

# **488LP**/ Propane Autogas Engine Diagnostic Manual



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This manual is designed as a support document for trained technicians in the maintenance and diagnostic procedures of the 488LPI<sup>™</sup> propane autogas engine and fuel system provided by Hexagon Agility<sup>®</sup>.

No attempt shall be made to install, maintain, or repair this product until this manual and all referenced supporting documentation have been read and fully understood.

Original Equipment Manufacturer (OEM) parts not serviced by Hexagon Agility<sup>®</sup> may be obtained by contacting Freightliner Custom Chassis Corporation or Thomas Built Buses.

Fuel system warranty or non-warranty product support may be obtained by calling or emailing Hexagon Agility<sup>®</sup> Customer Care and Technical Services (CCTS).

Please provide your name, phone number, email address, and complete vehicle information: VIN, year, make, model, mileage, unit number, vehicle owner, and current vehicle location. A service advisor will contact you to arrange vehicle repair or ship a part.

### 

All parts must adhere to the accepted standards and ratings as specified by Hexagon Agility<sup>®</sup>. Use of any part that is not approved by Hexagon Agility<sup>®</sup> is not recommended and may compromise the integrity and safety of the system.



Do not remove components from original packaging until necessary. Any components that are to be reinstalled must be thoroughly cleaned, inspected, and stored in a satisfactory manner until reinstallation.





Preface Acronyms Safety Warning and Signal Words Used in this Manual **Qualified Personnel** Suspect Parameter Number (SPN) and Indicator Lamp Definitions Diagnostic Trouble Code (DTC) List by SPN and FMI **Diagnostic Procedures** SPN 29 or 91 SPN 51 or 3673 SPN 51 Performance SPN 91 Performance **SPN 94 FMI 7 SPN 96 SPN 100 SPN 106 SPN 110** SPN 110 Performance SPN 111 FMI 1 SPN 111 FMI 3 or 4 **SPN 132** SPN 132 Performance **SPN 136 SPN 157** SPN 168 FMI 3 or 4 **SPN 172** SPN 172 Performance **SPN 174 SPN 191 SPN 595 SPN 597** SPN 609 FMI 11, SPN 639 FMI 11, SPN 2023 FMI 19, SPN 2033 FMI 19 SPN 609 or 3464





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## Acronyms

ABS	antilock brake system
APP	accelerator pedal position
CEL	check engine lamp
CKP	crankshaft position sensor
CMP	camshaft position sensor
DTC	diagnostic trouble code
ECM	engine control module
ETC	electronic throttle control sensor
ECT	engine coolant temperature sensor
EST	electronic service tool
EVAP	evaporative emissions
FMI	failure mode indicator
FPT	fuel pressure/temperature sensor
HEGO	heated exhaust gas oxygen sensor
IAT	intake air temperature sensor
LPG	liquid propane gas
LPI	Liquid Propane Injection
MAP	manifold absolute pressure sensor
MAF	mass air flow sensor
MIL	malfunction indicator lamp
MPR	main power relay
MS	millisecond
PTO	power take off
RSM	remote shutdown module
SEL	stop engine lamp
SPN	suspect parameter number
TPS	throttle position sensor
TSM	torque security module





Hexagon Agility<sup>®</sup> provides safety guidelines to ensure the safety of personnel servicing and / or operating liquid propane gas<sup>1</sup> (LPG) equipment. All personnel involved must adhere to industry standards, specialized training, and all federal, state, and municipal laws and regulations.

Hexagon Agility<sup>®</sup> minimizes potential hazards through state-of-the art design and testing practices. Always observe the procedures and recommendations of this manual.

Due to the presence of high-pressure and flammable fuel, LPG fuel systems are a form of hazardous energy storage.

### Warning and Signal Words Used in this Manual



WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

*NOTICE* is used to address practices not related to physical injury, such as best practices or tips to help an operation or procedure go smoothly and prevent equipment damage.



Product feature directly affects:

- Safety of vehicle users, people nearby and maintenance personnel, or
- Regulatory compliance.

### Qualified Personnel

LPG systems must be maintained and inspected exclusively by trained personnel with qualifications in accordance with the applicable codes.



Individuals involved in any aspect of LPG fuel system maintenance, emergency response, servicing or testing must be properly trained. Individuals who are not trained are not permitted to service, maintain, test, or inspect a system.

<sup>1</sup> LPG used for automotive applications is often referred to as "propane autogas."





## Suspect Parameter Number (SPN) and Indicator Lamp Definitions

The malfunction indicator lamp (MIL), check engine lamp (CEL), and stop engine lamp (SEL) are used to alert the driver of engine related concerns.

### NOTICE

### Depending on the severity of the concern, multiple lamps may be illuminated.

Suspect parameter numbers (SPN) are stored by the engine control module (ECM) to direct technicians to specific diagnostic concerns.

### Conditions to Clear MIL/SPN

There are 3 ways to the clear the MIL depending on SPN type:

1. ECM turns OFF MIL after 3 consecutive drive cycles that the diagnostic runs and does not fail.

## NOTICE

### Fault will remain in history for 40 consecutive warm-up cycles.

- 2. A history SPN clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- 3. Use an Electronic Service Tool (EST) to clear MIL and SPN manually.

### Conditions to Clear CEL/SPN

There are 3 ways to the clear the CEL depending on SPN type:

- 1. Clears the next drive cycle if the SPN runs and passes.
- 2. Clears while driving if SPN runs and passes while driving.
  - If failure occurs only once, failure will clear on the next drive cycle if the diagnostic runs and passes.
  - If failure occurs 2 or more times, failure will be recorded as confirmed in ECM history.
- 3. Clear CEL and SPN manually with an EST.

### Conditions to Clear SEL/SPN

There are 3 ways to the clear the SEL depending on SPN type.

- 1. Clears the next drive cycle if SPN runs and passes.
- 2. Clears while driving if SPN runs and passes while driving.
  - If failure occurs only once, failure will clear on the next drive cycle if the diagnostic runs and passes.
  - If failure occurs 2 or more times, failure will be recorded as confirmed in ECM history.
- 3. Clear SEL and SPN manually with an EST.





### **SPN Type Definitions**

SPN are grouped by fault type. The main SPN types are listed below. Certain SPN types have specific definitions which are covered in the diagnostic procedures for that SPN.

- MIL Type B Failed 2 consecutive drive cycles and turns ON the MIL.
- CEL Type A Failed this drive cycle and turns ON the CEL.
- CEL Type B Failed since last clear and turns ON the CEL.
- CEL Type C Failed while driving and turns ON the CEL.
- SEL Type A Failed this drive cycle and turns ON the SEL.
- SEL Type B Failed since last clear and turns ON the SEL.
- SEL Type C Failed while driving and turns ON the SEL.

### **Indicator Lamp Definitions**

- MIL Condition that caused the MIL must be corrected, and code cleared with an EST.
- CEL Condition that caused the CEL must be corrected, and code cleared with an EST.
- SEL Condition that caused the SEL must be corrected, and code cleared with an EST.

Refer to 488LPI™ Operators Manual for engine lamp description and operation.





SPN	FMI	Document Title / Circuit	Description
29	3	SPN 29 or 91	Accelerator Pedal Position APP2 Sensor Signal Voltage High
29	4	SPN 29 or 91	Accelerator Pedal Position APP2 Sensor Signal Voltage Low
51	2	SPN 51 Performance	Throttle Position Sensor Conflict
51	3	SPN 51 or 3673	Throttle Position Sensor TPS1 Sensor Signal Voltage High
51	4	SPN 51 or 3673	Throttle Position Sensor TPS1 Sensor Signal Voltage Low
51	7	SPN 51 Performance	Throttle Position Sensor TPS1 ECM–TSM Rationality Conflict
51	11	SPN 51 Performance	Throttle Position Sensor (TPS) Throttle Learn Error
51	19	SPN 51 Performance	Throttle Position Sensor (TPS) Invalid
91	2	SPN 91 Performance	Accelerator Pedal Position (APP) Sensor Conflict
91	3	SPN 29 or 91	Accelerator Pedal Position APP1 Sensor Signal Voltage High
91	4	SPN 29 or 91	Accelerator Pedal Position APP1 Sensor Signal Voltage Low
91	7	SPN 91 Performance	Accelerator Pedal Position APP1 ECM–TSM Rationality Conflict
91	19	SPN 91 Performance	Throttle Position Sensor (TPS) Invalid
94	7	SPN 94	Fuel System Fault / Low Fuel Rail Pressure
96	3	SPN 96	Fuel Level Sensor Voltage High
96	4	SPN 96	Fuel Level Sensor Voltage Low
100	1	SPN 100	Oil Pressure Low
100	3	SPN 100	Oil Pressure Sensor Signal Voltage High
100	4	SPN 100	Oil Pressure Sensor Signal Voltage Low





SPN	FMI	Document Title / Circuit	Description
106	3	SPN 106	Manifold Absolute Pressure (MAP) Sensor Signal Voltage High
106	4	SPN 106	Manifold Absolute Pressure (MAP) Sensor Signal Voltage Low
110	0	SPN 110 Performance	Engine Coolant Temperature Overheating
110	3	SPN 110	Engine Coolant Temperature (ECT) Sensor Circuit Voltage High
110	4	SPN 110	Engine Coolant Temperature (ECT) Sensor Circuit Voltage Low
110	7	SPN 110 Performance	Engine Coolant Temperature Not Warm
110	16	SPN 110 Performance	Engine Coolant Temperature High
111	1	SPN 111 FMI 1	Engine Coolant Level Low
111	3	SPN 111 FMI 3 or 4	Engine Coolant Level Sensor Voltage High
111	4	SPN 111 FMI 3 or 4	Engine Coolant Level Sensor Voltage Low
132	2	SPN 132 Performance	Mass Air Flow (MAF) Sensor Conflict
132	7	SPN 132 Performance	Mass Air Flow (MAF) Sensor/Speed Density Calculation Conflict
132	3	SPN 132	
132	4	SPN 132	Mass Air Flow (MAF) Sensor Signal Low
136	5	SPN 136	Evaporative Emissions (EVAP) Module Vacuum Pump Open/Short
157	3	SPN 157	Fuel Rail Pressure Sensor Signal Voltage High
157	4	SPN 157	Fuel Rail Pressure Sensor Signal Voltage Low





SPN	FMI	Document Title / Circuit	Description
168	3	SPN 168 FMI 3 or 4	Evaporative Emissions (EVAP) Module Battery Voltage High
168	4	SPN 168 FMI 3 or 4	Evaporative Emissions (EVAP) Module Battery Voltage Low
172	2	SPN 172 Performance	Intake Air Temperature (IAT) Sensor Conflict
172	3	SPN 172	Intake Air Temperature (IAT) Sensor Signal High
172	4	SPN 172	Intake Air Temperature (IAT) Sensor Signal Low
174	3	SPN 174	Fuel Rail Temperature Sensor Signal High
174	4	SPN 174	Fuel Rail Temperature Sensor Signal Low
191	19	SPN 191	Transmission Output Shaft Speed Conflict
595	2	SPN 595	Cruise Control Switch Signal Invalid
595	3	SPN 595	Cruise Control Switch Signal Voltage High
595	4	SPN 595	Cruise Control Switch Signal Voltage Low
595	7	SPN 595	Cruise Control Switch Signal Stuck
597	2	SPN 597	Brake Switch Conflict
609	11	SPN 609	Torque Security Module (TSM) Communication Invalid
609	12	SPN 609 or 3464	Main Processor Heartbeat Synchronization Fault
639	11	SPN 639	Communication Bus Is Passive
651	5	SPN 651–658	Fuel Injector Cylinder 1 Circuit Fault
652	5	SPN 651-658	Fuel Injector Cylinder 2 Circuit Fault
653	5	SPN 651-658	Fuel Injector Cylinder 3 Circuit Fault
654	5	SPN 651–658	Fuel Injector Cylinder 4 Circuit Fault





SPN	FMI	Document Title / Circuit	Description
655	5	SPN 651–658	Fuel Injector Cylinder 5 Circuit Fault
656	5	SPN 651–658	Fuel Injector Cylinder 6 Circuit Fault
657	5	SPN 651–658	Fuel Injector Cylinder 7 Circuit Fault
658	5	SPN 651–658	Fuel Injector Cylinder 8 Circuit Fault
970	19	SPN 970	Remote Shut Down Module Communication Invalid
1268	5	SPN 1268–1275	Ignition Coil Cylinder 1 Control Circuit Open/Short
1269	5	SPN 1268–1275	Ignition Coil Cylinder 2 Control Circuit Open/Short
1270	5	SPN 1268–1275	Ignition Coil Cylinder 3 Control Circuit Open/Short
1271	5	SPN 1268–1275	Ignition Coil Cylinder 4 Control Circuit Open/Short
1272	5	SPN 1268–1275	Ignition Coil Cylinder 5 Control Circuit Open/Short
1273	5	SPN 1268–1275	Ignition Coil Cylinder 6 Control Circuit Open/Short
1274	5	SPN 1268–1275	Ignition Coil Cylinder 7 Control Circuit Open/Short
1275	5	SPN 1268–1275	Ignition Coil Cylinder 8 Control Circuit Open/Short
1323	31	SPN 1323-1330	Misfire Cylinder 1
1324	31	SPN 1323–1330	Misfire Cylinder 2
1325	31	SPN 1323–1330	Misfire Cylinder 3
1326	31	SPN 1323-1330	Misfire Cylinder 4
1327	31	SPN 1323-1330	Misfire Cylinder 5
1328	31	SPN 1323-1330	Misfire Cylinder 6
1329	31	SPN 1323–1330	Misfire Cylinder 7
1330	31	SPN 1323-1330	Misfire Cylinder 8





SPN	FMI	Document Title / Circuit	Description
1347	5	SPN 1347	Primary Fuel Pump Relay Control Circuit Open/Short
1634	12	SPN 1634	Engine Control Module (ECM) Checksum Error
1765	5	SPN 1765	Fuel By-Pass Relay Control Circuit Open/Short
1766	3	SPN 1766	Evaporative Emissions (EVAP) Purge Solenoid Control Circuit Open/Short
1766	5	SPN 1766	Evaporative Emissions (EVAP) Purge Solenoid Current Conflict
2003	19	SPN 2003	Transmission Control Module (TCM) Communication Invalid
2011	19	SPN 2011	Antilock Brake System (ABS) Module Communication Invalid
2023	19	SPN 2023	Power Take Off (PTO) Control Communication Invalid
2033	19	SPN 2033	Bulk Head Module Communication Invalid
2119	19	SPN 2119	Evaporative Emissions (EVAP) Module Communication Invalid
2432	14	SPN 2432 FMI 14, 15, or 17	Engine Control Module (ECM) Torque Rationality Diagnostic
2432	15	SPN 2432 FMI 14, 15, or 17	Engine Control Module (ECM) Mass Air Flow Torque Calculation High
2432	16	SPN 2432 FMI 16	Requested Engine Torque Low
2432	17	SPN 2432 FMI 14, 15, or 17	Engine Control Module (ECM) Mass Air Flow Torque Calculation Low
2432	18	SPN 2432 FMI 18	Requested Engine Torque High
2609	5	SPN 2609	Air Conditioning Compressor Clutch 1 Control Circuit Open/Short
2609	6	SPN 2609	Air Conditioning Compressor Clutch 2 Control Circuit Open/Short





SPN	FMI	Document Title / Circuit	Description
2634	3	SPN 2634	Main Power Relay (MPR) Coil Circuit Open/Short
2634	5	SPN 2634	Main Power Relay (MPR) Self Test Failed
3050	18	SPN 3050 or 3051	Catalyst Bank A Malfunction
3051	18	SPN 3050 or 3051	Catalyst Bank B Malfunction
3217	3	SPN 3217 or 3256	HEGO Bank A Sensor 1 Voltage High
3217	4	SPN 3217 or 3256	HEGO Bank A Sensor 1 Voltage Low
3222	5	SPN 3222 or 3261	HEGO Bank A Pre catalyst Heater Circuit Open/Short
3227	3	SPN 3227 or 3266	HEGO Bank A Sensor 2 Voltage High
3227	4	SPN 3227 or 3266	HEGO Bank A Sensor 2 Voltage Low
3232	5	SPN 3232 or 3271	HEGO Bank A Post-catalyst Heater Circuit Open/Short
3256	3	SPN 3217 or 3256	HEGO Bank B Sensor 1 Voltage High
3256	4	SPN 3217 or 3256	HEGO Bank B Sensor 1 Voltage Low
3261	5	SPN 3222 or 3261	HEGO Bank B Pre-catalyst Heater Circuit Open/Short
3266	3	SPN 3227 or 3266	HEGO Bank B Sensor 2 Voltage High
3266	4	SPN 3227 or 3266	HEGO Bank A Sensor 2 Voltage Low
3271	5	SPN 3232 or 3271	HEGO Bank B Post-catalyst Heater Circuit Open/Short
3464	3	SPN 3464 or 3664	Electronic Throttle Control (ETC) Control Circuit Open/Short
3464	5	SPN 3464 or 3664	Electronic Throttle Control (ETC) Learned Value Conflict
3664	11	SPN 3464 or 3664	Electronic Throttle Control (ETC) Learned Value Conflict
3464	12	SPN 609 or 3464	Level 2 Processor Torque Security Module (TSM) Not Executed





SPN	FMI	Document Title / Circuit	Description
3509	10	SPN 3509 or 3510	5 Volt Reference Voltage 1 Low
3509	19	SPN 3509 or 3510	5 Volt Reference Voltage 1 High
3510	10	SPN 3509 or 3510	5 Volt Reference Voltage 2 Low
3510	19	SPN 3509 or 3510	5 Volt Reference Voltage 2 High
3597	3	SPN 3597	Driver Output Supply Voltage High
3597	4	SPN 3597	Driver Output Supply Voltage Low
3597	10	SPN 3597	Driver Output Voltage Low
3597	19	SPN 3597	Driver Output Voltage High
4203	5	SPN 4203 or 4204	Crankshaft (CKT) Sensor Signal Error
4204	5	SPN 4203 or 4204	Camshaft (CMT) Sensor Signal Error
4236	7	SPN 4236 or 4238	Short Term Fuel Trim Fault Bank A
4238	7	SPN 4236 or 4238	Short Term Fuel Trim Fault Bank B





## SPN 29 or 91 Fault Code

### DESCRIPTION OF CIRCUIT

The Accelerator Pedal Assembly contains two (2) Accelerator Pedal Position sensors, APP1 and APP2. The Engine Control Module (ECM) supplies five (5) volts to both sensors on two (2) different 5 V Reference Circuits. The ECM also provides Ground to each sensor on separate Low Reference Circuits. Each APP sensor provides an Accelerator Pedal Position signal to the ECM on a dedicated Signal circuit.

