Clutch relay fuse	C	AMBER
876	5	A/C Clutch Relay Control Circuit Open	• Malfunctioning Relay • Loose or intermittent connection • A/C Clutch relay fuse • Open in wiring	C	AMBER
876	6	A/C Clutch 2 Relay Control Circuit Open	• Malfunctioning Relay • Loose or intermittent connection • A/C Clutch relay fuse • Open in wiring	C	AMBER
876	16	A/C Clutch 2 Relay Control Circuit High	• Malfunctioning Relay • Loose or intermittent connection • Short to voltage • Open ground circuit	C	AMBER
876	18	A/C Clutch 2 Relay Control Circuit Low	• Malfunctioning Relay • Loose or intermittent connection • Short to ground • A/C Clutch relay fuse	C	AMBER

A/C Clutch Relay



A/C 2 Clutch Relay



Overview

The ECM drives the AC Clutch Control Relay by completing the ground circuit. Using the driver circuit shown below, circuit issues are detected as follows:

When the driver is on (*relay load activated*) the Test Point would be expected to read ground. If instead voltage is read at the Test Point, there is a short to voltage fault condition.

When the driver is off (*relay load deactivated*) the Test Point would be expected to read supply voltage. If instead a ground is read at the Test Point, there is a short to ground or open circuit fault condition.

Tools Required

- PSI PowerLink
- Digital Multimeter
- Relay Breakout Harness 69000090

To 6.0L Gasoline Setting Criteria

- SPN 876 FMI 3 – A/C Clutch Relay Control Circuit High
- SPN 876 FMI 4 – A/C Clutch Relay Control Circuit Low
- SPN 876 FMI 5 – A/C Clutch Relay Control Circuit Open
- SPN 876 FMI 6 – A/C Clutch 2 Relay Control Circuit Open
- SPN 876 FMI 16 – A/C Clutch 2 Relay Control Circuit High
- SPN 876 FMI 18 – A/C Clutch 2 Relay Control Circuit Low

Step-Based Diagnostic Routine: SPN 876 FMI 3, 4, 5

Step	Action	Decision
1	A. Key OFF B. Disconnect A/C Clutch Relay and Vehicle Interface Connectors (VIC) C. Check A/C Clutch Relay and Vehicle Interface Connector (VIC) terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are A/C Clutch Relay and Vehicle Interface Connectors (VIC), harnesses, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest.

Step	Action	Decision
2	A. Key OFF B. ECM Connector J1 disconnected C. VIC disconnected Key OFF, measure resistance between ECM Connector J1-53 and VIC (terminal D8). Is resistance less than 5 ohms?	Yes: Go To Step 3 No: Repair open or high resistance between ECM Connector J1-53 and VIC (terminal D8)

Step	Action	Decision
3	A. Key OFF B. ECM Connector J1 disconnected C. VIC disconnected Key OFF, measure resistance between VIC (terminal D8) and chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 4 No: Repair short to ground between ECM Connector J1-53 and VIC (terminal D8)

Step	Action	Decision
4	A. Key OFF B. ECM Connector J1 disconnected C. VIC connected D. A/C Clutch Relay removed Key ON, measure voltage between ECM Connector J1-53 and chassis ground. Is voltage less than 1V?	Yes: Go To Step 5 No: Repair short to voltage between ECM Connector J1-53 and VIC (terminal D8), if no short is found between ECM J1-53 and VIC (terminal D8), Go To Step 5

Step	Action	Decision
5	Go See OEM Diagnostics. After OEM diagnostics have been completed, has the fault been corrected?	Yes: End Diagnostics. No: Go To Step 6

Step	Action	Decision
6	See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section. After **1.3 Intermittent Fault Code Diagnostics** has been completed, has the fault been corrected?	Yes: End Diagnostics. No: Replace ECM, and retest.

Step-Based Diagnostic Routine: SPN 876 FMI 6, 16, 18

Step	Action	Decision
1	A. Key OFF B. Disconnect A/C Clutch Relay and Vehicle Interface Connectors (VIC) C. Check A/C Clutch Relay and Vehicle Interface Connector (VIC) terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are A/C Clutch Relay and Vehicle Interface Connectors (VIC), harnesses, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest.

Step	Action	Decision
2	A. Key OFF B. ECM Connector J1 disconnected C. VIC disconnected Key OFF, measure resistance between ECM Connector J1-51 and PIC (terminal S). Is resistance less than 5 ohms?	Yes: Go To Step 3 No: Repair open or high resistance between ECM Connector J1-51 and PIC (terminal S)

Step	Action	Decision
3	A. Key OFF B. ECM Connector J1 disconnected C. VIC disconnected Key OFF, measure resistance between PIC (terminal S) and chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 4 No: Repair short to ground between ECM Connector J1-51 and PIC (terminal S)

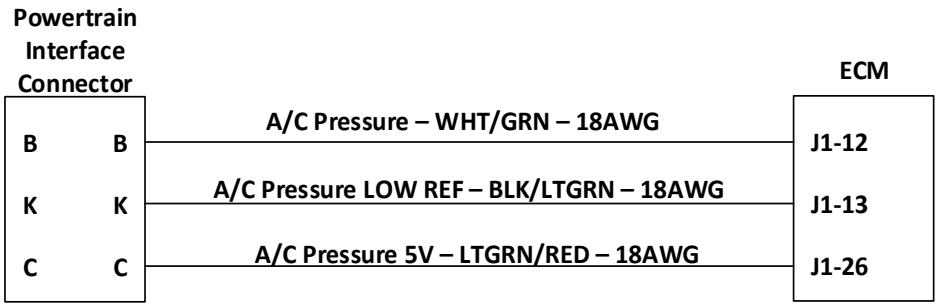
Step	Action	Decision
4	A. Key OFF B. ECM Connector J1 disconnected C. VIC connected D. A/C 2 Clutch Relay removed Key ON, measure voltage between ECM Connector J1-51 and chassis ground. Is voltage less than 1V?	Yes: Go To Step 5 No: Repair short to voltage between ECM Connector J1-51 and PIC (terminal S), if no short is found between ECM J1-51 and PIC (terminal S), Go To Step 5

Step	Action	Decision
5	Go See OEM Diagnostics. After OEM diagnostics have been completed, has the fault been corrected?	Yes: End Diagnostics. No: Go To Step 6

Step	Action	Decision
6	See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section. After **1.3 Intermittent Fault Code Diagnostics** has been completed, has the fault been corrected?	Yes: End Diagnostics. No: Replace ECM, and retest.

42 Refrigerant Pressure Sensor

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
2609	3	A/C Refrigerant Pressure Sensor "A" Circuit High	• Malfunctioning A/C Refrigerant Pressure sensor • Intermittent open in the A/C Refrigerant Pressure sensor wiring harness • Intermittent open in the A/C Refrigerant Pressure sensor connector • Open ground circuit • Signal Circuit short to voltage	C	AMBER
2609	4	A/C Refrigerant Pressure Sensor "A" Circuit Low	• Malfunctioning A/C Refrigerant Pressure sensor • Intermittent short to ground in the A/C Refrigerant Pressure sensor wiring harness • Intermittent short to ground in the A/C Refrigerant Pressure sensor connector • Signal Circuit short to ground	C	AMBER
2609	16	A/C Refrigerant Pressure Sensor 2 “A” Circuit High	• Malfunctioning A/C Refrigerant Pressure sensor • Intermittent open in the A/C Refrigerant Pressure sensor wiring harness • Intermittent open in the A/C Refrigerant Pressure sensor connector • Open ground circuit • Signal Circuit short to voltage	C	AMBER
2609	18	A/C Refrigerant Pressure Sensor 2 “A” Circuit Low	• Malfunctioning A/C Refrigerant Pressure sensor • Intermittent short to ground in the A/C Refrigerant Pressure sensor wiring harness • Intermittent short to ground in the A/C Refrigerant Pressure sensor connector • Signal Circuit short to ground	C	AMBER



Overview

The Air Conditioner Refrigerant Pressure Sensor Circuit Diagnostics compare the sensor input voltage to the low and high limits. The circuit is determined to have failed when the voltages are outside the allowable limits as specified by calibrations.

Tools Required

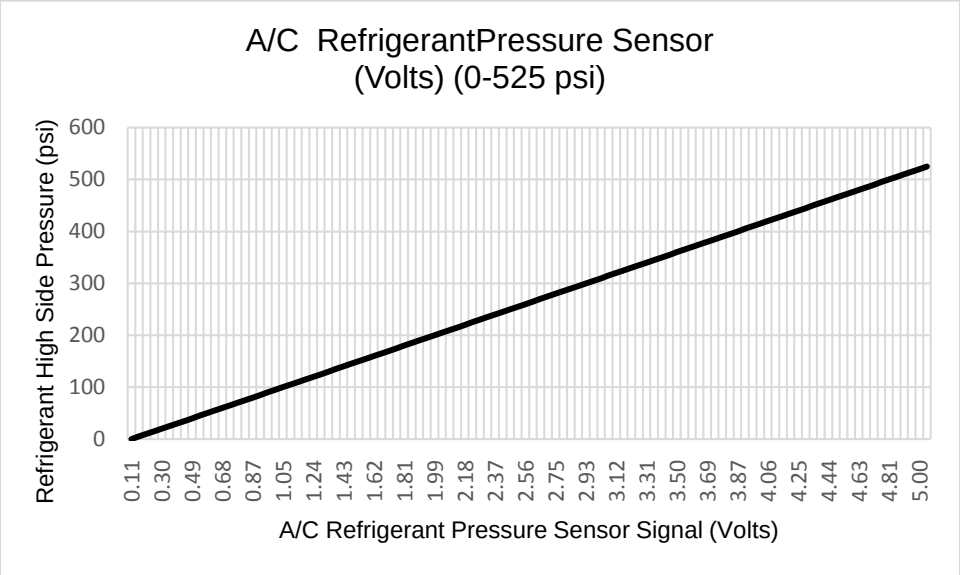
- PSI PowerLink
- Digital Multimeter (DMM)

To 6.0L Gasoline Setting Criteria

- SPN 2609 FMI 3 – A/C Refrigerant Pressure Sensor "A" Circuit High
- SPN 2609 FMI 4 – A/C Refrigerant Pressure Sensor "A" Circuit Low
- SPN 2609 FMI 16 – A/C Refrigerant Pressure Sensor 2 "A" Circuit High
- SPN 2609 FMI 18 – A/C Refrigerant Pressure Sensor 2 "A" Circuit Low

Sensor Signal Table

Refrigerant Pressure (psi)	Voltage
15	0.26
50	0.58
100	1.05
150	1.52
200	1.99
250	2.46
300	2.93
350	3.40
520	5.00


A/C RefrigerantPressure Sensor
(Volts) (0-525 psi)
Refrigerant High Side Pressure (psi)
600
500
400
300
200
100
0
0.11
0.30
0.49
0.68
0.87
1.05
1.24
1.43
1.62
1.81
1.99
2.18
2.37
2.56
2.75
2.93
3.12
3.31
3.50
3.69
3.87
4.06
4.25
4.44
4.63
4.81
5.00
A/C Refrigerant Pressure Sensor Signal (Volts)

Step-Based Diagnostic Routine: SPN 2609 FMI 3, 4

Step	Action	Decision
1	A. Key OFF B. Disconnect A/C Refrigerant Pressure sensor connector C. Disconnect Powertrain Interface connector (PIC) D. Disconnect ECM J1 connector E. Check A/C Refrigerant Pressure, Powertrain Interface and ECM J1 connector terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are all connectors, harnesses, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest for DTC.

Step	Action	Decision
2	A. Key OFF B. PIC disconnected C. ECM J1 connector installed Measure resistance between ECM side of PIC (terminal K) and chassis ground. Is resistance greater than 10 ohms?	Yes: Go To Step 3 No: Go To Step 4

Step	Action	Decision
3	A. Key OFF B. PIC disconnected C. ECM J1 disconnected Measure resistance between ECM side of PIC (terminal K) to ECM J1-13. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance in low reference circuit. No: Inspect for intermittent connections or rubbed through wires in low reference circuit.

Step	Action	Decision
4	A. Key OFF B. PIC disconnected C. ECM J1 connector installed Key ON, Measure voltage between ECM side of PIC (terminal C) and chassis ground. Is voltage less than, greater than, or between 4.8 and 5.2V?	Greater than 5.2V: Go To Step 7 Between: Go To Step 8 Less than 4.8V: Go To Step 5

Step	Action	Decision
5	A. Key OFF B. PIC disconnected C. ECM J1 connector disconnected Measure resistance between ECM side of PIC (terminal C) and chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 6 No: Repair short to ground between PIC (terminal C) and ECM J1-26

Step	Action	Decision
6	A. Key OFF B. PIC disconnected C. ECM J1 connector disconnected Measure resistance between ECM side of PIC (terminal C) and ECM J1-26. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance between PIC (terminal C) and ECM J1-26. No: Inspect for intermittent connections or rubbed through wires between PIC (terminal C) and ECM J1-26.

Step	Action	Decision
7	A. Key OFF B. PIC disconnected C. ECM J1 connector disconnected Key ON, measure voltage between ECM side of PIC (terminal C) and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage between PIC (terminal C) and ECM J1-26. No: Inspect for intermittent connections or rubbed through wires between PIC (terminal C) and ECM J1-26.

Step	Action	Decision
8	A. Key OFF B. PIC disconnected C. ECM J1 connector installed Key ON, wait 5 seconds. Check voltage between ECM side of PIC (terminal C) and ECM side of PIC (terminal B). Is voltage less than, greater than, or between 0.3 and 4.6V?	Greater than 4.9V: Go To Step 9 Between: Go To Step 11 Less than 0.3V: Go To Step 10

Step	Action	Decision
9	A. Key OFF B. PIC disconnected C. ECM J1 connector disconnected Key ON, measure voltage between ECM side of PIC (terminal B) and chassis ground. Is voltage greater than 1V?	Yes: Repair short to voltage between PIC (terminal B) and ECM J1-12. No: Inspect for intermittent connections or rubbed through wires between PIC (terminal B) and ECM J1-12.

Step	Action	Decision
10	A. Key OFF B. PIC disconnected C. ECM J1 connector disconnected Measure resistance between ECM side of PIC (terminal B) and ECM connector J1-12. Is resistance greater than 5 ohms?	Yes: Repair open or high resistance between PIC (terminal B) and ECM J1-12. No: Go To Step 11

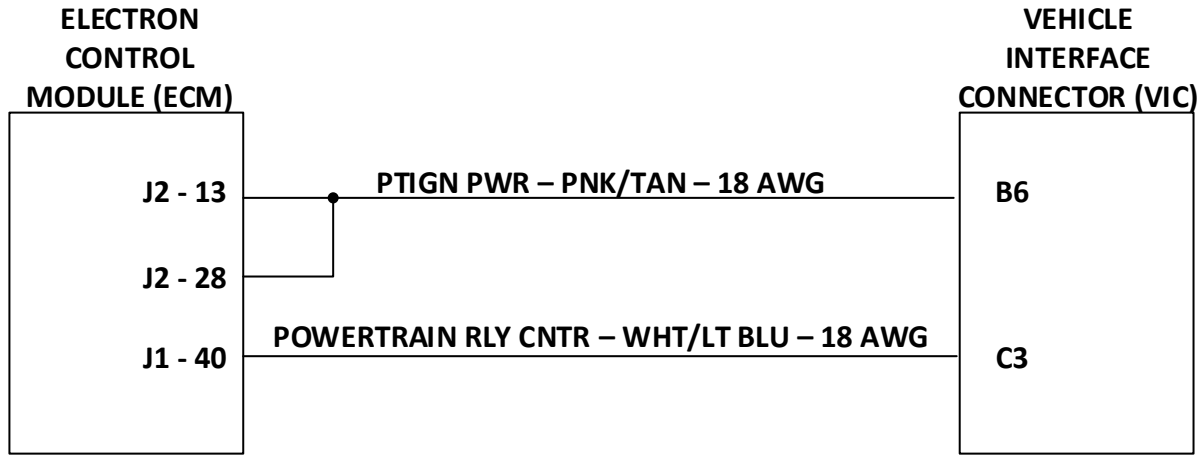
Step	Action	Decision
11	A. Key OFF B. PIC disconnected C. ECM J1 connector disconnected Measure resistance between ECM side of PIC (terminal B) and chassis ground. Is resistance less than 1000 ohms?	Yes: Repair short to ground between PIC (terminal B) and ECM J1-12. No: Go To Step 12

Step	Action	Decision
12	See OEM Diagnostics. After completing OEM Diagnostics, has the fault been repaired?	Yes: End Diagnostics No: Go To Step 13

Step	Action	Decision
13	See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section. After **1.3 Intermittent Fault Code Diagnostics** has been completed, has the fault been corrected?	Yes: End Diagnostics. No: Replace ECM, and retest.

43 System Voltage

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
2634	15	System Voltage High – Main Relay	• Incorrect settings during a jump start or charging • 12 V engine electrical system connected to 24 V chassis electrical system • Internal voltage regulator failure at full-field	A	MIL AMBER STOP
2634	17	System Voltage Low – Main Relay	• Faulty or incorrect powertrain relay • Open PTIGN 1 fuse • Open or high resistance between battery and powertrain relay • Open or high resistance between powertrain relay and ECM • Short to ground between powertrain relay and ECM	A	MIL AMBER STOP



Overview

The voltage being supplied by the Powertrain Relay is monitored to ensure the ECM and ECM output controlled components to ensure proper engine operation and performance. If Powertrain Relay voltage is observed above 24.2V or below 7.4V the corresponding fault will set.

To 6.0L Gasoline Setting Criteria

- SPN 2634 FMI 15 – System Voltage High – Main Relay
- SPN 2634 FMI 17 – System Voltage Low – Main Relay

Step-Based Diagnostic Routine – SPN 2634 FMI 15 "System Voltage High – Main Relay"

Step	Action	Decision
1	The engine wiring harness for this vehicle is a 12V system. If the system is exposed to a 24V power supply, high voltage jump start, or incorrect charger setting SPN 2634 FMI 15 will set. Was the vehicle jump started or charged with a 24V system?	Yes: Clear DTC and retest. No: Go To Step 2

Step	Action	Decision
2	Remove 10-Amp ECM Fuse in the Vehicle Power Center. Measure voltage between (terminal A) and (terminal B) on the fuse connector. Is the voltage greater than 16V?	Yes: Go To Step 3 No: Reinstall fuse, clear the DTC and retest.

Step	Action	Decision
3	If the chassis electrical system is 24V, there will be a step-down transformer to take the 24V chassis voltage down to 12V for the engine. Does the vehicle have a step-down transformer?	Yes: Refer to OEM procedures for testing and inspecting the transformer. No: Go See OEM diagnostics.

Step-Based Diagnostic – SPN 2634 FMI 17 "System Voltage Low – Main Relay"

Step	Action	Decision
1	A. Key OFF B. Disconnect Powertrain Relay and Vehicle Interface Connectors (VIC) C. Check Powertrain Relay and Vehicle Interface Connector (VIC) terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are Powertrain Relay and Vehicle Interface Connectors (VIC), harnesses, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damages. After repairs are complete, retest.

Step	Action	Decision
2	A. Key OFF B. ECM Connector J2 disconnected C. VIC disconnected Key OFF, measure resistance between ECM Connector J2-13 and VIC (terminal B6) Is resistance less than 5 ohms?	Yes: Go To Step 4 No: Repair open or high resistance between ECM Connector J2-13 and VIC (terminal B6)

Step	Action	Decision
3	A. Key OFF B. ECM Connector J2 disconnected C. VIC disconnected Key OFF, measure resistance between ECM Connector J2-28 and VIC (terminal B6) Is resistance less than 5 ohms?	Yes: Go To Step 5 No: Repair open or high resistance between ECM Connector J2-28 and VIC (terminal B6)

Step	Action	Decision
4	A. Key OFF B. ECM Connector J2 disconnected C. VIC disconnected Key OFF, measure resistance between VIC (terminal B6) and chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 6 No: Repair short to ground between ECM Connectors J2-13 or J2-28 and VIC (terminal B6). Inspect the PTIGN PWR 1 fuse and replace if necessary.

Step	Action	Decision
5	A. Key OFF B. ECM Connector J2 disconnected C. VIC connected D. Main Powertrain Relay removed Key ON, measure voltage between ECM Connector J2-13 and chassis ground Is voltage less than 1V?	Yes: Go To Step 7 No: Repair short to voltage between ECM Connector J2-13 and VIC (terminal B6), if no short is found between ECM J2-13 and VIC (terminal B6), Go To Step 10

Step	Action	Decision
6	A. Key OFF B. ECM Connector J2 disconnected C. VIC connected D. Main Powertrain Relay removed Key ON, measure voltage between ECM Connector J2-28 and chassis ground Is voltage less than 1V?	Yes: Go To Step 8 No: Repair short to voltage between ECM Connector J2-28 and VIC (terminal B6), if no short is found between ECM J2-28 and VIC (terminal B6), Go To Step 10

Step	Action	Decision
7	A. Key OFF B. ECM Connector J1 disconnected C. ECM Connector J2 connected D. VIC disconnected Key OFF, measure resistance between ECM Connector J1-40 and VIC (terminal C3). Is resistance less than 5 ohms?	Yes: Go To Step 9 No: Repair open or high resistance between ECM Connector J1-40 and VIC (terminal C3)

Step	Action	Decision
8	A. Key OFF B. ECM Connector J1 disconnected C. ECM Connector J2 connected D. VIC disconnected Key OFF, measure resistance between VIC (terminal C3) and chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To step 10 No: Repair short to ground between ECM Connector J1-40 and VIC (terminal C3)

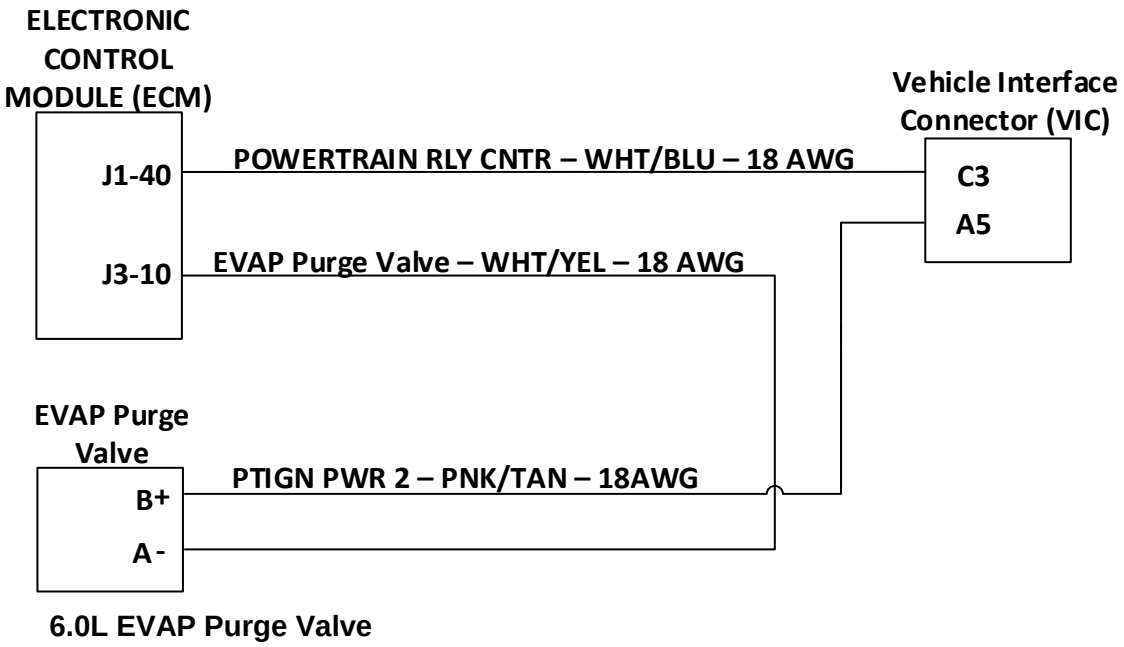
Step	Action	Decision
9	A. Key OFF B. ECM Connector J1 disconnected C. VIC connected D. Main Powertrain Relay removed Key ON, measure voltage between ECM Connector J1-40 and chassis ground. Is voltage less than 1V?	Yes: Go To Step 11 No: Repair short to voltage between ECM Connector J1-40 and VIC (terminal C3), if no short is found between ECM J1-40 and VIC (terminal C3), Go To Step 10

Step	Action	Decision
10	Go See OEM Diagnostics. After OEM diagnostics have been completed, has the fault been corrected?	Yes: End Diagnostics. No: Go To Step 11

Step	Action	Decision
11	See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section. After **1.3 Intermittent Fault Code Diagnostics** has been completed, has the fault been corrected?	Yes: End Diagnostics. No: Replace ECM and retest.

44 EVAP System Purge Control Valve

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
3053	1	EVAP System Leak Detected (Large Leak)	• Purge Solenoid Stuck Open • Leak between Purge Solenoid and EVAP canister • Faulty Fuel Cap • Open, high resistance, or short in EVAP Purge Solenoid control circuits • Faulty Purge Solenoid • Leaking EVAP Canister • Faulty Canister Vent Valve	A	MIL
3053	2	EVAP System Incorrect Purge Flow	• Clogged Purge Solenoid • Purge Solenoid Stuck Open • Leak between Purge Solenoid and EVAP canister • Faulty Fuel Cap • Open, high resistance, or short in EVAP Purge Solenoid control circuits • Faulty Purge Solenoid	B	MIL
7834	3	EVAP Purge System Control Valve Circuit High	• Signal circuit shorted to voltage • Low reference circuit shorted to voltage • Malfunctioning sensor	B	MIL
7834	4	EVAP Purge System Control Valve Circuit Low	• Signal circuit shorted to ground • Reference circuit open or shorted to ground • Signal circuit open, or high resistance • Reference circuit open or high resistance • Loose electrical connector or pin • Malfunctioning sensor	B	MIL
7834	5	EVAP Purge System Control Valve Circuit Open	• Signal circuit shorted to ground • Reference circuit open or shorted to ground • Signal circuit open, or high resistance • Reference circuit open or high resistance • Signal circuit shorted to voltage • Low reference circuit shorted to voltage • Loose electrical connector or pin • Malfunctioning sensor	B	MIL

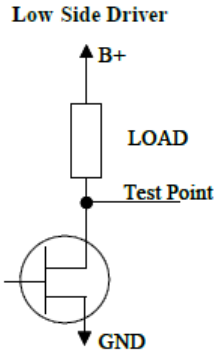


Overview

The ECM drives the Canister Purge Control solenoid by completing the ground circuit. Using the driver circuit shown below, circuit issues are detected as follows.

When the driver is on (*Solenoid activated*) the Test Point would be expected to read ground. If instead voltage is read at the Test Point there is a short to voltage fault condition.

When the driver is off (*Solenoid deactivated*) the Test Point would be expected to read supply voltage. If instead a ground is read at the Test Point, there is a short to ground or open circuit fault condition.



Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)
- 3 Amp Fused Jumper Wire
- Purge Control Valve Breakout Harness 69000190

To 6.0L Gasoline Setting Criteria

- SPN 3053 FMI 1 – EVAP System Leak detected (Large Leak)
- SPN 3053 FMI 2 – EVAP System Incorrect Purge Flow
- SPN 7834 FMI 3 – EVAP Purge System Control Valve Circuit High
- SPN 7834 FMI 4 – EVAP Purge System Control Valve Circuit Low
- SPN 7834 FMI 5 – EVAP Purge System Control Valve Circuit Open

Step-Based Diagnostic Routine - Purge Control Valve Circuit Testing SPN 7834 FMI 3, 4, 5

Step	Action	Decision
1	A. Key OFF B. Disconnect Powertrain Relay and Vehicle Interface Connectors (VIC) C. Check Powertrain Relay and Vehicle Interface Connector (VIC) terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are Powertrain Relay and Vehicle Interface Connectors (VIC), harnesses, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damages. After repairs are complete, retest.

Step	Action	Decision
2	A. Key OFF B. EVAP Purge Control Valve disconnected Key ON, measure voltage between EVAP Purge Control Valve Connector (terminal B) and chassis ground. Is B+ ± 0.5V present?	Yes: Go To Step 3 No: Go To Step 8

Step	Action	Decision
3	A. Key OFF B. EVAP Purge Control Valve disconnected C. ECM Connector J3 disconnected Key OFF, measure resistance between ECM Connector J3-10 and EVAP Purge Control Valve Connector (terminal A). Is resistance less than 5 ohms?	Yes: Go To Step 4 No: Repair open or high resistance between ECM Connector J3-10 and EVAP Purge Control Valve Connector (terminal A)

Step	Action	Decision
4	A. Key OFF B. EVAP Purge Control Valve disconnected C. ECM Connector J3 disconnected Key OFF, measure resistance between EVAP Purge Control Valve Connector (terminal A) and chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 5 No: Repair short to ground between ECM Connector J3-10 and EVAP Purge Connector (terminal A)

Step	Action	Decision
5	A. Key OFF B. EVAP Purge Control Valve disconnected C. ECM Connector J3 disconnected Key ON, measure voltage between Purge Valve Connector (terminal A) and chassis ground. Is voltage less than 1V?	Yes: Go To Step 6 No: Repair short to voltage between ECM Connector J3-10 and EVAP Purge Connector (terminal A)

Step	Action	Decision
6	A. Key OFF B. Fully install EVAP Purge Control Valve Relay Breakout harness 69000090 to EVAP Purge Control Valve only. Key OFF, measure resistance between EVAP Purge Control Valve (terminal B) and (terminal A) on breakout harness. Is resistance 20 ohms ± 5 ohms?	Yes: Go To Step 7 No: Replace EVAP Purge Control Valve and retest.

Step	Action	Decision
7	See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section. After **1.3 Intermittent Fault Code Diagnostics** has been completed, has the fault been corrected?	Yes: End Diagnostics No: Replace ECM and retest

Step	Action	Decision
8	A. Key OFF B. EVAP Purge Control Valve disconnected C. VIC disconnected Key OFF, measure resistance between EVAP Purge Control Valve Connector (terminal B) and VIC (terminal A5) Is resistance less than 5 ohms?	Yes: Go To Step 9 No: Repair open or high resistance between EVAP Purge Control Valve (terminal B) and VIC (terminal A5)

Step	Action	Decision
9	A. Key OFF B. EVAP Purge Control Valve disconnected C. VIC disconnected Key OFF, measure resistance between EVAP Purge Control Valve Connector (terminal B) and chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 10 No: Repair short to ground between EVAP Purge Control Valve Connector (terminal B) and VIC (terminal A5). Inspect PTIGN PWR 2 fuse and replace if necessary.

Step	Action	Decision
10	A. Key OFF B. EVAP Purge Control Valve connected C. ECM Connector J1 disconnected D. VIC disconnected Key OFF, measure resistance between ECM Connector J1-40 and VIC (terminal C3). Is resistance less than 5 ohms?	Yes: Go To Step 11 No: Repair open or high resistance between ECM Connector J1-40 and VIC (terminal C3)

Step	Action	Decision
11	A. Key OFF B. EVAP Purge Control Valve connected C. ECM Connector J1 disconnected D. VIC disconnected Key OFF, measure resistance between VIC (terminal C3) and chassis ground. Is resistance greater than 1000 ohms?	Yes: Go See OEM Diagnostics No: Repair short to ground between ECM Connector J1-40 and VIC (terminal C3)

Step-Based Diagnostic Routine – SPN 3053 FMI 1

Step	Action	Decision
1	Using Powerlink, check the ECM for active or inactive fault codes. Are any Purge Control Valve circuit faults present?	Yes: Complete diagnostics for Purge Control Valve circuit testing, repair faults, clear DTC's, and retest. No: Go To Step 2

Step	Action	Decision
2	A. Key OFF, Ensure Gas Cap is tightened and fully seated. Is Gas Cap full seated?	Yes: Go To Step 3 No: Tighten Gas Cap and Go To Step 3

Step	Action	Decision
3	A. Key OFF B. Disconnect Purge Control Valve connector C. Check Purge Control Valve terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Is the Purge Control Valve connector, harnesses, and terminals clean and undamaged?	Yes: Go To Step 4 No: Repair connector, harness, or terminal damages. After repairs are complete, retest.

Step	Action	Decision
4	A. Key OFF B. Inspect Purge Control Valve for damage C. Inspect Purge Line from Purge Control Valve to Intake Manifold for being: disconnected, improperly routed, kinked or damaged. Are the Purge Control Valve and Purge Line undamaged?	Yes: Go To Step 5 No: Repair Purge Control Valve or Purge Line damages. After repairs are complete, retest.

Step	Action	Decision
5	Key OFF, Fully install Purge Control Valve breakout harness 69000190. Key ON, measure voltage between terminal B and chassis ground. Is battery voltage present?	Yes: Go To Step 6 No: See Diagnostic Routine for Purge Control Valve Circuit Testing.

Step	Action	Decision
6	A. Key OFF B. Purge Control Valve breakout harness installed C. Install 3 A fused jumper wire between terminal A of breakout harness and chassis ground. D. Key-On, verify Purge Control Valve opens. An audible clicking noise from Purge Control Valve can be heard, or internal movement may be felt. Could the Purge Control Valve be heard or felt clicking?	Yes: Go To Step 9 No: Go To Step 7

Step	Action	Decision
7	A. Key OFF B. Remove Purge Control Valve Breakout Harness and fused jumper wire, leaving Purge Control Valve disconnected C. Remove EVAP line from canister side of Purge Control Valve D. Start Engine Is engine vacuum present on canister side of Purge Control Valve?	Yes: Replace Purge Control Valve and retest. No: Go To Step 8

Step	Action	Decision
8	A. Key OFF B. Purge Control Valve breakout harness installed C. Install 3 A fused jumper wire between terminal B of breakout harness and chassis ground. D. Start Engine Is engine vacuum present on canister side of Purge Control Valve?	Yes: Go To Step 9 No: Replace Purge Control Valve and retest.

Step	Action	Decision
9	Go See OEM Diagnostics. After OEM diagnostics have been completed, has the fault been corrected?	Yes: Replace leaking component per OEM recommendations. No: See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section.

Step-Based Diagnostic Routine – SPN 3053 FMI 2

Step	Action	Decision
1	Using Powerlink, check the ECM for active or inactive fault codes. Are any Purge Control Valve circuit faults present?	Yes: Complete diagnostics for Purge Control Valve circuit testing, repair faults, clear DTC's, and retest. No: Go To Step 2

Step	Action	Decision
2	A. Key OFF B. Disconnect Purge Control Valve connector C. Check Purge Control Valve terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Is the Purge Control Valve connector, harnesses, and terminals clean and undamaged?	Yes: Go To Step 3 No: Repair connector, harness, or terminal damages. After repairs are complete, retest.

Step	Action	Decision
3	A. Key OFF B. Inspect Purge Control Valve for damage C. Inspect Purge Line from Purge Control Valve to Intake Manifold for being: disconnected, improperly routed, kinked or damaged. Are the Purge Control Valve and Purge Line undamaged?	Yes: Go To Step 4 No: Repair Purge Control Valve or Purge Line damages. After repairs are complete, retest.

Step	Action	Decision
4	Key OFF, Fully install Purge Control Valve breakout harness 69000190. Key ON, measure voltage between terminal B and chassis ground. Is battery voltage present?	Yes: Go To Step 5 No: See Diagnostic Routine for Purge Control Valve Circuit Testing.

Step	Action	Decision
5	A. Key OFF B. Purge Control Valve breakout harness installed C. Install 3 A fused jumper wire between terminal A of breakout harness and chassis ground. D. Key-On, verify Purge Control Valve opens. An audible clicking noise from Purge Control Valve can be heard, or internal movement may be felt. Could the Purge Control Valve be heard or felt clicking?	Yes: Go To Step 7 No: Go To Step 6

Step	Action	Decision
6	A. Key OFF B. Remove Purge Control Valve Breakout Harness and fused jumper wire, leaving Purge Control Valve disconnected C. Remove EVAP line from canister side of Purge Control Valve D. Start Engine Is engine vacuum present on canister side of Purge Control Valve?	Yes: Replace Purge Control Valve and retest. No: Go To Step 6

Step	Action	Decision
7	A. Key OFF B. Purge Control Valve breakout harness installed C. Install 3 A fused jumper wire between terminal B of breakout harness and chassis ground. D. Start Engine Is engine vacuum present on canister side of Purge Control Valve?	Yes: Go To Step 7 No: Replace Purge Control Valve and retest.

Step	Action	Decision
8	A. Key OFF B. Disconnect EVAP Purge Control Valve connector C. EVAP line from EVAP cannister disconnected from Purge Control Valve D. Perform Intake Smoke test in section **3.7 Engine Intake and Exhaust Leaks** While performing intake smoke test, observe EVAP canister side of Purge Control Valve for smoke leaking past Purge Control Valve. Is smoke observed leaking past Purge Control Valve?	Yes: Replace EVAP Purge Control Valve. No: See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section.

45 EVAP System Vent Control Valve

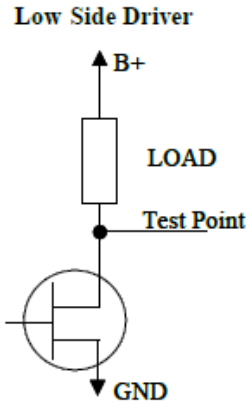
SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
7833	3	EVAP System Vent Control Circuit Shorted High	• Malfunctioning Relay • Short to voltage • Loose or intermittent connection • Open ground circuit	B	MIL
7833	4	EVAP System Vent Control Circuit Shorted Low	• Vent Control circuit short to ground • Vent control circuit open, or high resistance • Loose electrical connector or pin	B	MIL
7833	5	EVAP System Vent Control Circuit Open	• Malfunctioning Relay • Vent control circuit open • Loose electrical connector or pin	B	MIL
7833	7	EVAP System Vent Valve Stuck Closed	• Malfunctioning EVAP Vent Valve • Collapsed or damaged vent hose • Dirty or submerged fresh air vent filter	B	MIL



Overview

The ECM drives the vent control solenoid by completing the ground circuit. Using the driver circuit shown below, circuit issues are detected as follows:

When the driver is on (*Solenoid activated*) the Test Point would be expected to read ground. If instead voltage is read at the Test Point there is a short to voltage fault condition.
When the driver is off (*Solenoid deactivated*) the Test Point would be expected to read supply voltage. If instead a ground is read at the Test Point there is a short to ground or open circuit fault condition.



The diagnostics run when voltage is greater than a value continuously for a calibrated time as long as the diagnostic is not disabled due to another active fault. If X out of Y reads indicate a fault condition, a fault is set. If Y samples are completed without X failures, a pass is reported.

A diagnostic is also run to detect faults with the EVAP Canister system. The diagnostic will detect a dirty or submerged fresh air vent filter, a vent valve stuck closed or a crushed vent hose. The diagnostic commands the vent solenoid to its normally open position and commands the purge system to maintain a calibrated constant amount of purge flow. The fuel tank vacuum is monitored using fuel tank pressure sensor for a calibration-specified time amount of time. A normally functioning EVAP system will maintain a relatively low vacuum level, whereas, a failing EVAP system will experience an increasing vacuum level until a *"fail"* threshold is reached, at which time the test reports a *"fail"* condition.

Tools Required

- PSI Powerlink
- Digital Multimeter (DMM)

To 6.0L Setting Criteria

- SPN 7833 FMI 3 – EVAP System Vent Control Circuit Shorted High
- SPN 7833 FMI 4 – EVAP System Vent Control Circuit Shorted Low
- SPN 7833 FMI 5 – EVAP System Vent Control Circuit Open
- SPN 7833 FMI 7 – EVAP System Vent Valve Stuck Closed

Step-Based Diagnostic Routine – Canister Vent Valve Circuit Testing
SPN 7833 FMI 3, 4, 5

Step	Action	Decision
1	A. Key-Off B. Disconnect Vehicle Interface Connector (VIC), and ECM J3 Connector C. Check Canister Vent Valve Relay and Vehicle Interface Connector (VIC), and ECM J3 Connector terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Are Canister Vent Valve Relay and Vehicle Interface Connector (VIC), and ECM J1 Connector, harnesses, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damage. After repairs are complete, retest.

Step	Action	Decision
2	A. Key OFF B. ECM Connector J3 disconnected Key OFF, measure voltage from ECM Connector J3-11 to chassis ground. Is B+ ± 0.5V present?	Yes: Go To Step 5 No: Go To Step 3

Step	Action	Decision
3	A. Key OFF B. VIC disconnected C. ECM Connector J3 disconnected Key OFF, measure resistance between VIC (terminal B10) and ECM Connector J3-11 Is resistance less than 5 ohms?	Yes: Go To Step 4 No: Repair open or high resistance between ECM Connector J3-11 and VIC (terminal B10)

Step	Action	Decision
4	A. Key OFF B. VIC disconnected C. ECM Connector J3 disconnected Key OFF, measure resistance from VIC (terminal B10) to chassis ground. Is resistance greater than 1000 ohms?	Yes: Go To Step 5 No: Repair short to ground between VIC (terminal B10) and ECM Connector J3-11

Step	Action	Decision
5	A. Key OFF B. VIC connected C. ECM Connector J3 disconnected D. Vent Control Valve Relay disconnected Key ON, measure voltage between ECM Connector J3-11 and chassis ground Is voltage less than 1V?	Yes: Go To Step 6 No: Repair short to voltage between ECM Connector J3-11 and VIC (terminal B10), if no short is found between ECM J3-11 and VIC (terminal B10), Go To Step 6

Step	Action	Decision
6	Go See OEM Diagnostics. After OEM diagnostics have been completed, has the fault been corrected?	Yes: End Diagnostics. No: Go To Step 7

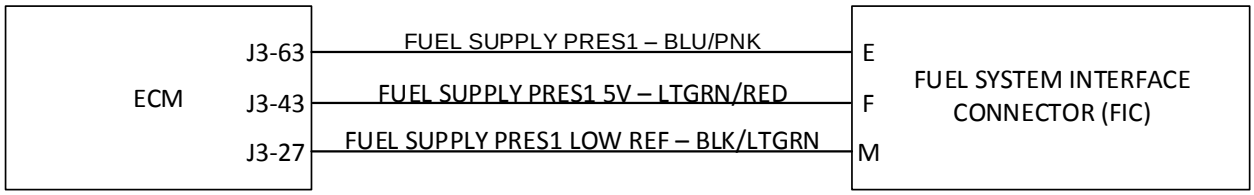
Step	Action	Decision
7	See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section. After **1.3 Intermittent Fault Code Diagnostics** has been completed, has the fault been corrected?	Yes: End Diagnostics. No: Replace ECM, and retest.

Step-Based Diagnostic Routine – Canister Vent Valve Functionality Testing
SPN 7833 FMI 7

Step	Action	Decision
1	Perform **Canister Vent Valve Circuit Testing.** Was fault found and corrected?	Yes: End Diagnostics. No: See OEM Diagnostics.

46 EVAP System Pressure Sensor/Switch

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
7835	0	EVAP System Pressure Sensor/ Switch Circuit Intermittent	• Loose electrical connector or pin • Malfunctioning sensor	B	MIL
7835	3	EVAP System Pressure Sensor/ Switch Circuit High	• Signal circuit shorted to voltage • Low reference circuit shorted to voltage • Malfunctioning sensor	B	MIL
7835	4	EVAP System Pressure Sensor/ Switch Circuit Low	• Signal circuit shorted to ground • Reference circuit open or shorted to ground • Signal circuit open, or high resistance • Reference circuit open or high resistance • Loose electrical connector or pin • Malfunctioning sensor	B	MIL
7835	7	EVAP System Pressure Sensor Circuit Range/ Performance Stuck	• Malfunctioning sensor • Signal circuit shorted to ground • Signal circuit open, or high resistance	B	MIL
7835	20	EVAP System Pressure Sensor Circuit Range/ Performance High	• Signal circuit shorted to voltage • Low reference circuit shorted voltage • Malfunctioning sensor	B	MIL
7835	21	EVAP System Pressure Sensor Circuit Range/ Performance Low	• Signal circuit shorted to ground • Signal circuit open, or high resistance • Loose electrical connector or pin • Malfunctioning sensor	B	MIL



Overview

Heat is transferred into a vehicle fuel tank while the vehicle is operating. When the vehicle is turned OFF, a change in the fuel tank vapor temperature occurs, which results in corresponding pressure changes in the fuel tank vapor space. This change is monitored by the control module using the fuel tank pressure sensor input. The control module then makes a judgement on the integrity of the system.

Tools Required

- PSI PowerLink
- Digital Multimeter (DMM)

To 6.0L Gasoline Setting Criteria

- SPN 7835 FMI 0 – EVAP System Pressure Sensor/Switch Circuit Intermittent
- SPN 7835 FMI 3 – EVAP System Pressure Sensor/Switch Circuit High
- SPN 7835 FMI 4 – EVAP System Pressure Sensor/Switch Circuit Low
- SPN 7835 FMI 7 – EVAP System Pressure Sensor Circuit Range/Performance Stuck
- SPN 7835 FMI 20 – EVAP System Pressure Sensor Circuit Range/Performance High
- SPN 7835 FMI 21 – EVAP System Pressure Sensor Circuit Range/Performance Low

Step-Based Diagnostic Routine: SPN 7835 FMI 0, 3, 4, 5, 7, 20, 21

Step	Action	Decision
1	A. Key OFF B. Disconnect ECM connector J3 and Fuel Interface Connector (FIC) C. Check ECM connector J3 and Fuel Interface Connector (FIC) terminals for: damaged or pinched wires, moist or corroded terminal; loose, bent, or broken pins; or broken connector housing. Is ECM connector J3 and Fuel Interface Connectors (FIC), harnesses, and terminals clean and undamaged?	Yes: Go To Step 2 No: Repair connector, harness, or terminal damages. After repairs are complete, retest.

Step	Action	Decision
2	A. Key OFF B. Disconnect Fuel Interface Connector (FIC) C. Measure voltage between FIC terminal F and terminal M Key ON, is voltage between 4.5 and 5.5 volts?	No, Higher: Repair short to voltage in 5V reference circuit. Yes: Go To Step 3 No, Lower: Go To Step 6

Step	Action	Decision
3	A. Key OFF B. Disconnect ECM connector J3 and Fuel Interface Connector (FIC) C. Measure resistance between ECM connector J3 (terminal 63) and FIC (terminal E) Is resistance greater than 10Ω?	Yes: Repair open or high resistance in signal circuit. No: Go To Step 4

Step	Action	Decision
4	A. Key OFF B. Disconnect Fuel Interface Connector (FIC) C. Measure resistance between FIC terminal E and chassis ground Is resistance less than 1000Ω?	Yes: Repair short to ground in signal circuit. No: Go To Step 5

Step	Action	Decision
5	A. Key OFF B. Disconnect Fuel Interface Connector (FIC) C. Measure voltage between FIC terminal E and chassis ground Key ON, is voltage greater than 1 volt?	Yes: Repair short to voltage in signal circuit. No: Go To Step 13

Step	Action	Decision
6	A. Key OFF B. Disconnect Fuel Interface Connector (FIC) C. Measure voltage between FIC terminal F and chassis ground Key ON, is 5V ± 0.5V present?	Yes: Go To Step 9 No: Go To Step 7

Step	Action	Decision
7	A. Key OFF B. Disconnect Fuel Interface Connector (FIC) C. Disconnect ECM connector J3 D. Measure resistance between FIC (terminal F) and ECM J3 (terminal 43) Is resistance greater than 10Ω?	Yes: Repair open or high resistance in 5V reference circuit. No: Go To Step 8

Step	Action	Decision
8	A. Key OFF B. Disconnect FIC and ECM connector J3 C. Measure resistance from FIC (terminal F) and chassis ground. Is resistance less than 1000Ω?	Yes: Repair short to ground in 5V reference circuit. No: Go To Step 13

Step	Action	Decision
9	A. Key OFF B. Disconnect FIC C. Measure resistance from FIC (terminal M) and chassis ground. Is resistance greater than 10Ω?	Yes: Go To Step 10 No: Go To Step 13

Step	Action	Decision
10	A. Key OFF B. Disconnect FIC C. Disconnect ECM connector J3 D. Measure resistance from FIC (terminal M) and ECM connector J3 (terminal 27). Is resistance greater than 10Ω?	Yes: Repair open or high resistance in low reference circuit. No: Go To Step 11

Step	Action	Decision
11	A. Key OFF B. Disconnect FIC C. ECM connector J3 installed D. Measure voltage between FIC terminal M and chassis ground Key ON, is voltage greater than 1 volt?	Yes: Repair short to voltage in low reference circuit. No: Go To Step 13

Step	Action	Decision
12	Go See OEM Diagnostics. After OEM diagnostics have been completed, has the fault been corrected?	Yes: End Diagnostics. No: Go To Step 13

Step	Action	Decision
13	See **1.3 Intermittent Fault Code Diagnostics** in the Symptom Based diagnostic section. After **1.3 Intermittent Fault Code Diagnostics** has been completed, has the fault been corrected?	Yes: End Diagnostics. No: Replace ECM, and retest.

47 Rough Road Sensor

SPN	FMI	Condition	Possible Causes	DTC Type	Lamp
3052	5	Rough Road Sensor Not Detected	• Malfunctioning Rough Road Sensor	C	AMBER

Overview

Rough Roads can cause driveline torque variations that, if severe enough, can cause false misfire faults. The signal from the Rough Road Sensor (wheel speed sensor or G-sensor) is used by the ECM to monitor if the vehicle is traveling over a rough surface, and during that period of time, disable misfire monitoring. If the Rough Road Sensor signal is not received by the ECM, SPN 3052 FMI 5 will set.

Tools Required

- PSI PowerLink

To 6.0L Gasoline Setting Criteria

- SPN 3052 FMI 5 – Rough Road Sensor Not Detected

Step-Based Diagnostic Routine: SPN 3052 FMI 5

Step	Action	Decision
1	Using PowerLink, check for active SPNs. Diagnose and repair all other fault codes besides SPN 3502 FMI 5. Clear DTC's and retest. Is SPN 3502 FMI 5 still present/active?	Yes: Go see OEM Diagnostics. No: End Diagnostic.

