

PLEASURECRAFT ENGINE GROUP

 **LEVITATOR**
PERFORMANCE AIRCRAFT ENGINES

 **PCM** marine engines

**CRUSADER
ENGINES**

GCP / 4G

Diagnostic

Manual



**This Page Was
Intentionally
Left Blank**

GCP / 4G Engine Management System

Section 1

General Information

This section will describe some general information about the engine management system. It explains how sensors work, aids in diagnosing intermittent problems, required tools to properly diagnose the system and wiring repair practices.

Contents

General Description	Page 4	Diagnosis of Drivability Concerns (No DTC's Set)	Page 7
Visual and Physical Inspection	Page 4	Aftermarket (Add On) Electrical and Vacuum Equipment	Page 7
Basic Knowledge and Tools Required	Page 4	Use of Circuit Testing Tools	Page 7
Electrostatic Discharge Damage	Page 4	Tools Needed to Service the System.....	Page 7
Engine Wiring.....	Page 4	Service Precautions	Page 10
Engine Control Module (ECM) Self Diagnostics	Page 4	Test Lamp Amperage Draw Test	Page 10
Malfunction Indicator Lamp (MIL)	Page 4	Diagnosis	Page 11
Check Gauges Lamp (CGL)	Page 5	On-Board Service	Page 11
Intermittent Malfunction Indicator Lamp (MIL)	Page 5	Wiring Harness Service	Page 11
Reading Diagnostic Trouble Codes (DTC's).....	Page 5	Wiring Connector Service	Page 12
On-Board Diagnostic (OBD) System Check	Page 5	Metri-Pack Series 150 Terminals	Page 12
Diacom Scan Tool	Page 6	Weather-Pack Connectors.....	Page 13
Diacom Use with Intermittents	Page 6	GCP / 4G ECM Connector	Page 14
How Diagnostic Trouble Codes (DTC) are Set	Page 6		
Clearing Diagnostic Trouble Codes (DTC).....	Page 6		

GENERAL INFORMATION

General Description

Visual and Physical Inspection

IMPORTANT: This visual and physical inspection is very important. Perform this inspection carefully and thoroughly. Perform a careful visual and physical inspection when performing any diagnostic procedure. This can often lead to repairing a problem without further steps. Use the following guidelines when performing a visual and physical inspection:

- Inspect all vacuum hoses for the following conditions:
 - Correct routing
 - Pinches
 - Cuts
 - Disconnects
- Inspect all wires in the engine compartment for the following conditions:
 - Proper connections
 - Burned or chafed spots
 - Pinched wires
 - Contact with sharp edges
 - Contact with hot exhaust manifolds

Basic Knowledge and Tools Required

To use this manual most effectively, a general understanding of basic electrical circuits and circuit testing tools is required. You should be familiar with wiring diagrams, the meaning of voltage, ohms, amps and the basic theories of electricity. You should also understand what happens if a circuit becomes open, shorted to ground or shorted to voltage.

To perform system diagnostics, several special tools and equipment are required. Please become acquainted with the tools and their use before attempting to diagnose the system. Special tools that are required for system service are illustrated in this section.

Electrostatic Discharge Damage

Electronic components used in control systems are often designed to carry very low voltage, and are very susceptible to damage caused by electrostatic discharge. It is possible for less than 100 volts of static electricity to cause damage to some electronic components. By comparison, it takes as much as 4,000 volts for a person to feel the zap of a static discharge.

There are several ways a person can become statically charged. The most common methods of charging are by friction and by induction. An example of charging by friction is a person sliding across a seat, in which a charge of as much as 25,000 volts can build up. Charging by induction occurs when a person with well insulated shoes stands

near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off, leaving the person highly charged with the opposite polarity. Static charges of either type can cause damage. Therefore, it is important to use care when handling and testing electronic components.

Engine Wiring

When it is necessary to move any of the wiring, whether to lift wires away from their harnesses or move harnesses to reach some component, take care that all wiring is replaced in its original position and all harnesses are routed correctly. If clips or retainers break, replace them. Electrical problems can result from wiring or harnesses becoming loose and moving from their original positions, or from being rerouted.

Engine Control Module (ECM) Self-Diagnostics

The failure of critical system components and/or circuits monitored by the ECM will generate and store Diagnostic Trouble Codes (DTCs) and illuminate the Malfunction Indicator Lamp (MIL) or Check Gauges Lamp (CGL) on the dash panel of boats.

The MIL or CGL will stay illuminated when the engine is running as long as the failure is present. If the problem is intermittent, or has been repaired, the MIL or CGL will stay illuminated for up to 3 ignition cycles after the fault goes from “active” to “history” status.

Note: When the DTC's are cleared using the Diacom scan tool (and the fault is not present), the MIL or CGL will immediately go out with the engine running.

Note: The Malfunction Indicator Lamp (MIL) is AMBER in color and the Check Gauges Lamp (CGL) is RED in color. Over-temperature and oil pressure faults illuminate the CGL, all other faults illuminate the MIL. Many manufacturers use digital displays for instrumentation. Faults are indicated through the displays and DO NOT use separate lamps.

Malfunction Indicator Lamp (MIL)

The majority of the trouble codes that the ECM stores are for emission related conditions. The AMBER Malfunction Indicator Lamp (MIL) is triggered for emission related faults. If the boat contains a Digital Display in the dash, in most cases the MIL is not used. All faults are displayed through the digital display.

Remember that DTC's have been commonized through Federal Regulations. This means that all engine manufacturers have the same identification numbers for each emission failure. Failures are now identified by a Suspect Parameter Number (SPN) and Failure Mode Indicator (FMI). Both of these numbers are required in order to identify the exact failure detected.

GENERAL INFORMATION

Note: Diacom ONLY reports the SPN and FMI numbers. Diacom does not report the DTC number.

Check Gauges Lamp (CGL)

Most of the trouble codes that the ECM stores for conditions detrimental to the engine and/or transmission turn on a RED Check Gauges Lamp, if equipped. The AMBER Malfunction Indicator Lamp is triggered for emission related faults. If the boat contains a Digital Display in the dash, in most cases neither lamp is used. All faults are displayed through the digital display. The ECM may enter into Power Derate Mode should one of the following conditions occur:

- an engine overheats (Cooling System failure),
- low engine oil pressure (Engine Mechanical failure), and
- exhaust cooling system overheats (indicated by an Exhaust Manifold Water Temperature sensors located in each manifold on CES equipped engines).

Power Derate Mode is a reduced performance mode that will allow an owner/operator sufficient performance to seek service and repairs. Power Derate Mode limits the engine RPM at two different stages. When the cooling temperature or oil pressure indicates a reading exceeding the Stage 1 value, the ECM limits the throttle body to 35% maximum throttle. If the problem continues to get worse and reaches a reading exceeding Stage 2 values, the ECM limits the throttle body to an elevated idle speed.

Warning: *The ECM never intentionally shuts the engine down. If the engine has low oil pressure or an overtemp condition, the operator has to make the decision to shut the engine down or get to a safe location.*

Intermittent Malfunction Indicator Lamp (MIL)

In the case of an “intermittent” problem, the Malfunction Indicator Lamp (MIL) will light for 10 seconds, and then go out. However, the corresponding DTC will be stored in the memory of the ECM. When DTC’s are set by an intermittent malfunction, they could be helpful in diagnosing the system.

If an intermittent DTC is cleared, it may or may not reset. If it is an intermittent failure, consult the “Diagnostic Aids” on the facing page of the corresponding Diagnostic Procedure. Symptoms section also covers the topic of “Intermittents.” A physical inspection of the applicable sub-system most often will resolve the problem.

Reading Diagnostic Trouble Codes (DTC’s)

The provision for communicating with the ECM is the CAN BUS Connector (Figure 1-1). It is part of the engine wiring harness, and is a 6-pin connector, which is electrically connected to the ECM. It is used in the assembly plant to receive information in checking that the engine is operating properly before it leaves the plant. The DTC(s) stored in the ECM’s memory can be retrieved using the Diacom Marine EFI Diagnostic Software, plugged into the CAN BUS connector.

Once Diacom has been connected, the ignition switch must be moved to the key “ON,” engine “OFF” position. Link Diacom to the ECM and observe the Malfunction Indicator Lamp display data. At this point, the MIL should be ON. Observe the Warning Buzzer Output display on the Diacom screen. The Warning Buzzer Output will be ON for approximately two seconds then go to OFF. If the MIL is flashing ON-OFF-ON-OFF repeatedly, there are codes stored in the ECM’s memory. A problem is present within the diagnostic system itself, and should be addressed by consulting the “On-Board Diagnostic (OBD) System Check” in the Diagnosis section.

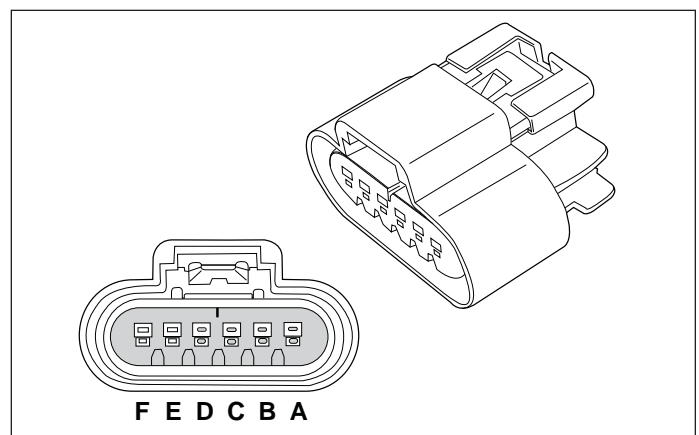


Figure 1-1 - GCP / 4G CAN BUS Connector

On-Board Diagnostic (OBD) System Check

Always follow the PCM Driveability Checklist when performing engine diagnosis. The “On-Board Diagnostic (OBD) System Check” is the starting point for all GCP / 4G diagnostic procedures. Refer to Diagnosis section.

The correct procedure to diagnose a problem is to follow two basic steps:

1. Perform the PCM Driveability Checklist in the order provided.
2. Begin diagnosis by performing the “On-Board Diagnostic (OBD) System Check” prior to performing any other Diagnostic Procedure.

GENERAL INFORMATION

Diacom Scan Tool

The ECM can communicate a variety of information through the CAN BUS connector. This data is transmitted at a high frequency which requires a scan tool for interpretation.

Diacom Marine Diagnostic Software is the preferred and required tool for diagnosing a GCP / 4G problem. With an understanding of the data which Diacom displays, and knowledge of the circuits involved, Diacom can be very useful in obtaining information which would be more difficult or impossible to obtain with other equipment.

Diacom does not make the use of Diagnostic Procedures unnecessary, nor do Diagnostic Procedures preclude the use of Diacom to indicate exactly where the problem is in a particular circuit. In fact the Diagnostic Procedures incorporate steps, that further utilize Diacom and its features, to further isolate a problem to its source.

Diacom Use With Intermittents

The Diacom provides the ability to perform a “wiggle test” on wiring harnesses or components with the Key-ON-Engine-OFF, while observing the Diacom ECM Data display.

Diacom may also be used while driving the boat under the condition when the MIL turns “ON” momentarily, or when the engine driveability is momentarily poor. If the problem seems to be related to certain parameters that can be observed on the Diacom display, they should be checked while driving the boat. If there does not seem to be any correlation between the problem and any specific circuit, Diacom may be used to make a recording of the engine parameters that can then be compared to a known good recording and watched for any abnormal deviations in the parameters from normal operation. Thus providing you the ability to isolate, for example, a sensor shifted in value that does not set a DTC.

Diacom has extended test capabilities that allow the technician access to various functions the ECM performs, such as fuel system operation, ignition system operation, and fuel injector operation, to name a few. The ability of the technician to maximize the capability of Diacom will save time in diagnosis and prevent the unnecessary replacement of good parts. The key to using Diacom successfully for diagnosis lies in the technicians ability to understand the engine system they are trying to diagnose, as well as an understanding of Diacom’s operation and limitations. The technician should read Diacom’s operating manual to become familiar with the tool’s operation, capabilities, and limitations.

How Diagnostic Trouble Codes (DTC) Are Set

The ECM is programmed to receive calibrated voltage signals from the sensors. The voltage signal from the sensor may range from as low as 0.1 volt to as high as 4.9 volts. The sensor voltage signal is calibrated for engine application. This would be the sensor’s operating parameter or “window.” The ECM and sensors will be discussed further in the ECM and Sensor section.

If a sensor is within its operating or acceptable parameters (Figure 1-2), the ECM does not detect a problem. When a sensor voltage signal falls out of this “window,” the ECM no longer receives a signal voltage within the operating “window.” When the ECM does not receive the “window” voltage for a calibratable length of time, a DTC will be set and stored in the ECM’s memory. The MIL will be illuminated and a known default value may be substituted for the sensor value to maintain a minimal level of engine performance, until the operator can seek service..

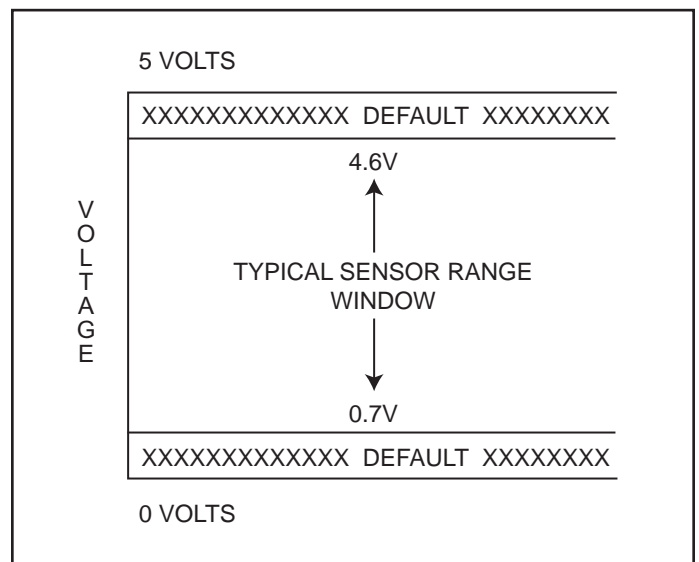


Figure 1-2 - Example of Sensor Normal Operation

Clearing Diagnostic Trouble Codes

1. Connect Diacom to the DLC connector.
2. Start engine.
3. Link Diacom to the engine’s ECM, then select the Codes tab on the Diacom display.
4. Select the Erase Codes option on the Diacom display., then exit the Codes display.
5. Turn ignition “OFF” for at least 20 seconds.
6. Turn ignition “ON” and check for stored DTC’s. If DTC’s are still present, check “Notice” below and repeat procedure following from step 2.

NOTICE: When clearing DTC’s, the ignition must be cycled to the “OFF” position or the DTC’s will not clear.

Diagnosis Of Drivability Concerns (No DTC's Set)

If a drivability concern exists following the performance of the OBD System Check and no DTC's are present, continue following the steps on the PCM Drivability Checklist. In most cases following the PCM Drivability Checklist will identify the problem.