### CONDITIONS TO RUN SUSPECT PARAMETER NUMBER (SPN)

SPN runs continuously while Ignition is ON.

### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
29	3	APP2 Sensor Signal Voltage High	ECM detects APP2 Sensor Signal Circuit greater than 5.0 V for more than 240 ms	M detects APP2 Sensor Signal cuit greater than 5.0 V for more n 240 ms M detects APP1 Sensor Signal	
91	3	APP1 Sensor Signal Voltage High	ECM detects APP1 Sensor Signal Circuit greater than 5.0 V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A
29	4	APP2 Sensor Signal Voltage Low	ECM detects APP2 Sensor Signal Circuit equal to 0.0 V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A
91	4	APP1 Sensor Signal Voltage Low	ECM detects APP1 Sensor Signal Circuit equal to 0.0 V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	А

## NOTICE

### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN indicator light
- Slowly depress Accelerator Pedal while observing Electronic Service Tool (EST) Accelerator Pedal Position 1 (APP1) and Accelerator Pedal Position 2 (APP2) parameters, verify signals change smoothly with pedal motion
- Test for intermittent connections again





### **TOOLS REQUIRED**

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
Fused Jumper		

## NOTICE

Do not insert multimeter probes into wires or connectors as it may damage the wire or seals and allow moisture into the connector. Do not insert test probes into any connector or fuse block terminal which may damage or deform terminals. A deformed terminal will cause a poor connection resulting in a system failure.

### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
29	3	APP2 Sensor Signal Voltage High	<ul> <li>Open/high resistance in Low Reference Circuit</li> <li>Short to voltage in Signal Circuit</li> </ul>
91	3	APP1 Sensor Signal Voltage High	<ul> <li>Short to voltage in Signal Circuit</li> <li>Short to voltage in 5 V Reference Circuit</li> </ul>
29	4	APP2 Sensor Signal Voltage Low	<ul> <li>Short to Ground in Signal Circuit</li> <li>Open/bigh resistance in Signal Circuit</li> </ul>
91	4	APP1 Sensor Signal Voltage Low	<ul> <li>Open/high resistance in 5 V Reference Circuit</li> </ul>

### CONNECTOR END VIEWS (not to scale)

Accelerator Pedal Connector

Refer to OEM vehicle service manual



J1-A (Black) ECM Connector



J1-B (Brown) ECM Connector



C4 Torque Security Module (TSM) Connector

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J1-C (Gray) ECM Connector







### CIRCUIT SCHEMATIC









### SYSTEM VERIFICATION













**SYSTEM VERIFICATION** (continued)













## SPN 51 or 3673 Fault Code

### DESCRIPTION OF CIRCUIT

The 488LPI<sup>™</sup> Electronic Throttle Control (ETC) Sensor is mounted in the Throttle Body Assembly which is replaced as an assembly. The Engine Control Module (ECM) supplies 5 V Reference and Low Reference signals to the ETC Sensor. The Throttle Position Sensor (TPS) supplies two output signals to the ECM on two separate signal circuits: TPS1 Signal Circuit supplies a high value signal at idle while TPS2 supplies a low value signal at idle. As throttle angle increases, TPS1 signal decreases and TPS2 signal increases.

### CONDITIONS TO RUN SUSPECT PARAMETER NUMBERS (SPNs)

SPNs run continuously while Ignition is ON.

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
51	3	TPS1 Sensor Signal Voltage High	ECM detects TPS1 Sensor Signal Circuit greater than 5.0V for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В
51	4	TPS1 Sensor Signal Voltage Low	ECM detects TPS1 Sensor Signal Circuit equals 0.0 V for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В
3673	3	TPS2 Sensor Signal Voltage High	Sensor Voltage gh ECM detects TPS2 Sensor Signal Circuit greater than 5.0 V for more than 240 ms ECM turns Malfunctior Light (MIL)		В
3673	4	TPS2 Sensor Signal Voltage Low	ECM detects TPS2 Sensor Signal Circuit equals 0.0 V for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В

### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

## NOTICE

### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / indicator light





### **TOOLS REQUIRED**

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
Fused Jumper		

### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
51	3	TPS1 Sensor Signal Voltage High	<ul> <li>Open/high resistance in ECT Sensor Low Reference Circuit</li> <li>Short to voltage in TPS1 Signal Circuit</li> <li>Short to voltage in ECT Sensor 5 V Reference Circuit</li> </ul>
51	4	TPS1 Sensor Signal Voltage Low	<ul> <li>Short to Ground in TPS1 Signal Circuit</li> <li>Open/high resistance in TPS1 Signal Circuit</li> <li>Open/high resistance in ECT Sensor 5 V Reference Circuit</li> </ul>
3673	3	TPS2 Sensor Signal Voltage High	<ul> <li>Open/high resistance in ECT Sensor Low Reference Circuit</li> <li>Short to voltage in TPS2 Signal Circuit</li> <li>Short to voltage in ECT Sensor 5 V Reference Circuit</li> </ul>
3673	4	TPS2 Sensor Signal Voltage Low	<ul> <li>Short to Ground in TPS2 Signal Circuit</li> <li>Open/high resistance in TPS2 Signal Circuit</li> <li>Open/high resistance in ECT Sensor 5 V Reference Circuit</li> </ul>

### **CONNECTOR END VIEWS**

















### **CIRCUIT SCHEMATIC**













488LP/













### SYSTEM VERIFICATION (continued)







## **SPN 51 Performance**

### DESCRIPTION OF CIRCUIT

The 488LPI<sup>™</sup> Throttle Position Sensor (TPS) is mounted in the Throttle Body Assembly and is replaced as an assembly. The Engine Control Module (ECM) supplies 5 V Reference and Low Reference signals to the Throttle Position Sensor (TPS). The TPS supplies two output signals to the ECM on two separate signal circuits: TPS1 Signal Circuit supplies a high value signal at idle while TPS2 Signal Circuit supplies a low value signal at idle. As throttle angle increases, TPS1 signal decreases and TPS2 signal increases.

The Torque Security Module (TSM) also receives a signal from TPS1. The TSM and ECM compare TPS1 signals to verify proper operation.

The ECM performs a series of functions to learn the throttle position every time the ignition is turned on. The Throttle Learn Function is performed to verify that the throttle is working correctly. The ECM throttle learn uses the average value of the TPS 1 and the TPS 2 values when looking at throttle position as it moves through a series of pre-determined positions. If the ignition is turned off during the throttle learn process, the function will be aborted and start on the next key cycle.

The first Throttle Learn sequence tests throttle position neutral state: with Ignition ON and 0% duty cycle, the throttle must be in a pre-determined neutral position value range. In the second sequence the throttle moves to the closed position which is checked against a pre-determined value range. In the third sequence the throttle then moves to the neutral position and its position is then verified against the pre-determined neutral position range. In the fourth sequence the throttle moves to the Wide Open Throttle (WOT) position which is checked against a pre-determined value range. In the fifth sequence the throttle moves to the neutral position and its position is verified again against the pre-determined neutral value range. At this point the Throttle Learn Function is complete.

SPN	FMI	Description	Conditions to Run SPN
51	2	Throttle Position Sensor Conflict	SPN runs continuously while Ignition is ON and TPS1 and TPS2 are valid (e.g., no circuit errors are present)
51	7	TPS1 Rationality Conflict between ECM and TSM	SPN runs continuously while Ignition is ON
51	11	TPS Throttle Learn Error	SPN runs once per drive cycle during Ignition ON with engine OFF
51	19	Throttle Position Sensor Invalid	SPN runs continuously while Ignition is ON

### CONDITIONS TO RUN SUSPECT PARAMETER NUMBERS (SPNs)





SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
51	2	Throttle Position Sensor Conflict	ECM detects difference between TPS1 and TPS2 greater than 6% for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В
51	7	TPS1 Rationality Conflict	Difference between ECM TPS1 input value and TSM TPS1 input value is greater than allowable amount for more than 240 ms	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> <li>ECM turns ON Stop Engine Light (SEL)</li> </ul>	A
51	11	TPS Throttle Learn Error	If at any point in the Throttle Learn Function throttle position is not in predetermined value range specified for that position, or if throttle position is in the value range but is not steady, the throttle position SPN will set.	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> <li>ECM turns ON Stop Engine Light (SEL)</li> <li>ECM de-energizes Main Power Relay (MPR)</li> </ul>	A
51	19	Throttle Position Sensor Invalid	ECM detects both TPS1 and TPS2 signal circuits are open or shorted for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В

### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

## NOTICE

### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematics and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN indicator light

### TOOLS REQUIRED

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp	Fused Jumper	





### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
51	3	TPS1 Sensor Signal Voltage High	<ul> <li>Open/high resistance in Low Reference Circuit</li> <li>Short to voltage in Signal Circuit</li> <li>Short to voltage in 5 V Reference Circuit</li> </ul>
51	4	TPS1 Sensor Signal Voltage Low	<ul> <li>Short to Ground in Signal Circuit</li> <li>Open/high resistance in Signal Circuit</li> <li>Open/high resistance in 5 V Reference Circuit</li> </ul>
3673	3	TPS2 Sensor Signal Voltage High	<ul> <li>Open/high resistance in Low Reference Circuit</li> <li>Short to voltage in Signal Circuit</li> <li>Short to voltage in 5 V Reference Circuit</li> </ul>
3673	4	TPS2 Sensor Signal Voltage Low	<ul> <li>Short to Ground in Signal Circuit</li> <li>Open/high resistance in Signal Circuit</li> <li>Open/high resistance in 5 V Reference Circuit</li> </ul>

### **CONNECTOR END VIEWS**







C4 Torque Security Module (TSM) Connector







### **CIRCUIT SCHEMATIC**









### SYSTEM VERIFICATION





488LP/

### SYSTEM VERIFICATION (continued)




















- Ignition OFF
- Install 3 A Fused Jumper between TP1S Signal Circuit and TPS1 5 V Reference Circuit

Step 5

- Ignition ON
- Use Electronic Service Tool to verify appropriate Throttle Position 1 parameter > 99%













# **SPN 91 Performance**

## **DESCRIPTION OF CIRCUIT**

The 488LPI<sup>™</sup> Accelerator Pedal Assembly contains two (2) Accelerator Pedal Position sensors, APP1 and APP2. The Engine Control Module (ECM) supplies five (5) volts to both sensors on two (2) different 5 V Reference Circuits. The ECM also provides Ground to each sensor on separate Low Reference Circuits. Each sensor provides an Accelerator Pedal Position signal to the ECM on a dedicated Signal Circuit.

The 488LPI<sup>™</sup> Torque Security Module (TSM) also receives a signal from APP1. The TSM and ECM compare APP1 signals to verify proper operation.

SPN	FMI	Description	Conditions to Run SPN
91	2	Accelerator Pedal Position Sensor Conflict	SPN runs continuously while Ignition is ON and APP1 and APP2 are valid (e.g., no circuit errors present).
91	7	APP1 Rationality Conflict between ECM and TSM	SPN runs continuously while Ignition is ON.
51	19	Throttle Position Sensor Invalid	SPN runs continuously while Ignition is ON.

#### CONDITIONS TO RUN SUSPECT PARAMETER NUMBERS (SPNs)

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
91	2	Accelerator Pedal Position Sensor Conflict	ECM detects difference between APP1 and APP2 greater than 9% for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A
91	7	APP1 Rationality Conflict between ECM and TSM	Difference between ECM APP1 input value and TSM APP1 input value is greater than allowable amount for more than 240 ms	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> <li>ECM turns ON Stop Engine Light (SEL)</li> </ul>	A
91	19	Throttle Position Sensor Invalid	ECM detects both APP1 and APP2 signal circuits are open or shorted for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A





## NOTICE

## Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic.
- Test for intermittent or poor connections.
- Review Circuit Schematic and Connector End Views to locate test points.
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN indicator light.

## TOOLS REQUIRED

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
Fused Jumper		

## NOTICE

Do not insert multimeter probes into wires or connectors as it may damage the wire or seals and allow moisture into the connector. Do not insert test probes into any connector or fuse block terminal which may damage or deform terminals. A deformed terminal will cause a poor connection resulting in a system failure.

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
91	3	Accelerator Pedal Position Conflict	Worn or damaged Accelerator Pedal Assembly
91	7	APP1 Rationality Conflict between ECM and TSM	Open or short in APP1 Signal Circuit
91	19	Throttle Position Sensor Signal Invalid	Open/high resistance in both APP1 and APP2 Signal Circuits





## CONNECTOR END VIEWS (not to scale)

Accelerator Pedal Connector

Refer to OEM vehicle service manual

C4 Torque Security Module (TSM) Connector



C28 Bulkhead Connector

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J1-A (Black) ECM Connector



J1-B (Brown) ECM Connector



J1-C (Gray) ECM Connector









#### CIRCUIT SCHEMATIC







## SYSTEM VERIFICATION





488LP/





488LP/





488LP|























488LP/







# SPN 94 FMI 7 Fault Code

## **DESCRIPTION OF CIRCUIT**

The 488LPI<sup>™</sup> Engine Control Module (ECM) monitors Fuel Tank Pressure and Fuel Rail Pressure. If the Fuel Rail Pressure does not increase to a calibrated value greater than Tank Pressure, a fuel system fault is suspected.

## CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

- SPN runs continuously while Ignition is ON **and** the following conditions are met:
- Fuel Rail Pressure/Temperature (FPT) Sensor Signal is valid (e.g., no circuit errors)
- Fuel Level Sensor Signal is valid (e.g., no circuit errors)
- Fuel level is greater than 5%
- Fuel Pump has run for more than 10 seconds

## SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
94	7	Fuel System Fault / Low Fuel Rail Pressure	ECM suspects a fault if Fuel Rail Pressure falls below 30 psi (2.0 bar) more than Fuel Tank Pressure for more than 10 seconds	ECM turns ON Check Engine Light (CEL)	A

## NOTICE

## Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic.
- Test for intermittent or poor connections.
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN indicator light.
- Inspect Fuel Lines for damage
- Confirm Fuel Filter has been maintained
- Verify Manual Fuel Shutoff Valves are open

## TOOLS REQUIRED

## Electronic Service Tool

## POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
94	7	Fuel System Fault / Low Fuel Rail Pressure	<ul> <li>Restricted Fuel Filter</li> <li>Damaged Fuel Line</li> <li>Fuel Pump malfunction</li> </ul>











# **SPN 96 Fault Code**

## DESCRIPTION OF CIRCUIT

The Engine Control Module (ECM) supplies five (5) volts to the Fuel Level Sensor Signal Circuit. The ECM monitors voltage on the signal circuit to determine the Fuel Level Sensor is operating properly.

## CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN runs continuously while Ignition is ON.

## SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
96	3	Fuel Level Sensor Signal Voltage High	ECM detects Fuel Level Sensor Signal Circuit greater than 5.0 V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A
96	4	Fuel Level Sensor Signal Voltage Low	ECM detects Fuel Level Sensor Signal Circuit equal to 0.0 V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	А

## Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic.
- Test for intermittent or poor connections.
- Review Schematics and Connector End Views to locate test points.
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN indicator light.

## TOOLS REQUIRED

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit

NOTICE

- Do not insert multimeter probes into wires or connectors as it may damage the wire or seals and allow moisture into the connector.
- Do not insert test probes into any connector or fuse block terminal which may damage or deform terminals. A deformed terminal will cause a poor connection resulting in a system failure.





## POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
96	3	Fuel Level Sensor Signal Voltage High	<ul> <li>Open/high resistance in Signal Circuit</li> <li>Short to voltage in Signal Circuit</li> </ul>
96	4	Fuel Level Sensor Signal Voltage Low	<ul><li>Short to Ground in Signal Circuit</li><li>Fuel Level Sensor malfunction</li></ul>

## CONNECTOR END VIEWS (not to scale)









## **CIRCUIT SCHEMATIC**







## SYSTEM VERIFICATION





488LP/







# **SPN 100 Fault Code**

## **DESCRIPTION OF CIRCUIT**

The 488LPI<sup>™</sup> Oil Pressure Sensor is a three (3) wire sensor that provides a signal to the Engine Control Module (ECM) relative to pressure changes in the oil supply line. Changes in oil pressure are based on temperature and engine RPM.

The ECM supplies the Oil Pressure Sensor with five (5) volts Reference power and Ground on the Low Reference Circuit.

## CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN runs continuously while Ignition is ON.

## SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
100	3	Oil Pressure Sensor Signal Voltage High	ECM detects Oil Pressure Sensor Signal greater than 5.0V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A
100	4	Oil Pressure Sensor Signal Voltage Low	ECM detects Oil Pressure Sensor Signal equal to 5.0 V for greater than 240 ms	ECM turns ON Check Engine Light (CEL)	A
100	1	Oil Pressure Low	ECM determines Oil Pressure < calibrated value for determined engine speed ( <i>see</i> <i>values below</i> )	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> <li>ECM turns ON Stop Engine Light (SEL)</li> </ul>	A

Engine RPM		600	800	1200	2000	2800	3600	4400
Minimum	bar	3.5	4.8	6.0	8.6	9.9	11.2	12.5
Calibrated Oil Pressure	psi	5	7	8.7	12.59	14.25	16.2	18.1





## Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN indicator light
- Check engine oil level
- Connect Oil Pressure Gauge and perform mechanical pressure test to verify actual oil pressure
- Oil Pressure Sensor performance may change with temperature and engine speed

#### TOOLS REQUIRED

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp	Fused Jumper	Mechanical Oil Pressure Gauge

## POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
100	3	Oil Pressure Sensor Signal Voltage High	<ul> <li>Open/high resistance in Low Reference Circuit</li> <li>Short to voltage in Signal Circuit</li> <li>Short to voltage in 5 V Reference Circuit</li> </ul>
100	4	Oil Pressure Sensor Signal Voltage Low	<ul> <li>Short to Ground in Signal Circuit</li> <li>Open/high resistance in Signal Circuit</li> <li>Open/high resistance in 5 V Reference Circuit</li> </ul>
100	1	Oil Pressure Low	<ul> <li>Open/high resistance in Low Reference Circuit</li> <li>Mechanical failure</li> </ul>

## CONNECTOR END VIEWS (not to scale)















## **CIRCUIT SCHEMATIC**







## SYSTEM VERIFICATION

























# **SPN 106 Fault Code**

## **DESCRIPTION OF CIRCUIT**

The 488LPI<sup>™</sup> Manifold Absolute Pressure (MAP) Sensor is a three (3) wire sensor that provides a signal to the Engine Control Module (ECM) based on pressure changes in the Intake Manifold. Pressure changes occur dependent on a combination of engine speeds, throttle openings, air temperature, and barometric pressure. The ECM supplies five (5) volts to the MAP Sensor on the 5 V Reference Circuit and Ground on the Low Reference Circuit.

The MAP Sensor provides a signal to the ECM on the Signal Circuit relative to intake pressure changes. The MAP Sensor Signal is low during idle or deceleration. The MAP Sensor Signal is high during Ignition ON, Engine OFF, or at Wide Open Throttle (WOT). The MAP Sensor also measures barometric pressure (BARO). This occurs with Ignition ON, Engine OFF. The BARO reading may also be updated whenever the Throttle Position Sensor (TPS) is at Wide Open Throttle.

## CONDITIONS TO RUN SUSPECTED PARAMETER NUMBERS (SPNs)

SPN runs continuously while Ignition is ON.

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
106	3	MAP Sensor Signal Voltage High	ECM detects MAP Sensor Signal greater than 5.0V for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В
106	4	MAP Sensor Signal Voltage Low	ECM detects MAP Sensor Signal equal to 0.0 V for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В

## SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

## NOTICE

## Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN indicator light
- Check for vacuum leaks
- Connect a Vacuum Pump to MAP Sensor and perform mechanical pressure test to verify Engine Intake Manifold 1 Pressure parameter changes smoothly as vacuum is applied to sensor





## **TOOLS REQUIRED**

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp	Fused Jumper	Vacuum Pump

## NOTICE

- Do not insert multimeter probes into wires or connectors as it may damage the wire or seals and allow moisture into the connector.
- Do not insert test probes into any connector or fuse block terminal which may damage or deform terminals. A deformed terminal will cause a poor connection resulting in a system failure.

## POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
106	3	MAP Sensor Signal Voltage High	<ul> <li>Open/high resistance in Low Reference Circuit</li> <li>Short to voltage in Signal Circuit</li> <li>Short to voltage in 5 V Reference Circuit</li> </ul>
106	4	MAP Sensor Signal Voltage Low	<ul> <li>Short to Ground in Signal Circuit</li> <li>Open/high resistance in Signal Circuit</li> <li>Open/high resistance in 5 V Reference Circuit</li> </ul>

## CONNECTOR END VIEWS (not to scale)











#### **CIRCUIT SCHEMATIC**

















488LP/










488LP/







# **SPN 110 Fault Code**

# DESCRIPTION OF CIRCUIT

The 488LPI<sup>™</sup> Engine Coolant Temperature (ECT) Sensor uses a variable resistor to measure the temperature of the engine coolant. The Engine Control Module (ECM) supplies five (5) volts on the ECT Sensor Signal Circuit and Ground on the ECT Sensor Low Reference Circuit.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN runs continuously while Ignition is ON.

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
110	3	ECT Sensor Signal Voltage Low	ECM detects ECT Sensor Signal greater than 5.0V for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В
110	4	ECT Sensor Signal Voltage High	ECM detects ECT Sensor Signal equals 0.0 V for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В

# SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

# NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this procedure
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Malfunction Indicator Light

#### Engine Coolant Temperature (ECT) Sensor Diagnostic Tips

- Start engine. ECT Sensor temperature should rise steadily and stabilize after dual Thermostats open.
- Test ECT Sensor at various temperatures to identify a potentially bad sensor; a faulty ECT Sensor can cause drivability issues.
- Disconnect ECT Sensor Harness Connector and use a Digital Multimeter between ECT Sensor Connector Terminals A and B to measure sensor resistance. The table below shows the relationship between temperature and ECT Sensor resistance.





# Engine Coolant Temperature (ECT) Sensor Resistance Variability with Temperature

Temperature	ECT Sensor Resistance*
-40° F (-40° C)	101 KΩ
-4° F (-20° C)	29 ΚΩ
32° F (0° C)	9.4 KΩ
104° F (40° C)	1.5 ΚΩ
176° F (80° C)	334 Ω
302° F (150° C)	47.5 Ω

\*Resistance values are approximate

# **TOOLS REQUIRED**

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp	Fused Jumper	

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
110	3	ECT Sensor Signal Voltage High	<ul><li>Open Low Reference Circuit</li><li>Open or short to voltage in Signal Circuit</li></ul>
110	4	ECT Sensor Signal Voltage Low	<ul> <li>Short to Ground in Signal Circuit</li> </ul>

# CONNECTOR END VIEWS (not to scale)



#### J1-B (Brown) ECM Connector



J1-C (Gray) ECM Connector







#### **CIRCUIT SCHEMATIC**







### SYSTEM VERIFICATION









Ground in circuit











# **SPN 110 Performance**

# **DESCRIPTION OF CIRCUIT**

The 488LPI<sup>™</sup> Engine Coolant Temperature (ECT) Sensor uses a variable resistor to measure the temperature of the engine coolant. The Engine Control Module (ECM) supplies five (5) volts signal on the ECT Sensor Signal Circuit and Ground on the ECT Sensor Low Reference Circuit.

During cold starts the ECM compares ECT Sensor, Intake Air Temperature (IAT) Sensor, and Mass Air Flow (MAF) temperature data. The three (3) temperature values should be very close.

# CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN	FMI	Description	Conditions to Run SPN
110	0	Engine Coolant Temperature Overheating	<ul><li>Ignition is ON</li><li>SPN 110-3 and SPN 110-4 are not set</li></ul>
110	7	Engine Coolant Temperature Not Warm	<ul> <li>SPN 110-3 and SPN 110-4 are not set</li> <li>Engine Speed &gt; 1500 RPM for 20 seconds</li> <li>ECM requires specific engine run times for given start temperatures (see table below)</li> </ul>
110	16	Engine Coolant Temperature High	<ul><li>Ignition is ON</li><li>SPN 110-3 and SPN 110-4 are not set</li></ul>

# ECM Required Engine Coolant Temperatures and Engine Run Times

Start Temperature	Engine Run Time
-30° F (-34° C)	67 minutes
-10° F (-23° C)	32 minutes
10° F (-12° C)	20 minutes
30° F (-1° C)	15 minutes
50° F (10° C)	7 minutes
62° F (18° C)	2 minutes





SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
110	0	Engine Coolant Temperature Overheating	ECM detects ECT Sensor Temperature greater than 250° F (121° C) for more than 1 second	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> <li>ECM turns ON Stop Engine Light (SEL)</li> <li><i>If equipped:</i> Warning Buzzer sounds and Overheat Message displays on Instrument Cluster</li> <li>Engine will operate in Reduced Power Mode</li> </ul>	А
110	7	Engine Coolant Temperature Not Warm	ECM detects ECT Sensor Temperature less than 149° F (65° C) when SPN 110-7 Conditions to Run are met	ECM turns ON Malfunction Indicator Light (MIL)	В
110	16	Engine Coolant Temperature High	ECM detects ECT Sensor Temperature greater than 250° F (121° C) for more than 1 second	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> <li>ECM turns ON Stop Engine Light (SEL)</li> <li><i>If equipped:</i> Warning Buzzer sounds and Overheat Message displays on Instrument Cluster</li> <li>Engine will operate in Reduced Power Mode</li> </ul>	A

# SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic.
- Test for intermittent or poor connections.
- Review Circuit Schematic and Connector End Views to locate test points.
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Malfunction Indicator Light.

#### Engine Coolant Temperature (ECT) Sensor Diagnostic Tips

- Start engine. Engine Coolant Temperature (ECT) Sensor temperature should rise steadily and stabilize after thermostat opens.
- Test ECT Sensor at various temperatures to identify a potentially bad sensor; a faulty ECT Sensor can cause drivability issues.
- Disconnect Harness Connector and use a Digital Multimeter between ECT Sensor Terminal A and B to measure sensor resistance. The table below shows the relationship between temperature and ECT Sensor resistance.





# Engine Coolant Temperature (ECT) Sensor Resistance Variability with Temperature

Temperature	ECT Sensor Resistance*
- 40° F (-40° C)	101 KΩ
-4° F (-20° C)	29 ΚΩ
32° F (0° C)	9.4 KΩ
104° F (40° C)	1.5 ΚΩ
176° F (80° C)	334 Ω
302° F (150° C)	47.5 Ω

\*Resistance values are approximate

# **TOOLS REQUIRED**

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp	Fused Jumper	

# POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
110	0	Engine Coolant Temperature Overheating	<ul> <li>Thermostat stuck</li> <li>Engine coolant low</li> <li>Cooling Fan Malfunction</li> <li>Faulty ECT Sensor</li> </ul>
110	1	Engine Coolant Temperature Not Warm	<ul> <li>Thermostat stuck</li> <li>High Resistance in ECT Low Reference Circuit</li> <li>Cooling Fan always ON</li> <li>Faulty ECT Sensor</li> </ul>
110	16	Engine Coolant Temperature High	<ul> <li>Thermostat stuck</li> <li>Engine coolant low</li> <li>Cooling Fan Malfunction</li> <li>Faulty ECT Sensor</li> </ul>





#### CONNECTOR END VIEWS (not to scale)





J1-C (Gray) ECM Connector



#### **CIRCUIT SCHEMATIC**







# SYSTEM VERIFICATION

























# **SPN 111 FMI 1**

# **DESCRIPTION OF CIRCUIT**

The OEM Engine Coolant Level Sensor uses a resistive type switch to measure engine coolant level. The 488LPI<sup>™</sup> Engine Control Module (ECM) supplies a five (5) volt signal on the Sensor Signal Circuit and Ground on the ECT Sensor Low Reference Circuit. The ECM monitors signal circuit voltage to determine if the Coolant Level Sensor is functioning properly.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN runs continuously while ignition is ON.

# SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
111	1	Engine Coolant Level Low	ECM detects Engine Coolant Level is low	ECM turns ON Check Engine Light (CEL) and Stop Engine Light (SEL) <b>NOTICE</b> ECM turns OFF SEL when Engine Coolant Level returns to normal.	A

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light
- Check Engine Coolant level
- Verify proper Engine Cooling System operation

#### **TOOLS REQUIRED**

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp	Fused Jumper	

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
111	1	Engine Coolant Level Low	<ul> <li>Engine coolant low</li> <li>Cooling System malfunction</li> <li>Engine Coolant Level Sensor short to voltage</li> </ul>





#### CONNECTOR END VIEWS (not to scale)

Engine Coolant Level (ECL) Sensor

Refer to OEM Service Instructions



J1-C (Gray) ECM Connector



#### **CIRCUIT SCHEMATIC**







# SYSTEM VERIFICATION



















# SPN 111 FMI 3 or 4

#### **DESCRIPTION OF CIRCUIT**

The 488LPI<sup>™</sup> Engine Coolant Level Sensor relies upon a resistive type switch to measure engine coolant level. The Engine Control Module (ECM) supplies five (5) volts on the sensor Signal Circuit and Ground on sensor Low Reference Circuit. The ECM monitors signal circuit voltage to verify normal Engine Coolant Level Sensor function.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN runs continuously while ignition is ON.

# SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
111	3	Engine Coolant Level Sensor Voltage High	ECM detects Engine Coolant Level Sensor voltage is greater than 5.0 V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A
111	4	Engine Coolant Level Sensor Voltage Low	ECM detects Engine Coolant Level Sensor voltage equals 0.0 V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A

# NOTICE

# Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light
- Check Engine Coolant Level
- Verify proper Engine Cooling System operation

# TOOLS REQUIRED

Terminal Test Probe Kit Digita

Digital Multimeter





# POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
111	3	Engine Coolant Level Sensor Voltage High	<ul> <li>Engine Coolant Level Sensor Signal short to voltage</li> <li>Engine Coolant Level Sensor malfunction</li> </ul>
111	4	Engine Coolant Level Sensor Voltage Low	<ul> <li>Engine Coolant Level Sensor Signal short to voltage</li> <li>Engine Coolant Level Sensor malfunction</li> </ul>

# CONNECTOR END VIEWS (not to scale)

Engine Coolant Level (ECL) Sensor

Refer to OEM Service Instructions J1-B (Brown) ECM Connector



J1-C (Gray) ECM Connector







### **CIRCUIT SCHEMATIC**







### SYSTEM VERIFICATION













# **SPN 132 Fault Code**

### DESCRIPTION OF CIRCUIT

The 488LPI<sup>™</sup> Mass Air Flow (MAF) Sensor provides a variable signal to the Engine Control Module (ECM) dependent on the amount of air that is moving through the sensor to the engine. Powered by battery voltage and ground, the MAF Sensor also incorporates an Intake Air Temperature (IAT) Sensor. The ECM supplies five (5) volts to the MAF Sensor on the Signal Circuit which the sensor uses to produce a frequency signal for the ECM.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBERS (SPNs)

SPN runs continuously while Ignition is ON.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
132	3	Mass Air Flow (MAF) Sensor Signal High	ECM detects MAF Sensor Signal Circuit > 3213 kg/h > 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В
132	4	Mass Air Flow (MAF) Sensor Signal Low	ECM detects MAF Sensor Signal Circuit = 0 kg/h for > 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic.
- Test for intermittent or poor connections.
- Review Circuit Schematic and Connector End Views to locate test points.
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Malfunction Indicator Light.

#### TOOLS REQUIRED

High Impedance Test Lamp	Digital Multimeter	Terminal Test Probe Kit
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# POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
132	3	Mass Air Flow (MAF) Sensor Signal High	<ul> <li>Open/high resistance in Low Reference Circuit</li> <li>Short to voltage in Signal Circuit</li> </ul>
132	4	Mass Air Flow (MAF) Sensor Signal Low	<ul> <li>Short to Ground in Signal Circuit</li> <li>Open voltage circuit</li> </ul>

#### CONNECTOR END VIEWS (not to scale)

Mass Air Flow (MAF) Sensor



J1-B (Brown) ECM Connector



J1-C (Gray) ECM Connector









#### **CIRCUIT SCHEMATIC**







### SYSTEM VERIFICATION





488LP/













# **SPN 132 Performance**

# **DESCRIPTION OF CIRCUIT**

The 488LPI™ Engine Control Module (ECM) compares the Mass Air Flow (MAF) Sensor signal to other engine component inputs to check MAF Sensor function. The ECM compares engine speed and data from the Throttle Position Sensor (TPS) and Intake Air Temperature (IAT) Sensor for potential conflicts with the MAF Sensor. The ECM also assesses values from Manifold Absolute Pressure (MAP), IAT, and engine speed for speed density calculations and determines if MAF data matches the results.