48 Setting Criteria

SPN 29 FMI 3 – “Pedal Position Sensor/Switch "E" Circuit High Input”

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Accelerator Pedal Position 2 sensor voltage is detected to be high out of range	APP2 is greater than 60%, or 3.0V OR VrefB fail criteria is met	Ignition ON Fail is not reported if VrefB fail counter is greater than 0 OR SPN 629 FMI 12 is not failed	Time to fail for a continuous fault (10 ms loop) – 0.07 seconds Failure not reported if Vref B fail counter is non-zero

SPN 29 FMI 4 – “Pedal Position Sensor/Switch "E" Circuit Low Input”

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Accelerator Pedal Position 2 sensor voltage is detected to be low out of range	APP2 is less than 2.5% or .12V OR VrefB fail criteria is met	Ignition ON Fail is not reported if VrefB fail counter is greater than 0 OR SPN 629 FMI 12 is not failed	Time to fail for a continuous fault (10 ms loop) – 0.07 seconds Failure not reported if Vref B fail counter is non-zero

SPN 51 FMI 2 - “Throttle Position Sensor/Switch "A" / "B" Voltage Correlation”

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if throttle position from TP1(TPS A) disagrees with TP2 (TPS B) after raw voltages are normalized (converted to the same slope and offset) Malfunction occurs when difference between normalized values of TP1 and TP2 is greater than a calibrated amount At the moment failure is confirmed, malfunction criteria for Throttle Position “A”	Absolute difference between normalized values of TP1 and TP2 is greater than a threshold. Threshold depends on engine running/ not running and normal/ abnormal operation conditions. Engine not running: TP Correlation minimum threshold is 0.5V Maximum threshold conditions to use abnormal base	Ignition ON AND No disabling faults present AND Throttle Position Sensor “A” Circuit high fail count is 0 AND Throttle Position Sensor “A” Circuit low fail count is 0 AND Throttle Position Sensor “B” Circuit high fail count is 0 AND Throttle Position Sensor “B” Circuit low fail count is 0 AND Sensor Voltage “A” Circuit fail count is 0 AND Engine is not running	Engine Running (varies by driving condition): Shortest possible time is 0.4 seconds Time range: 1-1.2 seconds Engine Not Running: 50 seconds

Performance and Throttle Position “B” Performance are checked, if the malfunction criteria is true for only one of them, that failure is reported instead of Throttle Position Sensor “A”/”B” Voltage Correlation	threshold: TP1 noisy and TP2 noisy OR Actual throttle position is greater than 40% OR Map sensor fault(s) active OR MAF sensor fault(s) active OR MAP/BARO ratio is greater than or equal to 0.9 ELSE use normal base threshold TP Correlation threshold calibration values for engine running: Base threshold for normal will range between 0.4V and 0.75V depending on desired throttle position and abnormal conditions will range between 0.4V and 0.7V and transmission gear modifier is 1 and maximum threshold is 0.6V Alternate fast fail when both TP’s are out of range: Engine is running AND TP1 out of range fault not present AND TP2 out of range fault not present AND Raw TP1 value is less than 0.25V OR Raw TP1 value is greater than 4.75V OR Most recent sample indicated that Sensor Reference Voltage “A” Circuit (SPN	OR Engine cylinder event counter is greater than 20 OR Engine coolant temperature is greater than 122°F (50°C)	

	3509 FMI 31) is exceeding the threshold OR Sensor Reference Voltage “A” Circuit (SPN 3509 FMI 31) test failed OR Normalized TP1 value minus TP1 learned minimum value is less than -0.15V AND Raw TP2 value is less than 0.25V AND Raw TP2 value is greater than 4.75V OR Most recent sample indicates that Sensor Reference Voltage “A” circuit is exceeding failure threshold OR Sensor Reference Voltage “A” Circuit test failed OR Normalized TP2 value minus TP2 learned minimum value is less than -0.15V AND TP correlation fail counter is greater than 20		

SPN 51 FMI 3 – “Throttle Position Sensor/Switch "A" Circuit High”

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects SENT signal stuck high fault	Current rolling pulse count state has not changed for 2.5 ms AND logical voltage level of the TPS SENT bus is high	Throttle position sensor interface is SENT AND SPN 3509 FMI 31 is not set	DTC sets after 0.05 seconds failure out of 0.3 seconds sample period

SPN 51 FMI 4 – “Throttle Position Sensor/Switch "A" Circuit Low”

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects SENT signal stuck low fault	Current rolling pulse count state has not changed for 2.5 ms AND logical voltage level of the TPS SENT bus is low	Throttle position sensor interface is SENT AND SPN 3509 FMI 31 is not set	DTC sets after 0.05 seconds failure out of 0.3 seconds sample period

SPN 51 FMI 7 - “Throttle Position Sensor/Switch "A" Circuit Range/Performance”

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if throttle position from TP1 (TPS A) shows functional issues like signal noise or incorrect airflow. One time test: when TP Correlation fails, checks for noise on TP1 OR airflow based on TP1 being too different compared to a reference flow.	One Time Test: When Throttle Position Sensor “A”/”B” Voltage Correlation SPN 51 FMI 2 test failed flag goes from false to true, TP2 noisy (high rate of change of raw value recently) AND TP1 is not noisy OR TP1 noisy AND TP2 noisy AND Engine is running AND Actual Throttle Position is less than 40% AND MAP Sensor is not failed AND MAF Sensor is not failed AND MAP/BARO is less than 0.9 ratio AND Ratio of (TP2 calculated airflow minus measured airflow) divided by measured airflow is less than -0.6 OR Ratio of (TP2 calculated airflow minus measured airflow) divided by	Throttle Position Sensor “A”/”B” Voltage Correlation (SPN 51 FMI 2) is enabled AND Throttle Position Sensor “A”/”B” Voltage Correlation (SPN 51 FMI 2) test failed AND Throttle Position Sensor “A”/”B” Voltage Correlation (SPN 51 FMI 2) test has not failed in the last 10 ms loop AND Engine power control mode is normal Continuous Test: Ignition ON AND Throttle Position Sensor “A” Circuit high (SPN 51 FMI 3) test has not failed AND Throttle Position Sensor “A” Circuit low (SPN 51 FMI 4) test has not failed AND Throttle Position Sensor “A” Circuit High fail count is 0 AND Throttle Position Sensor “A” Circuit Low fail count is 0 AND Sensor Reference Voltage “A” Circuit test (SPN 3509 FMI 31) has not failed	Time to fail for a continuous fault (10 ms continuous loop) Time to fail for a continuous noise fault (10 ms loop time) is 0.11 seconds Time to fail for a continuous flow fault is 1 second

	measured airflow is greater than 0.6 AND Ratio of (TP1 calculated airflow minus measured airflow) divided by measured airflow is greater than or equal to -0.6 AND Ratio of (TP1 calculated airflow minus measured airflow) divided by measured airflow is less than or equal to 0.6 Select airflow reference to use for real airflow if MAF is present on engine, use MAF, else, use MAP Continuous Test: When TP correlation SPN 51 FMI 2 is failed or TP2 is failed OR Engine is running AND Actual Throttle Position is less than 40% AND MAP sensor is test is false AND MAF sensor test is false AND MAP/BARO ratio is less than 0.9 AND Ratio of (TP2 calculated airflow minus measured airflow) divided by measured airflow is less than -0.6 OR Ratio of (TP2 calculated airflow minus measured airflow) divided by measured airflow is greater than 0.6	AND Sensor Reference Voltage “A” Circuit fail count is 0 AND ECM Processor (SPN 629 FMI 12) fault test has not failed AND SEND TPS Communication (SPN 51 FMI 19) test has not failed AND SEND TPS Signal Stuck High (SPN 51 FMI 3) test has not failed AND SEND TPS Signal Stuck Low (SPN 51 FMI 4) test has not failed AND Engine Power is normal AND Engine is running or engine cylinder event counter is greater than 20 or engine coolant temperature is greater than 122°F (50°C) or Throttle Position Sensor “A”/”B” Voltage Correlation (SPN 51 FMI 2) is enabled	

SPN 51 FMI 19 – “Invalid Data Received From Throttle Body Module”

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects SENT signal communication fault	Check for TPS message received for a certain amount of time is true AND TPS message not received for greater than 500 ms from the last execution OR Check for TPS message pulse count fault is true AND at least one of the faults occurred in the most recently received SENT message OR Too few pulses between cal pulses OR Too many pulses between cal pulses OR Pulse larger than cal pulse max OR Transmitter clock changed more than 1.56% OR Nibble value is less than 0 OR Nibble data is greater than 15 OR Calculated message CRC is failed	Throttle Position Sensor interface is SENT AND SPN 3509 FMI 31 is not set	DTC set after 0.05 seconds failure out of 0.3 seconds sample period

SPN 91 FMI 2 – “Throttle/Pedal Position Sensor/Switch "D"/"E" Voltage Correlation”

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Accelerator Pedal Position sensors (1 and 2) do not agree about the position of the accelerator pedal	The difference between APP 1 and 2 learned minimums is greater than 4.5% (0.23V) OR IF the calibration option is normalized OR calibration option is displacement, then: Engine Running: The difference between APP #1 and #2 normalized values is greater than threshold (varies) Engine Not Running: The difference between APP#1 and #2 values is greater than 8% (0.4V)	Ignition ON	Continuously monitored every 10ms DTC will set with engine running after 0.23 seconds fail out of a 6 second sample period. DTC will set with engine not running after 13 seconds fail out of a 6 second sample period. Failure not reported if any fail counter for VrefA, VrefB, or any APS Range diagnostic is non-zero.

SPN 91 FMI 3 – “Pedal Position Sensor/Switch "D" Circuit High Input”

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Accelerator Pedal Position sensor #1 voltage is detected to be high out of range	APP1 is greater than 97.5%, or 4.87V OR VrefA fail criteria is met	Ignition ON Fail is not reported if VrefA fail counter is greater than 0 OR SPN 629 FMI 12 is not failed	Continuously monitored DTC will set after 0.21 seconds of failure in a 5 second sample period Failure not reported if VrefA counter is non-zero

SPN 91 FMI 4 – “Pedal Position Sensor/Switch "D" Circuit Low Input”

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Accelerator Pedal Position sensor #1 voltage is detected to be low out of range	APP1 is less than 2.5% or 0.125V OR VrefB fail criteria is met	Ignition ON Fail is not reported if VrefA fail counter is greater than 0 OR SPN 629 FMI 12 is not failed	Continuously monitored DTC will set after 0.21 seconds of failure in a 5 second sample period Failure not reported if VrefA counter is non-zero

SPN 96 FMI 2 – “Fuel Level Sensor “A” circuit Intermittent”

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors variations in Fuel Level Signal A and looks for erratic or irregular behavior	Absolute value of difference between previous and current fuel level RAW Signal A greater than 15%	Determination of Noisy Signal Enable Conditions: No Disabling Faults present AND Ignition voltage is greater than 11V AND Not disabled in reverse or vehicle not in reverse AND Engine is running for at least 5 seconds AND Signal A not changing due to fuel sloshing AND Slosh Delay Timer exceeded the threshold	The DTC will set when setting criteria and enable conditions are met for 13 seconds out of a 26 second sample period.

SPN 96 FMI 3 – “Fuel Level Sensor “A” Circuit High”

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a continuous short to battery or open in circuit for Fuel Level Sensor 1	Sending Unit Assembly output is greater than 98% of threshold	No disabling faults present AND Ignition voltage is greater than 11 volts AND Test not disabled in reverse or Vehicle is not in reverse	The DTC will set when setting criteria/enabling conditions are met for 13 seconds out of a 26 second sample period.

SPN 96 FMI 4 – "Fuel Level Sensor "A" Circuit Low"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a continuous short to ground, or an open in circuit for Fuel Level Sensor 1	Sending Unit Assembly output is less than 5% of threshold	No disabling faults present AND Ignition voltage is greater than 11 volts AND Test not disabled in reverse or Vehicle is not in reverse	The DTC will set when setting criteria/enabling conditions are met for 13 seconds out of a 26 second sample period

SPN 96 FMI 7 – "Fuel Level Sensor "A" Circuit Range/Performance"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects a stuck condition for fuel level sender 1	Current Sender 1 fuel level reading is greater than 100% AND Sender 1 fuel level change since last completion is less than or equal 3% AND Consumed fuel since last test is greater than or equal to 13.2 gal (50 L) OR Current fuel level is less than or equal to 100% AND Sender 1 fuel level change since last test completion is less than or equal to 3% AND Consumed fuel since last test is greater than or equal to 13.2 gal (50 L)	No disabling faults present AND Fuel Level Sender 1 stuck fault not active AND Ignition voltage is greater than 11 volts AND Transmission is not in Reverse or transmission in reverse and test is allowed in reverse and SPN 639 FMI 8 not active and SPN 2003 FMI 8 not active AND Sender 2 fuel level reading between 0–100% AND Fuel Tank leveling in progress OR Tank leveling check bypass enabled.	Amount of time required to consume 13.2 gallons (50 liters) of fuel

SPN 100 FMI 1 – "Engine Oil Pressure Too Low"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors for extremely low engine oil pressure. When the engine oil pressure is too low for a period of time, the diagnostic's failure criteria are met. This diagnostic is in place alert the driver when the oil pressure is too low and could harm the engine.	Oil pressure is lower than a threshold based on Coolant Temperature and Engine RPM AND Low Oil Pressure Delay Timer is greater than threshold based on Coolant Temperature and Engine RPM	Engine is running for at least 18 seconds AND No disabling faults present.	The DTC will set when setting criteria/enabling conditions are met for 4 seconds out of an 8 second sample period

SPN 100 FMI 3 – "Engine Oil Pressure Sensor/Switch "A" High"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if engine oil pressure signal is high	Signal voltage is greater than 98% of reference voltage (4.9V)	No disabling faults are present	DTC sets after 6.4 seconds of failure out of 12.8 seconds sample period

SPN 100 FMI 4 – "Engine Oil Pressure Sensor/Switch "A" Low"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if engine oil pressure signal is low	Signal voltage is less than 2% of reference voltage (0.1V)	No disabling faults are present AND Engine is Running AND Ignition Voltage is greater than 8V	DTC sets after 6.4 seconds of failure out of 12.8 seconds sample period

SPN 110 FMI 0 – "Engine Coolant Over Temperature Condition"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code indicates engine coolant temperature exceeds specification	Coolant temperature is greater than, or equal to 262.4°F (128°C)	Engine is running for at least 18 seconds AND No disabling faults are present	The DTC will set when setting criteria/enable conditions are met for 8 seconds out of a 16 second sample period

SPN 110 FMI 2 – "Engine Coolant Temperature High Rationality"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code is set when unusually high coolant temperatures are detected under normal operating loads	Engine coolant temperature is measured to be above 230°F (110°C) AND Average air flow is less than or equal to 35 g/s AND EWMA filtered airflow is less than or equal to 65 g/s	No disabling faults are present AND Test is not complete this key cycle AND Undefaulted intake air temperature is less than or equal to 95°F (35°C), AND Engine soak time is greater than 360 minutes or the startup coolant temperature is less than 113°F (45°C), or cold start criteria has been met AND Engine is running AND Engine off time is less than 45 seconds AND Raw Coolant Reading is not out of range AND Undefaulted engine coolant temperature is greater than or equal to 122°F (50°C) AND Airflow sampling timer is greater than 60 seconds	The DTC will set when setting criteria/enable conditions are met for 1.6 seconds out of a 240 second sample period. Runs once per key cycle.

SPN 110 FMI 3 – "Engine Coolant Temperature Circuit High"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a continuous short to ground in the signal circuit or the sensor	Coolant temperature is less than, or equal to 120°F (49°C) AND Coolant signal is greater than 4.9V	Engine is running AND No disabling faults present AND Engine runtime is greater than 0 sec OR Engine soak time is greater than 0 min AND Undefaulted intake air temperature is greater than or equal to 50°F (-10°C)	The DTC will set when setting criteria/enable conditions are met for 9.6 seconds out of a 19.2 second sample period.

SPN 110 FMI 4 – "Engine Coolant Temperature Circuit Low"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a continuous short to ground in the signal circuit or the sensor	Low Pull Up: Coolant temperature is less than or equal to 120°F (49°C) AND Coolant temperature signal is less than 3.2% (0.16V) High Pull Up: Coolant temperature is greater than or equal to 124°F (51°C) AND Coolant temperature signal is less than 3.2% (0.16V)	Engine is running AND Engine has run longer than 0 sec OR Engine soak time is greater than 0 min	The DTC will set when setting criteria/enable conditions are met for 9.6 seconds out of a 19.2 second sample period.

SPN 110 FMI 7 – "Coolant Thermostat (Coolant Temperature Below Thermostat Regulating Temperature)"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors the time it takes for the coolant temperature to reach the temperature required to enable diagnostics or the manufacturer recommended Thermostat regulating temperature (52°F, 11°C) and compares it against a threshold to make a PASS/FAIL determination, provided airflow and idle conditions are met.	Engine coolant temperature is less than a calibrated threshold when accumulated idle time is less than a calibrated threshold and accumulated airflow is greater than a calibrated threshold.	Engine running AND No disabling faults present AND Test not complete this cycle AND Minimum air intake temperature this key cycle is greater than or equal to 20°F (-6.7°C), AND Startup coolant temperature is less than the difference between a calibrated threshold specified by startup coolant temperature and 68°F (20°C) AND Warm-Up Timer is greater than or equal to a calculated time based on startup coolant temperature AND At least 7 of 8 cylinders are on	Runs once per key cycle

SPN 110 FMI 15 – "Engine Coolant Temperature High Startup"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors for an incorrectly high coolant temperature at engine startup.	Engine Coolant temperature measured greater than 136.4°F (58°C) at start up	Test has not been completed for the key cycle AND Most recent sample indicates that the Raw Coolant Reading is not exceeding or less than the Engine Coolant AND There are no disabling faults present AND Engine soak time is greater than 360 minutes AND Startup intake air temperature is less than 95°F (35°C) AND The startup engine oil temperature was measured less than 122°F (50°C)	Runs once per key cycle

SPN 110 FMI 18 – "Engine Coolant Temperature Relapsed Below Diagnostic Monitoring Temperature"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects minimum closed loop coolant temperature has fallen below diagnostic operating temperature	Undefaulted engine coolant temperature drops below 140°F (60°C)	Engine running longer than 5 seconds AND No Disabling Faults present AND Coolant temperature is greater than or equal to 140°F (60°C), AND Undefaulted engine coolant temperature is greater than or equal to a calibrated value based on temperature of intake and coolant at startup AND Warm-Up stability time is greater than or equal to 5 seconds AND At least 7 of 8 cylinders are on AND combusted fuel flow is greater than 0.7 g/s AND cooling counter is 0	The DTC will set when setting criteria/enable conditions are met for 20 seconds out of a 40 second sample period.

SPN 110 FMI 31 – "Engine Coolant Temperature Stuck"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code is set when the coolant temperature sensor is stuck at the initialized value	Current coolant temperature has not changed more than 41°F (5°C) since engine startup	Engine coolant temperature stuck test is not complete AND No disabling faults present AND Engine soak time is greater than 360 min AND Engine is running	The DTC will set when setting criteria/enable conditions are met for 123 seconds out of a 154 second sample period

SPN 111 FMI 1 – "Engine Coolant Level Low"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code indicates engine coolant level in the surge tank is below sensor level	Coolant level is below sensor level	No disabling faults are present AND Engine has been running for at least 18 seconds	Continuous monitoring. The DTC will set when setting criteria/enable conditions are met for 16 seconds out of a 32 second sample period

SPN 111 FMI 3 – "Engine Coolant Level Sensor/Switch Circuit High"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This diagnostic detects a continuous short to high voltage in the signal circuit or the sensor.	Raw engine coolant level is greater than 90% of reference voltage (4.5V)	Ignition voltage is greater than or equal to 11V	The DTC will set when setting criteria/enable conditions are met for 16 seconds out of a 32 second sample period.

SPN 111 FMI 4 – "Engine Coolant Level Sensor/Switch Circuit Low"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This diagnostic detects a continuous short to low voltage in the signal circuit or the sensor.	Raw engine coolant level is less than 10% of reference voltage (0.5V)	Ignition voltage is greater than 11V	The DTC will set when setting criteria/enable conditions are met for 16 seconds out of a 32 second sample period.

SPN 132 FMI 0 – "Mass Air Flow Circuit High Input"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a MAF frequency that is high, indicating a circuit malfunction	Sensor signal is greater than 11900 Hz	Engine Speed is equal to, or greater than 1,000 RPM AND Engine runtime is greater than or equal to 5 seconds AND Ignition voltage is greater than or equal to 11V AND Stability delay time is greater than or equal to 1	DTC sets after 400 failed cylinder events, out of a 1600 event sample

SPN 132 FMI 1 – "Mass Air Flow Circuit Low Input"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a MAF frequency that is low, indicating a circuit malfunction	Sensor signal is less than 1000 Hz	Engine Speed is equal to, or greater than 1,000 RPM AND Engine runtime is greater than or equal to 5 seconds AND Ignition voltage is greater than or equal to 11V AND Stability delay time is greater than or equal to 1	DTC sets after 800 failed cylinder events, out of a 1600 event sample

SPN 132 FMI 2 – "Mass Air Flow Circuit Range/Performance"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
The MAF Rationality Diagnostic compares the MAF error (difference between MAF Sensor output and calculated flow rate value) to a calibration value	MAF sensor flow error is greater than a threshold based on engine speed and expected airflow OR MAF sensor flow error is less than a threshold based on engine speed and expected airflow	Engine is running AND Scan tool service mode is not active AND Most recent sample of MAF Circuit Low input and High Input passed AND Most recent sample of MAP rationality tests passed AND No disabling faults present AND Barometric pressure has updated since last pressure calculation AND Coolant Temperature is greater than or equal to 140°F (60°C) AND Engine Speed is greater than or equal to	DTC will set after 9.6 seconds failure out of 19.2 seconds sample period

		1000 RPM and less than or equal to 4000 RPM AND HVAC Clutch is not Transitioning AND Traction Control is not active AND Torque control is not cutting fuel to cylinders AND Torque Converter Clutch is stable AND Change in engine speed is less than or equal to 100 RPM AND Change in throttle position is less than or equal to 5% or change in MAP from initial MAP at start of test is less than or equal to 0 Psi (0 kPa) AND Change in Idle Airflow is less than or equal to 100% AND Change in Variable Cam Phasing Exhaust Valve 1 position is less than or equal to 52 phi AND Change in Variable Cam Phasing Exhaust Valve 2 position is less than or equal to 52phi AND Ignition voltage is greater than or equal to 11 V AND Ignition voltage is less than or equal to 16V AND Barometric Pressure greater than or equal to 10.4 Psi (72 kPa) AND Stability Delay Time is greater than or equal to 1.44 seconds	

SPN 132 FMI 20 – "Throttle Actuator Control Range/Performance"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects abnormally high engine Air flow Engine Air flow measurements not based on throttle position are compared with throttle position based estimated Air flow. If measured Air flow is much higher than throttle based estimated Air flow, the throttle body may not be "throttling" Air flow into the engine	Speed-Density (MAP/RPM) airflow minus ETC estimated airflow (TPS/RPM) is greater than 9 g/s OR MAF reading minus ETC estimated airflow (TPS/RPM) is greater than 9 g/s	Engine running, AND Throttle Actuation Mode is not OFF AND MAP sensor fault(s) not active AND MAF sensor fault(s) not active AND IAT sensor fault(s) not active	Continuously monitored, 2.5 second failure out of 10 seconds sample period

SPN 168 FMI 0 – "System Voltage High"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if system voltage is too high	System voltage is greater than 16 volts	Engine Running AND No Disabling faults present	DTC will set after 300 seconds of failure out of 360 seconds sample period

SPN 168 FMI 1 – "System Voltage Low"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if system voltage is too low	System voltage is less than 9 volts	Engine Running AND No Disabling faults present	DTC will set after 300 seconds of failure out of 360 seconds sample period

SPN 172 FMI 3 – "Intake Air Temperature Sensor 1 Circuit High"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Intake air temperature sensor signal is shorted to high voltage	IAT signal is greater than 4.95V (99%)	Engine running AND No disabling faults present	DTC will set after 9.6 seconds failure out of 19.2 seconds sample period

SPN 172 FMI 4 – "Intake Air Temperature Sensor 1 Circuit Low"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Intake air temperature sensor signal has been shorted to low voltage	IAT signal is less than 0.05V (1%)	Engine running AND No disabling faults present	DTC will set after 9.6 seconds failure out of 19.2 seconds sample period

SPN 172 FMI 10 – "Intake Air Temperature Sensor 1 Circuit Range/ Performance Bank 1"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Indicates when IAT sensor signal shows an unusually high rate of change that could only be attributed to electrical noise	Temperature change rate is greater than 18°F (10°C) per loop	Ignition On	DTC will set after 80 seconds failure out of 240 seconds sample period

SPN 172 FMI 20 – "Intake Air Temperature Sensor 1 – High Rationality"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Indicates when the intake air temperature sensor reading is unusually high given the vehicle and environment conditions in comparison to the reference sensor	The temperature reading of the IAT is at least 36°F (20°C) higher than the reference reading	Startup Coolant Temperature is greater than or equal to -4°F (-20°C) AND No Block Heater is present AND High Rationality Test has not run AND No Disabling Faults present AND Vehicle Soak time is greater than or equal to 6 hours or Cold Start Criteria has been met and Engine Runtime is less than or equal to 1000 seconds AND Engine is running AND Vehicle Speed is greater than or equal to 19 MPH (30 KPH) AND MAF is greater than or equal to 22 g/s and startup intake air temperature is less than 23°F (-5°C) for longer than 30 seconds	Runs once per key cycle based on the enable conditions

SPN 172 FMI 21 – “Intake Air Temperature Sensor 1 – Low Rationality”

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Indicates when the intake air temperature sensor reading is unusually low given the vehicle and environment conditions in comparison to the reference sensor	The startup temperature reading of the IAT is at least 36°F (20°C) lower than the reference reading	Startup Coolant Temperature is greater than or equal to -4°F (-20°C) AND No Block Heater is present AND High Rationality Test has not run AND No Disabling Faults present AND Vehicle Soak time is greater than or equal to 6 hours or Cold Start Criteria has been met and Engine Runtime is less than or equal to 1000 seconds AND Engine is running AND Vehicle Speed is greater than or equal to 19 MPH (30 KPH) AND MAF is greater than or equal to 22 g/s and startup intake air temperature is less than 23°F (-5°C) for longer than 30 seconds	Runs once per key cycle based on the enable conditions.

SPN 172 FMI 31 – "Intake Air Temperature Sensor Stuck"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Indicates when the intake air temperature sensor value is stuck at a value when it should be changing given the vehicle and environment conditions	The difference in minimum and maximum temperatures this key cycle is less than 5.4°F (3°C) AND Number of Complete Warming Cycles is greater than 3	**Common Enable Conditions** No Disabling Faults present AND Stuck test has not been completed AND Engine Soak Time is available AND Vehicle Soak Time is greater than or equal to 6 hours, or Cold Start criteria has been met and engine runtime is less than or equal to 1000 seconds AND IAT from last key cycle was saved AND Engine is running AND Coolant Temperature Bypass is false or Coolant Temperature is greater than or equal to -4°F (-20°C) **Drive Conditions** Vehicle Speed if greater than or equal to 19 MPH (30 KPH) AND MAF is greater than or equal to 22 g/s AND Drive Counter is greater than or equal to 60 **Idle Conditions** Throttle Position is less than or equal to 5% AND Vehicle Speed is less than or equal to 2 MPH (3 KPH) AND Idle counter is greater than or equal to 40	Runs once per key cycle based on the enable conditions

SPN 175 FMI 0 – "Engine Oil Over Temperature"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors for extremely high engine oil temperature. When the engine oil temperature is too high, the diagnostic's failure criterion is met. This diagnostic is in place alert the driver when the oil temperature is too high and could harm the engine.	Oil temperature is greater than 302°F (150°C)	Engine is running for at least 18 seconds AND No disabling faults are present.	The DTC will set when setting criteria/enabling conditions are met for 8 seconds out of a 16 second sample period

SPN 175 FMI 2 – "Engine Oil Temperature Sensor "A" Startup Rationality"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the engine oil temperature is similar to those of coolant and IAT upon achieving a cold start. Allowed to execute only for a short period of time after the cold start	The difference in oil and coolant temperature and oil and intake air temperature are greater than 68°F (20°C)	Engine Running AND Engine soak time is greater than 400 minutes OR Cold start criteria is met and accumulated engine runtime is less than 30 seconds AND No disabling faults present	The DTC will set when setting criteria/enabling conditions are met for 16 seconds out of a 32 second sample period. Test runs once per drive cycle.

SPN 175 FMI 2 – "Engine Oil Temperature Sensor "A" Warmed Up Rationality"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the engine oil temperature and coolant temperatures are similar given known air temperature and engine loads. Allows for continuous monitoring after startup conditions are achieved.	The difference in oil and coolant temperature greater than or equal to 140°F (60°C)	No disabling fault present AND Engine Running for longer than 1300 seconds OR No fuel cutoff conditions active OR Engine soak time is less than 10 minutes AND Coolant temperature is greater than 167°F (75°C) AND Warm up timer is greater than 900 seconds AND Oil warm pervious key is true AND Extreme heating conditions counter is less than 2000 seconds	The DTC will set when setting criteria/enabling conditions are met for 16 seconds out of a 32 second sample period. Test runs once per drive cycle.