As you perform the steps of the PCM Drivability Checklist, keep in mind that If a sensor is out of range, the problem may manifest itself in an unrelated system. Because a shifted sensor may still be within the operating "window" of the ECM, the problem may go undetected by the ECM and may result in a drivability concern.

Two good examples of this would be a coolant sensor reading incorrectly or a MAP sensor reading incorrectly. Typically, these problems appear as Fuel System problems. If the ECM detects coolant temperature at 50°F, but actual coolant temperature is at 150°F (Figure 1-3). This would cause the ECM to deliver more fuel than was actually needed by the engine. The same over fueling condition may exist with a MAP sensor reading out of range. This will result in an overly rich condition, causing a rough idle, possible stalling, backfire, and spark plug fouling. Typically, the operator may complain of stalling in long idle zones, or hard starts when the engine is hot, but will add that top end performance is great. These conditions will not cause a DTC to be set, as the ECM interprets the sensor values as being within the operating "window."

The preceding examples stress the need to follow the PCM Drivability Checklist whenever you are troubleshooting a drivability issue. By following the checklist, the Fuel System would have been eliminated early in your testing. Had the problem been over fueling as a result of a bad injector or pressure regulator, this would have been discovered when you took your fuel pressure readings. An Engine Coolant Temperature sensor, being shifted in value, would cause the displayed temperature reading to be low. This would have been discovered when you water tested the boat, as specified by the PCM Drivability Checklist.

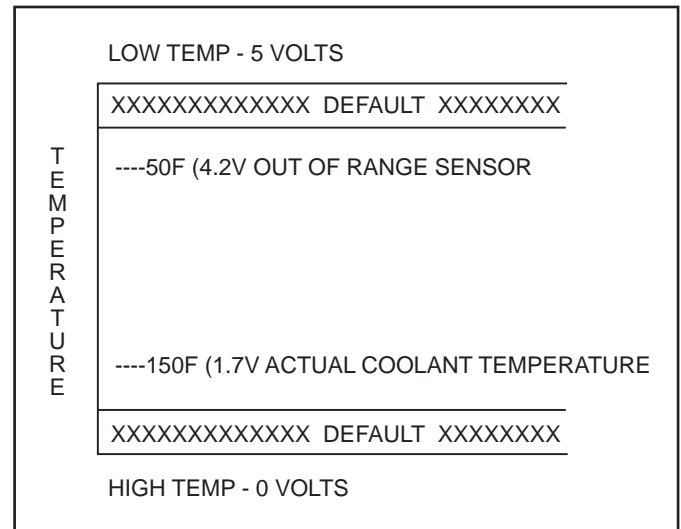


Figure 1-3 - Example of Shifted Sensor Operation

Aftermarket (Add-On) Electrical And Vacuum Equipment

Aftermarket, add-on electrical and vacuum equipment is defined as any equipment installed on a vehicle after leaving the factory that connects to the vehicles electrical or vacuum systems.

Notice: Do not attach add-on vacuum operated equipment to this engine. The use of add-on vacuum equipment may result in damage to engine components or systems.

Notice: Connect any add-on electrically operated equipment to the vehicle's electrical system at the battery (power and ground) in order to prevent damage to the vehicle.

Add-on electrical equipment, even when installed to these strict guidelines, may still cause the powertrain system to malfunction. This may also include equipment not connected to the vehicle's electrical system such as portable telephones and radios. Therefore, the first step in diagnosing any powertrain problem, is to eliminate all aftermarket electrical equipment from the vehicle. After this is done, if the problem still exists, diagnose the problem in the normal manner.

Use of Circuit Testing Tools


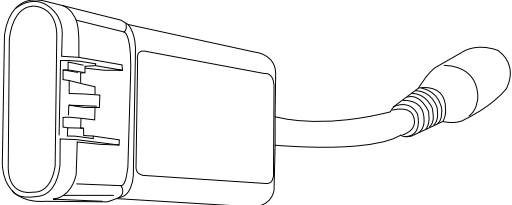
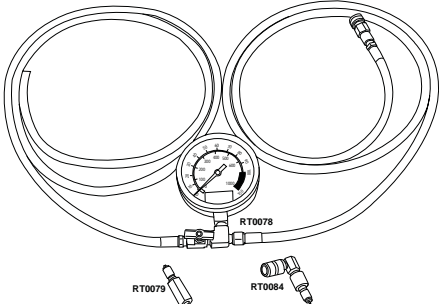
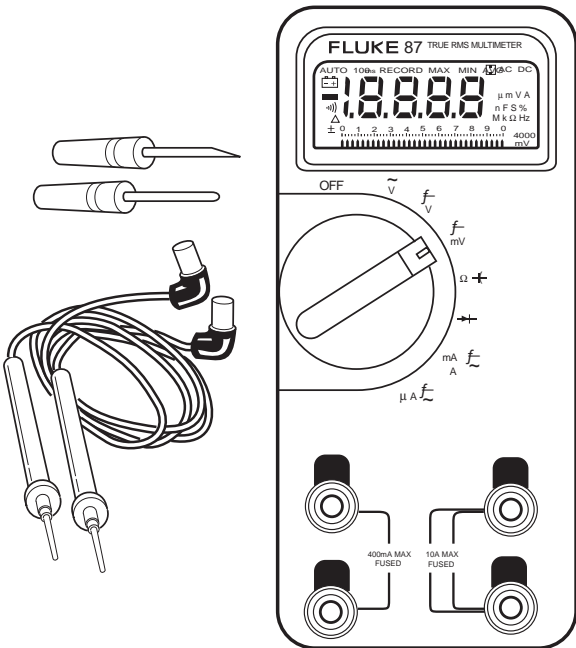
Do not use a test lamp in order to diagnose the engine electrical systems unless specifically instructed by the diagnostic procedures. Use the J 35616-A connector test adapter kit whenever diagnostic procedures call for probing any connectors.

Tools Needed To Service The System

Refer to RequiredTools in this section for engine control tools for servicing the system.

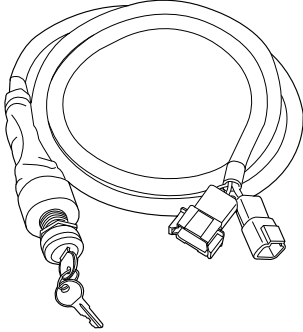
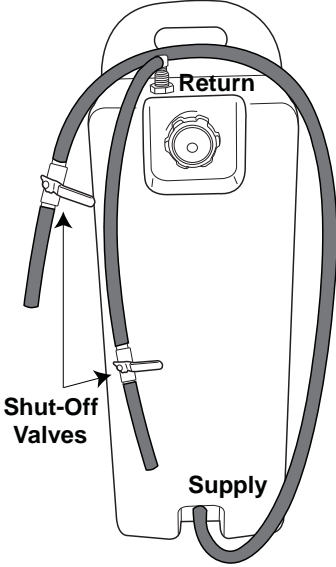
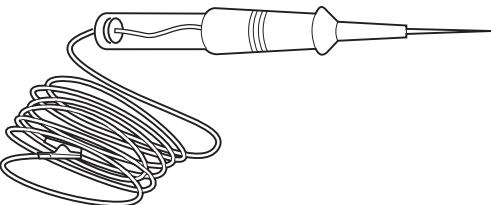
GENERAL INFORMATION

Required Tools

 <p>DIACOM[®] Marine Diagnostic System Version 2.7.3 Rinda Technologies</p>	<p>DIACOM SCAN TOOL</p> <p>Diacom is a Marine Diagnostic Software product from Rinda Technologies that is hosted on a laptop computer. This tool plugs into the DLC connector on the main engine harness and provides diagnostic capabilities for the GCP / 4G controllers as well as other marine engine ECM's.</p>
	<p>DIACOM CAN Network Adapter</p> <p>An accessory adapter for the Diacom scan tool for interface to the CAN Bus output of the GCP / 4G controllers. Used for calibration upgrades and extended diagnostics.</p>
	<p>FUEL PRESSURE GAUGE</p> <p>The fuel pressure gauge (PCM P/N - RTK0078) is essential for reading the fuel pressure under all operating conditions when diagnosing a fuel injected engine.</p>
	<p>VOLTMETER - Voltage position measures magnitude of voltage when connected in parallel to an existing circuit. A digital voltmeter with a 10 megohm input impedance is used because this type of meter will not load down the circuit and result in faulty readings. Some circuits require accurate low voltage readings because they have a very high resistance.</p> <p>AMMETER - When used as an ammeter, this meter accurately measures extremely low current flow. Refer to meter instructions for more information.</p> <ul style="list-style-type: none"> • Selector must be set properly for both function and range. DC is used for most measurements. <p>OHMMETER - Measures resistance of circuit directly in ohms. Refer to meter instructions for more information.</p> <ul style="list-style-type: none"> • OL display in all ranges indicates open circuit. • Zero display in all ranges indicates a short circuit. • An intermittent connection in a circuit may be indicated by a digital reading that will not stabilize on the circuit. • Range Switch - Automatic and Manual. <ul style="list-style-type: none"> 200Ω - Reads ohms directly 2K, 20K, 200KΩ - Reads ohms in thousands 2M, 20M, 200MΩ - Reads ohms in millions

GENERAL INFORMATION

Required Tools

 A coiled cable with a key attached to one end and two electrical connectors at the other.	<p>Remote Key Switch</p> <p>The Remote Key Switch (RT0091, for GCP / 4G equipped engines), is extremely useful for isolating the boat wiring from the engine wiring when trying to isolate electrical problems.</p>
 A diagram of a fuel tank with a 'Return' line at the top, a 'Supply' line at the bottom, and two 'Shut-Off Valves' on the side lines.	<p>Remote Fuel Tank</p> <p>An Auxiliary Fuel Tank (dealer fabricated) is absolutely essential for troubleshooting drivability problems that may be fuel related. Ensure that your fuel tank is equipped with a fuel return line. The ability to completely isolate the boat fuel system from the engine, using a known good fuel source, is essential for troubleshooting fuel system problems or perceived fuel system problems.</p> <p>Note: When using an auxiliary fuel source to test an engine with a FCC that returns fuel to the boat's fuel tank; the return fuel from the FCC must be redirected into the auxiliary fuel source.</p> <p>Important: Caution must be taken when using the remote fuel tank. The tank must be properly strapped down. The lines and fittings must be secure and away from heat and moving components.</p>
 A test lamp with a coiled cable and a pointed probe tip.	<p>Unpowered Test Lamp</p> <p>An Auxiliary Fuel Tank (dealer fabricated) is absolutely essential for troubleshooting drivability problems that may be fuel related. Ensure that your</p>

GENERAL INFORMATION

Service Precautions

The following requirements must be observed when working on GCP / 4G equipped engines.

1. Before removing any ECM system component, disconnect the negative battery cable.
2. Never start the engine without the battery being solidly connected.
3. Never separate the battery from the on-board electrical system while the engine is running.
4. Never separate the battery feed wire from the charging system while the engine is running.
5. When charging the battery, disconnect it from the vehicle's electrical system.
6. Ensure that all cable harnesses are connected solidly and the battery connections are thoroughly clean.
7. Never connect or disconnect the wiring harness at the ECM when the ignition is switched "ON."
8. Before attempting any electric arc welding on the vehicle, disconnect the battery leads and the ECM connector(s).
9. When steam cleaning engines, do not direct the nozzle at any ECM system components. If this happens, corrosion of the terminals or damage of components can take place.
10. Use only the test equipment specified in the diagnostic procedures, since other test equipment may either give incorrect test results or damage good components.
11. All measurements using a multimeter must use a digital meter with a rating of 10 megaohm input impedance.
12. When a test light is specified, a "low-power" test light must be used. Do not use a high-wattage test light. While a particular brand of test light is not suggested, a simple test on any test light will ensure it to be safe for system circuit testing (Figure 1-4). Connect an accurate ammeter (such as the high-impedance digital multimeter) in series with the test light being tested, and power the test light ammeter circuit with the vehicle battery.

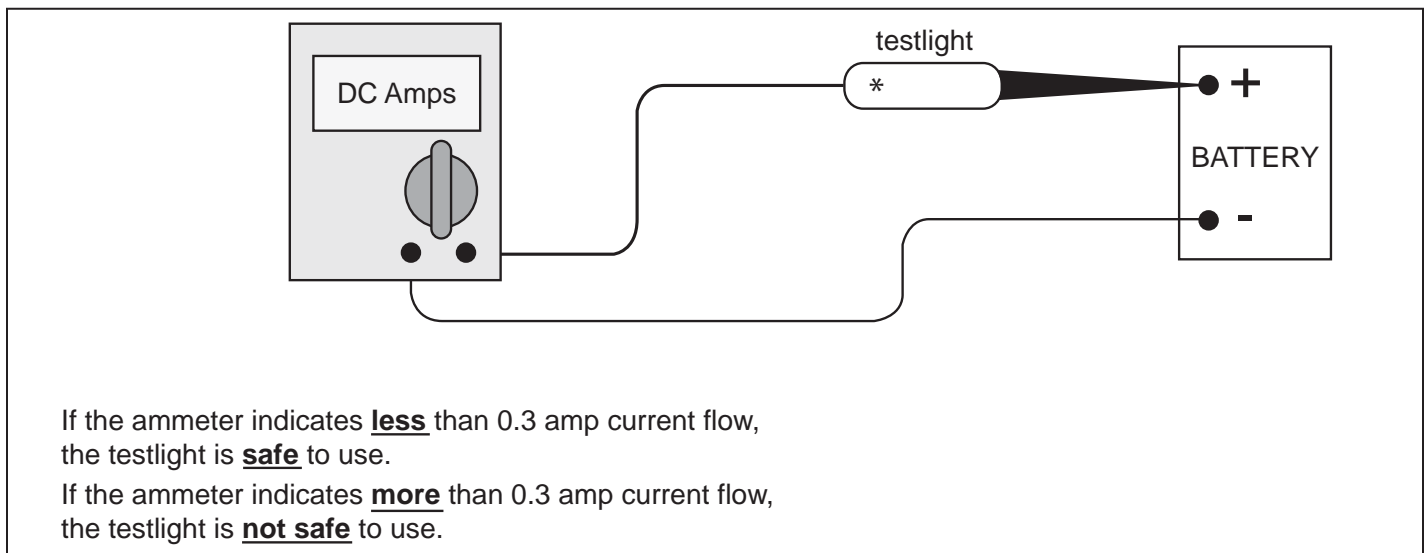


Figure 1-4 - Test Light Amperage Draw Test

Diagnosis

The diagnostic tables and functional checks in this manual are designed to locate a faulty circuit or component through logic based on the process of elimination. The tables are prepared with the requirement that the system functioned correctly at the time of assembly and that there are no multiple failures.

Engine control circuits contain many special design features not found in standard vehicle wiring. Environmental protection is used extensively to protect electrical contacts. Proper splicing methods must be used when necessary.