SPN	FMI	Description	Conditions to Run SPN	
132	2	Mass Air Flow (MAF) Sensor Conflict	<ul> <li>Ignition turned ON</li> <li>Intake Air Temperature (IAT) Sensor signal valid</li> <li>Throttle Position Sensor (TPS) signal valid</li> <li>Engine Speed valid</li> </ul>	
132	7	Mass Air Flow (MAF) Sensor / Speed Density Calculation Conflict	<ul> <li>Ignition turned ON</li> <li>Intake Air Temperature (IAT) Sensor signal valid</li> <li>Throttle Position Sensor (TPS) signal valid</li> <li>Engine Speed valid</li> </ul>	

# CONDITIONS TO RUN SUSPECTED PARAMETER NUMBERS (SPNs)

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
132	2	Mass Air Flow (MAF) Sensor Conflict	ECM suspects a fault if difference between MAF Sensor value and MAF alpha-N calculation is more than 60,000 g/s and ratio of MAF Sensor value to MAF alpha-N calculation is more than the threshold 1.25 or less than 0.4	ECM turns ON Check Engine Light (CEL)	В
132	7	Mass Air Flow (MAF) Sensor / Speed Density Calculation Conflict	ECM suspects a fault if difference between MAF Sensor value and MAF speed density calculation is more than 65 g/s		В





#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematics and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light
- Verify Air Intake Assembly is properly assembled and tight
- Test for vacuum leaks

# TOOLS REQUIRED

**Digital Multimeter** 

# POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
132	2	Mass Air Flow (MAF) Sensor Conflict	<ul><li>MAF Sensor malfunction</li><li>Vacuum leak</li><li>Air leak</li></ul>
132	7	Mass Air Flow (MAF) Sensor / Speed Density Calculation Conflict	<ul><li>MAF Sensor malfunction</li><li>Vacuum leak</li><li>Air leak</li></ul>

#### CONNECTOR END VIEWS (not to scale)

Mass Air Flow (MAF) Sensor



J1-A (Black) ECM Connector



J1-B (Brown) ECM Connector



J1-C (Gray) ECM Connector







#### **CIRCUIT SCHEMATIC**







# SYSTEM VERIFICATION




488LP/







# **SPN 136 FMI 5**

### **DESCRIPTION OF CIRCUIT**

The 488LPI<sup>™</sup> EVAP (Evaporative Emissions) Control Module controls the EVAP Pump motor. After the vehicle is shut off and unattended for 20 minutes or more, the EVAP Control Module energizes the pump to draw fuel vapors out of the Intake Manifold to the EVAP Charcoal Canister. The EVAP Control Module monitors voltage for proper operation.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN	FMI	Description	Conditions to Run SPN
136	5	EVAP Module Vacuum Pump Circuit Open/Short	<ul> <li>SPN runs continuously while Ignition is OFF for 20 mins or more</li> <li>SPN runs when Battery voltage is more than 12.1 V</li> </ul>

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
136	5	EVAP Module Vacuum Pump Circuit Open/Short	EVAP Control Module detects actual state of the Control circuit does not match commanded state.	EVAP Module will flash Check Engine Light (CEL)	В

# NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Schematics and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light
- Check for blown fuses
- Verify Battery voltage is 12.1 V or greater

#### **TOOLS REQUIRED**

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp	Fused Jumper	





#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
132	5	EVAP Module Vacuum Pump Open/Short	<ul> <li>Open/short to voltage in EVAP Pump Control Circuit</li> <li>Open/high resistance in EVAP Pump Voltage Supply Circuit</li> </ul>

### CONNECTOR END VIEWS (not to scale)



# C28 Bulkhead Connector J1-B (Brown) ECM Connector





# POWER DISTRIBUTION MODULE RELAYS AND FUSES









#### **CIRCUIT SCHEMATIC**







#### SYSTEM VERIFICATION





488LP/





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# **SPN 157 Fault Code**

### **DESCRIPTION OF CIRCUIT**

The Fuel Rail Pressure/Temperature (FPT) Sensor is a combination sensor that supplies the Engine Control Module (ECM) both pressure and temperature signals. The ECM supplies five (5) volts to the sensor on the 5 V Reference Circuit and Ground on the Low Reference Circuit. The Fuel Rail Pressure/Temperature Sensor provides separate Fuel Rail pressure and temperature signals to the ECM on the signal circuits.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN runs continuously while ignition is ON.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
157	3	Fuel Rail Pressure Sensor Signal Voltage High	ECM detects Fuel Rail Pressure Sensor Signal Circuit greater than 5.0 V for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В
157	4	Fuel Rail Pressure Sensor Signal Voltage Low	ECM detects Fuel Rail Pressure Sensor Signal Circuit equal to 0.0 V more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / MIL

# NOTICE

# If a fault condition exists in either the 5 V Reference Circuit or the Low Reference Circuit, SPNs for both pressure and temperature may set

#### TOOLS REQUIRED

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
Fused Jumper		





# POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
157	3	Fuel Rail Pressure Sensor Signal Voltage High	<ul> <li>Open/high resistance in Low Reference Circuit</li> <li>Short to voltage in Signal Circuit</li> <li>Short to voltage in 5 V Reference Circuit</li> </ul>
157	4	Fuel Rail Pressure Sensor Signal Voltage Low	<ul> <li>Short to Ground in Signal Circuit</li> <li>Open/high resistance in Signal Circuit</li> <li>Open/high resistance in 5 V Reference Circuit</li> </ul>

# CONNECTOR END VIEWS (not to scale)

C22 Fuel Rail Pressure / Temperature (FPT) Sensor







J1-C (Gray) ECM Connector







#### **CIRCUIT SCHEMATIC**



LEGEND:

--- Incomplete Component Pinout





#### SYSTEM VERIFICATION





488LPI











488LP/







# **SPN 168 Fault Code**

### **DESCRIPTION OF CIRCUIT**

The 488LPI<sup>™</sup> EVAP (Evaporative Emissions) Control Module controls the EVAP Pump motor. After the vehicle is shut off and unattended for twenty (20) minutes or more, the EVAP Control Module energizes the EVAP Pump to draw fuel vapors out of the Intake Manifold to the EVAP Charcoal Canister. The EVAP Control Module monitors voltage for proper operation.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPNs run for up to 110 hours when ignition is OFF for less than 20 minutes when Battery voltage is more than 12.1 V.

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
168	3	EVAP Module Battery Voltage High	EVAP Control Module detects voltage supply circuit greater than 18 V	EVAP Module will flash Check Engine Light (CEL)	В
168	4	EVAP Module Battery Voltage Low	EVAP Control Module detects voltage supply circuit less than 0.5 V	EVAP Module will flash Check Engine Light (CEL)	В

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

# NOTICE

### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light
- Check Power Distribution Module for blown fuses
- Verify Battery voltage is greater than 12.1 V

### TOOLS REQUIRED

Digital Multimeter Terminal Test Probe Kit





# POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
168	3	EVAP Module Battery Voltage High	EVAP Control Module malfunction
168	4	EVAP Module Battery Voltage Low	<ul> <li>Vehicle charging system malfunction</li> <li>Open/high resistance in EVAP Control Module Voltage Supply Circuit</li> <li>Open/short to voltage in EVAP Pump Control Circuit</li> </ul>

# CONNECTOR END VIEWS (not to scale)



C28 Bulkhead Connector



J1-B (Brown) Engine Control Module (ECM) Connector







# POWER DISTRIBUTION MODULE RELAYS AND FUSES









#### **CIRCUIT SCHEMATIC**







### SYSTEM VERIFICATION



















# SPN 172 Fault Code

#### **DESCRIPTION OF CIRCUIT**

The 488LPI<sup>™</sup> Intake Air Temperature (IAT) Sensor is a variable resistor in the Mass Air Flow (MAF) Sensor that measures the temperature of air entering the engine. The Engine Control Module (ECM) supplies five (5) volts on the IAT Signal Circuit and Ground on the Low Reference Circuit.

The Electronic Service Tool (EST) reads IAT Sensor data as "Engine Intake Manifold 1 Temperature."

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN runs continuously while Ignition is ON.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
172	3	Intake Air Temperature Sensor Signal Voltage Low	ECM detects IAT Sensor Signal voltage greater than 5.0V for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В
172	4	Intake Air Temperature Sensor Signal Voltage High	ECM detects IAT Sensor Signal voltage equal to 0.0 V for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this procedure
- Test for intermittent or poor connections
- Review Circuit Schematics and Connector End Views below to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Malfunction Indicator Light
- If a fault condition exists in either the 5 V Reference or Low Reference Circuit, SPNs for both intake air pressure and temperature may set
- Before starting engine, temperature readings for IAT Sensor and ECT Sensor should closely match
- Test IAT Sensor at various temperatures to identify a potentially bad sensor; a faulty IAT Sensor can cause driveability issues
- Disconnect IAT Sensor at the Mass Air Flow (MAF) Sensor Harness Connector and use a Multimeter between MAF Sensor Connector Terminals A and B to measure sensor resistance. The following table shows how IAT Sensor resistance varies with temperature:





ECT Sensor Resistance*
101 KΩ
29 ΚΩ
9.4 KΩ
1.5 KΩ
334 Ω
47.5 Ω

### Intake Air Temperature (IAT) Sensor Resistance Variability with Temperature

\*Resistance values are approximate

#### TOOLS REQUIRED

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
Fused Jumper		

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
110	3	ECT Sensor Signal Voltage High	<ul> <li>Open Low Reference Circuit</li> <li>Open or short to voltage in Signal Circuit</li> </ul>
110	4	ECT Sensor Signal Voltage Low	<ul> <li>Short to Ground in Signal Circuit</li> </ul>





#### CONNECTOR END VIEWS (not to scale)

Mass Air Flow (MAF) Sensor



J1-A (Black) ECM Connector



#### **CIRCUIT SCHEMATIC**

LEGEND:

J1-C (Gray) ECM Connector

**Engine Control** 

J1-B (Brown) ECM Connector

**OEM Wiring / Connector / Component** 

- →>→ Intermediate Connector
- -Incomplete Component Pinout







#### SYSTEM VERIFICATION



- Ignition OFF
- Disconnect Mass Air Flow (MAF) Sensor Harness Connector
- Use Multimeter to test for ≤ 10 Ω between IAT Sensor Low Reference Circuit Terminal A and Ground





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488LP/







# **SPN 172 Performance**

#### DESCRIPTION OF CIRCUIT

The Intake Air Temperature (IAT) Sensor is a variable resistor in the Mass Air Flow (MAF) Sensor that measures the temperature of air entering the engine. The 488LPI<sup>™</sup> Engine Control Module (ECM) monitors Intake Air Temperature (IAT) value at start up once calibrated requirements are met. SPN 172 will set if IAT value does not change greater than the minimum threshold.

#### **CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)**

SPN	FMI	Conditions to Run SPN		
172	2	<ul> <li>Ignition is ON</li> <li>IAT valid</li> <li>ECT valid</li> <li>MAF valid</li> <li>Engine is considered a Cold Start if the difference between IAT and ECT temperature inputs is less than 68° F (20° C) at start</li> <li>ECM monitors High and Low IAT values at engine start and compares them for 300 seconds</li> </ul>		

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
172	2	Intake Air Temperature (IAT) Sensor Conflict	ECM suspects a fault if difference between High and Low IAT value less than 3.6° F (2.6° C)	ECM turns ON Check Engine Light (CEL)	A

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this procedure
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light

#### TOOLS REQUIRED

No special tools required.

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
172	2	Intake Air Temperature (IAT) Sensor Conflict	Intake Air Temperature (IAT) Sensor malfunction





# SYSTEM VERIFICATION







# SPN 174 Fault Code

#### **DESCRIPTION OF CIRCUIT**

The 488LPI<sup>™</sup> Fuel Rail Pressure/Temperature (FPT) Sensor is a combination sensor that supplies the Engine Control Module (ECM) data relative to fuel pressure and temperature at the Fuel Rail. The ECM supplies five (5) volts to the FPT Sensor on the 5 V Reference Circuit and Ground on the Low Reference Circuit. The Fuel Rail Pressure/Temperature Sensor provides separate pressure and temperature signals to the ECM on the Signal Circuit.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN runs continuously while Ignition is ON.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
174	3	Fuel Rail Temperature Sensor Signal High	ECM detects FPT Temperature Sensor Signal voltage greater than 5.0 V for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В
174	4	Fuel Rail Temperature Sensor Signal Low	ECM detects FPT Temperature Sensor Signal voltage equal to 0.0 V for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this procedure
- Test for intermittent or poor connections
- Review Circuit Schematics and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Malfunction Indicator Light
- If a fault condition exists in either the 5 V Reference or Low Reference Circuit, SPNs for both pressure and temperature may set

#### TOOLS REQUIRED

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit	
Fused Jumper			





# POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
174	3	Fuel Rail Temperature Sensor Signal High	<ul> <li>Open/high resistance in Low Reference Circuit</li> <li>Short to voltage in Signal Circuit</li> <li>Short to voltage in 5 V Reference Circuit</li> </ul>
174	4	Fuel Rail Temperature Sensor Signal Low	<ul> <li>Short to Ground in Signal Circuit</li> <li>Open/high resistance in Signal Circuit</li> <li>Open/high resistance in 5 V Reference Circuit</li> </ul>

#### CONNECTOR END VIEWS (not to scale)







J1-C (Gray) ECM Connector







#### **CIRCUIT SCHEMATIC**



LEGEND:

Incomplete Component Pinout





#### SYSTEM VERIFICATION





488LP/




















# **SPN 191 Fault Code**

#### DESCRIPTION OF CIRCUIT

The 488LPI<sup>™</sup> Engine Control Module (ECM) compares Engine Speed and Transmission Output Shaft Speed when conditions are met and the Torque Converter Clutch is engaged. SPN 191 sets if the difference between Engine Speed and Transmission Output Shaft Speed is greater than a calibrated value.

#### **CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)**

SPN runs continuously while Ignition is ON.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
191	19	Transmission Output Shaft Speed Conflict	ECM detects difference between Transmission Output Shaft Speed and Engine Speed greater than 200 RPM for three (3) seconds with Torque Convertor Clutch engaged	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> <li>ECM disables Cruise Control</li> <li>ECM disables PTO</li> </ul>	A

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this procedure
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light

#### TOOLS REQUIRED

Electronic Service Tool

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
191	19	Transmission Output Shaft Speed Conflict	<ul> <li>Transmission Output Shaft Speed Sensor malfunction</li> <li>Torque Converter Clutch slipping/malfunction</li> <li>Transmission Clutch slipping</li> </ul>





### SYSTEM VERIFICATION







# **SPN 595 Fault Code**

#### **DESCRIPTION OF CIRCUIT**

Cruise Control for the 488LPI<sup>™</sup> Engine utilizes resistive type switches for ON/OFF and SET/RES (Set/Resume) functions. The Engine Control Module (ECM) supplies five (5) volts to the Cruise Control Switch Signal Circuit and Ground on the Low Reference Circuit. The ECM monitors Signal Circuit voltage to determine both Cruise Control Switches are operating properly.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN runs continuously while Ignition is ON.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
595	2	Cruise Control Switch Signal Invalid	ECM detects ECM detects Cruise Control Switch Signal voltage greater than or less than calibrated range for more than 240 ms	ECM turns ON Check Engine Light (CEL)	В
595	3	Cruise Control Switch Signal High	ECM detects Cruise Control Switch Signal voltage greater than 5.0 V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A
595	4	Cruise Control Switch Signal Low	ECM detects Cruise Control Switch Signal voltage equals 0.0 V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A
595	7	Cruise Control Switch Signal Stuck	ECM detects Cruise Control Switch Signal is stuck in a valid range for more than 10 seconds	ECM turns ON Check Engine Light (CEL)	A

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light

# NOTICE

#### Faults in either or both Cruise Control Switches could cause a SPN to set.

#### TOOLS REQUIRED

**Digital Multimeter** 

Terminal Test Probe Kit





## POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
595	2	Cruise Control Switch Signal Invalid	<ul> <li>Open/high resistance in Low Reference Circuit</li> <li>Open/high resistance in Signal Circuit</li> <li>Cruise Control Switch malfunction</li> </ul>
595	3	Cruise Control Switch Signal High	Short to voltage in Signal Circuit
595	4	Cruise Control Switch Signal Low	Short to Ground in Signal Circuit
595	7	Cruise Control Switch Signal Stuck	<ul> <li>Open/high resistance in Signal Circuit</li> <li>Open/high resistance in 5 V Reference Circuit</li> <li>Cruise Control Switch malfunction</li> </ul>

#### CONNECTOR END VIEWS (not to scale)

Cruise Control ON/OFF Switch Connector

> Refer to OEM Service Manual

Cruise Control SET/ RES Switch Connector

> Refer to OEM Service Manual



J1-C (Gray) ECM Connector







#### **CIRCUIT SCHEMATIC**







#### SYSTEM VERIFICATION

























# SPN 597 Fault Code

#### **DESCRIPTION OF CIRCUIT**

The 488LPI Engine Control Module (ECM) compares data from the Brake ON/OFF (BOO) Switch with Brake Pedal Position Switch (BPS) status messages from the Transmission Control Module (TCM) via the SAE J1939 CAN data link. With the Brake Pedal released, BOO Signal is low and BPS Signal is high. When the Brake Pedal is depressed, BOO Signal is high and BPS Signal is high.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN runs continuously while Engine is running.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
597	2	Brake Switch Conflict	ECM detects a fault if the BOO and BPS signals are not inversed	ECM turns ON Malfunction Indicator Light (MIL)	A

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematics and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Malfunction Indicator Light
- A stuck Brake ON/PFF Switch or Brake Pedal Position Switch may cause SPN 597-2 to set

#### TOOLS REQUIRED

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
Fused Jumper		

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
597	2	Brake Switch Conflict	Brake Pedal Switch malfunction





#### CONNECTOR END VIEWS (not to scale)

J1-C (Gray) ECM Connector



Brake Pedal Switch Connector

Refer to OEM Service Manual









#### SYSTEM VERIFICATION - CIRCUIT TESTING







#### SYSTEM VERIFICATION- CIRCUIT TESTING (continued)







#### SYSTEM VERIFICATION – COMPONENT TESTING







# SPN 609 FMI 11 Fault Code SPN 639 FMI 11 Fault Code SPN 2023 FMI 19 Fault Code SPN 2033 FMI 19 Fault Code

### **DESCRIPTION OF CIRCUIT**

The SAE J1939 Controller Area Network (CAN) data link allows the 488LPI<sup>M</sup> Engine Control Module (ECM), Torque Security Module (TSM), Evaporative Emissions (EVAP) Control Module, and the vehicle OEM Bulkhead Module and Power Take Off (PTO) Module to share and compare digital information over a low current circuit network. This data link consists of shielded, twisted wire pairs—CAN High and CAN Low—with a 120  $\Omega$  terminating Resistor on each wire.

Each module sends a State Of Health message to the other modules when Ignition is ON. If a module fails to provide a State Of Health Message, a Data Trouble Code (DTC) may set in one or more of the other modules via the data link. The data link also provides diagnostic information which may be accessed by the Electronic Service Tool (EST) using a Data Link Connector (DLC) inside the vehicle cab.

# NOTICE

Follow OEM module literature for other SAE J1939 diagnostic procedures.

#### **CONDITIONS TO RUN SPNs**

SPN runs continuously while Ignition is ON.





SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
639	11	Communication Bus Passive	State of communication circuits cannot be determined	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> </ul>	A
609	11	Torque Security Module (TSM) Communication Invalid	ECM did not receive a valid communication message from Torque Security Module	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> </ul>	A
2023	19	PTO Control Communication Invalid	ECM did not receive a valid communication message from PTO Control Module	<ul> <li>PTO disabled</li> <li>SPN 2023-19 stored as an active code</li> </ul>	-
2033	19	Bulkhead Module Communication Invalid	ECM did not receive a valid communication message from Bulkhead Module	<ul> <li>A/C inoperative</li> <li>Park Brake Switch inoperative</li> <li>Brake Switch inoperative</li> <li>Brake Switch Conflict SPN may set</li> </ul>	-

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

# NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this procedure
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review Conditions to Clear SPN
- Attempt to communicate with suspect module via CAN Circuits
- Verify suspect module has Power and Ground
- Verify Fuses are not blown
- Test for faulty C13 CAN 2 Terminating Resistors

#### TOOLS REQUIRED

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp		





## POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
609	11	Torque Security Module (TSM) Communication Invalid	<ul> <li>Open Serial Data Link Circuit</li> <li>Open/short in Power or Ground Circuits</li> <li>Torque Security Module (TSM) malfunction</li> </ul>
639	11	Communication Bus Passive	<ul> <li>CAN 2 High short to Ground</li> <li>CAN 2 Low short to Battery</li> <li>C13 CAN 2 Terminating Resistor malfunction</li> <li>Engine Control Module (ECM) malfunction</li> </ul>
2023	19	PTO Control Communication Invalid	<ul> <li>Open Serial Data Link Circuit</li> <li>Open/short in Power or Ground Circuits</li> <li>Bulkhead Module malfunction</li> <li>PTO Controller malfunction</li> </ul>
2003	19	Bulkhead Module Communication Invalid	<ul> <li>Open Serial Data Link Circuit</li> <li>Open/short in Power or Ground Circuits</li> <li>Bulkhead Module malfunction</li> </ul>

#### DATA LINK CONNECTOR (DLC) PINOUT

## J1939 OBD DLC Connector



# **Connector Pinout**

- A Ground
- **B** Battery Power
- C CAN 1 High
- D CAN 1 Low
- E Shield (Common)
- F J1708 High
- G J1708 Low
- J CAN 2 High
- H CAN 2 Low





#### DATA LINK CONNECTOR (DLC) CIRCUIT VERIFICATION



















#### MODULE COMMUNICATION VERIFICATION

Use Electronic Service Tool (EST) to attempt communication with PTO Control Module.

#### **MODULE COMMUNICATION VERIFICATION – CONNECTOR END VIEWS**

C13 CAN 2 Terminating Resistor Connector

C4 Torque Security Module (TSM) Connector







J1-B (Brown) ECM Connector







#### **MODULE COMMUNICATION VERIFICATION – CIRCUIT SCHEMATIC**

(partial - Refer to OEM service materials)



- $\gg$
- Splice
- **OEM Wiring**





#### **MODULE COMMUNICATION VERIFICATION**







#### MODULE COMMUNICATION VERIFICATION (continued)







## MODULE COMMUNICATION VERIFICATION (continued)







#### MODULE COMMUNICATION VERIFICATION (continued)







# SPN 609 FMI 12 & 3464 FMI 12 Fault Codes

#### DESCRIPTION OF CIRCUIT

The Engine Control Module (ECM) is programmed to receive a SAE J1939 CAN data link message from the Torque Security Module (TSM) at specific time intervals. If the TSM does not respond within the required interval, SPN 609 FMI 12 will set. Additionally, if the SAE J1939 CAN data link message is not processed by the ECM, SPN 3464 FMI will set.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBERS (SPNs)

SPNs run continuously while Ignition is ON.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
609	12	Main Processor Heartbeat Synchronization Fault	ECM detects a fault if no change in the synchronization counter field of the SAE J1939 CAN data link message is observed for a continuous period	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> <li>Power Limit Mode will be enabled for current key cycle</li> <li>ECM disables Cruise Control</li> <li>ECM disables PTO</li> </ul>	A
3464	12	Level 2 Processor (TSM) Not Executed	The ECM suspects a fault if correct answer is not received from TSM within 60 ms after corresponding algorithm argument is transmitted	<ul> <li>ECM turns ON Stop Engine Light (SEL)</li> <li>ECM turns ON Check Engine Light (CEL)</li> <li>ECM disables Main Power Relay (MPR)</li> </ul>	A

# NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this procedure
- Test for intermittent or poor connections
- Review Circuit Schematics and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light
- Test for faulty resistor





## **TOOLS REQUIRED**

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp		

## POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
609	12	Main Processor Heartbeat Synchronization Fault	<ul> <li>Intermittent or poor CAN Data Link connection in circuits between ECM and TSM</li> <li>Faulty terminating resistor</li> <li>Internal ECM malfunction</li> </ul>
3464	12	Level 2 Processor (TSM) Not Executed	Internal Torque Security Module (TSM) malfunction

#### CONNECTOR END VIEWS (not to scale)

#### Torque Security Module (TSM) Connector



#### J1-B (Brown) ECM Connector







#### **CIRCUIT SCHEMATIC**







#### SYSTEM VERIFICATION

















488LP/


















# SPN 651 – 658 FMI 5 Fault Codes

#### **DESCRIPTION OF CIRCUIT**

Fuel Injectors for the 488LPI Engine receive Ignition voltage via the Main Power Relay (MPR) through two (2) 15 A Fuses to protect the circuits. The Engine Control Module (ECM) supplies Ground path to open the Fuel Injectors through a driver and monitors eight (8) Injector Control Circuits for short or open circuits.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBERS (SPNs)

SPN runs continuously while Engine is running.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
651	5	Cylinder 1 Injector Circuit Fault			
652	5	Cylinder 2 Injector Circuit Fault			
653	5	Cylinder 3 Injector Circuit Fault	commanded state of	ECM turne ON	
654	5	Cylinder 4 Injector Circuit Fault	the Injector Control	Malfunction	B
655	5	Cylinder 5 Injector Circuit Fault	match the actual	Indicator Light	D
656	5	Cylinder 6 Injector Circuit Fault	state of the Driver for more than 240 ms		
657	5	Cylinder 7 Injector Circuit Fault			
658	5	Cylinder 8 Injector Circuit Fault			

### NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light
- MIL may flash when there is an engine misfire
- High resistance in Injector Circuits may set a Misfire SPN without setting an Injector SPN
- Injector resistance changes with temperature

## NOTICE

A blown fuse will set multiple Injector SPNs.





#### **TOOLS REQUIRED**

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp	Fused Jumper	

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
651	5	Cylinder 1 Injector Circuit Fault	
652	5	Cylinder 2 Injector Circuit Fault	<ul> <li>Open/high resistance in Injector Control</li> </ul>
653	5	Cylinder 3 Injector Circuit Fault	Circuit  Short to Ground in Injector Control Circuit
654	5	Cylinder 4 Injector Circuit Fault	<ul> <li>Open in Ignition Voltage Supply Circuit</li> </ul>
655	5	Cylinder 5 Injector Circuit Fault	NOTICE
656	5	Cylinder 6 Injector Circuit Fault	A blown fuse will set multiple Injector
657	5	Cylinder 7 Injector Circuit Fault	SPNs
658	5	Cylinder 8 Injector Circuit Fault	

#### CONNECTOR END VIEWS (not to scale)







C28 Bulkhead Connector





488LPI

#### **CIRCUIT SCHEMATIC**







#### SYSTEM VERIFICATION - CIRCUIT TESTING







#### SYSTEM VERIFICATION - CIRCUIT TESTING (continued)







#### SYSTEM VERIFICATION - CIRCUIT TESTING (continued)







#### SYSTEM VERIFICATION – COMPONENT TESTING







# SPN 970 FMI 19 Fault Code

#### **DESCRIPTION OF CIRCUIT**

The SAE J1939 Controller Area Network (CAN) data link allows the 488LPI<sup>m</sup> Engine Control Module (ECM), Torque Security Module (TSM), and other modules to share and compare digital information over a low current circuit network. This data link consists of shielded, twisted wire pairs—CAN High and CAN Low—with a 120  $\Omega$  terminating Resistor on each wire.

Each control module sends a State Of Health message to the other modules when Ignition is ON. If a module fails to provide a State Of Health Message, a Data Trouble Code (DTC) may set in one or more of the other modules via the data link. The data link also provides diagnostic information which may be accessed by the Electronic Service Tool (EST) using a Data Link Connector (DLC) inside the vehicle cab.

Follow OEM Vehicle Electrical Troubleshooting materials for other SAE J1939 diagnostic procedures.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN runs continuously while Ignition is ON.

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
970	19	Remote Shut Down Module Communication Invalid	ECM did not receive a valid communication message from Remote Shutdown Module	<ul> <li>Remote Shutdown disabled</li> <li>SPN 970-19 stored as an active code</li> </ul>	A

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this procedure
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type and Conditions to Clear SPN
- Attempt to communicate with Remote Shutdown Module
- Verify Remote Shutdown Module has Power and Ground
- Verify Fuses are not blown





#### **TOOLS REQUIRED**

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp		

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
970	19	Remote Shut Down Module Communication Invalid	<ul> <li>Open Serial Data Link Circuit</li> <li>Open/short in Power or Ground Circuits</li> <li>Bulkhead Module malfunction</li> <li>Remote Shutdown Module malfunction</li> </ul>

#### DATA LINK CONNECTOR (DLC) PINOUT

### J1939 OBD DLC Connector



### **Connector Pinout**

- A Ground
- **B** Battery Power
- C CAN 1 High
- D CAN 1 Low
- E Shield (Common)
- F J1708 High
- G J1708 Low
- J Proprietary CAN High
- H Proprietary CAN Low





#### DATA LINK CONNECTOR (DLC) CIRCUIT VERIFICATION













#### DATA LINK CONNECTOR (DLC) CIRCUIT VERIFICATION (continued)







#### **REMOTE SHUTDOWN MODULE (RSM) COMMUNICATION VERIFICATION**

Use Electronic Service Tool (EST) to attempt communication with individual Remote Shut Down Module (RSM):

- If RSM communicates: Verify SPN is clear
- If RSM does not communicate: Refer to OEM Vehicle Manual

#### **CONNECTOR END VIEWS**

Remote Shutoff Module Connector

Refer to OEM vehicle service manual

J1-B (Brown) ECM Connector



C28 Bulkhead Connector



#### **CIRCUIT SCHEMATIC**



\*Refer to OEM vehicle wiring schematic for component pinout





#### **REMOTE SHUTOFF MODULE (RSM) COMMUNICATION VERIFICATION**















#### **REMOTE SHUTOFF MODULE (RSM) COMMUNICATION VERIFICATION** (continued)







# SPN 1268 – 1275 FMI 5 Fault Codes

#### DESCRIPTION OF CIRCUIT

The 488LPI<sup>™</sup> Engine Ignition System uses eight (8) individual Ignition Coils—one for each cylinder. The Engine Control Module (ECM) directs the charge and discharge of each coil through separate control circuits. Electrical current flows through the primary windings of each coil when the control circuit is commanded ON creating a magnetic field. When the ECM determines conditions are appropriate for an ignition event, the ECM interrupts current flow causing the magnetic field to collapse across the secondary windings inside the coil producing a high voltage discharge across the Spark Plug electrodes.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBERS (SPNs)

SPN runs continuously while Ignition is ON.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
1268	5	Cylinder 1 Ignition Coil Circuit Open or Short			
1269	5	Cylinder 2 Ignition Coil Circuit Open or Short			
1270	5	Cylinder 3 Ignition Coil Circuit Open or Short	ECM detects commanded		
1271	5	Cylinder 4 Ignition Coil Circuit Open or Short	Control Circuit does not	ECM turns ON	Б
1272	5	Cylinder 5 Ignition Coil Circuit Open or Short	match state of Coil Control	Indicator Light (MIL)	D
1273	5	Cylinder 6 Ignition Coil Circuit Open or Short	for more than 240 ms		
1274	5	Cylinder 7 Ignition Coil Circuit Open or Short			
1275	5	Cylinder 8 Ignition Coil Circuit Open or Short			





## NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematics and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light
- If SPNs 1268, 1270, 1272, and 1274 are all present, test for open Battery Voltage Supply circuit
- If SPNs 1269, 1271, 1273, and 1275 are all present, test for open Battery Voltage Supply circuit

NOTICE

Verify fuse is not blown.

#### TOOLS REQUIRED

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp	Fused Jumper	

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
1268	5	Cylinder 1 Ignition Coil Circuit Open or Short	
1269	5	Cylinder 2 Ignition Coil Circuit Open or Short	
1270	5	Cylinder 3 Ignition Coil Circuit Open or Short	<ul> <li>Short to Voltage in appropriate</li> </ul>
1271	5	Cylinder 4 Ignition Coil Circuit Open or Short	Cylinder Coil Control Circuit <ul> <li>Open or Short to Ground in</li> </ul>
1272	5	Cylinder 5 Ignition Coil Circuit Open or Short	appropriate Cylinder Coil Control Circuit
1273	5	Cylinder 6 Ignition Coil Circuit Open or Short	Open voltage Supply Circuit
1274	5	Cylinder 7 Ignition Coil Circuit Open or Short	
1275	5	Cylinder 8 Ignition Coil Circuit Open or Short	





#### CONNECTOR END VIEWS (not to scale)

J1-A (Black) ECM Connector







C28 Bulkhead Connector









CIRCUIT SCHEMATIC - C17 Ignition Coils - Bank 1 - Cylinders 1, 3, 5, 7

------ OEM Wiring / Connector / Component







#### CIRCUIT SCHEMATIC - C19 Ignition Coils - Bank 2 - Cylinders 2, 4, 6, 8

- OEM Wiring/Connector/Component





#### SYSTEM VERIFICATION











488LP/













# **SPN 1323 – 1330 FMI 31 Fault Codes**

#### **DESCRIPTION OF CIRCUIT**

The 488LPI<sup>™</sup> Engine Control Module (ECM) uses signals from the Crankshaft Position (CKP) Sensor and Camshaft Position (CMP) Sensor to determine when an engine misfire occurs and on which cylinder. The ECM chooses whether the diagnostic is based on average RPM or instantaneous RPM data. For each cylinder an average RPM (measured between TDC firings) and instant RPM [measured between last 2 (two) Reluctor Wheel Encoder Teeth] are stored for twenty (20) previous Engine Cycles. The average RPM difference is calculated for each cylinder. For each cylinder a fault is suspected if the average difference is less than a threshold based on the stored data and average engine speed.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBERS (SPNs)

- Engine Coolant Temperature (ECT) higher than 158° F (70° C)
- Engine running for more than 60 seconds
- Engine RPM at steady state

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
1323	31	Misfire Cylinder 1		<ul> <li>ECM flashes</li> </ul>	
1324	31	Misfire Cylinder 2		Check Engine	
1325	31	Misfire Cylinder 3	ECM detects average RPM for a cylinder less than a threshold based upon stored data and Engine Speed	<ul> <li>ECM disables</li> </ul>	
1326	31	Misfire Cylinder 4		Fuel Injector for	^
1327	31	Misfire Cylinder 5		for which SPN	A
1328	31	Misfire Cylinder 6		is set	
1329	31	Misfire Cylinder 7		to Open Loop	
1330	31	Misfire Cylinder 8		Fuel Control	

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

### NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light
- High resistance on any Fuel Injector Circuit may set a misfire SPN
- High resistance on any Ignition Coil Circuit may set a misfire SPN



A misfire SPN may be caused by excessive vibration not related to engine vibration.





#### **TOOLS REQUIRED**

**Electronic Service Tool** 

#### **POSSIBLE CAUSES**

SPN	FMI	Description	Possible Causes
1323	31	Misfire Cylinder 1	
1324	31	Misfire Cylinder 2	
1325	31	Misfire Cylinder 3	Spark Plug defective
1326	31	Misfire Cylinder 4	<ul> <li>Ignition Coll detective</li> <li>Eucl Injector restricted or leaking</li> </ul>
1327	31	Misfire Cylinder 5	<ul> <li>Reluctor Wheel bent or damaged</li> </ul>
1328	31	Misfire Cylinder 6	<ul> <li>Engine mechanical issue</li> </ul>
1329	31	Misfire Cylinder 7	
1330	31	Misfire Cylinder 8	





#### SYSTEM VERIFICATION













## SPN 1347 Fault Code

#### **DESCRIPTION OF CIRCUIT**

The 488LPI<sup>™</sup> Engine Control Module (ECM) supplies Ignition voltage to the Primary Fuel Pump Relay Coil through the Main Power Relay (MPR). The Primary Fuel Pump Relay is controlled by the ECM. When the ECM grounds the Primary Fuel Pump Relay Coil Control Circuit, the relay energizes. Battery voltage is supplied though closed contacts of the relay switch to the Primary Fuel Pump. The ECM monitors control circuit status to determine operating state.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN runs continuously with Ignition ON.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
1347	5	Primary Fuel Pump Relay Control Circuit Open/Short	ECM detects commanded state of the Primary Fuel Pump Relay Control Circuit Driver does not match the state of the Primary Fuel Pump Relay Control Circuit for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В

### NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematics and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Malfunction Indicator Light
- Verify Fuse is not blown

#### **TOOLS REQUIRED**

High Impedance Test LampDigital MultimeterTerminal Test Probe Kit	High Impedance Test Lamp	Digital Multimeter	Terminal Test Probe Kit
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#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
1347	5	Primary Fuel Pump Relay Control Circuit Open/Short	<ul> <li>Open Relay Coil Voltage Supply Circuit</li> <li>Open or short to Ground in Relay Control Circuit</li> <li>Short to Voltage in Relay Control Circuit</li> </ul>

#### CONNECTOR END VIEWS (not to scale)







#### SYSTEM VERIFICATION - CIRCUIT TESTING





488LP/







# SPN 1634 FMI 12 Fault Code

#### DESCRIPTION OF CIRCUIT

The 488LPI Engine Control Module (ECM) performs an internal mathematical calculation upon each initial Ignition ON. If the answer to this calculation does not match a stored answer, the ECM will not continue to function for the current key cycle.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN runs continuously while Ignition is ON.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets		SPN Type
1634	12	ECM Checksum Error	ECM detects an internal calculation error	During Initial Ignition ON event	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> <li>ECM turns ON Stop Engine Light (SEL)</li> <li>ECM disables Main Power Relay (MPR)</li> </ul>	P
				During Second Ignition ON event	<ul> <li>After two (2) consecutive Ignition On failures, SPN will set</li> <li>ECM turns ON Malfunction Indicator Light (MIL)</li> </ul>	ם

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this procedure
- Test for intermittent or poor connections
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Malfunction Indicator Light
- Verify SAE J1939 CAN data link communications

#### **TOOLS REQUIRED**

Electronic Service Tool

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
1634	12	ECM Checksum Error	ECM internal malfunction





#### SYSTEM VERIFICATION







# SPN 1765 FMI 5 Fault Code

#### DESCRIPTION OF CIRCUIT

The Fuel By-Pass Relay is a key component of the 488LPI<sup>™</sup> propane autogas fuel system. The ECM (Engine Control Module) directs the Fuel By-Pass Relay using Ignition voltage supplied to the Fuel By-Pass Relay Coil via the Main Power Relay (MPR). When the ECM grounds the Fuel By-Pass Relay Coil Control Circuit, the relay switch side contacts close allowing battery voltage from the power distribution module to energize the Fuel By-Pass Solenoid. The ECM monitors Control Circuit status to determine the operating state and grounds the Fuel By-Pass Relay Control Circuit when the Wait To Start Light is illuminated.