SPN 175 FMI 3 – "Engine Oil Temperature Sensor High"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the oil temperature sensor is shorted to high voltage	Engine Oil Temperature signal is greater than 99% of reference voltage (4.94V)	Engine Run Time is greater than 90 seconds	The DTC will set when setting criteria/enabling conditions are met for 16 seconds out of a 32 second sample period

SPN 175 FMI 4 – "Engine Oil Temperature Sensor Low"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the oil temperature sensor is shorted to ground or open.	Engine Oil Temperature signal is less than 1.5% of reference voltage (0.07V)	Engine run time is greater than 60 seconds. AND Engine Coolant Temperature is less than 230°F (110°C)	DTC will set when setting criteria/enabling conditions are met for 16 seconds out of a 32 second sample period

SPN 188 FMI 16 – "Idle Control System RPM – Higher Than Expected"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects an idle speed that is 200 RPM more than the desired idle speed	Idle engine speed error (Actual RPM minus Desired RPM from idle control) is greater than 200 RPM	Idle Control is Active AND no disabling faults are present AND Canister Purge Fuel Flow is less than or equal to 100% AND Barometric pressure is greater than or equal to 10.4 Psi (72 kPa) AND Engine Runtime is greater than or equal to 2 seconds AND Air Intake Temperature is greater than or equal to -4°F (-20°C) AND Engine Coolant Temperature is greater than or equal to 32°F (0°C) AND Ignition Voltage is greater than or equal to 11V AND Ignition Voltage is less than or equal to 16V AND Scan Tool Service mode is not active AND CLO Request has not changed states AND The above conditions have been met for greater than or equal to 3 seconds AND RPM error is less than or equal to 200 RPM (passing) or RPM error is greater than 200 RPM when MAP is greater than or equal to 3 Psi (22 kPa) and throttle position is less than or equal to 0.6% or throttle position is greater than 0.6% when the desired throttle position has reached its control limit	Engine RPM continuously low for greater than or equal to 10.08 seconds

SPN 188 FMI 18 – "Idle Control System RPM – Lower Than Expected"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects an idle speed that is 100 RPM less than the desired idle speed	Desired RPM is greater than 100 RPM less than desired idle speed	Idle Control is Active AND No Disabling faults are present AND Canister Purge Fuel Flow is less than or equal to 100% AND Barometric Pressure is greater than or equal to 10.4 psi (72 kPa) AND Engine has been running for greater than or equal to 2 seconds AND Air Intake Temperature is greater than or equal to -4°F (-20°C) AND Coolant temperature is greater than or equal to 32° (0°C) AND Ignition voltage is greater than or equal to 11V AND Ignition voltage is less than or equal to 16V AND Scan Tool Service Mode is not active AND CLO request has not changed states AND Above conditions have been met for greater than or equal to 3 seconds AND RPM error is small (passing) is less than or equal to 100RPM or RPM error is greater than 100 RPM and MAP is less than or equal to 14.5 psi (100 kPa) and Idle Air Flow is greater than 70% or Idle Air Flow is less than or equal to 70% when Throttle Position has reached its control limit	Engine RPM continuously low for greater than or equal to 10.08 seconds

SPN 191 FMI 5 – "Vehicle Speed Sensor 'A' Circuit No Signal – Power Test"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a loss of vehicle speed signal	Power Test: Vehicle speed signal is showing vehicle speed as less than 6 MPH (10 KPH)	The vehicle is in a run state AND Ignition Voltage is between 10 V – 16 V AND No Throttle Position Sensor (TPS) fault present AND No Manifold Absolute Pressure (MAP) fault present AND Engine Coolant Temperature is greater than or equal to 140°F (60°C) AND Off Vehicle serial device is NOT in control of the vehicle AND MAP reading is greater than or equal to 7.3 Psi (50 kPa) AND Throttle angle is between 20% - 50%. AND The engine speed is between 1200 RPM – 2300 RPM. AND Vehicle speed from Transmission Output Speed Shaft Sensor (TOSS) is greater than or equal to 6 MPH (10 KPH)	DTC will set after 48 seconds of failure out of 80 seconds sample period

SPN 191 FMI 5 – "Vehicle Speed Sensor 'A' Circuit No Signal – Deceleration Test"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a loss of vehicle speed signal	Vehicle speed signal is showing vehicle speed as less than 6 MPH (10 KPH) AND The change in Engine RPMs is less than 2500 RPMs	The vehicle is in a run state AND Ignition Voltage is between 10 V – 16 V AND No Throttle Position Sensor (TPS) fault present AND No Manifold Absolute Pressure (MAP) fault present AND Engine Coolant Temperature is greater than or equal to 140°F (60°C) AND Off Vehicle serial device is NOT in control of the vehicle AND MAP is less than or equal to 6.5 Psi (45 kPa) AND TPS is less than or equal to 20% AND Engine speed is less than or equal to 3000 AND Engine Speed is greater than or equal to 1400 RPM	DTC will set after 48 seconds of failure out of 80 seconds sample period

SPN 251 FMI 2 – "ECM/PCM Engine On Timer Performance"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects inaccuracy of the LPC (Engine Off Timer) by comparing the elapsed start/end time of the LPC during a reference time period defined by a timer within the controller's main processor.	The difference between the change in time for the free running timer and the low power counter is greater than 1.7 seconds	No disabling faults present. AND LPC Power Off test has not been completed. AND Engine was running for at least 5 seconds AND Then Ignition was turned off AND Engine State is in Power Off Delay AND Free Running Timer has been on for greater than 2.2 seconds	The DTC will set when setting criteria/enable conditions are met for 0.16 seconds out of a 0.32 second sample period

SPN 518 FMI 2 – "Engine Torque Control Rationality Steady State"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if delivered torque is grossly different from desired torque	When Steady State Torque Error is greater than 74 ft/lb (100 Nm) while Actual Net Torque is greater than or equal to 14.7 ft/lb (20 Nm) OR Torque Throttle Load is greater than or equal to 1% OR Steady State Torque Error is less than -1510 ft/lb (-2048 Nm) while Desired ETC throttle position is less than or equal to 0%	If Engine is running AND Engine Speed is greater than 500 RPM AND Desired Flywheel Torque is within 14.7 ft/lb (20 Nm) AND ETC Power Control Module is not commanding forced engine shutdown AND Steady State Torque Timer is greater than 1	DTC sets after 0.04 seconds failure out of 0.4 seconds sample period

SPN 518 FMI 2 – "Engine Torque Control Rationality"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if delivered torque is grossly different from desired torque	When Dynamic Torque Error is greater than 30%, while Net Torque is greater than or equal to 14.7 ft/lb (20 Nm) or torque Throttle Load is greater than or equal to 1% OR Dynamic Torque Error is less than -256% while Desired ETC throttle position is less than or equal to 0%	If Engine is running and ETC Power Control Module is not commanding forced engine shutdown	Torque too high: DTC sets after 14 seconds failure out of 20 seconds sample period Torque too low: DTC sets after 10 seconds failure out of 20 seconds sample period

SPN 588 FMI 13 – "Engine Serial Number Not Programmed or Incompatible"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects if the Engine Identification Number (EIN) has not been programmed.	CAN diagnostics detects incorrect or missing engine identification number. EIN bytes or Hex values are all 0x00	The Ignition is in the On position for at least 0.01 seconds.	The DTC will set when setting criteria/enable conditions are met for 0.08 seconds out of a 0.2 second sample period

SPN 629 FMI 2 – "Internal Control Module Torque Calculation Performance"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Internal Control Module Torque Calculation Performance	ECM determines that delivered torque is grossly different from desired torque/calculated threshold	Engine is RUNNING	The DTC will set when setting criteria/enable conditions are met for 0.2 seconds out of a 2 second sample period

SPN 629 FMI 12 – "ECM Processor – CPU"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects errors in the main CPU A/D #1 operation	A/D #1 channel scan completes interrupt does not trigger, indicates A/D has stopped scanning	Ignition is ON AND Enable delay time is greater than or equal to 0. AND Various internal ECM checks passed	The DTC will set after 6.4 seconds of failure out of 12.8 seconds sample period

SPN 629 FMI 12 – "ECM Processor – ETC"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects a difference between primary and redundant paths for ETC critical parameters	Mismatch between paths for APS inputs, driver command or power control states exists	Ignition is ON	The DTC will set after 0.2 seconds of failure out of 0.3 seconds sample period

SPN 629 FMI 12 – "ECM Processor – Internal Communication"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects a state of health fault in the HWIO	SPI error and SPI Communication error internally detected	ECM is ON AND SPN 629 FMI 12 not active	40 ms (1 test loop)

SPN 629 FMI 12 – "ECM Processor – Main Processor"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects a state of health fault in the HWIO	Seven types of faults are internally detected by the CPU	ECM is ON AND SPN 629 FMI 12 not active	40 ms (1 test loop)

SPN 629 FMI 12 – "ECM Processor – Checking Processor"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects a state of health fault in the HWIO	Four types of faults are internally detected for the C&R	ECM Is ON AND Engine state is not in Power Off Delay OR Power Down Timer is less than or equal to 4 seconds and ETC SOH fault action has been taken and SPN 629 FMI 12 not set and no communication fault present OR Main CPU fault present and Checking CPU fault present and CPU fault is not present and communication fault is not present	40 ms (1 test loop)

SPN 629 FMI 12 – "ECM Processor – Internal"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects errors in the main CPU internal registers	Data patterns read back from internal registers after writing do not match	Ignition ON AND Enable delay time is greater than or equal to 0 AND various internal ECM checks passed	The DTC will set after 6.4 seconds of failure out of 12.8 seconds sample period

SPN 629 FMI 12 – "ECM Processor – Sequencing"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects an Out-of-Sequence of approximately 16 steps between the APS Read to TPS Out	Misc.: Sequence of Pedal to Throttle Processing gets out-of-order. Steps are order specific. Non-volatile Running reset occurs due to a problem with sequencing	Ignition ON	DTC will set after 1.6 seconds of continuous failure, diagnostic will not run until Ignition has been on for 63 seconds

SPN 629 FMI 14 – "ECM/PCM Processor – Analog to Digital APP Input Correlation"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects errors in the Analog to Digital processing of the Accelerator Position Pedal (APP) sensor by comparing readings from separate A/D units.	For APS1: When the difference between the Analog and Digital sensors are greater than the Correlation Threshold (5% Vref) For APS2: When the difference between the Analog and Digital sensors are greater than the Correlation Threshold (5% Vref)	Ignition is ON. AND Ignition voltage is between 5.5 and 20 V.	DTC will set after .94 seconds of failure out of a 0.31 second sample period.

SPN 629 FMI 31 – "ECM Processor"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects if the computer is operating properly and timers are not able to reset the Main CPU when actively tested	During PCM powerdown logic, the COP Timer is Tested. Servicing is stopped. The logic waits for a Reset. If no Reset occurs, the COP Timer Diagnostic Fails	Ignition is ON AND Enable delay time is greater than or equal to 0 sec AND Non-Volatile failure has not occurred AND Running reset has not occurred this Key-ON cycle AND HWIO has tested this diagnostic this loop (160 ms)	1 test per Power-Off (data sampled at next Power-On)

SPN 630 FMI 13 – "ECM RAM Stack Error"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects errors in Main CPU stack usage	Stack Pointer does not return to same initial value each loop OR data pattern written top to bottom of stack memory area is changed	RAM Stack Check is Enabled	Evaluated every 10 ms for pass or fail

SPN 630 FMI 13 – "ECM RAM Error"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects failed bits in Main CPU RAM	Data read from RAM is different from values written to RAM in the diagnostic test	System Voltage is greater than 8V	8 consecutive failures, tested at power on and during wait time

SPN 630 FMI 13 – "ECM ROM Checksum Error"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Compares checksum of S/W and calibrations to the expected checksum	Checksum of S/W and calibrations is not equal to expected checksum	None, runs when ECM is ON	Tested at power down

SPN 636 FMI 2 – “Crankshaft Position Sensor "A" Circuit Range/Performance”

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Extra or missing pulses between consecutive crank sensor reference pulses	At least 2 consecutive CKP errors have been sensed AND At least 20 total errors have been sensed	Engine speed is greater than or equal to 350 RPM AND Crank Revolution is complete	The DTC will set when 20 test failures are detected within 100 test samples.

SPN 636 FMI 4 – “Crankshaft Position Sensor "A" Circuit”

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
No crankshaft positions pulses received by the ECM; monitored using the cam state change method.	At least 19 camshaft pulses accumulated with no crank signal present	Engine Speed is less than 350 RPM AND Ignition is ON AND Diagnostic mode calibrated to Cam State Method AND Camshaft is rotating AND Time between cam enable events is greater than or equal to 0.4 events	Immediate

SPN 639 FMI 5 – “High Speed CAN Communication BUS”

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects if the BUS is in the BUS OFF state	BUS OFF state indicated by hardware	Ignition voltage is 8V AND Scan Tool Service Mode is OFF	DTC will set after 0.8 seconds of failure out of 1.2 seconds sample period

SPN 639 FMI 8 – "Vehicle Communication BUS A Performance"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects if CAN communication has a general failure and no communication is possible.	No messages received from the TCM, ABS and PTO AND No messages received from the BCM (Crank Inhibit) AND No Messages received from the RPTO (Park Brake) AND No messages received from the BCM (Engine Shutdown)	Engine is running AND Engine Runtime is greater than 2 seconds AND no scan tool control device is present AND ignition voltage is above 8V AND Time Delay after voltage returns above threshold to enable CAN diagnostic is greater than 1 second	DTC will set after 0.32 seconds of failure out of 1.28 seconds sample period

Injector Circuit High: SPN 651, 652, 653, 654, 655, 656, 657, 658 FMI 3

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a continuous high voltage in the ground control circuit from the fuel injector to the ECM.	Sensor signal is higher than threshold voltage Feedback voltage is greater than or equal to HWIO Threshold Voltage of 400mV	Main Relay Voltage is between 10V and 16V AND Main Relay Open, Main Relay STG, and Main Relay STB recent test completion status is Pass AND Main Relay Open, Main Relay STG and Main Relay STB Fail Criteria Not Met AND Main Relay commanded On AND Main Relay Stability Delay is greater than or equal to 1.3 seconds AND Engine Runtime Stability Delay is greater than or equal to 1.3 seconds	The DTC will set when setting criteria/enabling conditions are met for 0.4 seconds out of a 0.8 second sample period.

Injector Circuit Low: SPN 651, 652, 653, 654, 655, 656, 657, 658 FMI 4

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a continuous short to ground in the injector control circuit from the fuel injector to the ECM	Sensor signal is less than threshold Feedback resistance is less than or equal to HWIO Threshold of 0.5 ohms	Main Relay Voltage is between 10V and 16V AND Main Relay Open, Main Relay STG, and Main Relay STB recent test completion status is Pass AND Main Relay Open, Main Relay STG and Main Relay STB Fail Criteria Not Met AND Main Relay commanded On AND Main Relay Stability Delay is greater than or equal to 1.3 seconds AND Engine Runtime Stability Delay is greater than or equal to 1.3 seconds	The DTC will set when setting criteria/enabling conditions are met for 0.4 seconds out of a 0.8 second sample period.

Injector Circuit/Open: SPN 651, 652, 653, 654, 655, 656, 657, 658 FMI 5

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a continuous open on the fuel injector control wire circuit from the fuel injector to the ECM.	Sensor signal is less than threshold. Feedback resistance is greater than or equal to HWIO threshold is 200k ohms	Main Relay Voltage is between 10V and 16V AND Main Relay Open, Main Relay STG, and Main Relay STB recent test completion status is Pass AND Main Relay Open, Main Relay STG and Main Relay STB Fail Criteria Not Met AND Main Relay commanded On AND Main Relay Stability Delay is greater than or equal to 1.3 seconds AND Engine Runtime Stability Delay is greater than or equal to 1.3 seconds	The DTC will set when setting criteria/enabling conditions are met for 0.4 seconds out of a 0.8 second sample period.

SPN 677 FMI 3 – “Starter Relay “A” Circuit High”

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
DTC detects if Starter Relay Circuit is Shorted to Battery	Voltage reading less than or equal to 330 mV	**Powered by Main Relay** Main Relay Voltage is greater than or equal to 10V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open fault is not active AND Main Relay Short to Ground fault is not active AND Main Relay Short to Voltage fault is not active AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Open failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Ground failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Battery failure threshold AND Main Relay is commanded ON AND Main Relay Stability Delay is greater than or equal to 1.28 seconds AND Engine Runtime Stability Delay is greater than or equal to 1.28 seconds **Device Specific Logic** Device On If Device’s circuit low side drive is false, Short to Ground specific is enabled, else high side device is true, Short to Battery specific device is enabled Device Off Start switch bypass is true then start switch is closed	DTC will set after 6.40 seconds failure out of 12.8 seconds sample period

		AND Park Neutral Clutch Switch Bypass is true if manual transmission vehicle, no clutch input bottom position faults active and clutch is fully depressed, open device specific is enabled and if device is low side drive is false, short to ground device specific is enabled, else short to battery device specific is enabled ELSE manual transmission vehicle is false, CAN communication fault is not active and PRNDL data from CAN is valid and PRNDL switch is in park or neutral, open device specific is enabled and if device is low side drive is false, short to ground device specific is enabled else short to battery specific is enabled ELSE Park Neutral Clutch bypass is True, open device specific is enabled and if device low side drive is false, short to ground device specific is enabled else short to battery specific is enabled	

SPN 677 FMI 4 – "Starter Relay "A" Circuit Low"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
DTC detects if Starter Relay Circuit is Shorted to Ground	Resistance reading greater than or equal to 0.5 ohm	**Powered by Main Relay** Main Relay Voltage is greater than or equal to 10V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open fault is not active AND Main Relay Short to Ground fault is not active AND Main Relay Short to Voltage fault is not active AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Open failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Ground failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Battery failure threshold AND Main Relay is commanded ON AND Main Relay Stability Delay is greater than or equal to 1.28 seconds AND Engine Runtime Stability Delay is greater than or equal to 1.28 seconds **Device Specific Logic** Device On If Device's circuit low side drive is false, Short to Ground specific is enabled, else high side device is true, Short to Battery specific device is enabled Device Off Start switch bypass is true then start switch is closed	DTC will set after 6.40 seconds failure out of 12.8 seconds sample period

		AND Park Neutral Clutch Switch Bypass is true if manual transmission vehicle, no clutch input bottom position faults active and clutch is fully depressed, open device specific is enabled and if device is low side drive is false, short to ground device specific is enabled, else short to battery device specific is enabled ELSE manual transmission vehicle is false, CAN communication fault is not active and PRNDL data from CAN is valid and PRNDL switch is in park or neutral, open device specific is enabled and if device is low side drive is false, short to ground device specific is enabled else short to battery specific is enabled ELSE Park Neutral Clutch bypass is True, open device specific is enabled and if device low side drive is false, short to ground device specific is enabled else short to battery specific is enabled	

SPN 677 FMI 5 – "Starter "A" Circuit Open"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
DTC detects if Starter Relay Circuit is Open	Resistance reading less than or equal to 200k ohm	**Powered by Main Relay** Main Relay Voltage is greater than or equal to 10V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open fault is not active AND Main Relay Short to Ground fault is not active AND Main Relay Short to Voltage fault is not active AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Open failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Ground failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Battery failure threshold AND Main Relay is commanded ON AND Main Relay Stability Delay is greater than or equal to 1.28 seconds AND Engine Runtime Stability Delay is greater than or equal to 1.28 seconds **Device Specific Logic** Device On If Device's circuit low side drive is false, Short to Ground specific is enabled, else high side device is true, Short to Battery specific device is enabled Device Off Start switch bypass is true then start switch is closed	DTC will set after 6.40 seconds failure out of 12.8 seconds sample period

		AND Park Neutral Clutch Switch Bypass is true if manual transmission vehicle, no clutch input bottom position faults active and clutch is fully depressed, open device specific is enabled and if device is low side drive is false, short to ground device specific is enabled, else short to battery device specific is enabled ELSE manual transmission vehicle is false, CAN communication fault is not active and PRNDL data from CAN is valid and PRNDL switch is in park or neutral, open device specific is enabled and if device is low side drive is false, short to ground device specific is enabled else short to battery specific is enabled ELSE Park Neutral Clutch bypass is True, open device specific is enabled and if device low side drive is false, short to ground device specific is enabled else short to battery specific is enabled	

SPN 723 FMI 5 – “Camshaft Position Sensor "A" Circuit”

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines in the proper number of teeth/edges are read from the cam sensor on each cam revolution	58x cam reference event count is greater than or equal to 1	Engine Running	DTC set if 5 failures are detected out of every 50 test samples

SPN 723 FMI 7 – "Camshaft Position Sensor "A" Circuit Range/Performance"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the cam sensor is providing alternating high and low signals.	Cam tooth/edge counter is anything other than 4	Engine Running	DTC set if 5 test failures are detected within 15 test samples

SPN 876 FMI 3 – "A/C Clutch Relay Control Circuit High"

Back to Diagnostics – SPN 876 FMI 3

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
A/C Clutch Relay Control Circuit High – Short to Battery	Feedback voltage reading greater than or equal to threshold of 400 mV	Main Relay Voltage is greater than or equal to 10V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open fault is not active AND Main Relay Short to Ground fault is not active AND Main Relay Short to Voltage fault is not active AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Open failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Ground failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Battery failure threshold AND Main Relay Stability Delay is greater than or equal to 1.28 seconds AND Engine Runtime Stability Delay is greater than or equal to 1.28 seconds	DTC will set after 6.40 seconds failure out of 12.8 seconds sample period

SPN 876 FMI 4 – "A/C Clutch Relay Control Circuit Low"

Back to Diagnostics – SPN 876 FMI 4

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
A/C Clutch Relay Control Circuit Low – Short to Ground	Feedback resistance reading less than or equal to threshold of 0.5 ohm	Main Relay Voltage is greater than or equal to 10V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open fault is not active AND Main Relay Short to Ground fault is not active AND Main Relay Short to Voltage fault is not active AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Open failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Ground failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Battery failure threshold AND Main Relay Stability Delay is greater than or equal to 1.28 seconds AND Engine Runtime Stability Delay is greater than or equal to 1.28 seconds	DTC will set after 6.40 seconds failure out of 12.8 seconds sample period

SPN 876 FMI 5 – "A/C Clutch Relay Control Circuit Open"

Back to Diagnostics – SPN 876 FMI 5

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
A/C Clutch Relay Control Circuit Open	Feedback resistance reading greater than or equal to threshold of 200k ohm	Main Relay Voltage is greater than or equal to 10V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open fault is not active AND Main Relay Short to Ground fault is not active AND Main Relay Short to Voltage fault is not active AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Open failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Ground failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Battery failure threshold AND Main Relay Stability Delay is greater than or equal to 1.28 seconds AND Engine Runtime Stability Delay is greater than or equal to 1.28 seconds	DTC will set after 6.40 seconds failure out of 12.8 seconds sample period

SPN 876 FMI 6 – "A/C Clutch 2 Relay Control Circuit Open"

Back to Diagnostics – SPN 876 FMI 6

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
A/C Clutch Relay Control Circuit Open	Feedback resistance reading greater than or equal to threshold of 200k ohm	Main Relay Voltage is greater than or equal to 10V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open fault is not active AND Main Relay Short to Ground fault is not active AND Main Relay Short to Voltage fault is not active AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Open failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Ground failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Battery failure threshold AND Main Relay Stability Delay is greater than or equal to 1.63 seconds AND Engine Runtime Stability Delay is greater than or equal to 1.63 seconds	DTC will set after 6.40 seconds failure out of 12.8 seconds sample period

SPN 876 FMI 16 – "A/C Clutch 2 Relay Control Circuit High"

Back to Diagnostics – SPN 876 FMI 16

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
A/C Clutch Relay Control Circuit High – Short to Battery	Feedback voltage reading greater than or equal to threshold of 400 mV	Main Relay Voltage is greater than or equal to 10V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open fault is not active AND Main Relay Short to Ground fault is not active AND Main Relay Short to Voltage fault is not active AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Open failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Ground failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Battery failure threshold AND Main Relay Stability Delay is greater than or equal to 1.63 seconds AND Engine Runtime Stability Delay is greater than or equal to 1.63 seconds	DTC will set after 6.40 seconds failure out of 12.8 seconds sample period

SPN 876 FMI 18 – "A/C Clutch 2 Relay Control Circuit Low"

Back to Diagnostics – SPN 876 FMI 18

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
A/C Clutch Relay Control Circuit Low – Short to Ground	Feedback resistance reading less than or equal to threshold of 0.5 ohm	Main Relay Voltage is greater than or equal to 10V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open fault is not active AND Main Relay Short to Ground fault is not active AND Main Relay Short to Voltage fault is not active AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Open failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Ground failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Battery failure threshold AND Main Relay Stability Delay is greater than or equal to 1.63 seconds AND Engine Runtime Stability Delay is greater than or equal to 1.63 seconds	DTC will set after 6.40 seconds failure out of 12.8 seconds sample period

SPN 1045 FMI 2 – "Brake Switch A/B Correlation"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects failures in the 2 brake inputs by comparing them to each other while driving. This diagnostic is disabled if the vehicle is configured for a single brake switch, and if a control module is turning brake lights ON	If time (greater than 2.08 sec) from state change of one brake input to when the other brake input changes state (making switch states VBRAK1= VBRAKE2 equal again) is greater than a cal; increase fail count ELSE: If VBRAKE 1 becomes equal to VBRAKE2 in less time: decrease fail count	Engine running AND VSS No Signal diagnostic SPN 191 FMI 5 is not enabled AND Filtered cruise vehicle speed is greater than 12.5 mph (20 kph) for 1 second OR VSS No Signal diagnostic SPN 191 FMI 5 is enabled AND Brake 2 source is one among Primary CAN, Secondary CAN, or Hardwired input	When number of brake lamp or switch state changes with failure present occurs 39 times.