The proper operation of low amperage input/output circuits depend upon good continuity between circuit connectors. It is important before component replacement and/or during normal troubleshooting procedures that a visual inspection of any questionable mating connector is performed. Mating surfaces should be properly formed, clean and likely to make proper contact. Some typical causes of connector problems are listed below:

- Improperly formed contacts and/or connector housing.
- Damaged contacts or housing due to improper engagement.
- Corrosion, sealer or other contaminants on the contact mating surfaces.
- Incomplete mating of the connector halves during initial assembly or during subsequent troubleshooting procedures.

- Tendency for connectors to come apart due to vibration and/or temperature cycling.
- Terminals not fully seated in the connector body.
- Inadequate terminal crimps to the wire.

On-Board Service

Wiring Harness Service

Figure 1-5

Wiring harnesses should be replaced with proper part number harnesses. When wires are spliced into a harness, use the same gauge wire with high temperature insulation only.

With the low current and voltage levels found in the system, it is important that the best possible bond be made at all wire splices by soldering the splices as shown in Figure 1-5.

Use care when probing a connector or replacing a connector terminal. It is possible to short between opposite terminals. If this happens, certain components can be damaged. Always use jumper wires with the corresponding mating terminals between connectors for circuit checking. **NEVER** probe through connector seals, wire insulation, secondary ignition wires, boots, nipples or covers. Microscopic damage or holes may result in water intrusion, corrosion and/or component failure.

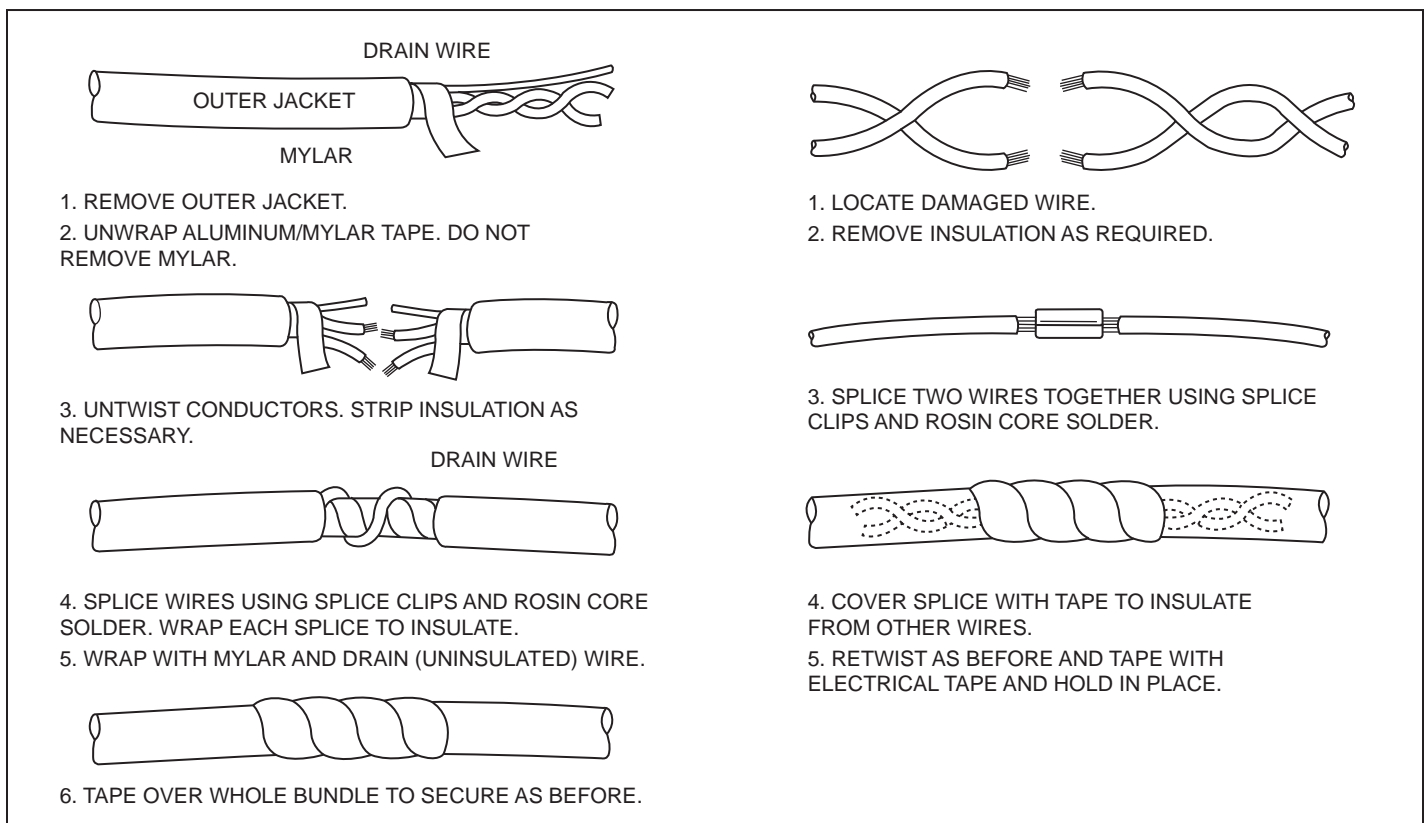


Figure 1-5 - Wiring Harness Repair

GENERAL INFORMATION

Wiring Connector Service

Most connectors in the engine compartment are protected against moisture and dirt which could create oxidation and deposits on the terminals. This protection is important because of the very low voltage and current levels found in the electronic system. The connectors have a lock which secures the male and female terminals together. A secondary lock holds the seal and terminal into the connector.

When diagnosing, open circuits are often difficult to locate by sight because oxidation or terminal misalignment are hidden by the connectors. Merely wiggling a connector on a sensor, or in the wiring harness, may locate the open circuit condition. This should always be considered when an open circuit or failed sensors is indicated. Intermittent problems may also be caused by oxidized or loose connections.

Before making a connector repair, be certain of the type of connector. Some connectors look similar but are serviced differently.

Metri-Pack Series 150 Terminals

Figure 1-6

Some ECM harness connectors contain terminals called Metri-Pack (Figure 1-6). These are used at some of the sensors and the distributor connector.

Metri-Pack terminals are also called "Pull-To-Seat" terminals because, to install a terminal on a wire, the wire is first inserted through the seal and connector. The terminal is then crimped on the wire, and the terminal is pulled back into the connector to seat it in place.

To remove a terminal:

1. Slide the seal back on the wire.
2. Insert tool J 35689 or equivalent, as shown in Figure 1-6, to release the terminal locking tang.
3. Push the wire and terminal out through the connector. If the terminal is being reused, reshape the locking tang.

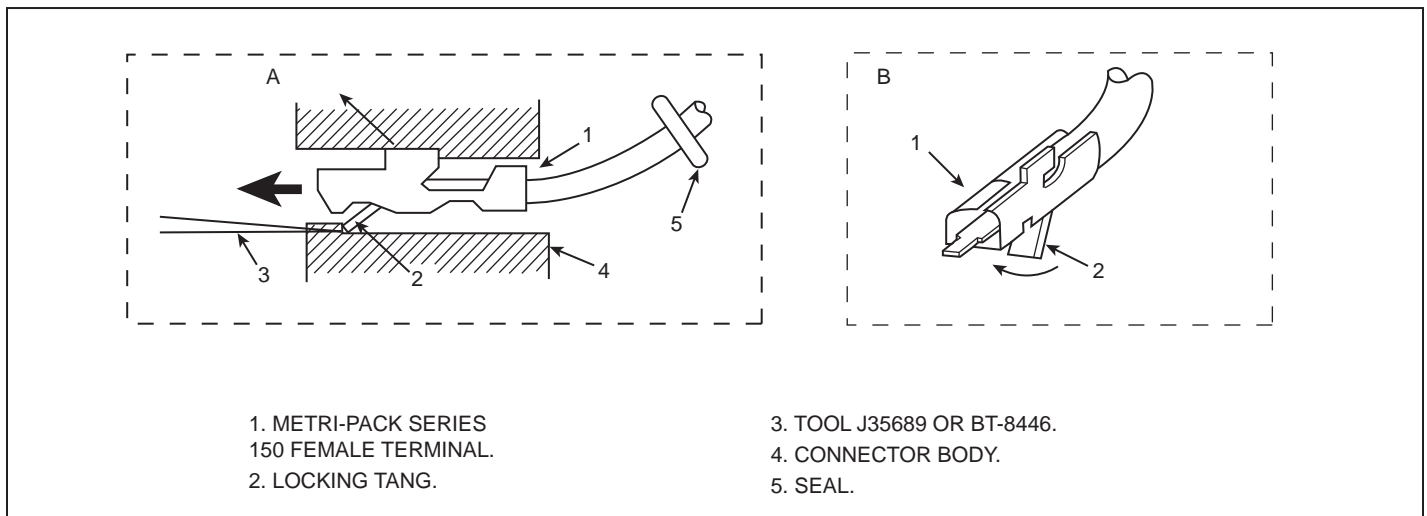


Figure 1-6 - Metri-Pack Series 150 Terminal Removal

GENERAL INFORMATION

Weather-Pack Connectors

Figure 1-7

Figure 1-7 shows a Weather-Pack connector and the tool (J28742 or equivalent) required to service it. This tool is used to remove the pin and sleeve terminals. If terminal removal is attempted without using the special tool required, there is a good chance that the terminal will be bent or deformed, and unlike standard blade type terminals, these terminals cannot be straightened once they are bent.

Make certain that the connectors are properly seated and all of the sealing rings in place when connecting leads. The hinge-type flap provides a secondary locking feature for the connector. It improves the connector reliability by retaining the terminals if the small terminal lock tangs are not positioned properly. Weather-Pack connections cannot be replaced with standard connections.

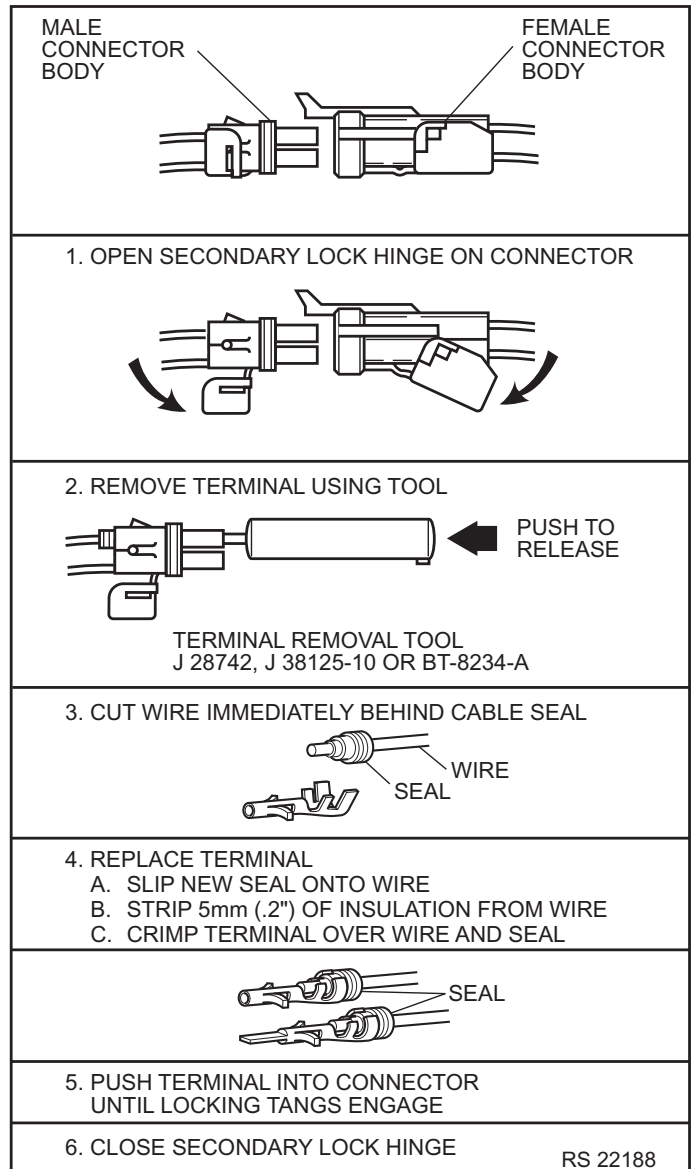


Figure 1-7 - Weather-Pack Terminal Repair

GENERAL INFORMATION

GCP / 4G ECM Connector

Figure 1-8

The harness connector used with the ECM is either a 90-Way or 120-Way. It is used for its ruggedized construction, capable of carrying more current and provides good sealing ability.

Remove or Disconnect ECM Connector

1. Negative battery cable.
2. Connector from ECM by sliding the locking tab away from the connector.
3. Carefully remove the connector from the ECM.

Inspect

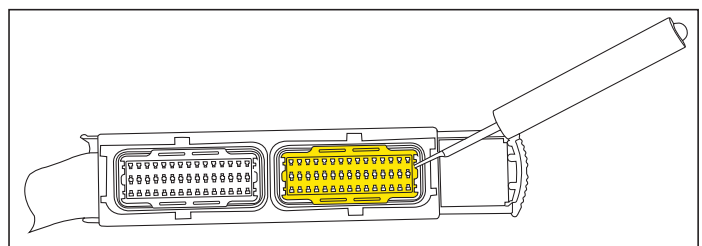
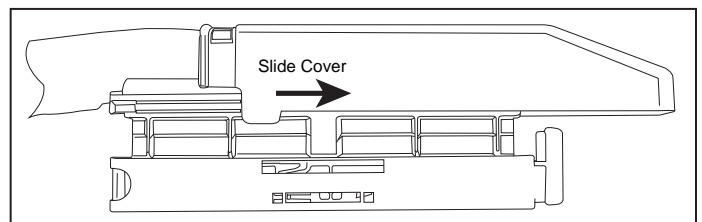
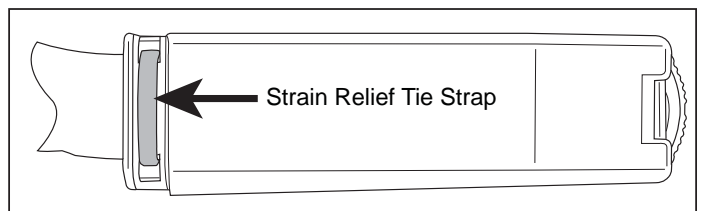
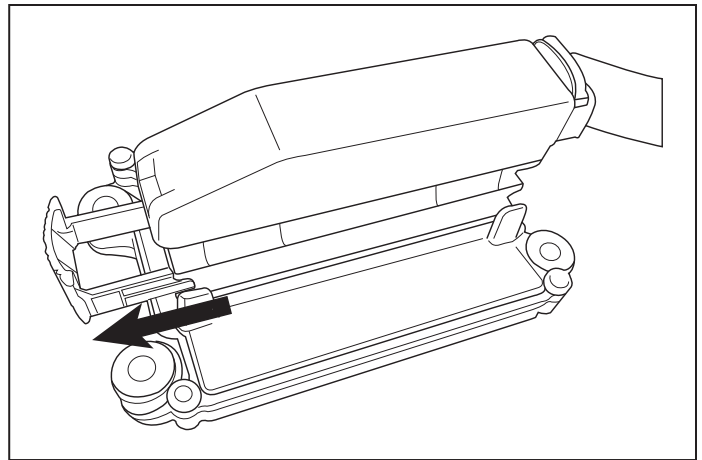
- Check strain relief for being missing or locking tab damaged.
- Check index cover for being cracked.
- Check seal for being torn, twisted or out of shape from improper installation.
- Check terminals for being corroded, out of position, bent or stretched out.