#### **CONDITIONS TO RUN SPN**

SPN runs continuously with Ignition ON.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
1765	5	Fuel By-Pass Relay Control Circuit Open/Short	ECM detects commanded state of LPG By-Pass Relay Control Circuit does not match actual state of LPG By-Pass Relay Control Circuit for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	A

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematics and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light

### NOTICE

#### Fuel By-pass Solenoid should energize while Wait To Start Light is illuminated

### NOTICE

Verify Fuse is not blown

#### TOOLS REQUIRED

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp	Fused Jumper	




### SUSPECTED PARAMETER NUMBER AND FAILURE MODE INDICATOR

SPN	FMI	Description	Possible Causes
1765	5	Fuel By-Pass Relay Control Circuit Open/Short	<ul> <li>Open/high resistance in Relay Control Circuit</li> <li>Short to Ground in Relay Control Circuit</li> <li>Short to Voltage in Relay Control Circuit</li> </ul>

### CONNECTOR END VIEWS (not to scale)









### **CIRCUIT SCHEMATIC**

#### LEGEND:

- Splice









### SYSTEM VERIFICATION







### **SYSTEM VERIFICATION** (continued)







# **SPN 1766 Fault Codes**

### DESCRIPTION OF CIRCUIT

The 488LPI<sup>™</sup> Engine Control Module (ECM) supplies Pulse Width Modulated (PWM) voltage to the Evaporative (EVAP) Emissions Purge Solenoid through an internal driver. The ECM monitors the state of the EVAP Purge Solenoid Control Circuit through the driver.

### **CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)**

SPN runs continuously with Ignition ON.

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
1766	3	EVAP Purge Solenoid Control Circuit Open/Short	ECM detects commanded state of EVAP Purge Solenoid Control Circuit does not match actual state of Driver for > 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В
1766	5	EVAP Purge Solenoid Conflict	ECM detects EVAP Purge Solenoid Control Circuit current > 10 A for 0.2 seconds <b>OR</b> ECM detects EVAP Purge Solenoid Control Circuit current < 0.10 A for two (2) when Purge Solenoid Duty Cycle > 15%	ECM turns ON Malfunction Indicator Light (MIL)	В

### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

### Check the following before proceeding:

- Check OEM Power Distribution Module for blown EVAP fuse
- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Malfunction Indicator Light

### TOOLS REQUIRED

Fused Jumper	Digital Multimeter	Terminal Test Probe Kit





J1-C (Gray) ECM Connector

### **DIAGNOSTICS – DATA TROUBLE CODE INSTRUCTIONS**

### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
1766	3	EVAP Purge Solenoid Control Circuit Open/Short	<ul> <li>Open/short to voltage in Control Circuit</li> <li>Open Low Reference Circuit</li> </ul>
1766	5	EVAP Purge Solenoid Current Conflict	<ul> <li>Open/short to voltage in Control Circuit</li> <li>EVAP Purge Solenoid malfunction</li> </ul>

### **CONNECTOR END VIEWS**



### **CIRCUIT SCHEMATIC**

#### LEGEND:













### **SYSTEM VERIFICATION** (continued)







### SYSTEM VERIFICATION (continued)







# SPN 2003 FMI 19 Fault Code

### **DESCRIPTION OF CIRCUIT**

The SAE J1939 Controller Area Network (CAN) data link allows the 488LPI<sup>™</sup> Engine Control Module (ECM), Torque Security Module (TSM), Evaporative Emissions (EVAP) Control Module, and other vehicle modules to share and compare digital information over a low current circuit network. This data link consists of shielded, twisted wire pairs—CAN High and CAN Low—with a 120 Ω terminating Resistor on each wire.

Each control module sends a State Of Health message to the other modules when Ignition is ON. If a module fails to provide a State Of Health Message, a Data Trouble Code (DTC) may set in one or more of the other modules via the data link. The data link also provides diagnostic information which may be accessed by the Electronic Service Tool (EST) using a Data Link Connector (DLC) inside the vehicle cab.

The diagnostic troubleshooting information below pertains primarily to the ECM, TSM, and EVAP Module. Follow OEM Transmission Service literature for other SAE J1939 diagnostic procedures.

### **CONDITIONS TO RUN SPNs**

SPN runs continuously while Ignition is ON.

### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
2003	19	Transmission Control Module Communication Invalid	ECM did not receive a valid communication message from Transmission Control Module (TCM)	SPN 2003-19 stored as an active code	-

## NOTICE

### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this procedure
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type and Conditions to Clear SPN
- Attempt to communicate with Transmission Control Module (TCM) via CAN Circuits
- Verify Transmission Control Module (TCM) has Power and Ground
- Verify Fuses are not blown
- Test for faulty C13 CAN 2 Terminating Resistors





### **TOOLS REQUIRED**

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp		

### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes	
2003	19	Transmission Control Module Communication Invalid	<ul> <li>Open Serial Data Link Circuit</li> <li>Open/short in Power or Ground Circuits</li> <li>Transmission Control Module (TCM) malfunction</li> </ul>	

### DATA LINK CONNECTOR (DLC) PINOUT

### J1939 OBD DLC Connector



### **Connector Pinout**

- A Ground
- **B** Battery Power
- C CAN 1 High
- D CAN 1 Low
- E Shield (Common)
- F J1708 High
- G J1708 Low
- J CAN 2 High
- H CAN 2 Low





### DATA LINK CONNECTOR (DLC) CIRCUIT VERIFICATION





















### MODULE COMMUNICATION VERIFICATION

Use Electronic Service Tool (EST) to attempt communication with Transmission Control Module (TCM):

Module	Communicates	Does Not Communicate	
Transmission Control Module (TCM)	Test remainder of CAN circuit	Refer to OEM Transmission Manual	

### TRANSMISSION CONTROL MODULE (TCM) COMMUNICATION VERIFICATION – CONNECTOR END VIEWS

C13 CAN 2 Terminating Resistor Connector



C4 Torque Security Module (TSM) Connector





J1-B (Brown) ECM Connector







#### TRANSMISSION CONTROL MODULE (TCM) COMMUNICATION VERIFICATION - CIRCUIT

SCHEMATIC (partial – Refer to OEM Vehicle and Transmission service materials)



LEGEND:

- - · Incomplete Component Pinout
- ->>- Intermediate Connector
- OEM Wiring





### TRANSMISSION CONTROL MODULE (TCM) COMMUNICATION VERIFICATION







### TRANSMISSION CONTROL MODULE (TCM) COMMUNICATION VERIFICATION (continued)







# SPN 2011 FMI 19 Fault Code

#### **DESCRIPTION OF CIRCUIT**

The SAE J1939 Controller Area Network (CAN) data link allows the 488LPI<sup>™</sup> Engine Control Module (ECM), Torque Security Module (TSM), and Antilock Braking System (ABS) Control Module to share and compare digital information over a low current circuit network. This data link consists of shielded, twisted wire pairs—CAN High and CAN Low—with a 120 Ω terminating Resistor on each wire.

The ABS Control Module sends a State Of Health message to the other modules when Ignition is ON. If a module fails to provide a State Of Health Message, a Data Trouble Code (DTC) may set in one or more of the other modules via the data link. The data link also provides diagnostic information which may be accessed by the Electronic Service Tool (EST) using a Data Link Connector (DLC) inside the vehicle cab.

### Follow OEM vehicle service literature for other SAE J1939 diagnostic procedures.

### **CONDITIONS TO RUN SPNs**

SPN runs continuously while Ignition is ON.

### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
2011	19	Antilock Braking System (ABS) Module Communication Invalid	ECM did not receive a valid communication message from ABS Control Module	SPN 2011 FMI 19 stored as an active code	-

### NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this procedure
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review Conditions to Clear SPN
- Attempt to communicate with ABS Control Module via CAN Circuits
- Verify ABS Module has Power and Ground

## NOTICE

### Verify Fuses are not blown.

Test for faulty C13 CAN 2 Terminating Resistors





### **TOOLS REQUIRED**

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp		

### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
2003	19	Antilock Braking System (ABS) Module Communication Invalid	<ul> <li>Open Serial Data Link Circuit</li> <li>Open/short in Power or Ground Circuits</li> <li>ABS Module malfunction</li> </ul>

### DATA LINK CONNECTOR (DLC) PINOUT





Pin	Function	Pin	Function
А	Ground	Ш	Shield (Common)
В	Battery Power +	F	J1708 High
С	CAN 1 High	G	J1708 Low
D	CAN 1 Low	J	CAN 2 High





### DATA LINK CONNECTOR (DLC) CIRCUIT VERIFICATION







### DATA LINK CONNECTOR (DLC) CIRCUIT VERIFICATION (continued)







### DATA LINK CONNECTOR (DLC) CIRCUIT VERIFICATION (continued)







# SPN 2119 FMI 19 Fault Code

### **DESCRIPTION OF CIRCUIT**

The SAE J1939 Controller Area Network (CAN) data link allows the 488LPI Engine Control Module (ECM), Evaporative Emissions (EVAP) Control Module, and other vehicle modules including the Torque Security Module (TSM) to share and compare digital information over a low current circuit network. This data link consists of shielded, twisted wire pairs—CAN High and CAN Low—each with a 120 Ω terminating Resistor.

Each control module sends a State Of Health message to the other modules when Ignition is ON. If a module fails to provide a State Of Health Message, a Data Trouble Code (DTC) may set in one or more of the other modules via the data link. The data link also provides diagnostic information which may be accessed by the Electronic Service Tool (EST) using an SAE J1939 Data Link Connector (DLC) inside the vehicle cab.

### CONDITIONS TO RUN SUSPECT PARAMETER NUMBER (SPN)

SPN runs continuously while Ignition is ON.

### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
2119	19	EVAP Control Module Communication Invalid	ECM did not receive a valid communication message from the EVAP Control Module for three (3) consecutive Drive Cycles	<ul> <li>SPN 2119-19 stored as pending</li> <li>SPN 2119-19 stored as an active code after three (3) consecutive Drive Cycles</li> </ul>	-

## NOTICE

### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this procedure
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review Conditions to Clear SPN
- Attempt to communicate with EVAP Control Module via CAN Circuits
- Verify EVAP Control Module has Power and Ground

# NOTICE

### Verify Fuses are not blown.

Test for faulty C13 CAN 2 Terminating Resistors





### **TOOLS REQUIRED**

Electronic Service Tool		rvice Tool	Digital Multimeter		Terminal Test Probe Kit
POSSI	POSSIBLE DTC CAUSES				
SPN	FMI	Description		Possible	e Causes
2119	19	EVAP Control Module Communication Invalid		■ Open 5 ■ Open/5 ■ EVAP	Serial Data Link (DLC) circuit short in Power or Ground circuits Control Module malfunction





#### **CAN CIRCUIT SCHEMATIC**







### **CONNECTOR END VIEWS AND PINOUTS**



**EVAP Control Module Connector** 



Pin	Color	Function
1	n/a	n/a
2 Purple		Sleep/Wake Signal
3 – 7	n/a	n/a
8	Green	CAN 1 Low
9	Yellow	CAN 1 High
10-12	n/a	n/a

Pin	Color	Function
13	Red	Battery Power +
14	Black	Ground
15	n/a	n/a
16 Red/Black		System Voltage
17-23 n/a		n/a
24 White		EVAP Control Pump





### DATA LINK CONNECTOR (DLC) CIRCUIT VERIFICATION – Voltage







### DATA LINK CONNECTOR (DLC) CIRCUIT VERIFICATION - CAN High Circuit







### DATA LINK CONNECTOR (DLC) CIRCUIT VERIFICATION - CAN Low Circuit







### EVAP CONTROL MODULE COMMUNICATION VERIFICATION

Use Electronic Service Tool (EST) to attempt communication with EVAP Control Module.

### EVAP CONTROL MODULE COMMUNICATION VERIFICATION







### EVAP CONTROL MODULE COMMUNICATION VERIFICATION (continued)







### EVAP CONTROL MODULE COMMUNICATION VERIFICATION (continued)







# SPN 3432 FMI 14, 15, 17 Fault Codes

### DESCRIPTION OF CIRCUIT

The 488LPI<sup>™</sup> Engine Control Module (ECM) uses two (2) separate calculations to measure Engine Torque. The first calculation is based on Mass Air Flow (MAF) in which the ECM observes air flow through the MAF Sensor to estimate engine torque. The second calculation is called Speed Density. The ECM uses Engine Speed, Manifold Absolute Pressure (MAP), and Throttle Position to estimate engine torque. The ECM compares the MAF and Speed Density values to determine the condition of the Air Intake System. Faulty ECM calculations, air intake tract leaks, or contaminated components may cause SPN 3432 codes to set.

### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBERS (SPNs)

SPNs run continuously while Ignition is ON.

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
2432	14	ECM Torque Rationality Diagnostic	ECM suspects a fault if two (2) redundant internal torque calculations do not match	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> <li>ECM controls engine torque based upon the lower of the two (2) torque calculations</li> </ul>	A
2432	15	ECM Mass Air Flow Torque Calculation High	ECM suspects a fault if Mass Air Flow torque calculation is greater than the Speed Density torque calculation	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> <li>ECM enables Power Limit Mode</li> </ul>	A
2432	17	ECM Mass Air Flow Torque Calculation Low	ECM suspects a fault if Mass Air Flow torque calculation is less than the Speed Density torque calculation	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> <li>ECM enables Power Limit Mode</li> </ul>	A

### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE





## NOTICE

### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this procedure
- Test for intermittent or poor connections
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light
- Inspect Mass Air Flow (MAF) Sensor for contamination
- Inspect Manifold Absolute Pressure (MAP) Sensor for contamination
- Inspect Throttle Plate for damage

### TOOLS REQUIRED

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp	Fused Jumper	

## NOTICE

- Do not insert multimeter probes into wires or connectors as it may damage the wire or seals and allow moisture into the connector.
- Do not insert test probes into any connector or fuse block terminal which may damage or deform terminals. A deformed terminal will cause a poor connection resulting in a system failure.

### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
2432	14	ECM Torque Rationality Diagnostic	<ul><li>Software malfunction</li><li>Internal ECM malfunction</li></ul>
2432	15	ECM Mass Air Flow Torque Calculation High	<ul> <li>Air leaks</li> <li>Exhaust restriction</li> <li>MAF Sensor contaminated</li> <li>MAP Sensor contaminated</li> </ul>
2432	17	ECM Mass Air Flow Torque Calculation Low	<ul> <li>Air leaks</li> <li>Exhaust restriction</li> <li>MAF Sensor contaminated</li> <li>MAP Sensor contaminated</li> </ul>



488LPI

### SYSTEM VERIFICATION




488LP/













# SPN 3432 FMI 16 & 18 Fault Codes

#### DESCRIPTION OF CIRCUIT

The 488LPI<sup>™</sup> Engine Control Module (ECM) uses two (2) separate calculations to measure Engine Torque. The first calculation is based on Mass Air Flow (MAF) in which the ECM observes air flow through the MAF Sensor to estimate engine torque. The second calculation is called Speed Density. The ECM uses Engine Speed, Manifold Absolute Pressure (MAP), and Throttle Position to estimate engine torque. The ECM compares the MAF and Speed Density values to determine the condition of the Air Intake System. Faulty ECM calculations, air intake tract leaks, or contaminated components may cause SPN 3432 codes to set.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBERS (SPNs)

SPNs run continuously while Ignition is ON.

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
243216Requested Engine Torque LowECM suspects when a reques increased engine 		ECM suspects a fault when a request for increased engine torque is not met	ECM turns ON Check Engine Light (CEL)	A	
ECM Mass Air 2432 18 Flow Torque Calculation High		ECM Mass Air Flow Torque Calculation High	ECM suspects a fault when engine torque is greater than requested	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> <li>ECM enables Power Limit Mode</li> <li>ECM turns ON Stop Engine Light (SEL)</li> </ul>	A

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE





## NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this procedure
- Test for intermittent or poor connections
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light
- Inspect exhaust for restriction
- Verify last Air Filter maintenance / inspect Air Filter
- Inspect Air Intake for restriction

#### **TOOLS REQUIRED**

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit	
High Impedance Test Lamp	Fused Jumper		

## NOTICE

- Do not insert multimeter probes into wires or connectors as it may damage the wire or seals and allow moisture into the connector.
- Do not insert test probes into any connector or fuse block terminal which may damage or deform terminals. A deformed terminal will cause a poor connection resulting in a system failure.