SPN 1045 FMI 7 – "Brake Switch "A" Circuit"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects failures in the brake 1 (brake lamp) input by monitoring it while the vehicle comes to a stop. A brake ON indication must occur as the vehicle stops and the brakes must have been OFF at some time since the last time the vehicle stopped.	IF Vehicle speed is less than 3.16 mph (5 kph) AND Vehicle acceleration is less than -3.4 mph/s (-5.5 kph/s) THEN Brake lamp input must switch states for at least 1.8 seconds AND Brake lamp input transition occurred since last stop	Engine Running AND VSS No Signal diagnostic (SPN 191 FMI 5) is not failed AND Filtered cruise vehicle speed is greater than 12.5 mph (20 kph) for 1 second	15 stops with the failure present

SPN 1109 FMI 0 – "Throttle Actuator Control System – Forced Idle"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code reports a fail if the system is in Forced Idle Mode (Limp-Home Mode)	ETC Driver Command Mode is Forced Idle	Engine is in Power Off Delay state	None, reports code when limp-home mode activates

SPN 1109 FMI 15 – "Throttle Actuator Control System – Forced Limited Power"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code reports a fail if the system is in Limit Performance Mode (Limp-Home Mode)	ETC Driver Command Mode is Limit Performance	Engine is in Power Off Delay state	None, reports code when limp-home mode activates

SPN 1109 FMI 16 – "Throttle Actuator Control System – Forced Limited RPM"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code reports a fail if the system is in Power Manage Mode (Limp-Home Mode)	ETC Power Control Mode is Power Manage	Engine is in Power Off Delay state	None, reports code when limp-home mode activates

SPN 1110 FMI 31 – "Throttle Actuator Control System – Forced Engine Shutdown"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code reports a fail if the system is in Forced Engine Shutdown Mode, alerting service to a severe problem	ETC Power Control Mode is Forced Shutdown	Engine is in Power Off Delay state	None, reports code when limp-home mode activates

SPN 1268 FMI 3 – “Ignition Coil "A" Primary Control Circuit High”
SPN 1275 FMI 3 – “Ignition Coil "B" Primary Control Circuit High”
SPN 1274 FMI 3 – “Ignition Coil "C" Primary Control Circuit High”
SPN 1269 FMI 3 – “Ignition Coil "D" Primary Control Circuit High”
SPN 1273 FMI 3 – “Ignition Coil "E" Primary Control Circuit High”
SPN 1272 FMI 3 – “Ignition Coil "F" Primary Control Circuit High”
SPN 1271 FMI 3 – “Ignition Coil "G" Primary Control Circuit High”
SPN 1270 FMI 3 – “Ignition Coil "H" Primary Control Circuit High”

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a continuous high voltage in the control circuit from the coil to the ECM	Feedback resistance is less than or equal to 100 ohms	Main Relay is commanded ON AND Main Relay voltage is greater than 9V And Main Relay voltage is less than 16V AND No Main Relay circuit faults are active AND Most recent sample does not indicate output driver exceeds Main Relay open, short to ground, or short to voltage thresholds AND Main Relay has been ON for greater than 0.04 seconds AND Engine has been running greater than or equal to 0 seconds	Continuous monitoring DTC sets after .94 seconds failure out of 1.88 seconds sample period

SPN 1268 FMI 4 – “Ignition Coil "A" Primary Control Circuit Low”
SPN 1275 FMI 4 – “Ignition Coil "B" Primary Control Circuit Low”
SPN 1274 FMI 4 – “Ignition Coil "C" Primary Control Circuit Low”
SPN 1269 FMI 4 – “Ignition Coil "D" Primary Control Circuit Low”
SPN 1273 FMI 4 – “Ignition Coil "E" Primary Control Circuit Low”
SPN 1272 FMI 4 – “Ignition Coil "F" Primary Control Circuit Low”
SPN 1271 FMI 4 – “Ignition Coil "G" Primary Control Circuit Low”
SPN 1270 FMI 4 – “Ignition Coil "H" Primary Control Circuit Low”

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a continuous short to ground in the control circuit from the coil to the ECM	Feedback resistance is less than or equal to 100 ohms	Main Relay is commanded ON AND Main Relay voltage is greater than 9V And Main Relay voltage is less than 16V AND No Main Relay circuit faults are active AND Most recent sample does not indicate output driver exceeds Main Relay open, short to ground, or short to voltage thresholds AND Main Relay has been ON for greater than 0.04 seconds AND Engine has been running greater than or equal to 0 seconds	Continuous monitoring DTC sets after .94 seconds failure out of 1.88 seconds sample period

SPN 1268 FMI 5 – "Ignition Coil "A" Primary Control Circuit Open"
SPN 1275 FMI 5 – "Ignition Coil "B" Primary Control Circuit Open"
SPN 1274 FMI 5 – "Ignition Coil "C" Primary Control Circuit Open"
SPN 1269 FMI 5 – "Ignition Coil "D" Primary Control Circuit Open"
SPN 1273 FMI 5 – "Ignition Coil "E" Primary Control Circuit Open"
SPN 1272 FMI 5 – "Ignition Coil "F" Primary Control Circuit Open"
SPN 1271 FMI 5 – "Ignition Coil "G" Primary Control Circuit Open"
SPN 1270 FMI 5 – "Ignition Coil "H" Primary Control Circuit Open"
Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a continuous open in the control circuit from the coil to the ECM	Feedback current is less than 25 uA	Main Relay is commanded ON AND Main Relay voltage is greater than 9V And Main Relay voltage is less than 16V AND No Main Relay circuit faults are active AND Most recent sample does not indicate output driver exceeds Main Relay open, short to ground, or short to voltage thresholds AND Main Relay has been ON for greater than 0.04 seconds AND Engine has been running greater than or equal to 0 seconds	Continuous monitoring DTC sets after .94 seconds failure out of 1.88 seconds sample period

SPN 1322 FMI 31 – "Random/Multiple Cylinder Misfire"
Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Random/Multiple Cylinder Misfire DTC will set when misfire is occurring on multiple cylinders	Emission Damaging Misfire malfunction criteria met OR Catalyst Damaging Misfire malfunction criteria met AND Random / Multiplier Cylinder Misfire P-code reporting 1 selected OR Multiplier (2 or more) Cylinder misfire detected	Misfire not delayed due to any enabling conditions listed in below misfire enabling conditions not being met AND All delays expired (Misfire delay counter equals 0)	Continuous Monitoring

SPN 1323 FMI 31 – “Cylinder 1 Misfire”
SPN 1324 FMI 31 – “Cylinder 2 Misfire”
SPN 1325 FMI 31 – “Cylinder 3 Misfire”
SPN 1326 FMI 31 – “Cylinder 4 Misfire”
SPN 1327 FMI 31 – “Cylinder 5 Misfire”
SPN 1328 FMI 31 – “Cylinder 6 Misfire”
SPN 1329 FMI 31 – “Cylinder 7 Misfire”
SPN 1330 FMI 31 – “Cylinder 8 Misfire”
Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Specific cylinder misfire DTC/s will be set when 'high' percentage of misfire is occurring on individual cylinder/s.	Emission Damaging Misfire malfunction criteria met OR Catalyst Damaging Misfire malfunction criteria met AND Random / Multiplier Cylinder Misfire P-code reporting 1 selected AND Ratio of specific cylinder misfire history counts to total misfire counts, calculated for every 200 revs (100 engine cycles) greater than 0.9	Check Air Conditioner transition status IF A/C clutch transition is not active and if the conditions transition from not active to active, wait for greater than or equal to 0 engine cycles to re-enable misfire AND check engine load above zero torque load line condition IF engine load is above the zero torque load line conditions transition from not active to active, wait for greater than or equal to 15 engine cycles to re-enable misfire AND Check engine operating conditions (speed and load) in detectable region IF Engine load is above zero torque load line AND Engine load and speed is in Cylinder Mode detectable region OR Engine load and speed is in Revolution Mode detectable region	Continuous Monitoring

SPN 1347 FMI 3 – "Fuel Pump 1 Circuit Short High"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a high voltage in the Fuel Pump Relay 1 output circuit	Feedback voltage is greater than or equal to HWIO threshold (400 mV)	Main Relay Voltage is greater than or equal to 10V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open, Main Relay STG, and Main Relay STB recent test completion status is Pass AND Main Relay Open, Main Relay STG and Main Relay STB Fail Criteria Not Met AND Main Relay commanded On AND Main Relay Stability Delay is greater than or equal to 1.3 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds	The DTC will set when setting criteria/enabling conditions are met for 0.1 seconds out of a 0.4 second sample period

SPN 1347 FMI 4 – "Fuel Pump 1 Circuit Short Low"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a low voltage in the Fuel Pump Relay 1 output circuit	Feedback resistance is less than or equal to HWIO threshold (0.5 ohm)	Main Relay Voltage is greater than or equal to 10V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open, Main Relay STG, and Main Relay STB recent test completion status is Pass AND Main Relay Open, Main Relay STG and Main Relay STB Fail Criteria Not Met AND Main Relay commanded On AND Main Relay Stability Delay is greater than or equal to 1.3 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds	The DTC will set when setting criteria/enabling conditions are met for 0.1 seconds out of a 0.4 second sample period

SPN 1347 FMI 5 – "Fuel Pump 1 Circuit Open"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects an open in the Fuel Pump Relay 1 output circuit	Feedback resistance is less than or equal to HWIO threshold (200k ohm)	Main Relay Voltage is greater than or equal to 10V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open, Main Relay STG, and Main Relay STB recent test completion status is Pass AND Main Relay Open, Main Relay STG and Main Relay STB Fail Criteria Not Met AND Main Relay commanded On AND Main Relay Stability Delay is greater than or equal to 1.3 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds	The DTC will set when setting criteria/enabling conditions are met for 0.1 seconds out of a 0.4 second sample period

SPN 1352 FMI 3 – "Knock Sensor 1 Circuit High"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a continuous short to battery in the signal circuit or the sensor	Knock sensor intensity is too large (greater than 95%)	Engine speed is greater than or equal to 800 RPM AND No disabling faults present AND Knock common enable criteria met	DTC set if failure is detected for 4.16 seconds out of Test sample is 10.24 seconds

SPN 1352 FMI 4 – "Knock Sensor 1 Circuit Low"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a continuous short to ground in the signal circuit or the sensor	Knock sensor intensity is too small (Less than 5%)	Engine Speed is equal to, or greater than 800 RPM AND no disabling faults are present AND Knock Common Enable Criteria met	DTC set if failure is detected for 4.16 seconds out of Test sample is 10.24 seconds

SPN 1352 FMI 5 – "Knock Sensor 1 Circuit"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code is set when the ECM detects sensor failure, or an open in sensor wiring	Knock sensor intensity is too small for engine conditions	Knock Common Enable Criteria met AND Engine Speed is equal to, or greater than 800 RPM	DTC set if failure is detected for 4.16 seconds out of Test sample is 20.48 seconds

SPN 1353 FMI 3 – "Knock Sensor 2 Circuit High"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a continuous short to battery in the signal circuit or the sensor	Knock sensor intensity is too large (greater than 95%)	Engine Speed is equal to, or greater than 800 RPM AND no disabling faults are present AND Knock Common Enable Criteria met	DTC set if failure is detected for 4.16 seconds out of Test sample is 10.24 seconds

SPN 1353 FMI 4 – "Knock Sensor 2 Circuit Low"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a continuous short to ground in the signal circuit or the sensor	Knock sensor intensity is too small (less than 5%)	Engine Speed is equal to, or greater than 800 RPM AND no disabling faults are present AND Knock Common Enable Criteria met	DTC set if failure is detected for 4.16 seconds out of Test sample is 10.24 seconds

SPN 1353 FMI 5 – "Knock Sensor 2 Circuit"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code is set when the ECM detects sensor failure, or an open in sensor wiring	Knock sensor intensity is too small for engine conditions	Knock Common Enable Criteria met AND Engine Speed is greater than or equal to 800 RPM	DTC set if failure is detected for 4.16 seconds out of Test sample is 20.48 seconds

SPN 1485 FMI 3 – "ECM Power Relay Control Circuit High"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the Powertrain Relay Control circuit is shorted high	Feedback voltage is greater than or equal to HWIO threshold (2V)	Ignition Voltage is between 11 and 16 volts. AND Ignition Stability Delay is greater than or equal to 1.3 secs AND Engine run time Stability Delay is greater than or equal to 0 sec.	The DTC will set when setting criteria/enable conditions are met for 6.4 seconds out of 12.8 second sample period.

SPN 1485 FMI 4 – "ECM Power Relay Control Circuit Low"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the Powertrain Relay Control circuit is shorted low	Feedback resistance is less than or equal to HWIO threshold (0.5 ohm)	Ignition Voltage is between 11 and 16 volts. AND Ignition Stability Delay is greater than or equal to 1.3 secs AND Engine run time Stability Delay is greater than or equal to 0 sec.	The DTC will set when setting criteria/enable conditions are met for 6.4 seconds out of 12.8 second sample period.

SPN 1485 FMI 5 – "ECM Power Relay Control Circuit Open"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the Powertrain Relay Control circuit is open	Feedback resistance is greater than or equal to HWIO threshold (200 kohm)	Ignition Voltage is between 11 and 16 volts. AND Ignition Stability Delay is greater than or equal to 1.3 secs AND Engine run time Stability Delay is greater than or equal to 0 sec.	The DTC will set when setting criteria/enable conditions are met for 6.4 seconds out of 12.8 second sample period.

SPN 1634 FMI 13 – "Internal Control Module Memory Checksum Error – System Software Verification Mismatch"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code checks for inconsistencies between the main CPU and checking CPU software and calibrations.	CPU's software and calibration versions do not match	Variable to test whether software and calibration versions don't match is TRUE. AND Tested only once	Continuous monitoring every 160 ms.

SPN 2003 FMI 8 – "Lost Communication with TCM"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects if CAN message from the TCM has a persistent message not received error.	Message timeout fault message received	Transmission type is automatic AND Engine is running AND Engine Runtime is greater than 2 seconds AND no scan tool control device is present AND ignition voltage is above 8V AND Time Delay after voltage returns above threshold to enable CAN diagnostic is greater than 1 second	DTC will set after 0.32 seconds of failure out of 1.28 seconds sample period

SPN 2003 FMI 19 – "Invalid Data Received From TCM – Alive Counter"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects if CAN message from the TCU has a persistent alive counter error	Alive counter fault message received	Transmission type is automatic AND Engine is running AND Engine Runtime is greater than 2 seconds AND no scan tool control device is present AND ignition voltage is above 8V AND Time Delay after voltage returns above threshold to enable CAN diagnostic is greater than 1 second	DTC will set after 0.32 seconds of failure out of 1.28 seconds sample period

SPN 2003 FMI 19 – "Invalid Data Received From TCM – Checksum"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects if CAN message from the TCU has a persistent checksum error	Checksum fault message received	Transmission type is automatic AND Engine is running AND Engine Runtime is greater than 2 seconds AND no scan tool control device is present AND ignition voltage is above 8V AND Time Delay after voltage returns above threshold to enable CAN diagnostic is greater than 1 second	DTC will set after 0.32 seconds of failure out of 1.28 seconds sample period

SPN 2007 FMI 8 – "Lost Communication with PTO Control Module"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects if CAN message from the PTO has a persistent message not received error	Timeout fault message received	Engine running longer than 2 seconds AND ignition voltage is greater than 8V AND no scan tool device control is in progress AND Time delay after voltage returns above threshold to enable CAN diagnostics is greater than 1 second	DTC will set after 0.32 seconds of failure out of 1.28 seconds sample period

SPN 2011 FMI 2 – "ABS Rough Road Message Rationality"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines id the pulse width modulated (PWM) input is within range	ABS PWM Frequency is less than 0 Hz OR ABS PWM Frequency is greater than 0 Hz OR ABS PWM Duty Cycle is less than 0% OR ABS PWM Duty Cycle is greater than 0%	Wheel Speed input to rough road detection obtained with PWM HW input AND Engine Runtime is greater than or equal to 10 seconds	DTC sets after 10 seconds failure out of 40 seconds of sample period

SPN 2011 FMI 19 – "ABS Rough Road Message Invalid"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines that ABS wheel speed fault is present by looking into the pulse width modulated (PWM) input	ABS PWM duty cycle is less than or equal to 0% AND ABS PWM duty cycle is greater than or equal to 0%	Wheel Speed input to rough road detection obtained with PWM HW input AND Engine Runtime is greater than or equal to 10 seconds	DTC sets after 10 seconds failure out of 40 seconds of sample period

SPN 2011 FMI 19 – "Invalid Data Received From Anti-Lock Brake System (ABS) Control Module – Alive Counter"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects if CAN message from the TCS has a persistent alive counter error	Alive counter fault messaged received	Engine running longer than 2 seconds AND ignition voltage is greater than 8V AND no scan tool device control is in progress AND Time delay after voltage returns above threshold to enable CAN diagnostics is greater than 1 second	DTC will set after 0.32 seconds failure out of 1.28 seconds sample period

SPN 2011 FMI 19 – "Invalid Data Received From Anti-Lock Brake System (ABS) Control Module - Checksum"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects if CAN message from the TCS has a persistent checksum error	Checksum fault messaged received	Engine running longer than 2 seconds AND ignition voltage is greater than 8V AND no scan tool device control is in progress AND Time delay after voltage returns above threshold to enable CAN diagnostics is greater than 1 second	DTC will set after 0.32 seconds failure out of 1.28 seconds sample period

SPN 2033 FMI 8 – "Lost Communication with Body Control Module"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects if CAN message from BCM has a persistent message not received errors	Checksum fault message is present	Engine running longer than 2 seconds AND ignition voltage is greater than 8V AND no scan tool device control is in progress AND Time delay after voltage returns above threshold to enable CAN diagnostics is greater than 1 second	DTC will set after 0.32 seconds failure out of 1.28 seconds sample period

SPN 2609 FMI 3 – "A/C Refrigerant Pressure Sensor "A" Circuit High"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors if AC pressure input is shorted to high voltage	Raw A/C Pressure is greater than 4.65V	Vehicle has an A/C system AND Ignition Voltage is greater than or equal to 11V	DTC sets after 16 seconds of failure out of 32 seconds sample period

SPN 2609 FMI 4 – "A/C Refrigerant Pressure Sensor "A" Circuit Low"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors if AC pressure input is shorted to low voltage	Raw A/C Pressure is less than 0.25V	Vehicle has an A/C system AND Ignition Voltage is greater than or equal to 11V	DTC sets after 16 seconds of failure out of 32 seconds sample period

SPN 2609 FMI 16 – "A/C Refrigerant Pressure Sensor 2 "A" Circuit High"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors if AC pressure input is shorted to high voltage	Raw A/C Pressure is greater than 4.65V	Vehicle has an A/C system AND Ignition Voltage is greater than or equal to 11V	DTC sets after 16 seconds of failure out of 32 seconds sample period

SPN 2609 FMI 18 – "A/C Refrigerant Pressure Sensor 2 "A" Circuit Low"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors if AC pressure input is shorted to low voltage	Raw A/C Pressure is less than 0.25V	Vehicle has an A/C system AND Ignition Voltage is greater than or equal to 11V	DTC sets after 16 seconds of failure out of 32 seconds sample period

SPN 2634 FMI 15 – "System Voltage High – Main Relay"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Main Relay Voltage too High	Main Relay Voltage is greater than 24.2V	Ignition on	DTC will set after 0.6 seconds of failure out of 0.72 seconds sample period

SPN 2634 FMI 17 – "System Voltage Low – Main Relay"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Main Relay Voltage too Low	Main Relay Voltage is Less than 7.4V	Ignition on	DTC will set after 0.03 seconds of failure out of 0.06 seconds sample period

SPN 3050 FMI 18 – "Bank 1 Catalyst System Efficiency Below Threshold"
SPN 3051 FMI 18 – "Bank 2 Catalyst System Efficiency Below Threshold"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects reduced catalyst conversion efficiency by monitoring oxygen sensors to determine the amount of oxygen storage in the catalyst (in units of time).	To FAIL this monitor, the EWMA Oxygen storage time for Bank 1 and 2 must be less than or equal to a calibrated threshold. To PASS this monitor, the EWMA Oxygen storage time for Bank 1 and 2 must be greater than or equal to a calibrated threshold.	*Required to Start Test:* Engine Runtime is greater than, or equal to 0 seconds AND Accumulated Combusted Fuel is greater than or equal to 700 grams AND Purge Concentration Learned OR Low Purge Fuel Concentration (less than 1.5%) for more than 60 seconds AND Airflow range is 3 to 20 grams per second AND Throttle Position is less than, or equal to 3% AND Coolant Temperature range is 140°F and 248°F (60°C and 120°C) AND Ambient Temperature range is 19°F and 221°F (-7°C and 105°C) AND Barometric Pressure is greater than or equal to 10.4 Psi (72 kPa)	The report timing depends on fuel control strategy and catalyst condition, and hence the reporting time is dynamic.

		AND The number of test attempts is less than or equal to 12 AND Closed Loop Fuel Control is Active AND Torque control is not cutting fuel to cylinders AND Catalyst Temperature range is 932°F and 1292°F (500°C to 700°C) AND Short term fuel trim deviation is less than or equal to 0.08 AND Vehicle speed is less than, or equal to 1.9 mph (3 kph) AND A/T PN transitions allowed OR Transmission states do not change to or from P/N AND Block Learn Multiplier corresponding to engine Idle state learned (Gear in Drive) OR Block Learn Multiplier corresponding to engine Idle state learned (Gear in P/N) AND Sufficient driving air flow since last test is at least 25 g/s AND Sufficient time to prep catalyst (at least 10 sec) AND IMCD has not completed the end of diagnostic air fuel ramping adjustment AND Idling Time is less than, or equal to 40 seconds AND Max allowed test attempts for current drive cycle is less than or equal to 12 AND No disabling faults present AND Off Vehicle Serial Communication device external control not active	

		Required to keep test running: Engine Speed Error (actual to desired) is less than, or equal to 200 RPM AND Commanded Air/Fuel Switch Achieved Pre-O2 (Lean) in less than 2 seconds (switch defined as less than or equal to 300 mV) AND Commanded Air/Fuel Switch Achieved Pre-O2 (Rich) in less than 4 seconds (switch defined as greater than or equal to 600 mV) AND Commanded Fan State (On/Off) not changed AND Commanded A/C Clutch State not changed and A/T PN transitions are allowed AND Evap Diagnostic Not Intrusively Controlling Purge	

SPN 3052 FMI 5 – "Rough Road Sensor Not Detected"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code will determine if a rough road source (ABS or WSS or G-Sensor) is detected.	Sufficient Engine Runtime has passed AND Rough Road Source Detected	Completed learning the input sensor for rough road detection AND Engine is on for at least 10 seconds AND Vehicle speed is greater than 3 MPH (5 KPH)	Continuous monitoring every 16 seconds of failure out of the 32 seconds of sample period

SPN 3053 FMI 1 – "EVAP System Leak Detected (Large Leak)"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
DTC sets if tank vacuum cannot reach a prescribed vacuum after a prescribed purge volume has been drawn at idle, or after leaving idle.	Tank vacuum is less than 10.1 inH2O (2513.2 Pa), AND purge integral is greater than 4800, AND at idle is True, OR Tank vacuum is less than	EVAP Diagnostic Disabling Fault Active is false, AND EVAP Diagnostic Disabling Fault this Key Cycle is False, AND Evaporative Control Limiting Fault Active is False,	Timing is varied as a function of purge effect and system leak size, can detect in 30 seconds when all other criteria are met

	10.1 in H2O (2513.2 Pa), AND purge integral is greater than 0, AND at idle is False Where idle conditions are defined by: Throttle Position is less than 1% AND vehicle speed is less than 1.9 MPH (3 KPH) AND Engine Speed is less than 1500 RPM AND Leak Test Delay Time is greater than or equal to 1 second	AND Evaporative Control Limiting Fault this Key Cycle is False, AND Engine is Running, AND Ignition Voltage is greater than or equal to 10V, AND Ignition Voltage is less than or equal to 16V, AND Barometric Pressure is greater than or equal to 10.4 Psi (72 kPA), AND Engine Runtime is greater than or equal to 1 second, AND Filtered Fuel Level is less than or equal to 85%, AND Filtered Fuel Level is greater than or equal to 15%, AND Time of the loss of Purge Control is less than 120 seconds, **Cold Start Temperature Criteria (Disabled when not “cold”)** AND Engine off time is greater than 720 minutes, or Startup Intake Air Temperature – Startup Coolant Temperature is less than 53.6°F (12°C) and Startup Coolant Temperature – Startup intake temperature is less than 491°F (255°C) AND Startup Coolant Temperature is greater than or equal to 32°F (0°C) AND Startup Coolant Temperature is less than or equal to 104°F (40°C) AND Startup Intake Air Temperature is greater than or equal to 32°F (0°C), AND Startup Intake Air Temperature is less than or equal to 104°F (40°C)	

		Refuel Detection Conditions (Disabled for significant refuel events) Vehicle speed is greater than 2 MPH (3 KPH) AND Tank pressure is less than -1.5 inH2O (-373.6 Pa) and increase in fuel level greater than 10% for at least 15.04 seconds, AND Increase in fuel level is greater than 10% **Cold Large Leak Specific Enable Conditions** Engine Runtime is less than 300 seconds AND Cold Leak Test is started while test time is less than or equal to 360 seconds AND Cold Leak Test is finished before 360 seconds AND Tank Concentration is less than or equal to 90%	

SPN 3053 FMI 2 – "EVAP System Incorrect Purge Flow"

Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
DTC sets if tank vacuum exceeds prescribed threshold based on fuel level for a prescribed time.	Tank vacuum is greater than the calibrated threshold in relation to fuel level AND fail timer is greater than 2.08 seconds AND Restricted path test failed is false AND Fuel consumed is less than 100,000 micro liters **Ambient Temperature Stability (conditions only apply for reporting a failure)**	EVAP Diagnostic Disabling Fault Active is false AND EVAP Diagnostic Disabling Fault this Key Cycle is False AND Evaporative Control Limiting Fault Active is False AND Evaporative Control Limiting Fault this Key Cycle is False AND Engine is Running AND Ignition Voltage is greater than or equal to 10V AND Ignition Voltage is less than or equal to 16V AND Barometric Pressure is greater than or equal to 10.4 Psi (72 kPA)	Executed once per drive cycle

	AND Ambient stability evaluation time (max time) is less than 360 seconds, AND Vehicle speed is greater than or equal to 20 MPH (32 KPH) and ambient stability evaluation time is greater than or equal to 30 seconds AND Air temperature decrease is less than to 6.6°F (3°C) or air temperature decrease is greater than or equal to 6.6°F (3°C) and time at air temperature decrease is less than 5 seconds	AND Engine Runtime is greater than or equal to 1 second AND Filtered Fuel Level is less than or equal to 85% AND Filtered Fuel Level is greater than or equal to 15% AND Time of the loss of Purge Control is less than 120 seconds **Cold Start Temperature Criteria (Disabled when not "cold")** AND Engine off time is greater than 720 minutes or Startup Intake Air Temperature – Startup Coolant Temperature is less than 53.6°F (12°C) and Startup Coolant Temperature – Startup intake temperature is less than 491°F (255°C) AND Startup Coolant Temperature is greater than or equal to 32°F (0°C) AND Startup Coolant Temperature is less than or equal to 104° (40°C) AND Startup Intake Air Temperature is greater than or equal to 32°F (0°C) AND Startup Intake Air Temperature is less than or equal to 104°F (40°C) **Refuel Detection Conditions (Disabled for significant refuel events)** Vehicle speed is greater than 3.7 MPH (6 KPH) AND Tank pressure is less than -0.006 Psi (-1.5 Pa) AND Increase in fuel level is greater than 10% for at least 15 seconds **Purge Flow Prerequisite Criteria (Disabled is Prerequisites not met)**	

		AND Purge Flow Test Time is greater than or equal to 100 seconds AND Filtered Fuel Level is less than or equal to 85% and Filter Fuel Level is greater than or equal to 15% **Purge Flow Pre-Test Preparation Criteria (Disabled until complete)** AND Purge Flow Test Time “Test Startup Delay” is greater than or equal to 3 seconds or Tank Vacuum is less than 0.05 in H2O (12.4 Pa) **Fuel Condensation From Slosh Detection (Disabled when detected)** AND Ratio of the Purge Leak Post Slosh slope (Condensation of Fuel) is less than or equal to 2.0996:1 or vehicle speed is less than 1.2 MPH (2 KPH), or slosh detection timer is less than or equal to 1.6 seconds, or Filtered Tank Vacuum is 0, or Minimum Intake Air Temperature on previous Key Cycle – Startup Intake Air temperature for current Key Cycle is less than -428.8°F (-256°C), or vehicle soak time is greater than or equal to 65535 minutes	

SPN 3217 FMI 0 – "Bank 1 Sensor 1 O2 Sensor Signal Stuck Rich"
SPN 3256 FMI 0 – "Bank 2 Sensor 1 O2 Sensor Signal Stuck Rich"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if O2 sensor indicates rich exhaust while in Deceleration Fuel Cut-Off (DFCO)	ECM detects voltage greater than .2V	Engine state is RUN, with RPM greater than/equal to 350 AND Ignition voltage is between 10 and 16V AND No Disabling Fault Present AND Off-Vehicle Serial Communication Device Control not active AND EITHER Engine run time is greater than/equal to 60 sec AND Engine coolant warm to greater than/equal to 140°F (60°C) OR Closed Loop Fuel Control Active AND Bank 1/2 Sensor 1/2 Circuit Open/High Voltage condition not present. AND Heater Duty Cycle state is chosen for enabled AND Sensor is not too cold AND Decel fuel shut-off is not active AND Above conditions met for greater than or equal to 1.44 seconds	The DTC will set after 38.4 seconds failure out of 51.2 seconds sample period