Remove ECM Connector Cover

4. Cut the tie strap used for strain relief.
5. Carefully slide the cover away from the end with the wires coming out of it.

Remove Locking Tab (Yellow)

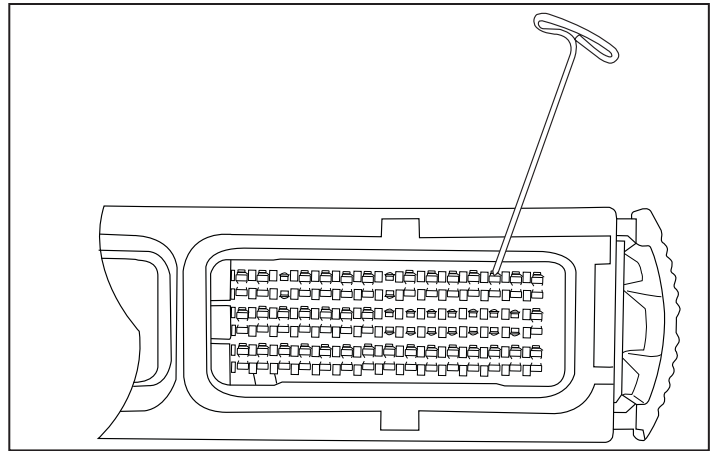
6. Using a pick, or small screwdriver, carefully pry up on each corner of the yellow locking tab.



GENERAL INFORMATION

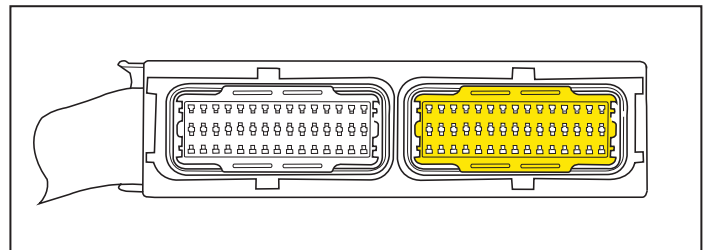
Remove Wire/Terminal

7. Using a T-Handle Pin, carefully insert the pin on each side of the terminal while carefully pulling and keeping pressure on the wire. Each side must be released before the terminal can be removed.



Install Wire/Terminal

1. Insert the terminal/wire into the back side of the connector. Make sure it is in the proper cavity.
2. Insert the terminal in far enough to lock in place.

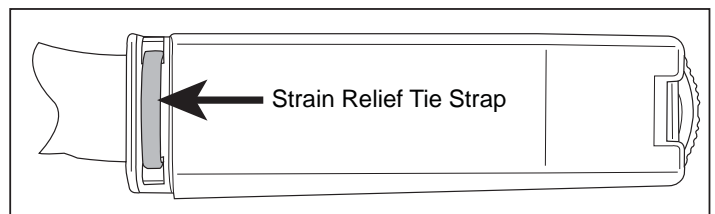
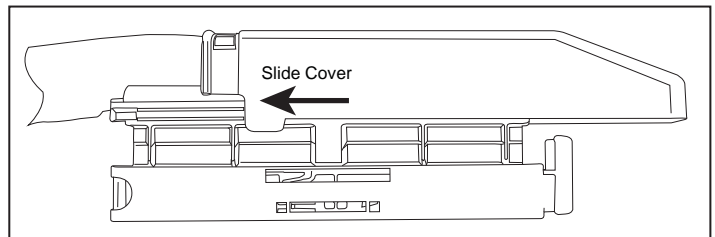


Install Locking Tab (Yellow)

3. Install the locking tab, making sure each corner snaps into place.

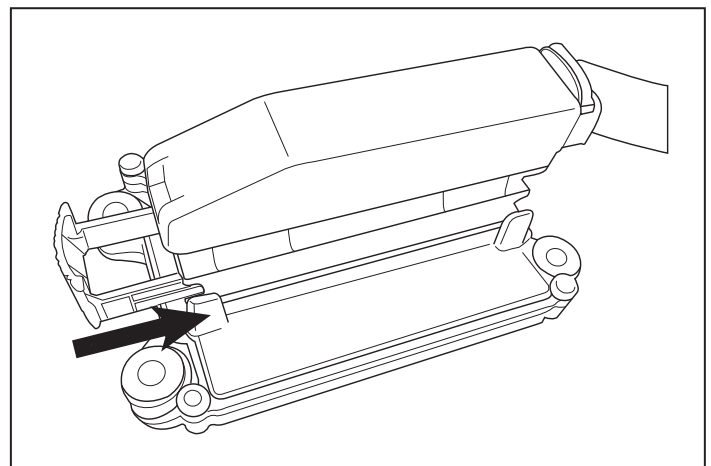
Install ECM Connector Cover

4. Position the ECM cover onto the connector about half way.
5. Slide the cover toward the end with the wires coming out.
6. The cover will snap into place.
7. Install a new Strain Relief Tie Strap.



Install ECM Connector

8. Position the ECM connector onto ECM.
9. With the connector square with the ECM, slide the locking tab toward the connector.



**This Page Was
Intentionally
Left Blank**

GCP / 4G Engine Management System

Section 2

Engine Control Module (ECM) and Sensors

This section will describe the function of the Engine Control Module (ECM) and the sensors. The section explains how voltages reflect the inputs and outputs of the ECM. The sensor descriptions include how they operate and how to replace them.

Contents

General Description	Page 18	Oil Pressure Sensor	Page 26
Computers and Voltage Signals	Page 18	Ignition Control (IC) Reference	Page 27
Analog Signals	Page 18	Camshaft Position (CMP) Sensor	Page 27
Three-Wire Sensors	Page 18	Crankshaft Position (CMP) Sensor	Page 27
Two-Wire Sensors	Page 18	Knock Sensor	Page 28
Digital Signals	Page 19	Discrete Switch Inputs	Page 28
Switch Types	Page 19	Electrical System Relays and	
Pulse Counters	Page 19	Fuse Block	Page 29
Engine Control Module (ECM)	Page 20	Diagnosis	Page 30
ECM Function	Page 20	Engine Control Module (ECM)	Page 30
Memory	Page 20	On-Board Service	Page 31
ROM	Page 20	Engine Control Module (ECM)	
RAM	Page 20	Replacement	Page 31
EEPROM	Page 20	Starter Relay	Page 31
Internal Processor Diagnostics	Page 21	Ignition Relay	Page 32
Speed Density System	Page 21	Fuel Pump Relay	Page 32
Speed	Page 21	Engine Coolant Temperature (ECT)	
Density	Page 21	Sensor	Page 32
ECM Inputs and Sensor Descriptions	Page 21	Intake Air Temperature (IAT)	
Input Components	Page 22	Sensor	Page 33
Output Components	Page 22	Throttle Position (TP) Sensor	Page 33
GCP / 4G Inputs and Outputs	Page 23	Engine Oil Pressure Sensor	Page 34
Engine Coolant Temperature (ECT)		Manifold Absolute Pressure (MAP) / Intake	
Sensor	Page 24	Air Temperature (IAT) Sensor	Page 34
Manifold Absolute Pressure (MAP)		Manifold Absolute Pressure (MAP) Sensor ...	Page 35
Sensor	Page 24	Throttle Control Position (TCP) Sensor	Page 36
Throttle Position (TPS) Sensor	Page 25	Knock Sensor (KS) (5.0/5.7L)	Page 37
Throttle Control Position (TCP) Sensor ...	Page 25	Knock Sensors (KS) (6.0L)	Page 37
Intake Air Temperature (IAT) Sensor	Page 26	Torque Specifications	Page 38

ECM and SENSORS

General Description

The ECM-07 Engine Management System is equipped with a computer that provides the operator with state-of-the-art control of fuel, air and spark delivery. Before we discuss the computers on the Marine applications, let's discuss how computers use voltage to send and receive information.

Computers and Voltage Signals

Voltage is electrical pressure. Voltage does not flow through circuits. Instead, voltage causes current. Current does the real work in electrical circuits. It is current, the flow of electrically charged particles, that energizes solenoids, closes relays and illuminates lamps.

Besides causing current flow in circuits, voltage can be used as a signal. Voltage signals can send information by changing levels, changing waveform (shape) or changing the speed (frequency at which the signal switches from one level to another.) Computers use voltage signals to communicate with one another. The different circuits inside computers also use voltage signals to talk to each other.

There are two kinds of voltage signals, analog and digital. Both of these are used in computer systems. It is important to understand the difference between them and the different ways they are used.

Analog Signals

An analog signal is continuously variable. This means that the signal can be any voltage within a certain range.

An analog signal usually gives information about a condition that changes continuously over a certain range. For example, in a marine engine, temperature is usually provided by an analog signal. There are two general types of sensors that produce analog signals, the 3-wire and the 2-wire sensors.

Three-Wire Sensors

Figure 2-1 shows a schematic representation of a 3-wire sensor. All 3-wire sensors have a reference voltage, a ground and a variable "wiper." The lead coming off of the "wiper" will be the signal to the Engine Control Module (ECM). As this "wiper" position changes, the signal voltage to the ECM also changes.

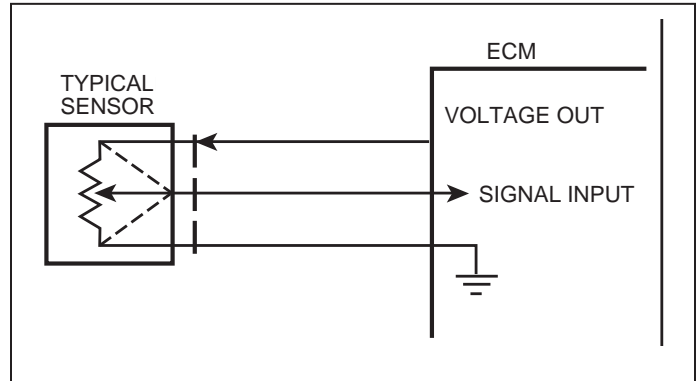


Figure 2-1 - Three-Wire Sensors

Two-Wire Sensors

Figure 2-2 shows a schematic representation of a 2-wire sensor. This sensor is basically a variable resistor in series with a known-fixed resistor within the ECM. By knowing the values of the input voltage and the voltage drop across the known resistor, the value of the variable resistor can be determined. The variable resistors that are commonly used are called thermistors. A thermistor's resistance varies with temperature.

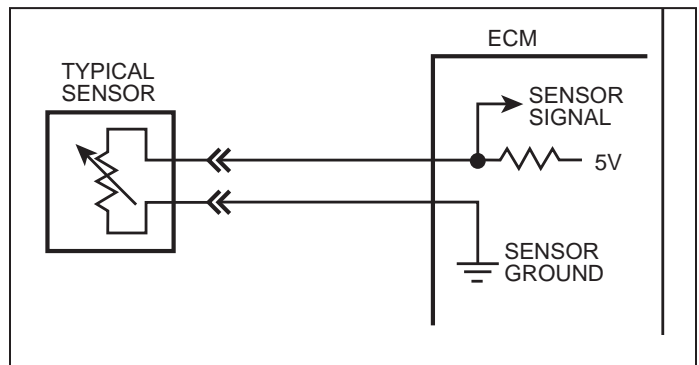


Figure 2-2 - Two-Wire Sensors

Digital Signals

Digital signals are also variable, but not continuously. They can only be represented by distinct voltages within a range. For example, 1V, 2V or 3V would be allowed, but 1.27V or 2.56V would not. Digital signals are especially useful when the information can only refer to two conditions: "YES" and "NO," "ON" and "OFF" or "HIGH" and "LOW." This would be called a digital binary signal. A digital binary signal is limited to two voltage levels. One level is a positive voltage, the other is no voltage (zero volts). As you can see in Figure 2-3, a digital binary signal is a square wave.

The ECM uses digital signals in a code that contains only ones and zeros. The high voltage of the digital signal represents a one (1), and no voltage represents a zero (0). Each "zero" and each "one" is called a bit of information, or just a "bit." Eight bits together are called a "byte." A byte, therefore, contains some combination of eight binary code bits.

Binary code is used inside the ECM and between a computer and any electronic device that understands the code. By stringing together thousands of bits, computers can communicate and store an infinite varieties of information. To a computer that understands binary, 11001011 might mean that it should turn an output device "ON" at slow speed. Although the ECM uses 8-bit digital codes internally and when talking to another computer, each bit can have a meaning.

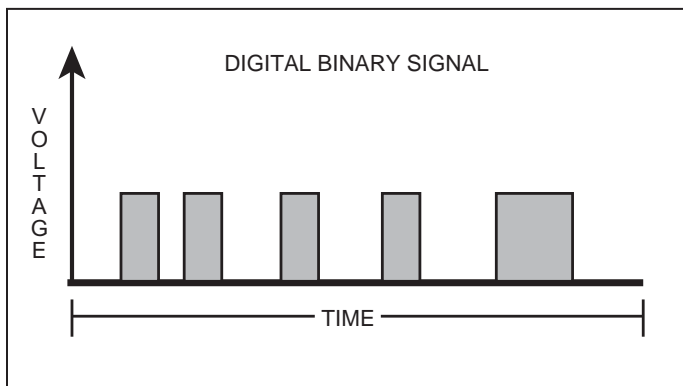


Figure 2-3 - Digital Voltage Signal

Switch Types

Switched inputs (also known as discretes) to the ECM can cause one bit to change, resulting in information being communicated to the ECM. Switched inputs can come in two types: "pull-up" and "pull-down" types. Both types will be discussed.

With "pull-up" type switch, the ECM will sense a voltage when the switch is CLOSED. With "pull-down" type switch, the ECM will sense a voltage when the switch is OPEN.

Pulse Counters

For the ECM to determine frequency information from a switched input, the ECM must measure the time between the voltage pulses. As a number of pulses are recorded in a set amount of time, the ECM can calculate the frequency. The meaning of the frequency number can have any number of meanings to the ECM.

An example of a pulse counter type of input is the Crankshaft Position (CKP) sensor input. The ECM can count a train of pulses, a given number of pulses per engine revolution. In this way, the ECM can determine the RPM of the engine.