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
2432	16	Requested Engine Torque Low	<ul><li>Exhaust restriction</li><li>Air Intake restriction</li></ul>
2432	18	Requested Engine Torque High	<ul><li>Exhaust restriction</li><li>Air Intake restriction</li></ul>





## SYSTEM VERIFICATION





488LP/













# **SPN 2609 Fault Codes**

#### **DESCRIPTION OF CIRCUIT**

On 488LPI<sup>™</sup> engines equipped with single or dual air conditioner compressors, each A/C Compressor Clutch Relay Coil receives Ignition voltage through the Main Power Relay (MPR) as commanded by the Engine Control Module (ECM). Each A/C Compressor Clutch Relay Coil also has a dedicated Control Circuit: when the ECM grounds the Coil Control Circuit, the relay switch side contacts close allowing Battery voltage from the Power Distribution Module to energize the coil. The ECM monitors the status of each A/C Compressor Clutch Relay Coil Control Circuit to determine its operating state.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN runs continuously with Ignition ON.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
2609	5	Air Conditioning Compressor Clutch 1 Control Circuit Open/Short	ECM detects commanded state of A/C Compressor Clutch 1 Relay Control Circuit Driver does not match the actual state of the control circuit for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A
2609	6	Air Conditioning Compressor Clutch 2 Control Circuit Open/Short	ECM detects commanded state of A/C Compressor Clutch 2 Relay Control Circuit Driver does not match the actual state of the control circuit for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views and Relay Pinouts to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light

# NOTICE

If both FMI 5 and FMI 6 are set, test Air Compressor Clutch Relay Coil Ignition Voltage Supply Circuit between the Coil and the Main Power Relay (MPR) for open/high resistance.







#### **TOOLS REQUIRED**

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit	
High Impedance Test Lamp	Fused Jumper		

## NOTICE

- Do not insert multimeter probes into wires or connectors as it may damage the wire or seals and allow moisture into the connector.
- Do not insert test probes into any connector or fuse block terminal which may damage or deform terminals. A deformed terminal will cause a poor connection resulting in a system failure.

### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
2609	5	Air Conditioning Compressor Clutch 1 Control Circuit Open/Short	<ul> <li>Open/short to voltage in A/C Relay Coil Control Circuit</li> <li>Open/short to Ground in A/C Relay Control Circuit</li> <li>Open in A/C Relay Coil Voltage Supply Circuit</li> </ul>
2609	6	Air Conditioning Compressor Clutch 2 Control Circuit Open/Short	<ul> <li>Open/short to voltage in A/C Relay Coil Control Circuit</li> <li>Open/short to Ground in A/C Relay Control Circuit</li> <li>Open in A/C Relay Coil Voltage Supply Circuit</li> </ul>

### CONNECTOR END VIEWS AND RELAY PINOUTS (not to scale)





J1-B (Brown) ECM Connector



J1-C (Gray) ECM Connector







#### SYSTEM VERIFICATION

NOTICE

Refer to 488LPI™ AC Electrical Harness Schematic (attached).



- Ignition OFF
- Disconnect appropriate Main Power Relay (MPR) from OEM Fuse Block. *Refer to OEM instructions.*
- Ignition ON
- Connect High Impedance Test Lamp between appropriate A/C Clutch Relay Coil Ignition Voltage Circuit Terminal 85 and Ground



















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488LPI Propane Autogas Engine

Diagnostic Manual

C20				
ENGINE BLOCK GRO	UND			
	CIRCUIT	COLOR		
ENGINE BLOCK GROUND	150E	BLACK		

_	001			
	C21			
	ENGINE BLOCK GRC	UND	-	
		CIRCUIT	COLOR	
	ENGINE BLOCK GROUND	150M	BLACK	

_					
	J1-A				
	ENGINE CONTROL MODULE				
	ECM				
	BLACK				
		CIRCUIT	COLOR		
	AC COMPRESSOR 1 CONTROL	459	GRN / BRN		
	AC COMPRESSOR 2 CONTROL	559	LT GRN		

_					
	J1-C				
	ENGINE CONTROL MODULE				
	(FCM)				
	GRAY				
	DESCRIPTION CIRCUIT COLOR				
	AC COMPRESSOR 1 REQ.	762	BLUE		
-	•				

J1-B				
ENGINE CONTROL MODULE				
(ECM)				
BROWN				
DESCRIPTION	CIRCUIT	COLOR		
AC COMPRESSOR 2 REQ.	862	BLK / ORG		

			17-May-22
HEXAGON	<sup>mr∟</sup> Service Wiring Diagram 488 LPI A.C. Compressor Clutch		LOTTED:
AGILITY	DRAWING NO.	REV.	<u>م</u>

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488LPI Propane Autogas Engine

**Diagnostic Manual** . . . . . .

C20 ENGINE BLOCK GROUND		
	CIRCUIT	COLOR
ENGINE BLOCK GROUND	150 E	BLACK

C21 ENGINE BLOCK GRC	OUND	
	CIRCUIT	COLOR
ENGINE BLOCK GROUND	150 M	BLACK

J1-A			
ENGINE CONTROL MODULE			
ECM			
BLACK	-		
	CIRCUIT	COLOR	
AC COMPRESSOR 1 RELAY	459	GRN BRN	
AC COMPRESSOR 2 RELAY	559	LT GRN	

J1-C				
ENGINE CONTROL MODULE				
(ECM)				
GRAY				
DESCRIPTION	CIRCUIT	COLOR		
AC COMPRESSOR 1 REQ.	762	BLUE		
			1	

J1-B				
ENGINE CONTROL MODULE				
(ECM)				
BROWN				
DESCRIPTION	CIRCUIT	COLOR		
AC COMPRESSOR 2 REQ.	862	BLK ORG		

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# **SPN 2634 Fault Codes**

#### **DESCRIPTION OF CIRCUIT**

At Ignition ON the 488LPI<sup>™</sup> Engine Control Module (ECM) and Torque Security Module (TSM) conduct a Self Test of the OEM vehicle Main Power Relay (MPR) as follows:

- Engine Control Module (ECM) grounds Main Power Relay (MPR) Coil. Torque Security Module (TSM) supplies 12 V to MPR Coil to energize MPR. MPR contacts provide Supply Voltage to the ECM.
- 2. ECM receives System Voltage and communicates system has power to TSM via a CAN 2 message.
- TSM turns off 12 V Supply Voltage to MPR Coil. MPR Coil de-energizes. System Voltage removed from ECM system.
- 4. ECM sends a CAN 2 message to the TSM indicating system does not have voltage.
- TSM interprets MPR and electrical circuit is functioning properly. TSM supplies 12 V to MPR Coil. MPR Coil energizes. System Voltage supplied for remainder of current Ignition Cycle.

The MPR Self Test occurs every time Ignition is ON. If any of the above steps fail, either the ECM or TSM may de-energize the MPR. When the MPR cuts voltage, power is withheld from the engine electrical system effectively turning Ignition OFF. If the MPR Self Test fails, one or more fault codes will set and the ECM will turn ON both the Check Engine Light (CEL) and the Stop Engine Light (SEL).

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN runs one time per Ignition Cycle.





SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
2634	3	Main Power Relay (MPR) Coil Circuit Open/Short	ECM or TSM detects open/short on the MPR Coil Control Circuits	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> <li>ECM turns ON Stop Engine Light (SEL)</li> <li>ECM prevents Engine Start</li> </ul>	A
2634	5	Main Power Relay (MPR) Self Test Failed	ECM or TSM detects a fault occurred during MPR Self Test	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> <li>ECM turns ON Stop Engine Light (SEL)</li> <li>ECM prevents Engine Start</li> </ul>	A

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

## NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Lights



#### A stuck Main Power Relay (MPR) may set SPN.

#### TOOLS REQUIRED

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp		

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
2634	3	Main Power Relay (MPR) Coil Circuit Open/Short	Open/short in MPR Coil Circuit
2634	5	Main Power Relay (MPR) Self Test Failed	<ul><li>MPR malfunction</li><li>MPR stuck</li></ul>





#### CONNECTOR END VIEWS (not to scale)

Torque Security Module (TSM) Connector



Main Power Relay (MPR) Pinout



**KEY:** 87 = Circuit number = Circuit pin prong

J1-A (Black) ECM Connector



J1-C (Gray) ECM Connector







#### **CIRCUIT SCHEMATIC**







### SYSTEM VERIFICATION





488LP/





488LP/





488LP/



















# SPN 3050 and 3051 FMI 18 Fault Codes

#### **DESCRIPTION OF CIRCUIT**

The 488LPI Engine Control Module analyzes signals from the Heated Exhaust Gas Oxygen (HEGO) Sensors to monitor Catalyst function. Post-catalyst HEGO Sensors switch from rich to lean at a slower rate and amplitude than Pre-catalyst HEGO Sensors. As the Catalyst degrades the switch time and amplitude of the Post-Catalyst HEGO Sensors increases. SPN 3050 and 3051 set if switch rate increase exceeds a calibrated threshold.

#### CONDITIONS TO RUN SUSPECT PARAMETER NUMBERS (SPNs)

- 1. Engine running at steady state for more than 10 seconds
- 2. Engine running in Closed Loop for more than 1 second
- 3. Mass Air Flow (MAF) Sensor reading more than 1000 g/s
- 4. Engine Coolant Temperature (ECT) between 158° F (70° C) and 248° F (120° C)
- 5. Intake Air Temperature (IAT) between 14° F (-10° C) and 140° F (60° C)
- 6. No other SPN(s) present

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
3050	18	Catalyst Malfunction Bank A	ECM detects Bank A Post-catalyst O2 rate of change faster than allowable limit	ECM turns ON Malfunction Indicator Light (MIL)	В
3051	18	Catalyst Malfunction Bank B	ECM detects Bank B Post-catalyst O2 rate of change faster than allowable limit	ECM turns ON Malfunction Indicator Light (MIL)	В

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

# NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Malfunction Indicator Light



Verify no Exhaust leaks are present.





### **TOOLS REQUIRED**

Electronic Service Tool

### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
3050	18	Catalyst Malfunction Bank A	<ul> <li>Exhaust leak</li> <li>Post-catalyst HEGO Sensor faulty</li> <li>Catalyst degraded</li> </ul>
3051	18	Catalyst Malfunction Bank B	<ul> <li>Exhaust leak</li> <li>Post-catalyst HEGO Sensor faulty</li> <li>Catalyst degraded</li> </ul>





#### SYSTEM VERIFICATION







# SPN 3217 and 3256 Fault Codes

#### DESCRIPTION OF CIRCUIT

Pre-catalyst Heated Exhaust Gas Oxygen (HEGO) Sensors play a crucial role in 488LPI<sup>TM</sup> engine management. Each HEGO Sensor measures the oxygen (O<sub>2</sub>) content of air around the sensor against oxygen present in Exhaust System gases. As HEGO Sensors warm up they generate voltage ranging from 50-1250 mV with which they communicate O<sub>2</sub> levels to the Engine Control Module (ECM).

The 488LPI ECM calculates air-fuel ratio in Open-Loop Mode at Engine Start. When the ECM receives continuous voltage signals from the HEGO Sensors, the ECM initiates Closed-Loop Mode. In Closed-Loop Mode, HEGO Sensor voltage signals are used to calculate air-fuel ratio. HEGO Sensor voltage which increases toward 1000 mV indicates a rich air-fuel mixture, while HEGO voltage which decreases toward 0 mV indicates a lean mixture. As the name suggests, HEGO Sensors contain a heater element which decreases running time required to meet Closed-Loop operating conditions.

#### CONDITIONS TO RUN SUSPECT PARAMETER NUMBERS (SPNs)

SPNs run continuously during Closed-Loop Mode.

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
3217	4	HEGO Bank A Sensor 1 Voltage Low	ECM detects Pre-catalyst HEGO Signal Voltage less than 150 mV for more than 15 seconds	ECM turns ON Malfunction Indicator Light (MIL)	В
3217	3	HEGO Bank A Sensor 1 Voltage High	ECM detects Pre-catalyst HEGO Signal Voltage greater than 1.2 V for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В
3256	4	HEGO Bank B Sensor 1 Voltage Low	ECM detects Pre-catalyst HEGO Signal Voltage less than 150 mV for more than15 seconds	ECM turns ON Malfunction Indicator Light (MIL)	В
3256	3	HEGO Bank B Sensor 1 Voltage High	ECM detects Pre-catalyst HEGO Signal Voltage greater than 1.2 V for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В

## SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE





## NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Malfunction Indicator Light
- Inspect Exhaust System for leaks
- Verify no Engine misfire
- Inspect for vacuum leaks



Verify no Fuses are blown.

#### TOOLS REQUIRED

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
Fused Jumper		

# NOTICE

- Do not insert multimeter probes into wires or connectors as it may damage the wire or seals and allow moisture into the connector.
- Do not insert test probes into any connector or fuse block terminal which may damage or deform terminals. A deformed terminal will cause a poor connection resulting in a system failure.

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes	
3217	4	HEGO Bank A Sensor 1 Voltage Low	<ul> <li>Open/short to Ground on HEGO Signal Circuit</li> <li>Open/high resistance in HEGO Low Reference Circuit</li> </ul>	
3256	4	HEGO Bank B Sensor 1 Voltage Low	<ul><li>HEGO Heater malfunction</li><li>HEGO Sensor malfunction</li></ul>	
3217	3	HEGO Bank A Sensor 1 Voltage High	Short to voltage in HEGO Signal Circuit	
3256	3	HEGO Bank B Sensor 1 Voltage High	<ul> <li>HEGO sensor malfunction</li> </ul>	





### CONNECTOR END VIEWS (not to scale)

Pre-Catalyst HEGO Sensor Connector



C28 Bulkhead Connector



J1-B (Brown) ECM Connector







#### **CIRCUIT SCHEMATIC**



→>→ Intermediate Connector

--- Incomplete Component Pinout





#### SYSTEM VERIFICATION



















# SPN 3222 and 3261 Fault Codes

#### **DESCRIPTION OF CIRCUIT**

At Ignition On, the 488LPI<sup>™</sup> HEGO Heater Relay supplies Battery voltage to each of the Heated Exhaust Gas Oxygen (HEGO) Sensors. The Engine Control Module (ECM) manages each HEGO Heater through a Control Circuit, the status of which the ECM monitors to determine Engine operating state.

#### CONDITIONS TO RUN SUSPECT PARAMETER NUMBERS (SPNs)

SPNs run continuously with Ignition ON.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
3222	5	HEGO Bank A Heater Circuit Open/Short	ECM detects commanded state of Heater Control Circuit Driver does not match the state of the Heater Control Circuit for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В
3261	5	HEGO Bank B Heater Circuit Open/Short	ECM detects commanded state of Heater Control Circuit Driver does not match the state of the Heater Control Circuit for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematics and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Malfunction Indicator Light



If SPNs 3222, 3232, 3261, and 3271 are all present, test HEGO Heater Relay.



If SPNs 3222 are 3261 are present, test Voltage Supply Circuit for short to Ground

NOTICE

Verify no Fuses are blown.





#### TOOLS REQUIRED

**Digital Multimeter** 

Terminal Test Probe Kit

# NOTICE

- Do not insert multimeter probes into wires or connectors as it may damage the wire or seals and allow moisture into the connector.
- Do not insert test probes into any connector or fuse block terminal which may damage or deform terminals. A deformed terminal will cause a poor connection resulting in a system failure.

### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
3222	5	HEGO Bank A Heater Circuit Open/Short	<ul> <li>Open/short to Ground on HEGO Voltage Supply Circuit</li> <li>Short to voltage in Pre-catalyst HEGO Heater Bank A Control Circuit</li> <li>HEGO Heater Relay malfunction</li> </ul>
3261	5	HEGO Bank B Heater Circuit Open/Short	<ul> <li>Open/short to Ground on HEGO Voltage Supply Circuit</li> <li>Short to voltage in Pre-catalyst HEGO Heater Bank B Control Circuit</li> <li>HEGO Heater Relay malfunction</li> </ul>

#### CONNECTOR END VIEWS (not to scale)

Pre-Catalyst HEGO Sensor Connector



J1-B (Brown) ECM Connector






#### **CIRCUIT SCHEMATIC**







#### SYSTEM VERIFICATION







#### SYSTEM VERIFICATION (continued)











488LP|

#### **COMPONENT VERIFICATION**







#### **COMPONENT VERIFICATION** (continued)







# SPN 3227 and 3266 Fault Codes

#### DESCRIPTION OF CIRCUIT

POST-catalyst Heated Exhaust Gas Oxygen (HEGO) Sensors play a crucial role in 488LPI<sup>™</sup> engine management. Each HEGO Sensor measures the oxygen (O2) content of air around the sensor against oxygen present in Exhaust System gases. As HEGO Sensors warm up they generate voltage ranging from 50-1250 mV with which they communicate O2 levels to the Engine Control Module (ECM).

The 488LPI<sup>™</sup> ECM calculates air-fuel ratio in Open-Loop Mode at Engine Start. When the ECM receives continuous voltage signals from the HEGO Sensors, the ECM initiates Closed-Loop Mode. In Closed-Loop Mode, HEGO Sensor voltage signals are used to calculate air-fuel ratio. HEGO Sensor voltage which increases toward 1000 mV indicates a rich air-fuel mixture, while HEGO voltage which decreases toward 0 mV indicates a lean mixture. As the name suggests, HEGO Sensors contain a heater element which decreases running time required to meet Closed-Loop operating conditions.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBERS (SPNs)

SPNs run continuously during Closed-Loop Mode.