SPN 3227 FMI 0 – "Bank 1 Sensor 2 O2 Sensor Signal Stuck Rich"
SPN 3266 FMI 0 – "Bank 2 Sensor 2 O2 Sensor Signal Stuck Rich"
Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if O2 sensor indicates rich exhaust while in Deceleration Fuel Cut-Off (DFCO)	ECM detects voltage greater than 0.2V	Engine is running at 350 RPM or greater, AND Ignition Voltage is greater than or equal to 10V or less than or equal to 16V AND No Disabling faults present AND Off Vehicle Serial Communication Device Control is false AND Engine Runtime is greater than or equal to 1 minute AND Engine Coolant Temperature is greater than or equal to 140°F (60°C) AND Current Open Circuit condition/High Circuit is Not Present AND Heater Duty Cycle is enabled AND Sensor is not too cold AND Deceleration Fuel Cut off is Not Active AND All conditions have been met for greater than or equal to 2.56 seconds	The DTC will set after 38.4 seconds failure out of 51.2 seconds sample period

SPN 3217 FMI 1 – "Bank 1 Sensor 1 O2 Sensor Signal Stuck Lean"
SPN 3227 FMI 1 – "Bank 1 Sensor 2 O2 Sensor Signal Stuck Lean"
SPN 3256 FMI 1 – "Bank 2 Sensor 1 O2 Sensor Signal Stuck Lean"
SPN 3266 FMI 1 – "Bank 2 Sensor 2 O2 Sensor Signal Stuck Lean"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if O2 sensor indicates lean exhaust while in Power Enrichment (PE)	O2 Sensor filtered voltage is less than 0.55V (0.3V for SPN 3266 FMI 1) AND Air Fuel Ratio less than/equal to 13.5:1	Engine state is RUN, with RPM greater than/equal to 350 AND Ignition voltage is between 10 and 16V AND Disabling Fault Not Present AND Off-Vehicle Serial Communication Device Control Not Active AND Heater Duty Cycle chosen for Enabled AND Bank 1/2 Sensor 1/2 Circuit Low Voltage condition is not Present AND Torque control cutting fuel to cylinders NOT active AND Power Enrichment Fuel Control active AND Above conditions met for greater than/equal to 1.44 seconds for SPN's 3217 and 3256 or 2.56 seconds for SPN's 3227 and 3266	The DTC will set after 38.4 seconds failure out of 51.2 seconds sample period

SPN 3217 FMI 3 – "Bank1 Sensor 1 O2 Sensor Circuit High Voltage"
SPN 3256 FMI 3 – "Bank 2 Sensor 1 O2 Sensor Circuit High Voltage"
Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if O2 sensor circuit is shorted high	O2 sensor filtered voltage greater than 1.05V	Engine state is RUN, with RPM greater than/equal to 350 RPM AND Ignition voltage is between 10 and 16V AND Disabling Fault NOT Present AND Off-Vehicle Serial Communication Device Control not active AND EITHER Engine running greater than/equal to 60 seconds AND Engine coolant temperature greater than/equal to 140°F (60°C) OR Calibration choice to bypass coolant and runtime when Closed Loop Fuel control is active AND Heater Duty Cycle State chosen for Enable AND Sensor not too cold AND Power Enrichment Fueling is not active AND Idle Catalyst Monitor Intrusive Fuel Control not active AND Bank 1/2 Sensor 1/2 Circuit Open condition not present AND Above conditions met for greater than/equal to 5 seconds	The DTC will set after 12.8 seconds failure out of 19.2 seconds sample period

SPN 3227 FMI 3 – "Bank 1 Sensor 2 O2 Sensor Circuit High Voltage"
SPN 3266 FMI 3 – "Bank 2 Sensor 2 O2 Sensor Circuit High Voltage"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if O2 sensor circuit is shorted high	O2 sensor filtered voltage greater than/equal to 1.05V	Engine is running at 350 RPM or higher AND Ignition Voltage is greater than/equal to 10V and less than/equal to 16V AND No Disabling faults are present AND Off-Vehicle Serial Communication Device Control is not active AND Engine run time is greater than or equal to 60 sec AND Coolant Temperature is greater than or equal to 140°F (60°C) AND Heater Duty Cycle is enabled AND Sensor is not too cold AND Power Enrichment Fueling is not active AND Idle Catalyst Monitor Intrusive Fuel Control is not active AND Current Open Circuit/high circuit condition is not present. AND the above conditions have been met for greater than or equal to 5 seconds	The DTC will set after 38.4 seconds failure out of 51.2 seconds sample period

SPN 3217 FMI 4 – "Bank 1 Sensor 1 O2 Sensor Circuit Low Voltage"
SPN 3227 FMI 4 – "Bank 1 Sensor 2 O2 Sensor Circuit Low Voltage"
SPN 3256 FMI 4 – "Bank 2 Sensor 1 O2 Sensor Circuit Low Voltage"
SPN 3266 FMI 4 – "Bank 2 Sensor 2 O2 Sensor Circuit Low Voltage"
Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if O2 sensor circuit is shorted low	ECM detects voltage less than 0.0249V	Engine state is RUN, with RPM greater than/equal to 350 AND Ignition voltage is between 10 and 16V AND No Disabling Faults Present AND Off Vehicle Serial Communication Device Control Active is Non-Active AND Heater Duty Cycle chosen for enable AND Fuel level is greater than 15% AND Torque control cutting fuel to cylinders is not active AND Decel fuel shut-off is not active AND Idle Catalyst Monitor Intrusive Fuel Control active is not active AND Above conditions met for greater than or equal to 5 seconds	SPN 3227/3266: DTC will set after 38.4 seconds failure our of 51.2 seconds sample period SPN 3217/3256: DTC will set after 12.8 seconds failure out of 19.2 seconds sample period

SPN 3217 FMI 5 – "Bank 1 Sensor 1 O2 Sensor Circuit No Activity Detected"
SPN 3256 FMI 5 – "Bank 2 Sensor 1 O2 Sensor Circuit No Activity Detected"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if O2 sensor circuit is open	If Pumping Current is ON: Filtered O2 sensor voltage is greater than or equal to 1.7V and less than or equal to 2.1V If Pumping Current is OFF: Filtered O2 sensor voltage is greater than or equal to 0.42V and less than or equal to 0.52V	Engine state is RUN, with RPM greater than/equal to 350 Ignition voltage is between 10 and 16V AND Disabling Fault NOT Present AND Off Vehicle Serial Communication Device Control Active is Non-Active AND Heater Duty Cycle chosen for enable AND Engine Coolant greater than or equal to 19.4°F (-7°C) AND Engine state RUN AND Runtime Threshold greater than/equal to 60 sec and all subsequent enable events per Driving Cycle use Runtime Threshold Runtime greater than/equal to 20 sec AND Closed Loop Fuel Control Active AND Sensor not cold AND Idle Catalyst Monitor Intrusive Fuel Control is Non-Active AND Above conditions met for a time of greater than/equal to 5 sec	Pumping Current OFF: DTC sets after 76.8 seconds of failure out of 92.8 seconds sample period Pumping Current ON: DTC sets after 12.8 seconds of failure out of 19.2 seconds sample period

SPN 3227 FMI 5 – "Bank 1 Sensor 2 O2 Sensor Circuit No Activity Detected"
SPN 3266 FMI 5 – "Bank 2 Sensor 2 O2 Sensor Circuit No Activity Detected"
Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if O2 sensor circuit is open	If Pumping Current is ON: Filtered O2 sensor voltage is greater than or equal to 1.7V and less than or equal to 2.1V If Pumping Current is OFF: Filtered O2 sensor voltage is greater than or equal to 0.42V and less than or equal to 0.48V	Engine is running at 350 RPM or higher AND ignition voltage is greater than or equal to 10V and less than or equal to 16V AND No Disabling Faults are present AND Off Vehicle Serial Communication Device Control is Non-Present AND Engine Runtime is greater than or equal to 1 minute for first enable event drive cycle use and greater than or equal to 20 seconds for all subsequent enable events AND Engine Coolant Temperature is greater than or equal to 19.4°F (-7°C) AND Heater Duty Cycle is enabled AND Sensor is not too cold AND Idle Catalyst Monitor Intrusive Fuel Control is Not Active AND the above conditions have been met for greater than or equal to 5 seconds	Pumping Current OFF: DTC sets after 160 seconds of failure out of 192 seconds sample period Pumping Current ON: DTC sets after 12.8 seconds of failure out of 19.2 seconds sample period

SPN 3222 FMI 1 – "HO2S Heater Control Circuit Bank 1 Sensor 1"
SPN 3232 FMI 1 – "HO2S Heater Control Circuit Bank 1 Sensor 2"
SPN 3262 FMI 1 – "HO2S Heater Control Circuit Bank 2 Sensor 1"
SPN 3271 FMI 1 – "HO2S Heater Control Circuit Bank 2 Sensor 2"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Compares the current that is passing through the O2 Heater to a low limit	If filtered O2 heater current less than low threshold at desired duty cycle, code will set	Filter sample counter greater/equal to 100 AND Engine run time at greater/equal to 200 seconds AND No heater output driver STB (short to battery), STG (short to ground) fault, or Open fault detected AND Stability delay timer greater/equal to 2 sec	DTC sets after 5.12 seconds of failure our of 10.24 second sample period

SPN 3222 FMI 3 – "Bank1 Sensor1 O2S Heater Control Circuit High"
SPN 3262 FMI 3 – "Bank2 Sensor1 O2S Heater Control Circuit High"
Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the heater control circuit is shorted to power	Feedback voltage is greater than or equal to HWIO threshold of 520 mV	Powered By Main Relay: Main Relay Voltage is between 10V and 16V AND Main Relay short to ground, short to battery status is PASS AND Main Relay commanded on AND Most recent sample does NOT indicate output driver diagnostic exceeding Main Relay Open, STG, or STB failure threshold AND Main Relay commanded on AND Main Relay Stability Delay is greater than or equal to 1.3 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds AND O2 Heater Bank 1 for SPN 3222 or Bank 2 for SPN 3262, Front Sensor Device STB, STG and Open Criteria Met AND HWIO has tested the device (only certain faults can be tested based on ECU control state ON/OFF)	DTC sets after 6.4 seconds of failure out of 12.8 seconds sample period

SPN 3232 FMI 3 – "Bank1 Sensor2 O2S Heater Control Circuit High"
SPN 3272 FMI 3 – "Bank2 Sensor2 O2S Heater Control Circuit High"
Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the heater control circuit is shorted to power	Feedback voltage is greater than or equal to HWIO threshold of 520 mV	Powered By Main Relay: Main Relay Voltage is between 10V and 16V AND Main Relay short to ground, short to battery status is PASS AND Main Relay commanded on AND Most recent sample does NOT indicate output driver diagnostic exceeding Main Relay Open, STG, or STB failure threshold AND Main Relay commanded on AND Main Relay Stability Delay is greater than or equal to 1.3 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds AND O2 Heater Bank 1 for SPN 3232 or Bank 2 for SPN 3272, Rear Sensor Device STB, STG and Open Criteria Met AND HWIO has tested the device (only certain faults can be tested based on ECU control state ON/OFF)	DTC sets after 6.4 seconds of failure out of 12.8 seconds sample period

SPN 3222 FMI 4 – "Bank1 Sensor1 O2S Heater Control Circuit Low"
SPN 3262 FMI 4 – "Bank2 Sensor1 O2S Heater Control Circuit Low"
Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the heater control circuit is shorted to ground	Feedback resistance is less than or equal to HWIO threshold of 0.5 ohms.	Powered By Main Relay: Main Relay Voltage is between 10V and 16V AND Main Relay short to ground, short to battery status is PASS AND Main Relay commanded on AND Most recent sample does NOT indicate output driver diagnostic exceeding Main Relay Open, STG, or STB failure threshold AND Main Relay commanded on AND Main Relay Stability Delay is greater than or equal to 1.3 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds AND O2 Heater Bank 1 for SPN 3222 or Bank 2 for SPN 3262, Front Sensor Device STB, STG and Open Criteria Met AND HWIO has tested the device (only certain faults can be tested based on ECU control state ON/OFF)	DTC sets after 6.4 seconds of failure out of 12.8 seconds sample period

SPN 3232 FMI 4 – "Bank1 Sensor2 O2S Heater Control Circuit Low"
SPN 3272 FMI 4 – "Bank2 Sensor2 O2S Heater Control Circuit Low"
Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the heater control circuit is shorted to ground	Feedback resistance is less than or equal to HWIO threshold of 0.5 ohms.	Powered By Main Relay: Main Relay Voltage is between 10V and 16V AND Main Relay short to ground, short to battery status is PASS AND Main Relay commanded on AND Most recent sample does NOT indicate output driver diagnostic exceeding Main Relay Open, STG, or STB failure threshold AND Main Relay commanded on AND Main Relay Stability Delay is greater than or equal to 1.3 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds AND O2 Heater Bank 1 for SPN 3232 or Bank 2 for SPN 3272, Rear Sensor Device STB, STG and Open Criteria Met AND HWIO has tested the device (only certain faults can be tested based on ECU control state ON/OFF)	DTC sets after 6.4 seconds of failure out of 12.8 seconds sample period

SPN 3222 FMI 5 – "Bank1 Sensor 1 O2S Heater Control Circuit Open"
SPN 3262 FMI 5 – "Bank2 Sensor 1 O2S Heater Control Circuit Open"
Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the heater control circuit is open	Feedback resistance is greater than or equal to HWIO threshold of 200 kohms	Powered By Main Relay: Main Relay Voltage is between 10V and 16V AND Main Relay short to ground, short to battery status is PASS AND Main Relay commanded on AND Most recent sample does NOT indicate output driver diagnostic exceeding Main Relay Open, STG, or STB failure threshold AND Main Relay commanded on AND Main Relay Stability Delay is greater than or equal to 1.3 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds AND O2 Heater Bank 1 for SPN 3222 or Bank 2 for SPN's 3262, Front Sensor Device STB, STG and Open Criteria Met AND HWIO has tested the device (only certain faults can be tested based on ECU control state ON/OFF)	DTC sets after 6.4 seconds of failure out of 12.8 seconds sample period

SPN 3232 FMI 5 – "Bank 1 Sensor 2 O2S Heater Control Circuit Open"
SPN 3272 FMI 5 – "Bank 2 Sensor 2 O2S Heater Control Circuit Open"
Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the heater control circuit is open	Feedback resistance is greater than or equal to HWIO threshold of 200 kohms	Powered By Main Relay: Main Relay Voltage is between 10V and 16V AND Main Relay short to ground, short to battery status is PASS AND Main Relay commanded on AND Most recent sample does NOT indicate output driver diagnostic exceeding Main Relay Open, STG, or STB failure threshold AND Main Relay commanded on AND Main Relay Stability Delay is greater than or equal to 1.3 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds AND O2 Heater Bank 1 for SPN 3232 or Bank 2 for SPN 3272, Rear Sensor Device STB, STG and Open Criteria Met AND HWIO has tested the device (only certain faults can be tested based on ECU control state ON/OFF)	DTC sets after 6.4 seconds of failure out of 12.8 seconds sample period

SPN 3222 FMI 10 – "O2 Sensor Circuit Loss of Ready Status Bank 1 Sensor 1"
SPN 3262 FMI 10 – "O2 Sensor Circuit Loss of Ready Status Bank 2 Sensor 1"
Back to Diagnostics

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects Loss of O2 Ready status, which would lead to Open Loop Fueling operation, a default mode	Fuel Control determines that O2 Readiness for Closed Loop Fuel Control is Non-Active	No disabling faults present AND Engine is running AND Number of Cylinders On is greater than or equal to 7 OR Fuel cut off timer is less than 10 seconds AND Closed loop fuel control currently active AND Stability timer greater than or equal to 5 seconds	Continuous monitoring, DTC sets after 25.6 seconds failure out of 32 seconds sample period

SPN 3222 FMI 10 – "O2 Sensor Circuit Time Ready Status Bank 1 Sensor 1"
SPN 3262 FMI 10 – "O2 Sensor Circuit Time Ready Status Bank 2 Sensor 1"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines when the Primary Oxygen Sensor has taken too much time to show enough activity to be used for Closed-Loop Fuel control	Fuel Control determines that O2 Readiness for Closed Loop Fuel Control is Non-Active AND Activity Timer is greater than or equal to 120 seconds	No disabling faults present AND Engine is running AND Off Vehicle Serial Communications Device external control is Non-Active AND Coolant Temperature is greater than or equal to 14°F (-10°C) AND Number of Cylinders On is greater than or equal to 7 AND Airflow is Greater than 512 g/s OR Oxygen Sensor Heater Duty Cycle is Greater than or equal to 20	Detection time is 120 seconds

SPN 3227 FMI 10 – "Bank 1 Sensor 2 O2 Sensor Signal Performance"
SPN 3266 FMI 10 – "Bank 2 Sensor 2 O2 Sensor Signal Performance"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if Rear O2 sensor response rate has slowed to an unacceptable rate	Average time for voltage rise during lean-to-rich transmission in 0.5 sec or greater With a Voltage drop measuring transition from 0.3 V to 0.6 V	No disabling faults present AND Off Vehicle Serial Communication Device Control not active AND Engine running for greater than or equal to 20 seconds and sensor warmed this DC or engine runtime is greater than 60 seconds AND Engine Coolant Temperature is greater than or equal to 140°F (60°C) AND O2 Heater Control is in Steady State AND Air/Fuel Ratio is less than or equal to 14.7:1 AND Air Flow is greater than or equal to 30 g/s AND Power Enrichment is active or bypass is disabled AND O2 Signal Reversal is not detected or bypass is enabled AND Test was enabled for previous loop or Bank 2 Sensor 2 Rear Oxygen Sensor Voltage is less than or equal to 0.25V	Failure is indicated when average test value reaches failure threshold

SPN 3227 FMI 10 – "Bank 1 Sensor 2 O2 Sensor Circuit Range/Performance"
SPN 3266 FMI 10 – "Bank 2 Sensor 2 O2 Sensor Circuit Range/Performance"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if Rear O2 Sensor is acceptable for Idle Catalyst Monitor use	Average time for voltage greater/equal to 0.7 sec Voltage drop is measured during a transition from 0.55 V to 0.3 V	Disabling Faults NOT Present AND Off Vehicle Serial Communication Device Control Non-Active AND Engine RUN state AND RUN time greater than / equal to 120 sec. AND Engine cooling temp. greater than / equal to 68°F (20°C) AND O2 heater control in steady state AND Deceleration Fuel Cut Off in effect AND Test Enables Previous Loop OR Bank 1/2 Sensor 2 Rear Oxygen Sensor Voltage greater than/equal to 0.6499 V AND O2 Signal Reversal Detected is Non-Active OR Reversal detection bypass	Failure is indicated when average test value reaches failure threshold

SPN 3227 FMI 16 – "Bank 1 Post Catalyst Fuel Trim System too Lean"
SPN 3266 FMI 16 – "Bank 2 Post Catalyst Fuel Trim System too Lean"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines when the Rear Fuel trim is trying to respond to a very lean system, and has reached either the fuel control limit of authority or has reached the diagnostic threshold on the control variables.	Rear Sensor Primary Closed-Loop long term fueling adjustment has reached its limit of authority or the learned portion of the Front oxygen sensor switch point offset has reached the diagnostic threshold AND EITHER: Secondary criteria is bypassed by calibration choice OR Rear Sensor Voltage is greater than and still trying to move the adjustment further in the same direction, when compared to FUEL and FSYD thresholds.	Current BLM Cell is enabled for diagnostic AND Disabling Fault NOT Present AND Off-Vehicle Serial Communication Device control is not active AND Barometric Pressure greater than/equal to 10.4 psi (72 kPa) AND Intake Air Temp greater than/equal to 14°F (-10°C) AND Ignition Voltage greater than/equal to 11 V AND Fuel learn Enable (for Rear Sensor-based adjustments) (diagnostic will run when Fuel Control adjustments are enabled)	FAIL: Current Excursion timer exceeds a calibrated threshold time (1-3 seconds, dependent on operating mode) AND THEN Fail counter for current BLM Cell exceeds a count threshold (40-60 counts, dependent on operating mode) PASS: Diagnostic must pass in 2 BLM Cells to report a pass after a non-volatile memory clear A specified number of sample counts (40-60 counts, dependent on operating mode) are required to pass a BLM Cell

SPN 3227 FMI 18 – "Bank 1 Post Catalyst Fuel Trim System Too Rich"
SPN 3266 FMI 18 – "Bank 2 Post Catalyst Fuel Trim System Too Rich"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines when the Rear Fuel trim is trying to respond to a very rich system, and has reached either the fuel control limit of authority or has reached the diagnostic threshold on the control variables.	Rear Sensor Primary Closed-Loop long term fueling adjustment has reached its limit of authority OR The learned portion of the Front oxygen sensor switch point offset has reached the diagnostic threshold AND EITHER: Secondary criteria is bypassed OR (If secondary criteria not bypassed) Rear Sensor Voltage is still trying to move the adjustment further in the same direction, when compared to FUEL and FSYD thresholds	Current BLM Cell is enabled for diagnostic AND Disabling Fault Not Present AND Barometric Pressure greater than/equal to 72 kPa, AND Intake Air Temp greater than/equal to 14°F (-10°C) AND Ignition Voltage greater than/equal to 11 V AND Fuel learn Enable (for Rear Sensor-based adjustments)	FAIL: Current Excursion timer exceeds 5 seconds AND THEN Fail counter for current BLM Cell exceeds a count threshold (50-60 counts, dependent on operating mode) PASS: Diagnostic must pass in 2 BLM Cells to report a pass after a non-volatile memory clear A specified number of sample counts (80-100, dependent on operating mode) are required to pass a BLM Cell

SPN 3301 FMI 2 – "ECM/PCM Engine On Timer Performance"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects inaccuracy of the LPC (Engine Off Timer) by comparing the elapsed start/end time of the LPC during a reference time period defined by a timer within the controller's main processer.	Engine Off Timer Error is greater than 3 seconds in duration	Engine is on AND Engine run test has not been completed in the drive cycle AND Evaluation time is greater than or equal to 20 seconds. AND Ignition voltage is greater than 8 V	The DTC will set when setting criteria/enable conditions are met for 50 seconds out of a 60 second sample period

SPN 3306 FMI 2 – ""A" Camshaft Profile Control Performance/Stuck Off"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the phaser is off, or if there is a steady-state control error	Camshaft Position is less than -10 CAD AND Cam Position is greater than -40 CAD AND Duty cycle is greater than 90% OR Duty cycle is less than 10% OR Camshaft Position error is greater than 7.5 AND Delay counter is greater than 20	Engine Running AND ETC Power Control mode is not Shutdown	DTC set after 12.8 seconds failure out of 32 seconds sample period

SPN 3306 FMI 7 – "Crankshaft Position-Camshaft Position Correlation"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the camshaft target is correctly aligned to the crankshaft	Narrow Temperature Window: Camshaft offset array element is either below a minimum calibrated ratio based on narrow temperature window, or above a maximum calibrated ratio based on narrow temperature window Wide Temperature Window: Camshaft offset array element is either below a minimum calibrated ratio based on wide temperature window, or above a maximum calibrated ratio based on wide temperature window	Narrow Temperature Window: Phaser temperature within the tighter temperature window Wide Temperature Window: Phaser temperature not within the tighter temperature window	DTC set if 10 failures are detected out of every 40 test samples

SPN 3306 FMI 10 – ""A" Camshaft Position Slow Response"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the phaser is moving at the minimum expected rate (average velocity)	Cam phasing average rate in the negative region is less than 10 CAD/s OR Cam phasing average rate in the positive region is less than 10 CAD/s	Offsets learned OR NVM offsets not used AND No disabling faults present AND Start desired actual change in cam position is less than 1.5 CAD OR Start desired actual delta is less than 7.5 CAD and desired position is stable AND Accumulated desired position is greater than 6.25 CAD AND Start desired rate is greater than 65 CAD/s AND desired response rate is less than 10 CAD/s and time since start is greater than or equal to 0.25 seconds OR Desired response rate is less than 10 CAD/s and Response Evaluation counter is greater than 5 OR Absolute Position Error is less than 2.5 CAD	16 Samples (based on phaser response positive/negative filter coefficients)

SPN 3464 FMI 2 – "Throttle Actuator Control Performance Steady State"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects throttle position control problems at steady state conditions (desired value stable). Fault set for large differences between Indicated and Desired Throttle position (0-100%)	Absolute throttle position (Actual TP minus Desired TP) greater than 5% AND Actual throttle position is less than 40% OR Absolute throttle position is greater than 20% Note: Larger error threshold allowed at high throttle positions	Engine is running AND throttle actuation mode is normal AND variation in desired throttle position is less than 0.5% for longer than 1 second	DTC will set after 0.01 seconds out of 0.3 second sample threshold

SPN 3464 FMI 2 – "Throttle Actuator Control Performance"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects when throttle position is not being controlled to the desired position. Fault set for large differences between actual (measured from TP1 and TP2) and Desired Throttle position (0-100%)	If Actual Throttle Position minus Desired Throttle Position is greater than a calculated threshold OR If Actual Throttle Position minus Desired Throttle Position is less than a calculated threshold The error thresholds for throttle too high and too low vary continuously as the sum of a static and dynamic term, limited to a no more than a maximum magnitude	Engine is running AND Throttle Actuation Mode is normal or override AND Ignition Voltage is greater than 5V	Continuously monitored every 10 ms Too high, engine running: 0.34 seconds Throttle too high, engine not running: 3.34 seconds Too low, engine running: 0.5 seconds Too low engine not running: 5 seconds

SPN 3464 FMI 7 – "Throttle Closed Position Performance"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects when throttle fails to return to the unpowered default position when power to the ETC motor is turned off. Fault set for failure to return to default position within a time.	Throttle Position Sensors do not return to expected unpowered default range within a time after throttle output is turned OFF Normalized TP1 is greater than 26.25% (1.31V) AND Normalized TP1 is less than 38.25% (1.91V) OR Normalized TP2 is greater than 26.25% (1.31V) AND Normalized TP2 is less than 38.25% (1.91V) Time Depends on Temperature If engine coolant temperature is less than -4°F (-20°C) return time must be less than 4 seconds, else, return time must be less than 1 second	Previous Throttle Actuation Mode is not OFF AND Current Throttle Actuation Mode is OFF AND Normalized TP1 Is less than 26.25% (1.31V) OR Normalized TP1 Is greater than 38.25% (1.91V) AND Engine Power Control Mode is normal AND SPN 51 FMI's 2,3 and 4 are not active AND SPN 3673 FMI's 3,4 are not active AND SPN 3509 FMI 31 is not active AND SPN 3510 FMI 31 is not active	Test runs at key off. DTC will set after .22 seconds of continuous failure out of .1 seconds sample period

SPN 3509 FMI 31 – "Sensor Reference Voltage "A" Circuit"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects an open, short, or ground in the 5V Reference A circuit	Voltage monitored on the A circuit is out of range; Reference voltage is greater than 5.3 V or less than 4.7 V.	Ignition ON AND Ignition voltage is greater than 5.5V	The DTC will set when setting criteria/enable conditions are met for 0.21 seconds out of a 1.2 second sample period.