ECM and SENSORS

Engine Control Module (ECM)

The Engine Control Module (ECM), located on the engine, is the control center of the engine management system. It controls the following:

- Fuel pumps circuit (fuel supply)
- Fuel injector circuits (fuel delivery)
- Ignition control circuit (spark)
- Throttle Body (air)
- Knock Sensor (KS) system
- On-board diagnostics for engine functions

It constantly looks at the information from various sensors, and controls the systems that affect engine performance. The ECM also performs the diagnostic function of the system. It can recognize operational problems, alert the operator through the MIL (Malfunction Indicator Lamp) and store diagnostic trouble codes, which identify the problem areas to aid the technician in making repairs. Refer to General Information section for more information on using the diagnostic function of the ECM.

ECM Function

The ECM supplies either 5 or 12 volts to power various sensors or switches. This is done through resistances in the ECM which are so high in value that a test light will not light when connected to the circuit. In some cases, even an ordinary shop voltmeter will not give an accurate reading because its resistance is too low. Therefore, a digital voltmeter with at least 10 megohms input impedance is required to ensure accurate voltage readings. Tool J 39978 meets this requirement.

The ECM controls output circuits such as the injectors, Throttle Body, relays, etc. by controlling the ground or power feed circuit.

Memory

There are three types of memory storage within the ECM. They are ROM, RAM and EEPROM.

ROM

Read Only Memory (ROM) is a permanent memory that is physically soldered to the circuit boards within the ECM. The ROM contains the overall control programs. Once the ROM is programmed, it cannot be changed. The ROM memory is non-erasable, and does not need power to be retained.

RAM

Random Access Memory (RAM) is the microprocessor "scratch pad." The processor can write into, or read from this memory as needed. This memory is erasable and needs a constant supply of voltage to be retained. If the voltage is lost, the memory is lost.

EEPROM

The Electronically Erasable Programmable Read Only Memory (EEPROM) is a permanent memory that is physically soldered within the ECM. The EEPROM contains program and calibration information that the ECM needs to control engine operation.

The EEPROM is not replaceable. If the ECM is replaced, the new ECM will need to be programmed with the calibration information that is specific to the engine the ECM is to be used on.

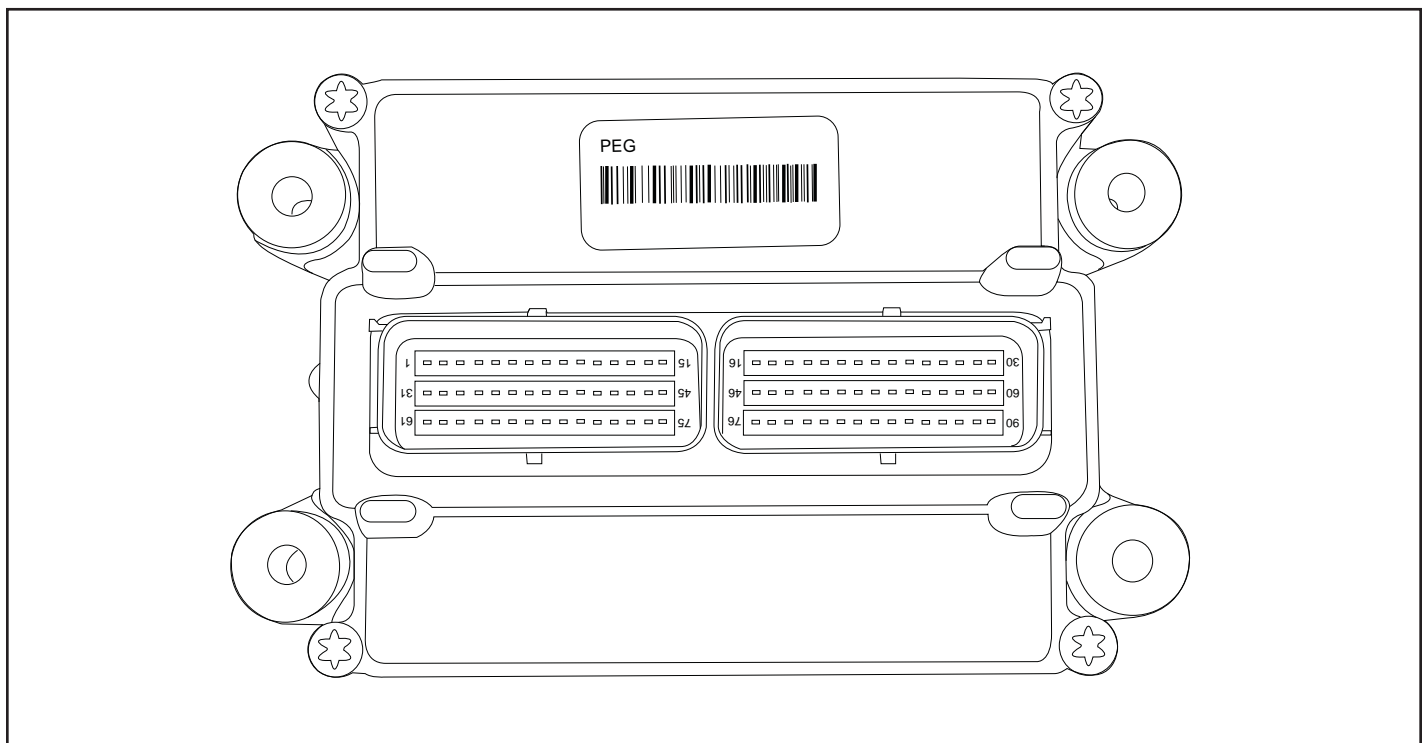


Figure 2-4 - Engine Control Module (ECM)

Internal Processor Diagnostics

The ECM constantly monitors its internal functions for error. The ECM should set one or more of the following codes for an internal processor failure. If a code is set; clear the codes, remove power from the ECM by disconnecting the battery power to the engine for at least 30 seconds, reconnect the battery and re-test. If the code returns replace the ECM. Any ECM failure code will result in a reduced throttle condition. The engine will not operate above 800 RPM. If equipped with a buzzer, the buzzer will sound for .5 sec then be off for .25 sec.

- DTC 601 Flash Checksum Invalid
- DTC 604 RAM Failure
- DTC 606 Microprocessor Failure - COP
- DTC 1612 RTI 1 Loss
- DTC 1613 RTI 2 Loss
- DTC 1614 RTI 3 Loss
- DTC 1615 A/D Loss

Speed Density System

The GCP / 4G system is a speed and air density system. The system is based on "speed density" fuel management.

Sensors provide the ECM with the basic information for the fuel management portion of its operation. Signals to the ECM establish the engine speed and air density factors.

Speed

The engine speed signal comes from the CKP sensor to the ECM. The ECM uses this information to determine the "speed" or RPM factor for fuel and spark management.

Density

One particular sensor contributes to the density factor, the Manifold Absolute Pressure (MAP) sensor. The MAP sensor is a 3-wire sensor that monitors the changes in intake manifold pressure which results from changes in engine loads. These pressure changes are supplied to the ECM in the form of electrical signals.

As intake manifold pressure increases, the vacuum decreases. The air density in the intake manifold also increases, and additional fuel is needed.

The MAP sensor sends this pressure information to the ECM, and the ECM increases the amount of fuel injected, by increasing the injector pulse width. As manifold pressure decreases, the vacuum increases, and the amount of fuel is decreased.

These two inputs, MAP and RPM, are the major determinants of the air/fuel mixture delivered by the fuel injection system. The remaining sensors and switches provide electrical inputs to the ECM, which are used for modification of the air/fuel mixture, as well as for other ECM control functions, such as idle control.

GCP / 4G

ECM Inputs and Sensor Descriptions

Figure 2-5 lists the data sensors, switches, and other inputs used by the ECM to control its various systems. Although we will not cover them all in great detail, there will be a brief description of each.

The ECM provides two 5 Volt Reference Supply voltages to be used for sensor signals. The 5 Volt Reference Supply provides the required operating voltage for the various sensors located on the engine. The ECM monitors these supplies for proper operation and should set a DTC for a 5 Volt Reference Supply failure. In addition to the 5 Volt Reference Supply codes, there may be various sensor codes also. Always verify that VREF #1 and #2 voltages and circuits are correct before troubleshooting the sensor code. If VREF #2 fails, the operator will have Idle Only operation of the throttle. Also, if equipped with a buzzer, the buzzer will sound for .5 sec and be off for .25 sec.

- DTC 642 - Sensor Supply Voltage 1 Low
- DTC 643 - Sensor Supply Voltage 1 High
- DTC 652 - Sensor Supply Voltage 2 Low
- DTC 653 - Sensor Supply Voltage 2 High
- DTC 1611 - Sensor Supply Voltage 1/2 Simultaneous Out Of Range

SENSOR to 5V REFERENCE SUPPLY

SENSOR	VREF #1	VREF #2
MAP/IAT	X	
OIL PRES.	X	
CRANK	X	
CAM	X	
ECT	X	
TPS	X	
TCP	X	X

ECM and SENSORS

Input Components

The ECM monitors the input components for circuit continuity and out-of-range values. This includes performance checking. Performance checking refers to indicating a fault when the signal from a sensor does not seem reasonable, such as a throttle position sensor (TPS) that indicates high throttle position at low engine loads or MAP voltage. The input components may include, but are not limited to, the following sensors:

- Crankshaft Position (CKP) sensor
- Camshaft Position (CMP) sensor
- Engine coolant temperature (ECT) sensor
- Intake Air Temperature (IAT) sensor
- Knock Sensor(s) (KS)
- Manifold absolute pressure (MAP) sensor
- Oil Pressure sensor
- Throttle Control Position (TCP) sensor
- Throttle Position sensor (TPS)

Output Components

Diagnose the output components for the proper response to ECM commands. Components where functional monitoring is not feasible, will be monitored for circuit continuity and out-of-range values, if applicable.

Output components to be monitored include, but are not limited to, the following circuits:

- Fuel Injectors
- Ignition Control (IC) circuits
- Throttle Body
- Fuel Pump and Ignition Relays
- VREF, 5V reference voltage
- Tachometer Output
- Malfunction Indicator Lamp
- Warning Buzzer

GCP / 4G INPUTS AND OUTPUTS (TYPICAL)

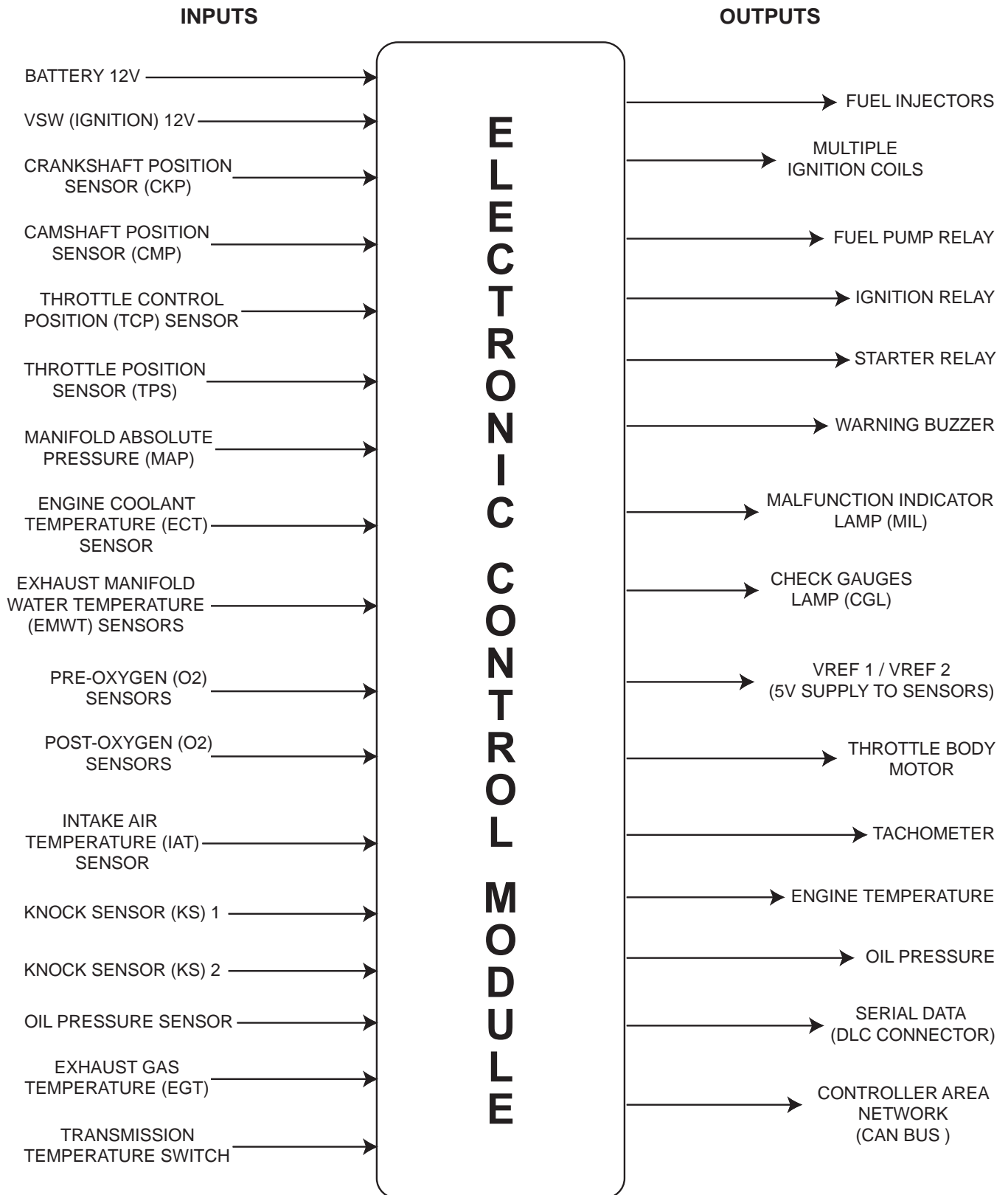


Figure 2-5 - ECM Inputs and Outputs (Typical)

ECM and SENSORS

Engine Coolant Temperature (ECT) Sensor

The engine coolant temperature (ECT) sensor is a thermistor (a resistor which changes value based on temperature) mounted in the engine coolant stream. Low coolant temperature produces a high resistance (100,000 ohms at -40°C/-40°F) while high temperature causes low resistance (70 ohms at 130°C/266°F).

The ECM supplies a 5 volt signal to the ECT sensor through a resistor in the ECM and measures the voltage. The voltage will be high when the engine is cold, and low when the engine is hot. By measuring the voltage, the ECM calculates the engine coolant temperature. Engine coolant temperature affects most systems the ECM controls.

A hard fault in the engine coolant sensor circuit should set DTC 117 or DTC 118; an intermittent fault may or may not set a DTC. ECM-07 also monitors the sensor for over temperature conditions and DTC 116 or DTC 217 may be present if the engine was running hot. The DTC "Diagnostic Aids" also contains a chart to check for sensor resistance values relative to temperature.