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
3227	4	HEGO Bank A Sensor 2 Voltage Low	ECM detects Post- catalyst HEGO Signal Voltage less than 50 mV for more than 60 seconds	ECM turns ON Malfunction Indicator Light (MIL)	В
3227	3	HEGO Bank A Sensor 2 Voltage High	ECM detects Post- catalyst HEGO Signal Voltage greater than 1.2 V for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В
3266	4	HEGO Bank B Sensor 2 Voltage Low	ECM detects Post- catalyst HEGO Signal Voltage less than 50 mV for more than 60 seconds	ECM turns ON Malfunction Indicator Light (MIL)	В
3266	3	HEGO Bank B Sensor 2 Voltage High	ECM detects Post- catalyst HEGO Signal Voltage greater than 1.2 V for more than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE



488LP/

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematics and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Malfunction Indicator Light
- Inspect Air Intake System for leaks or restrictions
- Inspect Exhaust System for leaks or restrictions
- Verify no Engine misfire
- Inspect for vacuum leaks



#### Verify no Fuses are blown.

#### TOOLS REQUIRED

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
Fused Jumper		

### NOTICE

- Do not insert multimeter probes into wires or connectors as it may damage the wire or seals and allow moisture into the connector.
- Do not insert test probes into any connector or fuse block terminal which may damage or deform terminals. A deformed terminal will cause a poor connection resulting in a system failure.

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
3227	4	HEGO Bank A Sensor 2 Voltage Low	<ul> <li>Open/short to Ground on HEGO Signal Circuit</li> <li>Open/high resistance in HEGO Low Reference Circuit</li> <li>HEGO Heater malfunction</li> <li>HEGO Sensor malfunction</li> </ul>
3227	3	HEGO Bank A Sensor 2 Voltage High	<ul> <li>Short to voltage in HEGO Signal Circuit</li> <li>HEGO Sensor malfunction</li> </ul>
3266	4	HEGO Bank B Sensor 2 Voltage Low	<ul> <li>Open/short to Ground on HEGO Signal Circuit</li> <li>Open/high resistance in HEGO Low Reference Circuit</li> <li>HEGO Heater malfunction</li> <li>HEGO Sensor malfunction</li> </ul>
3266	3	HEGO Bank B Sensor 2 Voltage High	<ul> <li>Short to voltage in HEGO Signal Circuit</li> <li>HEGO Sensor malfunction</li> </ul>





#### CONNECTOR END VIEWS (not to scale)



DSM.0055 Ver. 1.0 05/31/2022





#### POWER DISTRIBUTION MODULE RELAYS AND FUSES







**CIRCUIT SCHEMATIC** 



- - - - Incomplete Component Pinout























# SPN 3232 and 3271 Fault Codes

#### **DESCRIPTION OF CIRCUIT**

At Ignition ON, the 488LPI<sup>™</sup> HEGO Heater Relay supplies Battery voltage to each of the Heated Exhaust Gas Oxygen (HEGO) Sensors. The Engine Control Module (ECM) manages each HEGO Heater through a Control Circuit, the status of which the ECM monitors to determine Engine operating state.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBERS (SPNs)

SPNs run continuously with Ignition ON.

## SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
3232	5	HEGO Bank A Post-catalyst Heater Circuit Open/Short	ECM detects commanded state of Heater Control Circuit Driver does not match the state of the Heater Control Circuit for longer than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В
3271	5	HEGO Bank B Post-catalyst Heater Circuit Open/Short	ECM detects commanded state of Heater Control Circuit Driver does not match the state of the Heater Control Circuit for longer than 240 ms	ECM turns ON Malfunction Indicator Light (MIL)	В

### NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views below to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Malfunction Indicator Light





Verify no Fuses are blown





#### **TOOLS REQUIRED**

Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
High Impedance Test Lamp	Fused Jumper	

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
3232	5	HEGO Bank A Post-catalyst Heater Circuit Open/Short	<ul> <li>Open/short to Ground on HEGO Voltage Supply Circuit</li> <li>Short to voltage in Post-catalyst HEGO Heater Bank A Control Circuit</li> <li>HEGO Heater Relay malfunction</li> </ul>
3271	5	HEGO Bank B Post-catalyst Heater Circuit Open/Short	<ul> <li>Open/short to Ground on HEGO Voltage Supply Circuit</li> <li>Short to voltage in Post-catalyst HEGO Heater Bank B Control Circuit</li> <li>HEGO Heater Relay malfunction</li> </ul>

#### CONNECTOR END VIEWS AND RELAY PINOUTS (not to scale)

#### Main Power Relay (MPR) Pinout J1-B (Brown) ECM Connector 86 88 C28 Bulkhead Connector 85 87a 87 **KEY:** [87] = Circuit number \_\_\_\_ = Circuit pin prong Post-Catalyst HEGO Sensor J1-C (Gray) ECM Connector Connector В А ф

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#### POWER DISTRIBUTION MODULE RELAYS AND FUSES







**CIRCUIT SCHEMATIC** 



- - - - Incomplete Component Pinout





#### SYSTEM VERIFICATION







#### SYSTEM VERIFICATION (continued)













#### **COMPONENT VERIFICATION**







#### **COMPONENT VERIFICATION** (continued)







# SPN 3464 and 3664 Fault Codes

#### DESCRIPTION OF CIRCUIT

The 488LPI<sup>™</sup> Engine Control Module (ECM) provides bi-directional twelve (12) volt power and Ground to the Electronic Throttle Control (ETC) motor on the Throttle Body assembly. The ECM receives inputs from the Accelerator Pedal Position (APP) Sensor and Throttle Position Sensor (TPS) to determine the required throttle opening and monitors current and voltage on the ETC control circuits to determine whether the ETC is operating properly.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBERS (SPNs)

SPNs run continuously while Ignition is ON.

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
3464	3	Electronic Throttle Control (ETC) Control Circuit Open/Short	ECM detects ETC control circuit is open or shorted for > 240 ms	ECM turns ON Check Engine Light (CEL)	A
3464	5	Electronic Throttle Control (ETC) Control Circuit Current Out of Range	ECM detects a fault if current feedback is > 10 A for > 0.2 seconds <b>OR</b> < 0.5 A when commanded duty cycle is > 80% for > 2 seconds	ECM turns ON Check Engine Light (CEL)	A
3664	11	Electronic Throttle Control (ETC) Learned Value Conflict	ECM detects a fault if ETC Throttle Position is < learned closed position	<ul> <li>ECM turns ON Check Engine Light (CEL)</li> <li>ECM turns ON Stop Engine Light (SEL)</li> <li>ECM reduces engine power</li> </ul>	A

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views below to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light

### NOTICE

A stuck, binding, bent, or worn Throttle Plate/Throttle Shaft may cause this SPN.





#### TOOLS REQUIRED

High	Impedance	Test Lamp
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**Digital Multimeter** 

Terminal Test Probe Kit

## NOTICE

Do not insert multimeter probes into wires or connectors as it may damage the wire or seals and allow moisture into the connector.

## NOTICE

Do not insert test probes into any connector or fuse block terminal which may damage or deform terminals. A deformed terminal will cause a poor connection resulting in a system failure.

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
3464	3	Electronic Throttle Control (ETC) Control Circuit Open/Short	<ul> <li>Electronic Throttle Control (ETC) circuit short to voltage</li> <li>Electronic Throttle Control (ETC) circuit short to Ground</li> <li>Electronic Throttle Control (ETC) circuit open</li> </ul>
3464	5	Electronic Throttle Control (ETC) Control Circuit Current Out of Range	<ul> <li>Electronic Throttle Control (ETC) circuit high resistance</li> <li>Electronic Throttle Control (ETC) motor malfunction</li> </ul>
3664	11	Electronic Throttle Control (ETC) Learned Value Conflict	<ul> <li>Sticking/binding Electronic Throttle Control (ETC) motor</li> <li>Stuck, binding, bent, or worn Throttle Plate/Throttle Shaft</li> </ul>

#### **CONNECTOR END VIEWS**





J1-C (Gray) ECM Connector







#### **CIRCUIT SCHEMATIC** (not to scale)







#### SYSTEM VERIFICATION







#### SYSTEM VERIFICATION (continued)







# SPN 3509 and 3510 Fault Codes

#### **DESCRIPTION OF CIRCUIT**

The 488LPI<sup>™</sup> Engine Control Module (ECM) has two (2) internal five (5) volt reference outputs which supply multiple sensors and components with a constant 5 V Reference signal. Shorts to power or Ground will affect each component connected to the 5V Reference Circuit.

Sensors and Respective 5 V Reference Circuits				
5 V Reference Circuit 1	5 V Reference Circuit 2			
Accelerator Pedal Position 1 (APP1) Sensor	Accelerator Pedal Position 2 (APP2) Sensor			
Camshaft (CMP) Position Sensor	Crankshaft (CKP) Position Sensor			
Fuel Pressure/Temperature (FPT) Sensor	Electronic Throttle Control (ETC) Sensor			
Oil Pressure Sensor	Manifold Absolute Pressure (MAP) Sensor			

#### **CONDITIONS TO RUN SUSPECT PARAMETER NUMBERS (SPNs)**

SPNs run continuously with Ignition ON.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
3509	10	5 V Reference Circuit 1 Voltage High	ECM detects 5 V Reference Circuit 1 Voltage greater than 5.2 V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A
3509	19	5 V Reference Circuit 1 Voltage Low	ECM detects 5 V Reference Circuit 1 Voltage less than 4.8 V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A
3510	10	5 V Reference Circuit 2 Voltage High	ECM detects 5 V Reference Circuit 2 Voltage greater than 5.2 V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A
3509	19	5 V Reference Circuit 2 Voltage Low	ECM detects 5 V Reference Circuit 2 Voltage less than 4.8 V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A





## NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematic and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Indicator Light
- Test for faulty sensors: disconnect each of the sensors supplied by the respective 5 V Reference Circuits (see table above) one at time while monitoring the appropriate 5 V Reference Circuit voltage
- Verify no Fuses are blown.

#### TOOLS REQUIRED

Electronic Service I ool Digital Multimeter I erminal Test Probe Kit	Electronic Service Tool	Digital Multimeter	Terminal Test Probe Kit
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#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
3509	10	5 V Reference Voltage 1 High	<ul> <li>Short to voltage in 5 V Reference Circuit</li> <li>Short to voltage in sensor Signal Circuit</li> <li>Sensor malfunction</li> </ul>
3509	19	5 V Reference Voltage 1 Low	<ul><li>Short to Ground in 5 V Reference Circuit</li><li>Sensor malfunction</li></ul>
3510	10	5 V Reference Voltage 2 High	<ul> <li>Short to voltage in 5 V Reference Circuit</li> <li>Short to voltage in sensor Signal Circuit</li> <li>Sensor malfunction</li> </ul>
3509	19	5 V Reference Voltage 2 Low	<ul><li>Short to Ground in 5 V Reference Circuit</li><li>Sensor malfunction</li></ul>





#### CONNECTOR END VIEWS (not to scale)







#### CIRCUIT SCHEMATIC







#### SYSTEM VERIFICATION







#### SYSTEM VERIFICATION (continued)







# **SPN 3597 Fault Codes**

#### **DESCRIPTION OF CIRCUIT**

When Ignition is ON the 488LPI<sup>™</sup> Engine Control Module (ECM) supplies Battery Voltage to various power Relays and the Fuel Injectors. The ECM monitors the state of both Supply and Output Circuits to confirm normal engine operation.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPN)

SPN runs continuously while Ignition is ON.

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
3597	3	Driver Output Supply Voltage High	ECM detects 12 V Supply Voltage Circuit greater than 18 V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A
3597	4	Driver Output Supply Voltage Low	ECM detects 12 V Supply Voltage Circuit less than 5 V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	А
3597	10	Driver Output Voltage Low	ECM detects 12 V Voltage Circuit less than 5 V for more than 240 ms	ECM turns ON Check Engine Light (CEL)	A
3597	19	Driver Output Voltage High ECM detects 12 V Voltage Circuit greater than 18 V for more than 240 ms		ECM turns ON Check Engine Light (CEL)	А

### NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Verify no Fuses are blown
- Test for intermittent or poor connections
- Review Circuit Schematics and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / CEL
- Verify Charging System is operating properly



A stuck Main Power Relay (MPR) may set SPN.





#### TOOLS REQUIRED

High Impedance Test Lamp

**Digital Multimeter** 

Terminal Test Probe Kit

## NOTICE

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- Do not insert multimeter probes into wires or connectors as it may damage the wire or seals and allow moisture into the connector.
- Do not insert test probes into any connector or fuse block terminal which may damage or deform terminals. A deformed terminal will cause a poor connection resulting in a system failure.

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
3597	3	Driver Output Supply Voltage High	Open/high resistance in Battery Supply Voltage Circuit
3597	4	Driver Output Supply Voltage Low	<ul><li>Battery over voltage</li><li>Charging system over voltage</li><li>MPR stuck</li></ul>
3597	10	Driver Output Voltage Low	Short to Ground on Driver Output Voltage Circuit
3597	19	Driver Output Voltage High	<ul><li>Battery over voltage</li><li>Charging system over voltage</li></ul>

#### CONNECTOR END VIEWS (not to scale)



#### J1-A (Black) ECM Connector



#### J1-C (Gray) ECM Connector






#### **CIRCUIT SCHEMATIC**











488LP/





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488LP/



















# SPN 4203 FMI 5 or 4204 FMI 5

#### **DESCRIPTION OF CIRCUIT**

The Camshaft Position (CMP) and Crankshaft Position (CKP) Sensors are mounted in the Engine Front Cover of the 488LPI<sup>™</sup> engine. The CKP and CMP Sensors "look" at regular field variations caused by missing teeth on both the Crankshaft and Camshaft Reluctor Wheels to determine crank and cam rotational speeds. The Engine Control Module (ECM) compares signal data from the CMP and CKP determine if the Camshaft and Crankshaft are properly synchronized at various engine speeds.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBERS (SPNs)

SPN	FMI	Description	Conditions to Run SPN
4203	5	Crankshaft Position Sensor Error	SPN runs continuously while Ignition is ON
4204	5	Camshaft Position Sensor Error	SPN runs continuously while Ignition is ON

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
4203	5	Crankshaft Position Sensor Error	<ul> <li>ECM detects a fault if the count of the crank encoder faults increases from previous time step (indicating a fault at that moment).</li> <li>Fault is one of the following: <ul> <li>Synchronization error</li> <li>Source loss (reluctor not rotating)</li> <li>Inverted reluctor missing tooth signal (sensor polarity reversed)</li> <li>Phase error (cam and crank correlation error)</li> <li>Absent missing tooth (reluctor missing tooth vas expected but not seen yet)</li> </ul> </li> </ul>	ECM turns ON Malfunction Indicator Light (MIL)	В





SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
4204	5	Camshaft Position Sensor Error	ECM detects a fault if the count of the cam encoder faults increases from previous time step (indicating a fault at that moment). Fault is one of the following: Synchronization error Source loss (sprocket not rotating) Inverted sprocket missing tooth signal (sensor polarity reversed) Phase error (cam and crank correlation error) Absent missing tooth (sprocket missing tooth was expected but not seen yet)	ECM turns ON Malfunction Indicator Light (MIL)	В

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this diagnostic
- Test for intermittent or poor connections
- Review Circuit Schematics and Connector End Views to locate test points
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN Malfunction Indicator Light

#### TOOLS REQUIRED

Electronic Service Tool

#### POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
4203	5	Crankshaft Position Sensor Error	<ul> <li>Damaged Crankshaft Reluctor Wheel</li> <li>Damaged Camshaft Sprocket</li> </ul>
4204	5	Camshaft Position Sensor Error	<ul> <li>Noise/interference on signal circuit</li> <li>Improper sensor installation</li> </ul>























# SPN 4236 FMI 7 or 4238 FMI 7 Fault Codes

## **DESCRIPTION OF CIRCUIT**

The 488LPI<sup>™</sup> Engine Control Module (ECM) uses inputs from the pre-Catalyst Heated Exhaust Gas Oxygen (HEGO) Sensors to establish proper air-fuel mixture to balance engine performance with emissions requirements. SPN sets if conditions cause the ECM to adjust air-fuel ratio above the prescribed limit.

#### CONDITIONS TO RUN SUSPECTED PARAMETER NUMBER (SPNs)

SPNs run continuously during Closed-Loop operation.

SPN	FMI	Description	Conditions to Set SPN	Action Taken When SPN Sets	SPN Type
4236	7	Short Term Fuel Trim Fault Bank A	ECM detects Bank A operating above or below allowable air- fuel adjustment limits	ECM turns on Malfunction Indicator Light (MIL)	В
4238	7	Short Term Fuel Trim Fault Bank B	ECM detects Bank B operating above or below allowable air- fuel adjustment limits ECM detects Bank A operating above or below allowable air- fuel adjustment limits	ECM turns on Malfunction Indicator Light (MIL)	В

#### SPN/FMI DESCRIPTION, CONDITIONS TO SET, ACTION TAKEN WHEN SET, & SPN TYPE

# NOTICE

#### Check the following before proceeding:

- Perform Diagnostic System Check prior to using this procedure
- Test for intermittent or poor connections
- Review SPN Type, Indicator Lamp Definitions, and Conditions to Clear SPN / Malfunction Indicator Light
- Inspect for vacuum leaks
- Inspect Air Inlet System for leaks or restrictions
- Inspect Exhaust System for leaks or restrictions

## TOOLS REQUIRED

Electronic Service Tool





# POSSIBLE DTC CAUSES

SPN	FMI	Description	Possible Causes
4236	7	Short Term Fuel Trim Fault Bank A	<ul> <li>Vacuum leaks</li> <li>Fuel Injector(s) leaking</li> <li>Fuel contamination / lower than required grade</li> </ul>
4238	7	Short Term Fuel Trim Fault Bank B	<ul> <li>Exhaust System leak or restriction</li> <li>Intake Air System leak or restriction</li> <li>Engine mechanical issue</li> </ul>











# Step 2

Inspect for the following conditions:

- Air Filter clogged or missing
- Air Intake System leak or restrictions
- Engine oil contamination
- EVAP Canister/Hoses missing, loose, or cracked
- EVAP Canister Purge Valve leak
- Exhaust components bent, kinked, leaking, or missing
- Fuel contamination/low grade fuel
- Fuel Injector(s) leaking or restricted
- Fuel level low
- Fuel pressure exceeding limits
- Positive Crankcase Ventilation (PCV) System Leak
- Vacuum Hoses for splits, kinks, improper connection



# **Engine Harness Component Diagram**