SPN 3510 FMI 31 – “Sensor Reference Voltage "B" Circuit”

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects an open, short, or ground in the 5V reference B circuit	Voltage monitored on the B circuit is out of range; Reference voltage is greater than 5.3 V or less than 4.7 V.	Ignition ON AND Ignition voltage is greater than 5.5V	The DTC will set when setting criteria/enable conditions are met for 0.21 seconds out of a 1.2 second sample period.

SPN 3563 FMI 3 – “Manifold Absolute Pressure Circuit High Input”

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects a short to battery	MAP signal is out of range (greater than 95% of reference voltage), or shorted high	No Disabling Faults present, AND Ignition voltage is greater than 11V AND Reverse Rotation is false AND Flow Path Cal chosen is Plenum and engine is running, if bypass negative throttle change is true then throttle change this loop is less than or equal to 2% and negative throttle change delay is completed (greater than 3.84 seconds) or timer has been reset (0 seconds) AND most recent sample indicates that the TPS is not exceeding the range threshold AND Throttle Position is less than or equal to 100%	DTC sets after 0.1 seconds of failure out of 8 seconds sample period

SPN 3563 FMI 4 – "Manifold Absolute Pressure Circuit Low Input"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects a short to ground or open	MAP signal is out of range (less than 5% of reference voltage) or shorted low	No Disabling faults present AND Ignition voltage is at least 11 volts AND Reverse Rotation is false AND Airflow path is plenum then proceed with the following criteria; no disabling faults present and most recent sample indicates that the TPS is exceeding 0%	DTC sets after 4 seconds of failure out of 8 seconds sample period

SPN 3563 FMI 7 – "Manifold Absolute Pressure Stuck"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects a relatively constant input signal from the MAP sensor when conditions are present to expect a changing output	Once Enabled conditions are met for Engine Speed, Throttle, and Air Flow an Event is started. Once an Event is complete, too small of a delta pressure (less than 5%) will get a failed sample	No disabling faults present. AND No MAP high/low circuit faults present AND Ignition Voltage is greater than or equal to 11 V AND Chosen Air Flow Path Calibration is for the Plenum AND Engine is on with a speed of at least 800 RPM. AND Airflow rate is between 30 g/s – 100 g/s AND Change in Airflow is greater than or equal to 20 g/s	DTC sets after 4 seconds of failure out of 10 seconds sample period

SPN 3563 FMI 7 – "Manifold Absolute Pressure Stuck at Startup"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code detects when the MAP sensor circuit signal is stuck at a value that is within the normal sensor operating range at startup.	The DTC will set if the change in MAP sensor values captured between Key ON and during engine start is less than or equal to 0.07 Psi (0.5 kPa) OR Diagnostics will report a pass if the change in MAP sensor values captured between Key ON and engine start is greater than 0.3 Psi (2 kPa)	No disabling faults present AND Key Cycle is not first start after Keep Alive Memory reset AND engine runtime is less than or equal to 3 seconds AND Most recent MAP Sensor tests have passed AND Engine speed is greater than 150 RPM AND Throttle Position is less than 50%	DTC sets after 1 second of failure out of 1.2 seconds sample period

SPN 3563 FMI 10 – "Manifold Absolute Pressure/Barometric Pressure Sensor Circuit Intermittent"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This code checks for large deviations in the pressure values recorded by the sensor during driving conditions which ought to have a stable manifold pressure	Diagnostic checks to see whether the change in pressure values recorded by the MAP sensor are greater than 10% from loop to loop	Stability Conditions Met: Chosen airflow path is plenum AND Engine runtime is greater than or equal to 10 seconds AND Throttle change rate is less than or equal to 3% per second AND Stability delay has been met for 0.5 seconds Enable Conditions Met: Engine speed is less than or equal to 1000 RPM AND no disabling faults are present	DTC sets after 6.40 seconds of failure out of 20 second sample period

SPN 3563 FMI 20 – "Manifold Absolute Pressure/Mass Air Flow – Throttle Position Correlation at Higher Load"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
The MAP reading is compared to expected MAP high and low limits based on engine speed and Throttle Position. This is for both a Deceleration and Power condition.	Power Condition: Minimum altitude compensated MAP is less than a threshold based on engine speed and throttle position OR Maximum Altitude compensated MAP is greater than a threshold based on engine speed and throttle position Deceleration Condition: Altitude compensated MAP is greater than a threshold based on engine speed	Common: Common enable condition criteria is met AND SPN 3563 FMI 3 and FMI 4 are not active AND Scan tool service mode not active AND SPN 51 FMI 3 and FMI 4 and SPN 3673 FMI3 and FMI 4 not active AND no disabling faults are present Deceleration Enable Conditions: Common enable conditions met AND Deceleration stable conditions present AND Throttle Position is less than or equal to 3% AND Vehicle Speed is greater than or equal to 9.3 MPH (15 KPH) AND Decel Enable Delay has been complete for greater than or equal to 7.7 seconds Power Enable Conditions: Power Enable Conditions Criteria met AND Decel enable conditions met AND Power stable conditions present AND Power Enable Delay complete for 7.7 seconds	DTC sets after 80 seconds of failure out of 160 seconds sample period

SPN 3563 FMI 21 – "Manifold Absolute Pressure/Mass Air Flow – Throttle Position Correlation at Idle"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
The MAP reading is compared to expected MAP high and low limits based on engine speed and Throttle Position. This is for both a Deceleration and Power condition.	Power Condition: Minimum altitude compensated MAP is less than a threshold based on engine speed and throttle position OR Maximum Altitude compensated MAP is greater than a threshold based on engine speed and throttle position Deceleration Condition: Altitude compensated MAP is greater than a threshold based on engine speed	Common: Engine is running AND SPN 3563 FMI 20 and SPN 3563 FMI 21 not active and there has been a valid barometric pressure update or SPN 3563 FMI 20 and SPN 3563 FMI 21 are active OR SPN 3563 FMI 20 and SPN 3563 FMI 21 tests failed this key ON AND Torque Converter Clutch Engagement status is the same as the previous loop Deceleration Enable Conditions: Common enable conditions met AND Deceleration stable conditions present AND engine speed is greater than or equal to 1000 RPM AND Engine speed is less than 4000 RPM AND Idle airflow variation is less than or equal to 5% AND Engine Coolant Temperature is greater than or equal to 62.6°F (17°C) Power Enable Conditions: Common enable conditions met AND Power stable conditions present AND engine speed is greater than or equal to 1000 RPM	DTC sets after 80 seconds of failure out of 160 seconds sample period

		AND Engine speed is less than 4000 RPM AND HVAC Clutch not commanded to transition AND Traction Control is not active AND Torque Control is not cutting fuel to cylinders AND Engine Coolant Temperature is greater than or equal to 62.6°F (17°C) AND Change in engine speed is less than or equal to 100 RPM AND Change in TPS is less than or equal to 3% or change in MAP is less than or equal to 1.4 Psi (10 kPa) AND Change in idle airflow is less than or equal to 5% AND Variable Camshaft Position Exhaust #1 stable is less than or equal to 0.2 degrees	

SPN 3673 FMI 3 - “Throttle Position Sensor/Switch "B" Circuit High”

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects a high out of range Throttle Position Sensor 2 (TPS2) voltage	TPS2 signal is greater than 95% (4.75V)	Ignition On AND SPN 51 FMI’s 3,4 and 19 are not active AND SPN 3509 FMI 31 is not active AND Sensor Reference Voltage “A” Circuit Fail Count is 0	DTC sets after 0.11 seconds failure out of 5.5 seconds sample period

SPN 3673 FMI 4 - “Throttle Position Sensor/Switch "B" Circuit Low”

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects a low out of range Throttle Position Sensor 2 (TPS2) voltage	TPS2 signal is less than 5% (0.25V)	Ignition On AND SPN 51 FMI’s 3,4 and 19 are not active AND SPN 3509 FMI 31 is not active AND Sensor Reference Voltage “A” Circuit Fail Count is 0	DTC sets after 0.11 seconds failure out of 5.5 seconds sample period

SPN 3673 FMI 7 - “Throttle Position Sensor/Switch "B" Circuit Range/Performance”

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if Throttle Position from TPS2 (TPSB) shows functional issues like signal noise or incorrect airflow One Time test: After TP correlation or TP1 fails, checks for noise on TP2 or airflow based on TP2 compared to a reference flow being greater than the threshold Continuous Test: Each loop noise on TP2 is detected (by an abnormally high rate of change in voltage) increase the fault counter If conditions are met to use airflow, compare airflow calculated using TP2 to reference airflow from MAP or MAF, if the airflow ratio is not in the expected range, increase the fail counter	One Time Test: When Throttle Position Sensor “A”/”B” Voltage Correlation SPN 51 FMI 2 test failed flag goes from false to true TP2 noisy (high rate of change of raw value recently) AND TP1 is not noisy OR TP1 noisy AND TP2 noisy AND Engine is running AND Actual Throttle Position is less than 40% AND MAP Sensor is not failed AND MAF Sensor is not failed AND MAP/BARO is less than 0.9 ratio AND Ratio of (TP2 calculated airflow minus measured airflow) divided by measured airflow is less than -0.6 OR Ratio of (TP2 calculated airflow minus measured airflow) divided by measured airflow is greater than 0.6 AND Ratio of (TP1 calculated airflow minus measured airflow) divided by measured airflow is greater than or equal to -0.6 AND Ratio of (TP1 calculated airflow minus measured	Throttle Position Sensor “A”/”B” Voltage Correlation (SPN 51 FMI 2) is enabled AND Throttle Position Sensor “A”/”B” Voltage Correlation (SPN 51 FMI 2) test failed AND Throttle Position Sensor “A”/”B” Voltage Correlation (SPN 51 FMI 2) test has not failed in the last 10 ms loop AND Engine power control mode is normal Ignition Switch State: Ignition ON AND Throttle Position Sensor “B” Circuit high (SPN 3673 FMI 3) test has not failed AND Throttle Position Sensor “B” Circuit low (SPN 3673 FMI 4) test has not failed AND Throttle Position Sensor “B” Circuit High fail count is 0 AND Throttle Position Sensor “B” Circuit Low fail count is 0 AND Sensor Reference Voltage “A” Circuit test (SPN 3509 FMI 31) has not failed AND Sensor Reference Voltage “A” Circuit fail count is 0 AND ECM Processor (SPN 629 FMI 12) fault test has not failed AND SEND TPS Communication (SPN 51 FMI 19) test has not failed AND SEND TPS Signal Stuck High (SPN 51 FMI 3) test has not failed	Time to fail for a continuous noise fault (10 ms continuous loop) is 0.06 seconds Time to fail for a continuous flow fault is 1.01 seconds

	airflow) divided by measured airflow is less than or equal to 0.6 Select airflow reference to use for real airflow if MAF is present on engine, use MAF, else, use MAP Continuous Test: When TP correlation SPN 51 FMI 2 is failed or TP1 is failed TP2 is noisy this 10 ms loop OR Engine is running AND Actual Throttle Position is less than 40% AND MAP sensor is test is false AND MAF sensor test is false AND MAP/BARO ratio is less than 0.9 AND Ratio of (TP2 calculated airflow minus measured airflow) divided by measured airflow is less than -0.6 OR Ratio of (TP2 calculated airflow minus measured airflow) divided by measured airflow is greater than 0.6	AND SEND TPS Signal Stuck Low (SPN 51 FMI 4) test has not failed AND Engine Power is normal AND Engine is running or engine cylinder event counter is greater than 20 or engine coolant temperature is greater than 122°F (50°C) or Throttle Position Sensor “A”/”B” Voltage Correlation (SPN 51 FMI 2) is enabled	

SPN 4203 FMI 13 – "Crankshaft Position (CKP) System Variation Not Learned – EOL"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This DTC indicates that crankwheel tooth error has not been learned or is out of range	Individual Tooth Error Correct (TEC) factors are outside a calibrated range OR Sum of the variation of TEC factors are outside a calibrated range AND Not enough samples have been learned within the distance driven threshold during the OTR learn method	Common Enable Conditions: The engine has been on for at least 10 seconds. AND Coolant Temperature is between 32°F and 248°F (0°C and 120°C) AND Ignition Voltage is between 11 V – 16 V AND No TEC disabling faults active AND EOL test has not failed on the current drive cycle End of Line: Automatic transmission is not in gear AND RPM does not increase during fuel cut off	This diagnostic is run continuously when the enable conditions are met

SPN 4237 FMI 15 – "Bank 1 System Too Lean at Idle"
SPN 4239 FMI 15 – "Bank 2 System Too Lean at Idle"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines when the fuel control is trying to respond to a very lean system, and has reached either the fuel control limit of authority or has reached the diagnostic threshold on the control variables at idle conditions.	Long Term Fuel Control in current BLM Cell has reach either the fuel control limit of authority or has reached the diagnostic limit and remained there for a calibrated length of time	Current BLM Cell is enabled for diagnostic AND Disabling Fault NOT Present AND Off-board Device control is not active AND Barometric Pressure is greater than/equal to 10.4 psi (72 kPa) AND Intake Air Temp greater than/equal to 14°F (-10°C) AND Ignition Voltage is greater than, or equal to 11 volts AND Fuel Learning is Enabled	Fail: Current Excursion timer exceeds 5 seconds AND THEN Fail counter for current BLM Cell exceeds 120 counts PASS: Diagnostic must pass in 1 BLM Cell to report a pass after a non-volatile memory clear 160 sample counts are required to pass a BLM Cell

SPN 4237 FMI 16 – "Bank 1 System Too Lean"
SPN 4239 FMI 16 – "Bank 2 System Too Lean"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines when the fuel control is trying to respond to a very lean system, and has reached either the fuel control limit of authority or has reached the diagnostic threshold on the control variables at idle conditions.	Long Term Fuel Control in current BLM Cell has reach either the fuel control limit of authority or has reached the diagnostic limit and remained there for a calibrated length of time	Current BLM Cell is enabled for diagnostic AND Disabling Fault NOT Present AND Off-board Device control is not active AND Barometric Pressure is greater than/equal to 72 kPa AND Intake Air Temp greater than/equal to 14°F (-10°C) AND Ignition Voltage is greater than, or equal to 11 volts AND Fuel Learning is Enabled	Fail: Current Excursion timer exceeds 5 seconds AND THEN Fail counter for current BLM Cell exceeds 60 counts PASS: Diagnostic must pass in 3 BLM Cells to report a pass after a non-volatile memory clear 80 sample counts are required to pass a BLM Cell

SPN 4237 FMI 17 – "Bank 1 System Too Rich at Idle"
SPN 4239 FMI 17 – "Bank 2 System Too Rich at Idle"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines when the fuel control is trying to respond to a very rich system, and has reached either the fuel control limit of authority or has reached the diagnostic threshold on the control variables at idle conditions.	Long Term Fuel Control in current BLM Cell has reached either the fuel control limit of authority OR Has reached the diagnostic limit AND has remained there for the calibrated length of time.	Current BLM Cell s enabled for Diagnostic AND Disabling Fault NOT Present AND Off-board Device control active NOT Present AND Barometric Pressure is greater than, or equal to 72 kPa AND Intake Air Temperature is greater than/equal to 14°F (-10°C) AND Ignition Voltage is greater than, or equal to 11 volts AND Fuel Learn is Enabled	FAIL: Current Excursion timer exceeds 5 seconds AND THEN Fail counter for current BLM Cell exceeds 120 counts PASS: Diagnostic must pass in 1 BLM Cell to report a pass after a non-volatile memory clear 160 sample counts are required to pass a BLM Cell

SPN 4237 FMI 18 – "Bank 1 System Too Rich"
SPN 4239 FMI 18 – "Bank 2 System Too Rich"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines when the fuel control is trying to respond to a very rich system, and has reached either the fuel control limit of authority or has reached the diagnostic threshold on the control variables at idle conditions.	Long Term Fuel Control in current BLM Cell has reached either the fuel control limit of authority OR Has reached the diagnostic limit AND has remained there for the calibrated length of time.	Current BLM Cell s enabled for Diagnostic AND Disabling Fault NOT Present AND Off-board Device control active NOT Present AND Barometric Pressure is greater than, or equal to 72 kPa AND Intake Air Temperature is greater than/equal to 14°F (-10°C) AND Ignition Voltage is greater than, or equal to 11 volts AND Fuel Learn is Enabled	FAIL: Current Excursion timer exceeds 5 seconds AND THEN Fail counter for current BLM Cell exceeds 60 counts PASS: Diagnostic must pass in 3BLM Cells to report a pass after a non-volatile memory clear 80 sample counts are required to pass a BLM Cell

SPN 4240 FMI 10 – "O2 Sensor Circuit Slow Response Bank 1 Sensor 1 (Rich to Lean Transition Rate)"
SPN 4241 FMI 10 – "O2 Sensor Circuit Slow Response Bank 2 Sensor 1 (Rich to Lean Transition Rate)"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors oxygen sensor by averaging rich-to-lean signal transitions during the test and comparing that average to a calibratable acceptability threshold.	During data collection period (60 sec), the Rich to Lean transition timer runs while the O2 signal moves from greater than 0.7 V to less than 0.4 V After data collection time is complete the transition times are averaged and a fault is reported if in the Perturbation method: RPM Compensation is not active AND Average Rich-to-Lean transition rate is greater than or equal to 150 ms for low to high and 90 ms for high to low RPM Compensation Method: RPM Compensation is not active AND Average Rich-to-Lean transition rate is greater than or equal to 0 ms	Intrusive Perturbation Selected AND Number of intrusive tests completed is less than 3 AND Intrusive Control of Fuel System is Allowed OR Intrusive Perturbation Not Selected (Current Block Learn Multiplier Call calibrated for use in monitoring) AND Closed Loop Fuel Control Active AND Block Learn Multiplier (BLM) Stability bypass Not Enabled or current block learn multiplier call is equal to the previous AND All Cylinders Being Fueled AND Stoichiometric Air/Fuel Ratio Commanded AND Off Vehicle Serial Communication Device external control is Non-Active (Scantool Service Mode) AND Fuel Level is greater than 0% AND Barometric pressure greater than 10.4 psi (72 kPa) AND Percent Of Engine Fuel Coming From Purge Less than or equal to 15% AND Engine Coolant Temperature is Greater than or equal to 140°F (60°C) AND Purge Concentration Learned AND Engine Bank 1 Short Term Fuel Trim Integrator	The diagnostic requires a calibrated time of enablement, after which the report occurs immediately. Since enablement is dependent on vehicle conditions, the timing for reporting is variable and cannot be stated directly.

		correction (abs value in lambda) is less than or equal to 0.2 AND Engine Bank 2 Short Term Fuel Trim Integrator correction (abs value in lambda) is less than or equal to 0.2 AND No Disabling Faults present AND Air Flow is Greater than or equal to 20 gs and Less than or equal to 220 g/s AND Enable Criteria Stability Delay Timer Greater than or equal to 3.5 seconds	

SPN 4240 FMI 10 – "O2 Sensor Circuit Slow Response Bank 1 Sensor 1 (Lean to Rich Transition Rate)"
SPN 4241 FMI 10 – "O2 Sensor Circuit Slow Response Bank 2 Sensor 1 (Lean to Rich Transition Rate)"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors oxygen sensor by averaging lean-to-rich signal transitions during the test and comparing that average to a calibratable acceptability threshold.	During data collection period (60 seconds) the Lean to Rich transition timer runs while the O2 signal moves from 0.4 V or greater to 0.7 V or less After data collection time is complete the transition times are averaged and a fault is reported if the Perturbation Method: Average Lean-to-Rich transition rate greater than/equal to 150 ms for low to high, or 90 ms for high to low RPM Compensation Method: Only used if RPM Compensation is false AND Average lean to rich transition rate is greater than or equal to 0 ms	Intrusive Perturbation Selected AND Number of intrusive tests completed is less than 3 AND Intrusive Control of Fuel System is Allowed OR Intrusive Perturbation Not Selected (Current Block Learn Multiplier Call calibrated for use in monitoring AND Closed Loop Fuel Control Active AND Block Learn Multiplier (BLM) Stability bypass Not Enabled or current block learn multiplier call is equal to the previous AND All Cylinders Being Fueled AND Stoichiometric Air/Fuel Ratio Commanded AND Off Vehicle Serial Communication Device external control is Non-Active (Scantool Service Mode) AND Fuel Level is greater than 0% AND Barometric pressure greater than 10.4 psi (72 kPa) AND Percent Of Engine Fuel Coming From Purge Less than or equal to 15% AND Engine Coolant Temperature is Greater than or equal to 140°F (60°C) AND Purge Concentration Learned AND Engine Bank 1 Short Term Fuel Trim Integrator	The diagnostic requires a calibrated time of enablement, after which the report occurs immediately. Since enablement is dependent on vehicle conditions, the timing for reporting is variable and cannot be stated directly.

		correction (abs value in lambda) is less than or equal to 0.2 AND Engine Bank 2 Short Term Fuel Trim Integrator correction (abs value in lambda) is less than or equal to 0.2 AND No Disabling Faults present AND Air Flow is Greater than or equal to 20 g/s and Less than or equal to 220 g/s AND Enable Criteria Stability Delay Timer Greater than or equal to 3.5 seconds	

SPN 4240 FMI 10 – "O2 Sensor Circuit Slow Response Bank 1 Sensor 1 (Number of Transitions)"
SPN 4241 FMI 10 – "O2 Sensor Circuit Slow Response Bank 2 Sensor 1 (Number of Transitions)"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors oxygen sensor functionality by comparing the number of exhaust content transitions commanded by FUEL to the number of transitions observed by the oxygen sensor.	During data collection period (60 seconds) the Low to High (Lean to Rich) transition counter increments when the O2 signal moves from less than 0.4 V to greater than 0.7 V The High to Low (Rich to Lean) transition counter increments when the O2 signal moves from greater than 0.7 V to less than 0.4 V After the data collection time is completed a failure is reported if the Low to High (Lean to Rich) transition counter less than 5 counts OR High to Low (Rich to Lean) transition counter less than 5 counts	Intrusive Perturbation Selected AND Number of intrusive tests completed is less than 3 AND Intrusive Control of Fuel System is Allowed OR Intrusive Perturbation Not Selected (Current Block Learn Multiplier Call calibrated for use in monitoring AND Closed Loop Fuel Control Active AND Block Learn Multiplier (BLM) Stability bypass Not Enabled or current block learn multiplier call is equal to the previous AND All Cylinders Being Fueled AND Stoichiometric Air/Fuel Ratio Commanded AND Off Vehicle Serial Communication Device external control is Non-Active (Scantool Service Mode) AND Fuel Level is greater than 0% AND Barometric pressure greater than 10.4 psi (72 kPa) AND Percent Of Engine Fuel Coming From Purge Less than or equal to 15% AND Engine Coolant Temperature is Greater than or equal to 140°F (60°C) AND Purge Concentration Learned AND Engine Bank 1 Short Term Fuel Trim Integrator	The diagnostic requires a calibrated time of enablement, after which the report occurs immediately. Since enablement is dependent on vehicle conditions, the timing for reporting is variable and cannot be stated directly.

		correction (abs value in lambda) is less than or equal to 0.2 AND Engine Bank 2 Short Term Fuel Trim Integrator correction (abs value in lambda) is less than or equal to 0.2 AND No Disabling Faults present AND Air Flow is Greater than or equal to 20 g/s and Less than or equal to 220 g/s AND Enable Criteria Stability Delay Timer Greater than or equal to 3.5 seconds	

SPN 4240 FMI 10 – "O2 Sensor Circuit Slow Response Bank 1 Sensor 1 (Symmetric Transition Rate)"
SPN 4241 FMI 10 – "O2 Sensor Circuit Slow Response Bank 2 Sensor 1 (Symmetric Transition Rate)"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors oxygen sensor by averaging both signal transitions (Lean to Rich and Rich to Lean) during the test and comparing the average of the two to a calibratable acceptability threshold.	During data collection period of 60 sec the Lean to Rich transition timer runs while the O2 signal moves from greater than 0.4 V to Less than 0.7 V The Rich to Lean transition counter increments when the O2 signal moves from Greater than 0.7 V to Less than 0.4 V After data collection time is complete the Lean-to-Rich and Rich-to-Lean transition times	Intrusive Perturbation Selected AND Number of intrusive tests completed is less than 3 AND Intrusive Control of Fuel System is Allowed OR Intrusive Perturbation Not Selected (Current Block Learn Multiplier Call calibrated for use in monitoring AND Closed Loop Fuel Control Active AND Block Learn Multiplier (BLM) Stability bypass Not Enabled or current block learn multiplier call is equal to the previous AND All Cylinders Being Fueled AND Stoichiometric Air/Fuel Ratio Commanded	The diagnostic requires a calibrated time of enablement, after which the report occurs immediately. Since enablement is dependent on vehicle conditions, the timing for reporting is variable and cannot be stated directly.

	are averaged and a fault is reported if Perturbation Method: The average of the two is: greater than/equal to 640 ms RPM Compensation Method: (Method only used if "Use RPM Compensation") The average of the two is: greater than/equal to 640 ms AND The ratio of the Lean-to-Rich and Rich-to-Lean averages is close to 1 (minus low error limit): greater than/equal to 0.6992 AND The ratio of the Lean-to-Rich and Rich-to-Lean averages is close to 1 (plus high error limit): less than/equal to 1.5 Ratio close to 1, indicates that the signal is behaving symmetrically	AND Off Vehicle Serial Communication Device external control is Non-Active (Scantool Service Mode) AND Fuel Level is greater than 0% AND Barometric pressure greater than 10.4 psi (72 kPa) AND Percent Of Engine Fuel Coming From Purge Less than or equal to 15% AND Engine Coolant Temperature is Greater than or equal to 140°F (60°C) AND Purge Concentration Learned AND Engine Bank 1 Short Term Fuel Trim Integrator correction (abs value in lambda) is less than/equal to 0.2 AND Engine Bank 2 Short Term Fuel Trim Integrator correction (abs value in lambda) is less than or equal to 0.2 AND No Disabling Faults present AND Air Flow is Greater than or equal to 20 g/s and Less than or equal to 220 g/s AND Enable Criteria Stability Delay Timer Greater than or equal to 3.5 seconds	

SPN 4240 FMI 10 – "O2 Sensor Circuit Slow Response Bank 1 Sensor 1 (Rich to Lean Delay to Respond)"
SPN 4241 FMI 10 – "O2 Sensor Circuit Slow Response Bank 2 Sensor 1 (Rich to Lean Delay to Respond)"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors oxygen sensor by averaging time spent Rich during the test and comparing that average to a calibratable acceptability threshold.	During data collection period is 60 sec the Rich delay timer runs while the O2 signal is greater than 0.700 V (does not include any time spent rich commanded by rear O2 fuel control.) Each individual rich excursion period is Normalized (divided by) a ratio determined by a calibrated threshold After data collection time is complete the time spent rich is averaged and a fault is reported if the Average time spent Rich greater than 150 ms	Intrusive Perturbation Selected AND Number of intrusive tests completed is less than 3 AND Intrusive Control of Fuel System is Allowed OR Intrusive Perturbation Not Selected (Current Block Learn Multiplier Call calibrated for use in monitoring AND Closed Loop Fuel Control Active AND Block Learn Multiplier (BLM) Stability bypass Not Enabled or current block learn multiplier call is equal to the previous AND All Cylinders Being Fueled AND Stoichiometric Air/Fuel Ratio Commanded AND Off Vehicle Serial Communication Device external control is Non-Active (Scantool Service Mode) AND Fuel Level is greater than 0% AND Barometric pressure greater than 10.4 psi (72 kPa) AND Percent Of Engine Fuel Coming From Purge Less than or equal to 15% AND Engine Coolant Temperature is Greater than or equal to 140°F (60°C) AND Purge Concentration Learned AND Engine Bank 1 Short Term Fuel Trim Integrator	The diagnostic requires a calibrated time of enablement, after which the report occurs immediately. Since enablement is dependent on vehicle conditions, the timing for reporting is variable and cannot be stated directly.

		correction (abs value in lambda) is less than or equal to 0.2 AND Engine Bank 2 Short Term Fuel Trim Integrator correction (abs value in lambda) is less than/equal to 0.2 AND No Disabling Faults present AND Air Flow is Greater than or equal to 20 g/s and Less than or equal to 220 g/s AND Enable Criteria Stability Delay Timer Greater than or equal to 3.5 seconds	

SPN 4240 FMI 10 – "O2 Sensor Circuit Slow Response Bank 1 Sensor 1 (Lean to Rich Delay to Respond)"
SPN 4241 FMI 10 – "O2 Sensor Circuit Slow Response Bank 2 Sensor 1 (Lean to Rich Delay to Respond)"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors oxygen sensor by averaging time spent Lean during the test and comparing that average to a calibratable acceptability threshold.	During data collection period (60 sec) the Lean delay timer runs while the O2 signal is Less than/equal to 0.4V (does not include any time spent lean commanded by rear O2 fuel control) Each individual lean excursion period is normalized (divided by) a ratio determined by a calibrated threshold After data collection time is complete the time spent lean is averaged and a fault is reported if the	Intrusive Perturbation Selected AND Number of intrusive tests completed is less than 3 AND Intrusive Control of Fuel System is Allowed OR Intrusive Perturbation Not Selected (Current Block Learn Multiplier Call calibrated for use in monitoring AND Closed Loop Fuel Control Active AND Block Learn Multiplier (BLM) Stability bypass Not Enabled or current block learn multiplier call is equal to the previous AND All Cylinders Being Fueled AND Stoichiometric Air/Fuel Ratio Commanded	The diagnostic requires a calibrated time of enablement, after which the report occurs immediately. Since enablement is dependent on vehicle conditions, the timing for reporting is variable and cannot be stated directly.