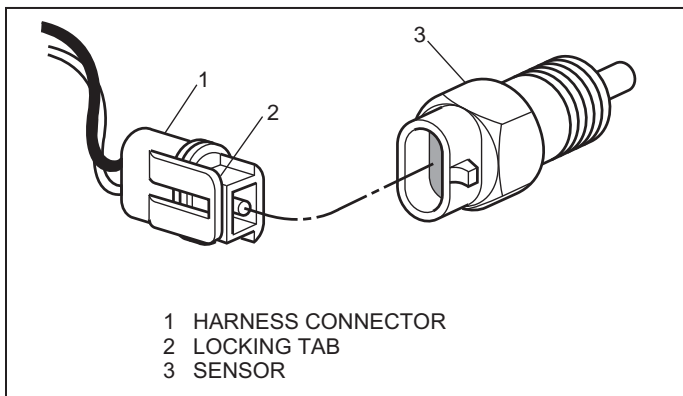


Figure 2-6 - Engine Coolant Temperature (ECT) Sensor

Manifold Absolute Pressure (MAP) Sensor

The Manifold Absolute Pressure (MAP) sensor is a pressure transducer that measures the changes in the intake manifold pressure. The pressure changes as a result of engine load and speed change, and the MAP sensor converts this into a voltage output.

A closed throttle on engine coastdown would produce a relatively low MAP output voltage, while a wide open throttle would produce a high MAP output voltage. This high output voltage is produced because the pressure inside the manifold is almost the same as outside the manifold, so you measure almost 100% of outside air pressure. MAP is the opposite of what you would measure on a vacuum gauge. When manifold pressure is high, vacuum is low, causing a high MAP output voltage. The MAP sensor is also used to measure barometric pressure, this occurs once an ignition cycle at key ON, which allows the ECM to automatically adjust for different altitudes.

The ECM supplies a 5 volt reference voltage to the MAP sensor. As the manifold pressure changes, the electrical resistance of the MAP sensor also changes. By monitoring the sensor output voltage, the ECM knows the manifold pressure. A higher pressure, low vacuum (high voltage) requires more fuel. A lower pressure, high vacuum (low voltage) requires less fuel. The ECM uses the MAP sensor to control fuel delivery and ignition timing. A failure in the MAP sensor circuit should set a DTC 107 or DTC 108 for a MAP failure and DTC 2229 or DTC 129 for a Barometric Pressure reading failure..

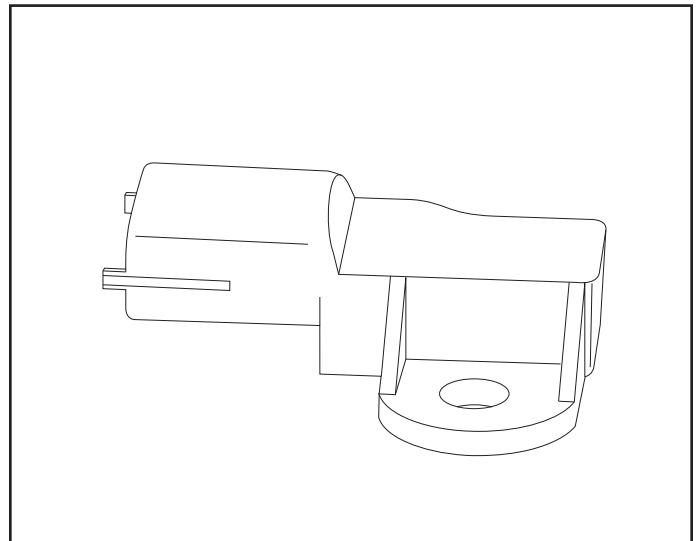


Figure 2-7 - Manifold Absolute Pressure (MAP) Sensor/Intake Air Temperature (IAT) Sensor (Used On 5.0/5.7L Engines)

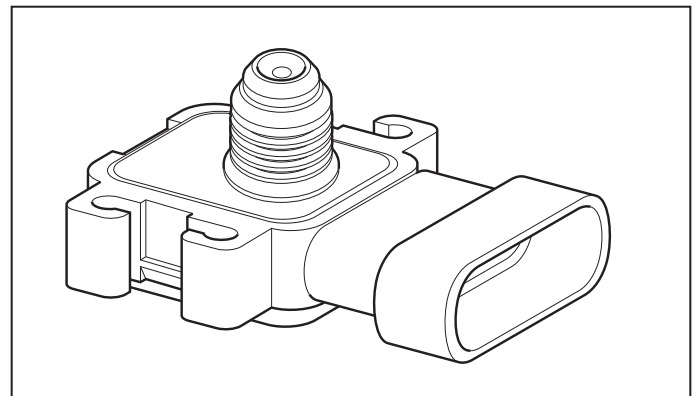


Figure 2-8 - Manifold Absolute Pressure (MAP) Sensor (Used On 6.0L Engines)

Throttle Position Sensor (TPS)

The Throttle Position Sensor is located within the Throttle Body Assembly. The ECM commands the throttle plate to move based on the Throttle Control Position (TCP) sensor inputs then outputs commands (DBW +) to the throttle plate motor. Feedback is provided back to the ECM via TPS1 and TPS2 signals. The TPS uses the 5V REF #1 supply to develop the output signals.

The Throttle Position Sensor (TPS) is a dual potentiometer connected to the throttle shaft on the throttle body. By monitoring the voltage on the signal lines, TPS1 and TPS2, the ECM verifies throttle position, as commanded. As the throttle valve angle is changed (TCP Sensor indicates a change), the throttle plate drive motor will change position and the TPS signals also change. At a closed throttle position, the output of the TPS1 is low and TPS2 is high. As the throttle valve opens, the output at TPS1 increases so that at Wide Open Throttle (WOT), the output voltage should be above 4 volts, and TPS2 output will be low.

The ECM calculates fuel delivery based on throttle valve angle (driver demand). A broken or loose TPS connection or defective potentiometer may cause intermittent bursts of fuel from an injector and unstable idle because the ECM thinks the throttle is moving.

If any of the failures listed occur, the buzzer, if equipped, will sound for .5 sec and be off for .25 sec. Also, the throttle will have no effect, the owner will have idle speed only. DTC 122 TPS1 Voltage Low, DTC 123 TPS1 Voltage High, DTC 222 TPS2 Voltage Low, DTC 223 TPS2 Voltage High, DTC 121 TPS1 Lower Than TPS2, DTC 221 TPS1 Higher Than TPS2, DTC 2111 Unable to reach Lower TPS, DTC 2112 Unable to reach Higher TPS, DTC 2135 TPS 1/2 Simultaneous Voltages Out Of Range,

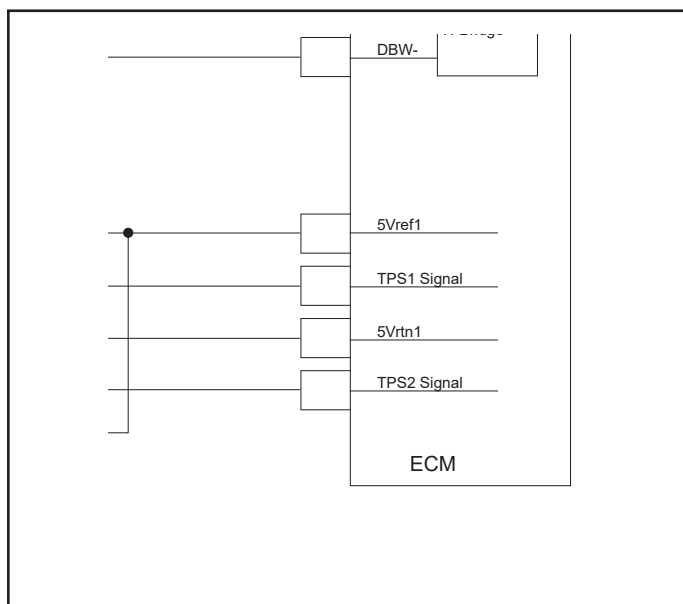


Figure 2-9 - Throttle Body-Throttle Position Sensor (TPS)

Throttle Control Position (TCP) Sensor

The Throttle Control Position (TCP) sensor is comprised of two internal variable resistors (TCP1 and TCP2 signals) and an Idle Validation Switch (IVS). The TCP provides redundant signals to the ECM for throttle control. Should the TCP partially fail, you will still have full control of the throttle, but an error code will be set. TCP signals will be indicated as FPP (Foot Pedal Position is a carryover term from automotive) in the error code description.

The ECM supplies two 5 volt signals to the sensor (VREF#1 and VREF#2) then measures the voltage as TCP position is changed. A cable connects the TCP to the Throttle handle. The TCP1 voltage will be low when the TCP/throttle handle is in its idle position, then increase as the throttle handle position is increased. TCP2 voltage follows TCP1 voltage at approximately half its value. By measuring the voltage, the ECM calculates the throttle demand, outputs the control signal to move the throttle plate in the throttle body, and verifies the commanded position took place by the TPS signal values.

If any two sections of the TCP fail, or the VREF#2 input is lost, this will cause the buzzer, if equipped, to sound for .5 sec and be OFF for .25 sec. Also, the throttle will have no effect, the owner will have idle speed only. The scan tool will display the various TCP parameters, if the TCP fails one or more of the following codes may be present DTC 2122 FPP1 Voltage High, DTC 2123 FPP1 Voltage Low, DTC 2127 FPP2 Voltage Low, DTC 2128 FPP2 Voltage High, DTC 2115 FPP1 Higher Than IVS, DTC 2139 FPP1 Lower than IVS, DTC 2116 FPP2 Higher Than IVS, DTC 2140 FPP2 Lower than IVS, DTC 2126 FPP1 Higher than FPP2, DTC 2121 FPP1 Lower than FPP2, DTC 2130 IVS Stuck at idle, FPP1/2 match, DTC 2131 IVS Stuck off idle, FPP1/2 match, DTC 1121 FPP1/2 simultaneous voltages out of range, DTC 2120 FPP1 invalid voltage and FPP2 disagrees with IVS, DTC 2125 FPP1 invalid voltage and FPP2 disagrees with IVS, and DTC 1122 FPP1/2 do not match each other or the IVS

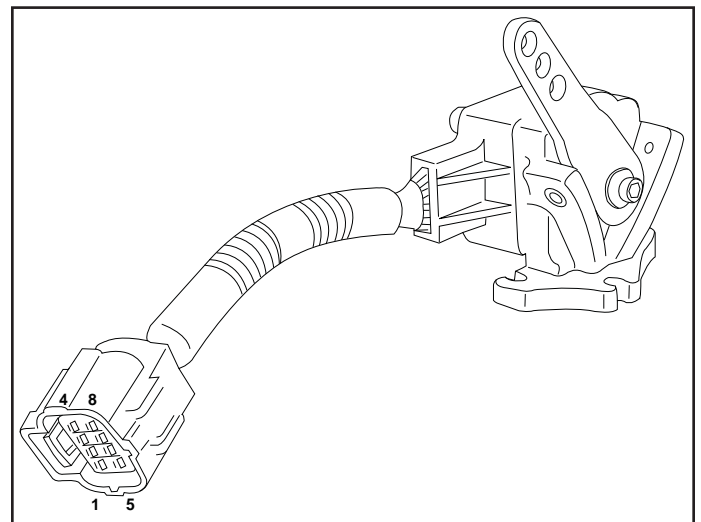


Figure 2-10 - Throttle Control Position (TCP) Sensor

ECM and SENSORS

Intake Air Temperature (IAT) Sensor

The Intake Air Temperature (IAT) sensor is a thermistor which changes value based on the temperature of air entering the engine (Figure 2-11). Low temperature produces a high resistance (100,000 ohms at -40°C/-40°F) while high temperature causes low resistance (70 ohms at 130°C/266°F).

The ECM supplies a 5 volt signal to the sensor through a resistor in the ECM and measures the voltage. The voltage will be high when the incoming air is cold, and low when the incoming air is hot. By measuring the voltage, the ECM calculates the incoming air temperature. The IAT sensor signal is used to determine spark timing based on incoming air density.

The scan tool displays temperature of the air entering the engine, which should read close to ambient air temperature when engine is cold, and rise as engine compartment temperature increases. If the engine has not been run for several hours (overnight), the IAT sensor and ECT sensor temperatures should read close to each other. A failure in the IAT sensor circuit should set DTC 111 IAT Higher Than Expected Stage 1, DTC 112 IAT Voltage Low, DTC 113 IAT Voltage High, DTC 127 IAT Higher Than Expected Stage 2,

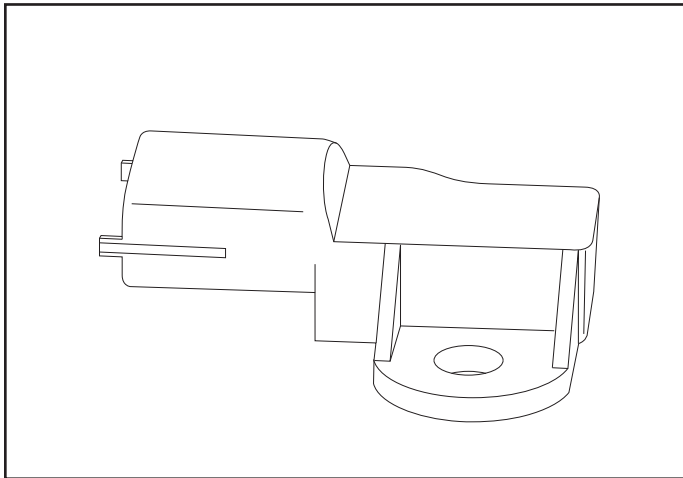


Figure 2-11A - Manifold Absolute Pressure (MAP) Sensor/Intake Air Temperature (IAT) Sensor (Used On 5.0/5.7L Engines)

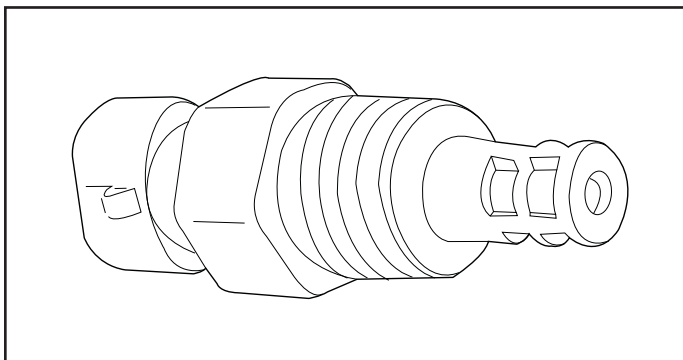


Figure 2-11B - Intake Air Temperature (IAT) Sensor (Used On 6.0L Engines)

Oil Pressure Sensor

The Oil Pressure sensor is a pressure transducer that measures the changes in the oil pressure. The pressure changes as a result of engine load and speed change, and the Oil Pressure sensor converts this into a voltage output.

The ECM supplies a 5 volt reference voltage to the Oil Pressure sensor. As the oil pressure changes, the electrical resistance of the Oil Pressure sensor also changes. By monitoring the sensor output voltage, the ECM knows the oil pressure. The ECM monitors the Oil Pressure sensor and provides signal out put to drive an oil pressure gauge on the dash. A failure in the Oil Pressure sensor circuit should set a DTC 521 Oil Pressure Sender High Pressure, DTC 522 Oil Pressure Sender Voltage Low, DTC 523 Oil Pressure Sender Voltage High, and DTC 524 Oil Pressure Sender Low Pressure,

NOTE: An over- or under-filled crankcase can cause low oil pressure, always verify that the proper oil level exists and re-test; before performing costly engine repairs or replacement of the sensor.

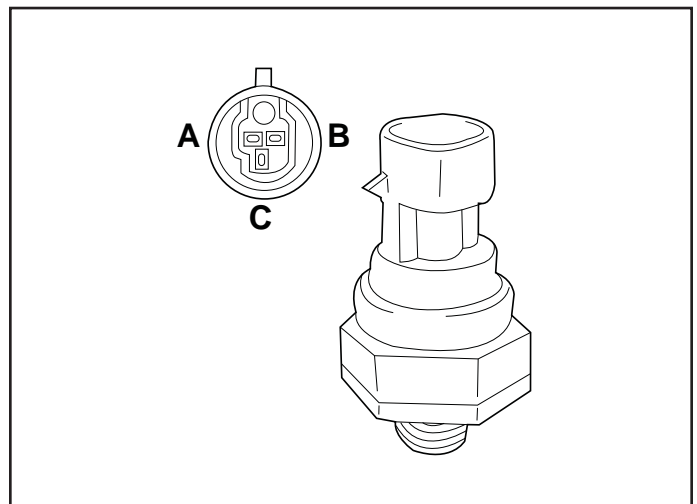


Figure 2-12 - Oil Pressure Sensor

Ignition Control (IC) Reference

The Ignition Control (IC) reference (RPM signal) is supplied to the ECM by way of the crankshaft position sensor. This pulse counter type input creates the timing signal for the pulsing of the fuel injectors, as well as the IC functions. This signal is used for a number of control and testing functions within the ECM.

Camshaft Position (CMP) Sensor and Reluctor Wheel

The camshaft position (CMP) sensor works in conjunction with a 1X reluctor wheel mounted inside the distributor housing (5.0/5.7L) or at the rear of the camshaft (6.0/8.1L). The CMP is used to determine the top dead center position of cylinder #1, and will synchronize with the 4X CKP (5.0/5.7L) or 24X CKP (6.0/8.1L) sensor signal for quicker starting. The CMP signals are output as a digital waveform.

Typically, a Cam Position Sensor failure will have a no start condition. If the sensor fails while the engine is running, the MIL will be lit and engine operation will be normal until the engine is shut off, then the engine will not restart. A failure in the Camshaft Position Sensor circuit should set DTC 341 Cam Input Signal Noise, or DTC 342 Loss of Cam Input Signal.

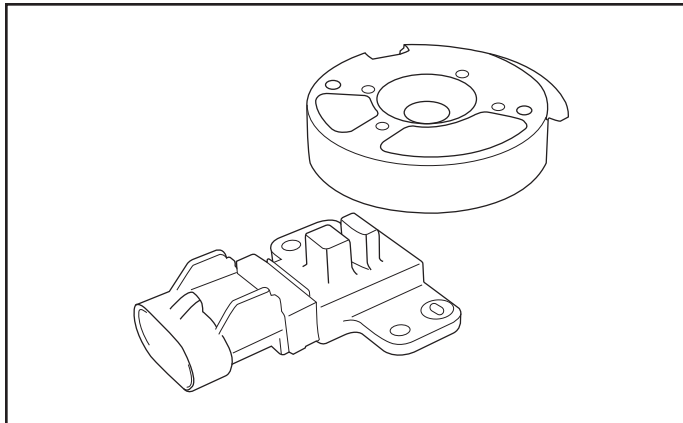


Figure 2-13A -Camshaft Position Sensor (CMP)
(Used On 5.0/5.7L Engines)

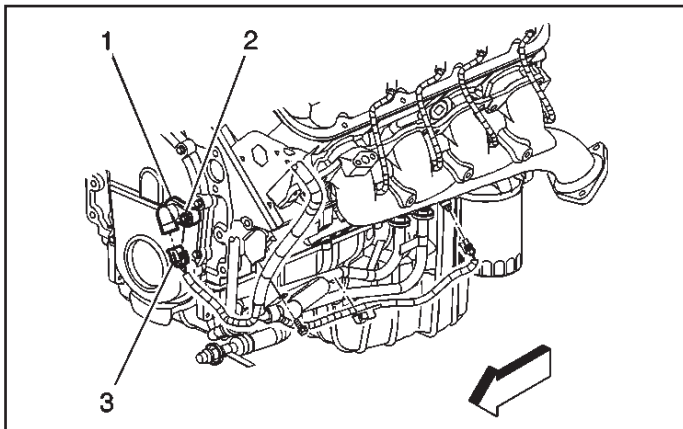


Figure 2-13B -Camshaft Position Sensor (CMP)
(Used On 6.0L Engines)

Crankshaft Position (CKP) Sensor and Reluctor Wheel

The crankshaft position (CKP) sensor is a magneto resistive type sensor. The CKP sensor works in conjunction with a 4X (5.0/5.7L) or 24X (6.0/8.1L) reluctor wheel. The reluctor wheel is mounted on the front (5.0/5.7L) or rear (6.0/8.1L) of the crankshaft. The CKP sensor outputs a 4X (5.0/5.7L) or 24X encoded (6.0/8.1L) signal for spark control, tachometer output and fuel control. All CKP signals are output as a digital waveform.

NOTE: The 5.7L, right-hand rotation, uses a different crankshaft reluctor wheel than a normal, left-hand rotation engine.

The ECM processes the 4X or 24X encoded CMP signal input into a separate 5 Volt switched tachometer output that is used by an instrument panel analog gauge or by the Perfect Pass speed control system (optional). A failure in this internal circuit should set DTC 2618 Tach Output Ground Short, or DTC 2619 Tach Output Short to Power. Should one of these codes be present; clear the codes; then one at a time, isolate the boat's Tach gauge, then Perfect Pass System, from the engine harness and retest if the code returns troubleshoot the engine harness for a short to ground or power, if no wiring problem is present replace the ECM.

Typically, a Crankshaft Position Sensor failure will be a no start condition. Crank the engine for 20 seconds to verify that one of the following codes set. If the sensor fails while the engine is running, the engine will shut off and not restart. A failure in the Crankshaft Position Sensor circuit should set DTC 16 Never Crank Synced at Start, DTC 336 Crank Input Signal Noise, or DTC 337 Crank Signal Loss.

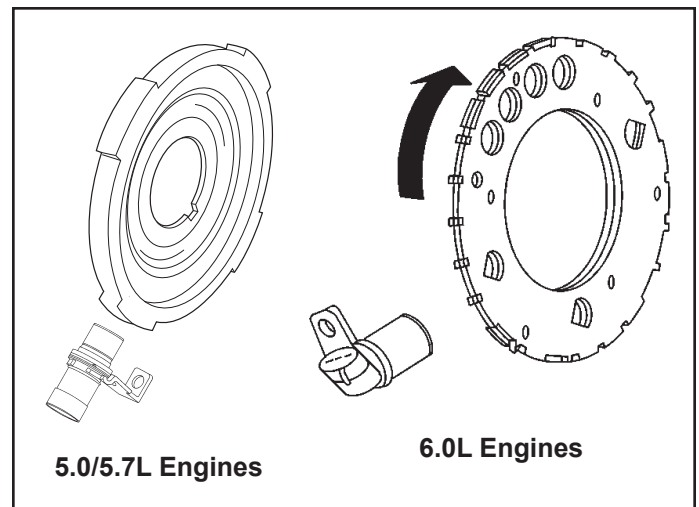


Figure 2-14 - Crankshaft Position Sensor (CKP)

ECM and SENSORS

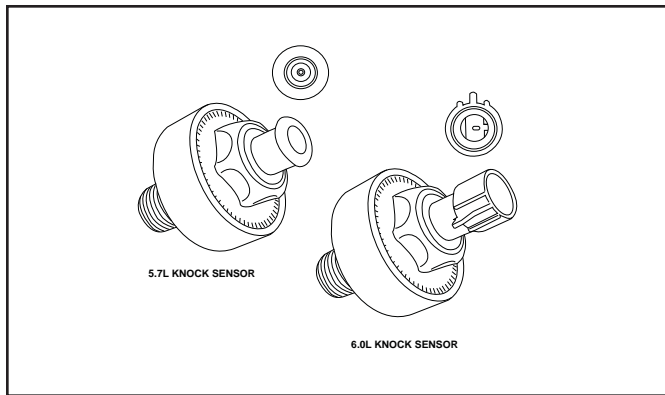
Knock Sensor (KS) System Description

Purpose:

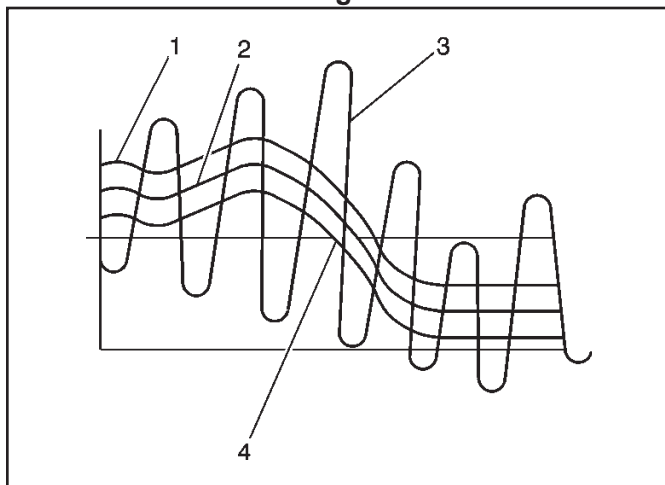
To control spark knock (detonation), a knock sensor (KS) system is used. This system is designed to retard spark timing when excessive spark knock is detected in the engine. The KS system allows the engine to use maximum spark advance for optimal driveability and fuel economy under all operating conditions.

Operation:

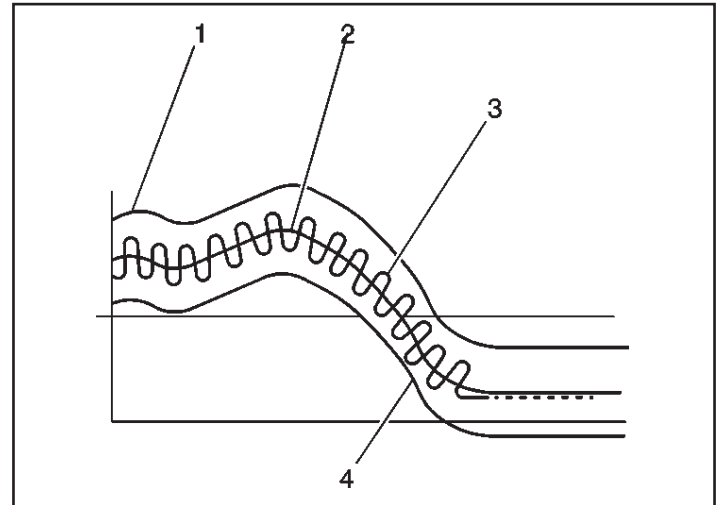
The ECM uses a knock sensor(s) to detect abnormal vibration in the engine (detonation/spark knock). Mounted on the engine block, the knock sensor(s) produces an AC voltage signal at all engine speeds and loads. The ECM then adjusts the spark timing based on the amplitude and frequency of the KS signal. The ECM uses the KS signal to calculate an average voltage. Then, the ECM assigns a voltage range above and below the average voltage value. The ECM checks the KS and related wiring by comparing the actual knock signal to the assigned voltage range. A normal KS signal should vary outside the assigned voltage range as shown in the NORMAL KS figure. If the ECM detects a KS signal within the assigned voltage range as shown in the ABNORMAL KS figure, the applicable DTC will set - DTC 326 Knock Sensor 1/2 Excessive Signal or DTC 327 Knock Sensor 1/2 Sensor Open.



Normal Knock Sensor Signal



Abnormal Knock Sensor Signal



Legend

1. Upper fail region
2. Knock sensor calculated average
3. Knock sensor signal
4. Lower fail region

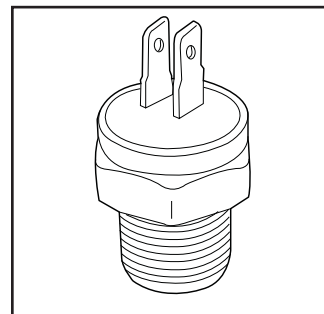
Discrete Switch Inputs

Discrete switch inputs are utilized by the ECM-07 system to identify abnormal conditions that may affect engine operation. Pull-up and pull-down type switches are currently used in conjunction with the ECM to detect critical conditions to engine operation.

If a switch changes states from its normal at rest position, that is, normally open to closed, the ECM senses a change in voltage and responds by setting a DTC 2428 EGT Temperature High or DTC 1542 Transmission Temperature High. The Buzzer, if equipped, will sound for one second every minute.

Switches that may be used with the ECM-07 system to detect critical engine operation parameters are:

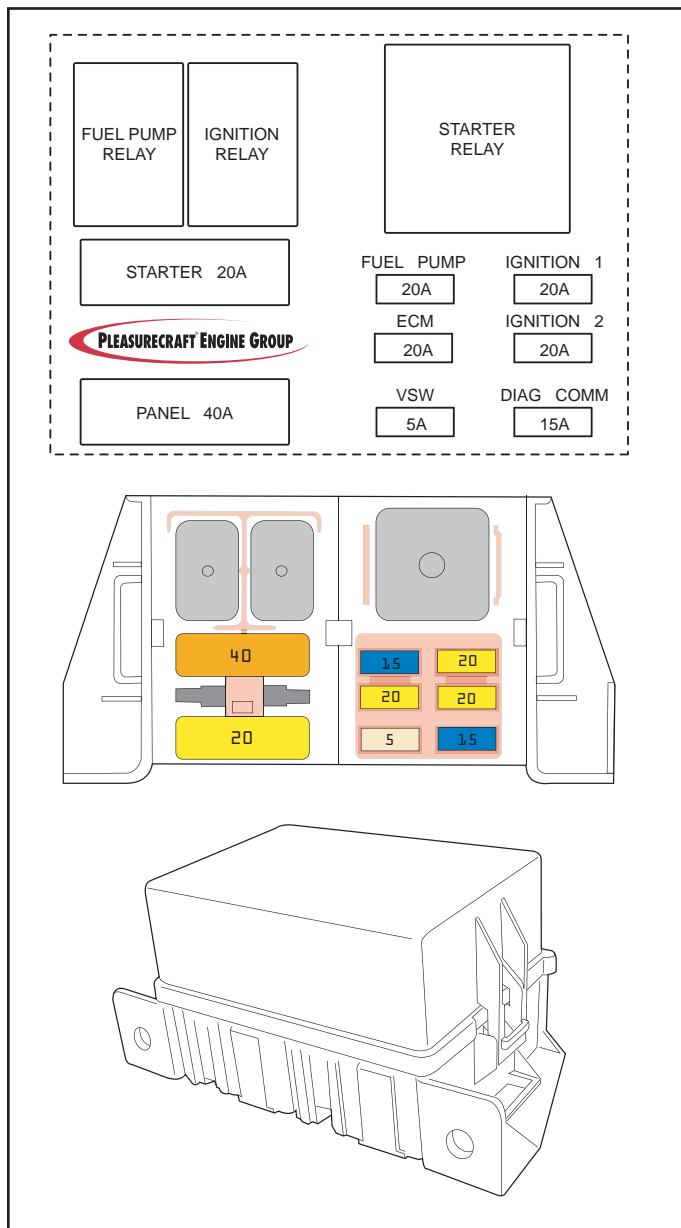
- Transmission Temperature Switch



Transmission Temperature Switch

Electrical System Relay and Fuse Block

The engine utilizes fuses to protect critical engine components and devices. The fuel pump, ECM, ignition components, fuel injectors, starter and diagnostic devices are protected by fuses. Relays are used to enable critical circuit functions to include the fuel pumps, ignition and fuel injector components and the starter. The fuse block is mounted on a bracket near the rear of the engine.