	Average time spent Lean (Greater than 170 ms)	AND Off Vehicle Serial Communication Device external control is Non-Active (Scantool Service Mode) AND Fuel Level is greater than 0% AND Barometric pressure greater than 10.4 psi (72 kPa) AND Percent Of Engine Fuel Coming From Purge Less than or equal to 15% AND Engine Coolant Temperature is Greater than or equal to 140°F (60°C) AND Purge Concentration Learned AND Engine Bank 1 Short Term Fuel Trim Integrator correction (abs value in lambda) is less than or equal to 0.2 AND Engine Bank 2 Short Term Fuel Trim Integrator correction (abs value in lambda) is less than or equal to 0.2 AND No Disabling Faults present AND Air Flow is Greater than or equal to 20 g/s and Less than or equal to 220 g/s AND Enable Criteria Stability Delay Timer Greater than or equal to 3.5 seconds	

SPN 4240 FMI 10 – "O2 Sensor Circuit Slow Response Bank 1 Sensor 1 (Symmetric Delay to Respond)"
SPN 4241 FMI 10 – "O2 Sensor Circuit Slow Response Bank 2 Sensor 1 (Symmetric Delay to Respond)"
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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors oxygen sensor by averaging both rich and lean time during the test and compares the average of the two to a calibratable acceptability threshold.	During data collection period (60 sec) the Lean delay timer runs while the O2 signal is less than 0.4 V the Rich delay timer runs while the O2 signal is greater than 0.7 V (timers do not include any time spent lean or rich commanded by rear O2 fuel control) Each individual lean excursion period is normalized (divided by) a ratio determined by a calibrated threshold Each individual rich excursion period is normalized (divided by) a ratio determined by a calibrated threshold After data collection time is complete the rich and lean times are averaged and a fault is reported if the average is:	Intrusive Perturbation Selected AND Number of intrusive tests completed is less than 3 AND Intrusive Control of Fuel System is Allowed OR Intrusive Perturbation Not Selected (Current Block Learn Multiplier Call calibrated for use in monitoring AND Closed Loop Fuel Control Active AND Block Learn Multiplier (BLM) Stability bypass Not Enabled or current block learn multiplier call is equal to the previous AND All Cylinders Being Fueled AND Stoichiometric Air/Fuel Ratio Commanded AND Off Vehicle Serial Communication Device external control is Non-Active (Scantool Service Mode) AND Fuel Level is greater than 0% AND Barometric pressure greater than 10.4 psi (72 kPa) AND Percent of Engine Fuel Coming From Purge Less than or equal to 15% AND Engine Coolant Temperature is Greater than or equal to 140°F (60°C) AND Purge Concentration Learned AND Engine Bank 1 Short Term Fuel Trim Integrator	The diagnostic requires a calibrated time of enablement, after which the report occurs immediately. Since enablement is dependent on vehicle conditions, the timing for reporting is variable and cannot be stated directly.

	Greater than/equal to 290 ms AND The ratio of the Lean and Rich delay times is close to 1 (minus low error limit): Greater than or equal to 0.6992 ratio AND The ratio of the Lean and Rich delay times is close to 1 (minus low error limit): Less than or equal to 1.5 ratio Ratio close to 1, indicates that the signal is behaving symmetrically	correction (abs value in lambda) is less than or equal to 0.2 AND Engine Bank 2 Short Term Fuel Trim Integrator correction (abs value in lambda) is less than or equal to 0.2 AND No Disabling Faults present AND Air Flow is Greater than or equal to 20 gs and Less than or equal to 220 g/s AND Enable Criteria Stability Delay Timer Greater than or equal to 3.5 seconds	

SPN 5077 FMI 31 – "Engine Protection Mode"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors for when torque control subsystem meets one of its extreme conditions. Indicates that any of the following faults are active: SPN 100 FMI 1 SPN 110 FMI 0 SPN 111 FMI 1 SPN 175 FMI 0	TORQ Low Engine Oil Pressure met OR TORQ High Engine Oil Temperature met OR TORQ High Coolant Temperature met OR TORQ High Transmission Oil Temperature met	Engine is running for at least 18 seconds AND No disabling faults present	The DTC will set when setting criteria/enabling conditions are met for 4 seconds out of an 8 second sample period

SPN 5323 FMI 7 – "Insufficient Coolant Temperature for Closed Loop"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
This diagnostic monitors the time it takes for the coolant temperature to reach the closed loop temperature and compares against a maximum threshold in order to make a PASS/FAIL determination, provided airflow and idle conditions are met	Coolant temperature is less than a calibrated threshold when Warm-Up timer is greater than or equal to a calibrated value as long as Accumulated Air Flow is greater than a calibrated threshold and Accumulated Idle time is less than a calibrated value	Coolant time to Closed Loop test not Complete AND No disabling faults present AND Minimum intake air temperature this key cycle is greater than or equal to 44°F (-6.7 °C) AND Bypass start up coolant check is not enabled OR Startup coolant temp less than a calibrated threshold. AND Engine is running AND number of cylinders running is greater than or equal to 7	Monitor runs once per key cycle

SPN 5358 FMI 15 – "Cylinder 1 – Fuel Trim at Min Limit"
SPN 5359 FMI 15 – "Cylinder 2 – Fuel Trim at Min Limit"
SPN 5360 FMI 15 – "Cylinder 3 – Fuel Trim at Min Limit"
SPN 5361 FMI 15 – "Cylinder 4 – Fuel Trim at Min Limit"
SPN 5362 FMI 15 – "Cylinder 5 – Fuel Trim at Min Limit"
SPN 5363 FMI 15 – "Cylinder 6 – Fuel Trim at Min Limit"
SPN 5364 FMI 15 – "Cylinder 7 – Fuel Trim at Min Limit"
SPN 5365 FMI 15 – "Cylinder 8 – Fuel Trim at Min Limit"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines when the ICFC control is trying to respond to a very lean cylinder, and has reached either the ICFC control limit of authority or has reached the diagnostic threshold on the control variables.	Indicated Cylinder Control in current ICFC Cell has reached either the fuel control limit of authority (greater than/ equal to 1.14) OR Has reached the diagnostic limit (greater than/equal to 1.12) AND Has remained there for the calibrated length of time	Current ICFC Cell is enabled for diagnostic AND Disabling Fault NOT Present AND Off-Vehicle Serial Communication Device Control not active AND Barometric Pressure greater than / equal to 10.4 Psi (72 kPa) AND Intake air temp greater than/equal to 14°F (-10°C) AND Ignition voltage greater than/equal to 11V AND Fuel Learn Enabled	FAIL: Current Excursion timer exceeds threshold 1 sec. AND THEN Fail counter for current ICFC Cell exceeds threshold 60 counts PASS: Diagnostic must pass in 5 ICFC Cells to report a pass after a non-volatile memory clear 80 Sample counts required to pass a ICFC Cell

SPN 5358 FMI 17 – "Cylinder 1 – Fuel Trim at Max Limit"
SPN 5359 FMI 17 – "Cylinder 2 – Fuel Trim at Max Limit"
SPN 5360 FMI 17 – "Cylinder 3 – Fuel Trim at Max Limit"
SPN 5361 FMI 17 – "Cylinder 4 – Fuel Trim at Max Limit"
SPN 5362 FMI 17 – "Cylinder 5 – Fuel Trim at Max Limit"
SPN 5363 FMI 17 – "Cylinder 6 – Fuel Trim at Max Limit"
SPN 5364 FMI 17 – "Cylinder 7 – Fuel Trim at Max Limit"
SPN 5365 FMI 17 – "Cylinder 8 – Fuel Trim at Max Limit"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines when the ICFC control is trying to respond to a very rich cylinder, and has reached either the ICFC control limit of authority or has reached the diagnostic threshold on the control variables.	Individual Cylinder Control in current ICFC Cell has reached either the fuel control limit of authority (less than or equal to 0.897) OR Has reached the diagnostic limit (less than or equal to 0.908)	Current ICFC Cell is enabled for diagnostic AND No Disabling Fault Present AND Off Vehicle Serial Communication Device control is not active AND Barometric Pressure greater than / equal to 10.4 Psi (72 kPa) AND Intake air temp greater than/equal to 14°F (-10°C) AND Ignition voltage greater than / equal to 11 Volts AND Fuel Learn Enabled	FAIL: Current Excursion timer exceeds 1 second AND THEN Fail counter for current BLM Cell exceeds 60 counts PASS: Diagnostic must pass in 5 ICFC Cells to report a pass after a non-volatile memory clear 80 sample counts are required to pass a BLM Cell

SPN 6336 FMI 3 – "Variable Camshaft Oil Control Solenoid Short to Battery"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the Variable Camshaft Oil Control Solenoid circuit is shorted high	Feedback resistance is greater than or equal to HWIO threshold (0.5 ohms)	Main Relay voltage is greater than or equal to 10V and less than or equal to 16V AND Main Relay open, short to ground, and short to voltage faults not active AND Most recent sample indicates output driver diagnostic does not exceed Main Relay open, short to ground, and short to battery failure threshold AND Main Relay is commanded on AND Main Relay Stability Delay is greater than or equal to 1.28 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds	DTC sets after 6.4 seconds failure out of 12.8 seconds sample period

SPN 6336 FMI 4 – "Variable Camshaft Oil Control Solenoid Short to Ground"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the Variable Camshaft Oil Control Solenoid circuit is shorted low	Feedback resistance is greater than or equal to HWIO threshold (0.5 ohms)	Main Relay voltage is greater than or equal to 10V and less than or equal to 16V AND Main Relay open, short to ground, and short to voltage faults not active AND Most recent sample indicates output driver diagnostic does not exceed Main Relay open, short to ground, and short to battery failure threshold AND Main Relay is commanded on AND Main Relay Stability Delay is greater than or equal to 1.28 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds	DTC sets after 6.4 seconds failure out of 12.8 seconds sample period

SPN 6336 FMI 5 – "Variable Camshaft Oil Control Solenoid Open"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the Variable Camshaft Oil Control Solenoid circuit is open	Feedback resistance is greater than or equal to HWIO threshold (300 kohms)	Main Relay voltage is greater than or equal to 10V and less than or equal to 16V AND Main Relay open, short to ground, and short to voltage faults not active AND Most recent sample indicates output driver diagnostic does not exceed Main Relay open, short to ground, and short to battery failure threshold AND Main Relay is commanded on AND Main Relay Stability Delay is greater than or equal to 1.28 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds	DTC sets after 6.4 seconds failure out of 12.8 seconds sample period

SPN 6336 FMI 7 – ""A" Camshaft Profile Control Stuck"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Determines if the Oil Control Valve is stuck	Camshaft position is greater than -10 CAD OR Camshaft position is less than -40 CAD and Camshaft position error is greater than 15 CAD and timing counter is greater than 15 counts	Oil Control Valve cleaning in progress AND Offsets are learned OR NVM offsets are not used	DTC sets after 6.4 seconds failure out of 32 seconds sample period

SPN 7355 FMI 2 – "Engine Timing Advance Error"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of commanded to actual delivered spark timing	Spark timing is either advanced or retarded from the commanded spark timing Spark Timing Error (Advance) is greater than or equal to 2° (crank) OR Spark Timing Error (Retard) is greater than or equal to 2° (crank)	No disabling faults are present AND Ignition voltage is between 11V and 16V AND Engine is running (Engine Speed is greater than or equal to 350 RPM) AND System is in catalyst light off mode or continuous spark timing is requested AND Engine is not rapidly accelerating or decelerating AND Change in commanded spark is less than 5 degrees crank	Continuous monitoring every cylinder event. The DTC will set when 200 test failures occur within 300 test samples at cylinder event rate

SPN 7833 FMI 3 – "EVAP System Vent Control Circuit Shorted High"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
DTC detects a short to voltage in the EVAP System Vent Control Circuit	Feedback voltage is greater than or equal to 330 mV	Main Relay Voltage is greater than or equal to 11V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open Fault is not active AND Main Relay Short to Ground Fault is not active AND Main Relay Short to Battery Fault is not active AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Open Failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Ground Failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Battery Failure threshold AND Main Relay is commanded on AND Main Relay Stability Delay is greater than or equal to 1.28 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds	DTC will set after 6.40 seconds of failure out of 12.8 seconds of sample period

SPN 7833 FMI 4 – "EVAP System Vent Control Circuit Shorted Low"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
DTC detects a short to ground in the EVAP System Vent Control Circuit	Feedback resistance is less than or equal to 0.5 ohms	Main Relay Voltage is greater than or equal to 11V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open Fault is not active AND Main Relay Short to Ground Fault is not active AND Main Relay Short to Battery Fault is not active AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Open Failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Ground Failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Battery Failure threshold AND Main Relay is commanded on AND Main Relay Stability Delay is greater than or equal to 1.28 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds	DTC will set after 6.40 seconds of failure out of 12.8 seconds of sample period

SPN 7833 FMI 5 – "EVAP System Vent Control Circuit Open"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
DTC detects an open in the EVAP System Vent Control Circuit	Feedback resistance is greater than or equal to 220k ohms	Main Relay Voltage is greater than or equal to 11V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open Fault is not active AND Main Relay Short to Ground Fault is not active AND Main Relay Short to Battery Fault is not active AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Open Failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Ground Failure threshold AND Most recent sample indicates output driver diagnostic does not exceed Main Relay Short to Battery Failure threshold AND Main Relay is commanded on AND Main Relay Stability Delay is greater than or equal to 1.28 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds	DTC will set after 6.40 seconds of failure out of 12.8 seconds of sample period

SPN 7833 FMI 7 – "EVAP System Vent Valve Stuck Closed"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
DTC sets if tank vacuum exceeds a prescribed threshold for a prescribed time when purging at a prescribed rate **Continuous Monitor:** Test is failed if unfiltered tank vacuum exceeds a prescribed threshold for a prescribed time OR Filtered tank vacuum exceeds a prescribed threshold	Tank vacuum is greater than 14.8 in H2O (3682.8 Pa) AND Fail Timer is greater than 5 seconds, WHILE purge flow rate is equal to 0.3 g/s and vacuum integral is less than or equal to 400 **Continuous Monitor:** Tank unfiltered vacuum is greater than 14.8 in H2O (3682.8 Pa) AND Timer is greater than or equal to 2 seconds OR Filtered tank vacuum is greater than 14.8 in H2O (3682.8 Pa)	EVAP Diagnostic Disabling Fault Active is false AND EVAP Diagnostic Disabling Fault this Key Cycle is False AND Evaporative Control Limiting Fault is not Active AND Evaporative Control Limiting Fault this Key Cycle is False AND Engine is Running AND Ignition Voltage is greater than or equal to 10V AND Ignition Voltage is less than or equal to 16V AND Barometric Pressure is greater than or equal to 10.4 Psi (72 kPA) AND Engine Runtime is greater than or equal to 1 second AND Filtered Fuel Level is less than or equal to 85% AND Filtered Fuel Level is greater than or equal to 15% AND Time of the loss of Purge Control is less than 120 seconds **Cold Start Temperature Criteria (Disabled when not "cold")** AND Engine off time is greater than 720 minutes or Startup Intake Air Temperature – Startup Coolant Temperature is less than 53.6°F (12°C) and Startup Coolant Temperature – Startup intake temperature is less than 491°F (255°C) AND Startup Coolant Temperature is greater than or equal to 32°F (0°C)	Timing is varied as a function of purge effort and system leak size, DTC will set after 5 seconds of failure when all other criteria has been met

		AND Startup Coolant Temperature is less than or equal to 104°F (40°C) AND Startup Intake Air Temperature is greater than or equal to 32°F (0°C) AND Startup Intake Air Temperature is less than or equal to 104°F (40°C) **Refuel Detection Conditions (Disabled for significant refuel events)** Vehicle speed is greater than 3 MPH (5 KPH) AND Tank pressure is less than -0.006 Psi (-1.5 Pa) for at least 15 seconds AND Increase in fuel level is greater than 10% **Restricted Vent Specific Enable Conditions** Engine Runtime is less than 300 seconds, AND Restricted Path test Time is less than 120 seconds AND Tank pressure faults not active AND Tank pressure sensor auto zero delay time is greater than or equal to 0.8 seconds	

SPN 7834 FMI 3 – "EVAP System Purge Control Valve Circuit High"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects a short to voltage in the EVAP Purge Control Valve Circuit	Feedback voltage is greater than or equal to 330mV	Main Relay Voltage is greater than or equal to 11V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open Fault is not active AND Main Relay Short to Ground Fault is not active AND Main Relay Short to Battery Fault is not active AND Most recent sample indicates output driver does not exceed Main Relay Open failure threshold AND Most recent sample indicates output driver does not exceed Main Relay Short to Ground failure threshold AND Most recent sample indicates output driver does not exceed Main Relay Short to Battery failure threshold AND Main Relay is commanded ON AND Main Relay Stability Delay is greater than or equal to 1.28 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds	DTC will set after 6.4 seconds of failure out of 12.8 seconds of sample period

SPN 7834 FMI 4 – "EVAP System Purge Control Valve Circuit Low"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects a short to ground in the EVAP Purge Control Valve Circuit	Feedback resistance is less than or equal to 0.5 ohms	Main Relay Voltage is greater than or equal to 11V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open Fault is not active AND Main Relay Short to Ground Fault is not active AND Main Relay Short to Battery Fault is not active AND Most recent sample indicates output driver does not exceed Main Relay Open failure threshold AND Most recent sample indicates output driver does not exceed Main Relay Short to Ground failure threshold AND Most recent sample indicates output driver does not exceed Main Relay Short to Battery failure threshold AND Main Relay is commanded ON AND Main Relay Stability Delay is greater than or equal to 1.28 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds	DTC will set after 6.4 seconds of failure out of 12.8 seconds of sample period

SPN 7834 FMI 5 – "EVAP System Purge Control Valve Circuit Open"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects an open in the EVAP Purge Control Valve Circuit	Feedback resistance is greater than or equal to 200K ohms	Main Relay Voltage is greater than or equal to 11V AND Main Relay Voltage is less than or equal to 16V AND Main Relay Open Fault is not active AND Main Relay Short to Ground Fault is not active AND Main Relay Short to Battery Fault is not active AND Most recent sample indicates output driver does not exceed Main Relay Open failure threshold AND Most recent sample indicates output driver does not exceed Main Relay Short to Ground failure threshold AND Most recent sample indicates output driver does not exceed Main Relay Short to Battery failure threshold AND Main Relay is commanded ON AND Main Relay Stability Delay is greater than or equal to 1.28 seconds AND Engine Runtime Stability Delay is greater than or equal to 0 seconds	DTC will set after 6.4 seconds of failure out of 12.8 seconds of sample period

SPN 7835 FMI 0 – "EVAP System Pressure Sensor/Switch Circuit Intermittent"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
The Tank Pressure Noisy Diagnostic continuously monitors the fuel tank pressure to determine if there is external noise impinging on the fuel tank pressure measurement	Change in Fuel Tank Pressure Sensor voltage signal is greater than 1.65V in one Execution loop of 160 ms	No Disabling Faults are present AND Engine is running AND Intake Air Temp Greater than or equal to 24.8°F (-4°C) AND Fuel Tank Vacuum Autozeroing is not disabled or autozeroing delay time is greater than or equal to 0.8 seconds	DTC will set after 1.92 seconds failure out of 12.8 seconds sample period

SPN 7835 FMI 3 – "EVAP System Pressure Sensor/Switch Circuit High"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects sensor signal short to high voltage	Fuel Tank Pressure greater than 98%	Ignition ON	DTC will set after 6.40 seconds failure out of 12.8 seconds sample period

SPN 7835 FMI 4 – "EVAP System Pressure Sensor/Switch Circuit Low"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detects sensor signal short to low voltage	Fuel Tank Pressure less than 4%	Ignition ON	DTC will set after 6.40 seconds failure out of 12.8 seconds sample period

SPN 7835 FMI 7 – "EVAP System Pressure Sensor Circuit Range/Performance Stuck"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Continuously monitors the fuel tank pressure sensor output for a stuck condition	Change in Tank Pressure Signal Voltage is less than 1.85V For a Time Period of greater than 60 Seconds For a number of test cycles being greater than equal to 5 counts Change in Tank Pressure Signal Voltage is less than 1.85V AND Tank Vacuum Integral greater than 4,560 counts	No Disabling Faults present AND Ignition Voltage is greater than equal to 5.5V AND Filtered Tank Vacuum is less than -8 kPa (-32 in H2O) OR Intake Air Temperature is less than 491°F (255°C) OR Engine Coolant Temperature is less than 491°F (255°C) AND Fuel Tank Pressure Circuit Low is not possible AND Fuel Tank Pressure Circuit High is not possible AND Enable Stability Time is greater than equal to 0.8 Seconds AND Purge Valve Duty Cycle is 0 AND Transition Criteria Met OR Transition Criteria Met Previous Execution Loop ****TRANSTION CRITERIA – ON TO OFF**** Evaporative Control System State is Off AND Evaporative Control System State On Last Execution Loop AND Purge Mass Flow is greater than 0.5 g/sec AND Barometric Pressure is greater than equal to 10.4 psi (72 kPa) No Disabling Faults present AND Ignition Voltage is greater than equal to 5.5 Volts	Immediately Once

		AND Filtered Tank Vacuum is less than -8 kPa (-32 in H2O) OR Intake Air Temperature is less than 491°F (255°C) OR Engine Coolant Temperature is less than 491°F (255°C) AND Fuel Tank Pressure Circuit Low is not possible AND Fuel Tank Pressure Circuit High is not possible AND Enable Stability Time is greater than equal to 0.8 Seconds AND Evaporative System Diagnostics is Running Purge Flow Test or Evaporative System is Running Cold Leak Tests	

SPN 7835 FMI 20 – "EVAP System Pressure Sensor Circuit Range/Performance High"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detect abnormally high tank vacuum at startup	Filtered Fuel Tank Vacuum is greater than or equal to 0.62 kPa or 2.5 inches of H2O	No Disabling Faults present AND Startup Fuel Tank Pressure High Rationality Diagnostic has not run this key cycle AND Vehicle Soak Time is greater than or equal to 0 min AND Engine has achieved "RUN" state since last test completion AND Fuel Tank Vacuum Autozeroing enabled OR Autozeroing delay time is greater than or equal to 0.8 seconds AND Fuel level greater than equal to 15% OR Less than equal to 85% AND Coolant Temp Upon Engine Start greater than equal to 32°F (0°C) OR Less than equal to 176°F (80°C) AND Intake air temperature Upon Engine Start is greater than equal to 32°F (0°C) OR Less than equal to 104°F (40°C) AND Barometric pressure is greater than equal to 10.4 psi (72 kPa)	DTC will set after 0.96 seconds failure out of 1.28 seconds sample period

SPN 7835 FMI 21 – "EVAP System Pressure Sensor Circuit Range/Performance Low"

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Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Detect abnormally low tank vacuum at startup	Filtered Fuel Tank Vacuum less than equal to -0.6 kPa or -2.5 Inches H2O Intake Air Temperature Drop Since Engine Start less than 9°F (5°C) While Vehicle Speed greater than or equal to 6 MPH (10 KPH) for a time period of Greater than equal to 30 minutes Fuel Level Increase Since Last Ignition off Event less than 15% for a time period of greater than or equal to 30 Seconds OR Fuel Level Increase Since Last Ignition off Event less than 15% AND vehicle Speed greater than or equal to 5 MPH (8 KPH)	No Disabling Faults are present AND Startup Fuel Tank Pressure Low Rationality diagnostic has not run this key cycle AND Vehicle Soak Time is greater than equal to 0 Min AND Engine has achieved "RUN" state since last test completion is True AND Fuel Tank Vacuum Autozeroing is enabled OR Autozeroing delay time is greater than or equal to 0.8 seconds AND Fuel level is greater than equal to 15% OR Less than equal to 85% AND Coolant Temperature Upon Engine Start is greater than or equal to 32°F (0°C) OR Less than equal to 176°F (80°C) AND Intake air temperature Upon Engine Start is greater than equal to 32°F (0°C) OR Less than equal to 104°F (40°C) AND Barometric pressure is greater than equal to 10.4 psi (72 kPa)	DTC will set after 0.96 seconds failure out of 1.28 seconds sample period