Electrical System Relay and Fuse Block

Fuel Pump Relay

Controlled by the ECM, it is energized at initial Key ON, for 2-4 seconds to prime the fuel system. Once the ECM recognizes the Crank Position Sensor signal, the fuel pumps will remain on while the engine is running or until Key OFF. The ECM monitors the relay driver circuit and should set one of the following codes for a failure: DTC 627 Fuel Pump Relay Coil Open, DTC 628 Fuel Pump

Relay Control Ground Short, or DTC 629 Fuel Pump Relay Coil Short to Power.

Ignition Relay:

Controlled by the ECM, it is energized at initial Key ON, for 2-4 seconds. Once the ECM recognizes the Crank Position Sensor signal, the relay will remain energized until Key OFF. When energized, battery power will be supplied to the Ignition Module(s), Ignition Coil(s), and all eight Fuel Injectors. If the ignition switch is left in the Key-ON-Engine OFF position for more than 4 seconds without trying to start the engine, the ECM will de-energize the Ignition Relay. Cycle the Ignition Switch OFF to ON or START the engine to energize the Ignition Relay. The ECM monitors the relay driver circuit and should set one of the following codes for a failure: DTC 685 Power Relay Coil Open, DTC 686 Power Relay Control Ground Short, or DTC 687 Power Relay Coil Short to Power.

Starter Relay

Controlled by the boat's ignition switch, when the Key is in the START position this relay will energize and apply battery voltage to the Starter Solenoid to enable the starter and crank the engine.

Starter Fuse - 20 AMP MAXI

Provides protection to the Starter Solenoid circuit. If the Starter Solenoid draws too much current or is shorted to ground this fuse will open. Note: The Starter Relay will still energize when the Key is in the START position when this fuse is open.

Panel Fuse - 40 AMP MAXI

Provides overload protection for the Boat Accessory devices that may be using this battery feed circuit. If this fuse is open, you may have a no start/no run condition if this battery feed is used to power the boat's ignition key switch. However, many boats are wired such that when this fuse is open, it will only affect boat accessory device operation and the engine will continue to operate normally.

Fuel Pump Fuse - 20 AMP

This fuse provides overload protection for the Fuel Pump Relay, High Pressure Fuel Pump, Low Pressure Fuel Pump, and Remote Electric Fuel Solenoid (if equipped).

ECM Fuse - 20 AMP

Provides overload protection for the ECM battery feed circuits.

VSW - 5 AMP

Provides overload protection for the ECM Voltage Switched (Ignition voltage) circuit. If this fuse is open, neither the Fuel Pump Relay nor the Ignition Relay will energize.

Figure 2-13 - Engine Control Module (ECM)

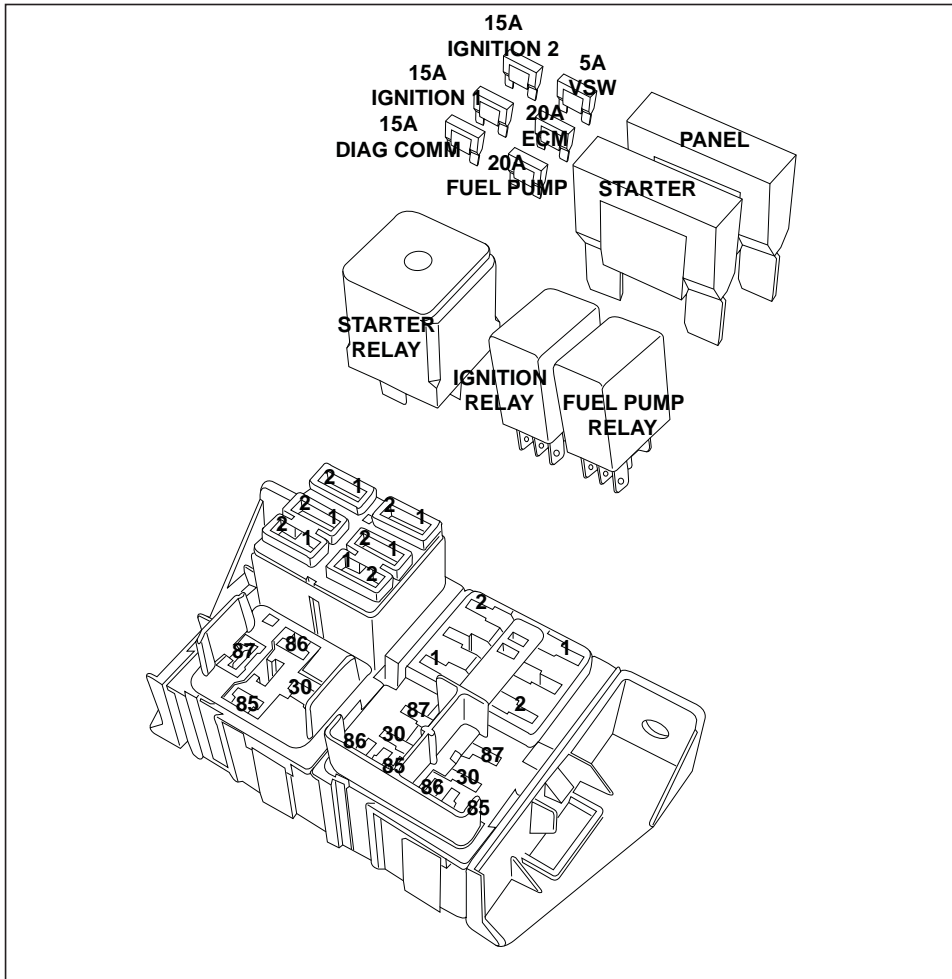
ECM and SENSORS

Diagnostic Connector - 15 AMP

Provides overload protection of the battery feed circuit when a Diagnostic Scan/Calibration Tool is connected.

Ignition Fuses - 15 AMP

Provides overload protection for the Ignition Module(s), Ignition Coil(s), Fuel Injectors, and the Alternator's regulator circuit Sense Input.



Diagnosis

Engine Control Module (ECM)

To read and clear diagnostic trouble codes, use Diacom Marine Diagnostic Software, loaded on a laptop as a scan tool.

Since the ECM can have a failure which may affect more than one circuit, following the diagnostic procedures will determine which circuit has a problem and where it is.

If a diagnostic procedure indicates that the ECM connections or ECM is the cause of a problem and the ECM is replaced, but does not correct the problem, one of the following may be the reason:

- Check for good ECM power and grounds.
- There is a problem with the ECM terminal connections. The diagnostic table will say ECM connections or ECM. The terminals may have to be removed from the connector in order to check them properly.
- Calibration Program is not correct for the application. Incorrect components may cause a malfunction and may or may not set a DTC.
- The problem is intermittent. This means that the problem is not present at the time the system is being checked. In this case, refer to the *PCM Drivability Checklist* portion of the manual and make a careful physical inspection of all portions of the system involved.
- Shorted relay coil or harness. Relays are turned "ON" and "OFF" by the ECM using internal electronic switches called drivers. A shorted relay coil or harness may not damage the ECM but will cause the relay to be inoperative.

On-Board Service

Engine Control Module (ECM) Replacement

Notice: When replacing the ECM, the ignition must be "OFF" then disconnect the battery before disconnecting or reconnecting the ECM connector to prevent internal damage to the ECM.

Notice: To prevent possible electrostatic discharge damage to the ECM, do not touch the connector pins. The ECM is an electrical component. Do Not soak in any liquid cleaner or solvent, as damage may result.

Remove or Disconnect

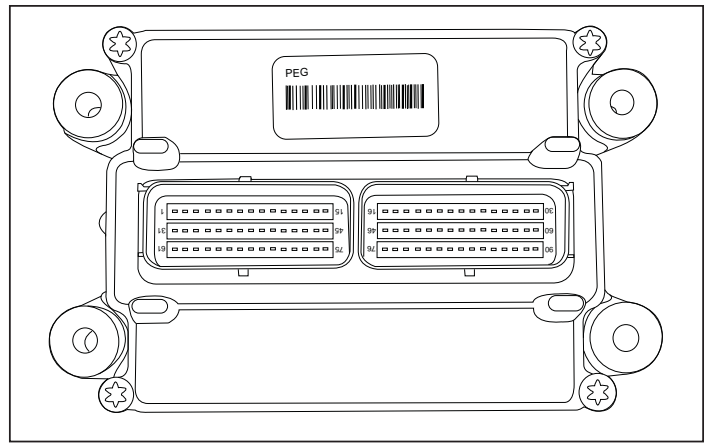
1. Negative battery cable.
2. The connector from ECM.
3. The ECM mounting screws.
4. ECM from mounting bracket.

Important

- Make sure the new ECM has the same part number and service number as the old ECM, to insure proper engine performance.

Install or Connect

1. New ECM to mounting bracket.
2. The ECM mounting screws. Torque to 10-14 N•m (88-124 lb in).
3. The connector to ECM.
4. Negative battery cable.



Starter Relay Replacement

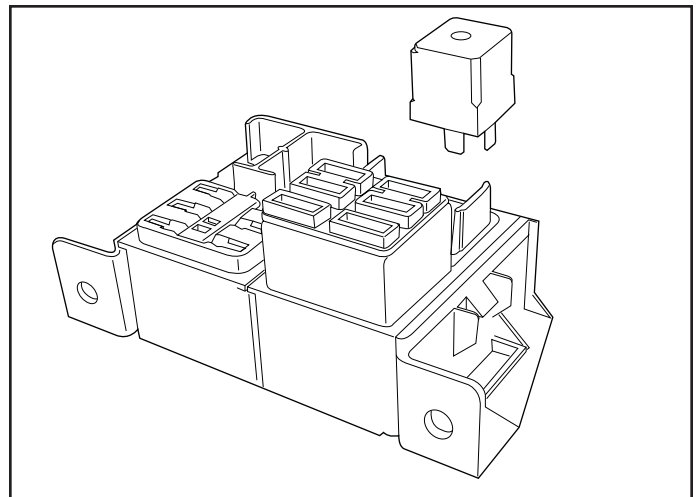
Removal Procedure

1. Turn the ignition OFF.
2. Remove the Fuse Block Cover.
3. Remove the starter relay.

Important: The starter relay is an electrical component. Do Not soak in any liquid or solvent as damage may result.

Installation Procedure

1. Install the starter relay.
2. Install the Fuse Block Cover.



ECM and SENSORS

Ignition Relay Replacement

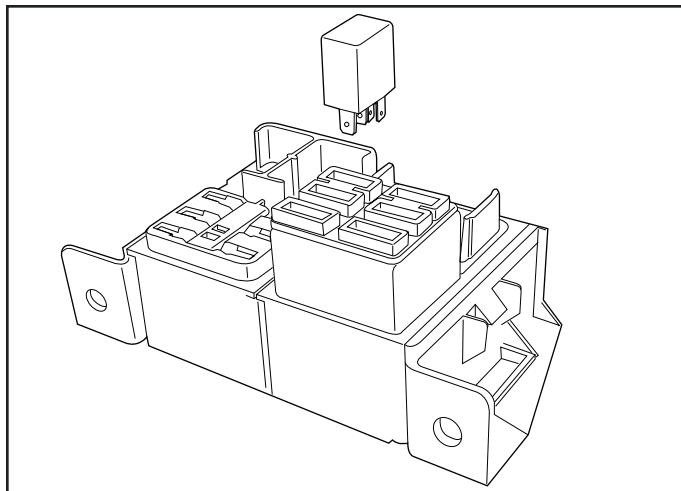
Removal Procedure

1. Turn the ignition OFF.
2. Remove the Fuse Block Cover.
3. Remove the ignition relay.

Important: The ignition relay is an electrical component. Do Not soak in any liquid or solvent as damage may result.

Installation Procedure

1. Install the ignition relay.
2. Install the Fuse Block Cover.



Fuel Pump Relay Replacement

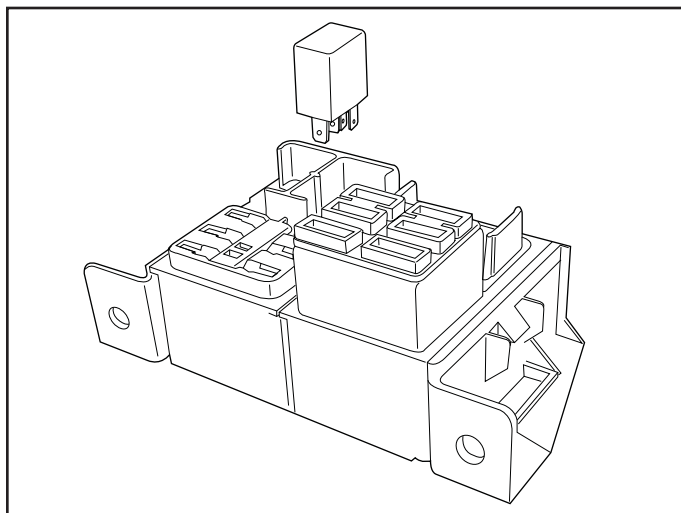
Removal Procedure

1. Turn the ignition OFF.
2. Remove the Fuse Block Cover.
3. Remove the fuel pump relay.

Important: The fuel pump relay is an electrical component. Do Not soak in any liquid or solvent as damage may result.

Installation Procedure

1. Install the fuel pump relay.
2. Install the Fuse Block Cover.



Engine Coolant Temperature (ECT) Sensor Replacement

Notice: Care must be taken when handling the ECT sensor. Damage to the sensor will affect proper operation of the engine control system.

Remove or Disconnect

1. Turn OFF the ignition.
2. Drain the cooling system below the level of the ECT sensor (if necessary).
3. Disconnect the ECT electrical connector.
4. Remove the ECT sensor.

Installation Procedure

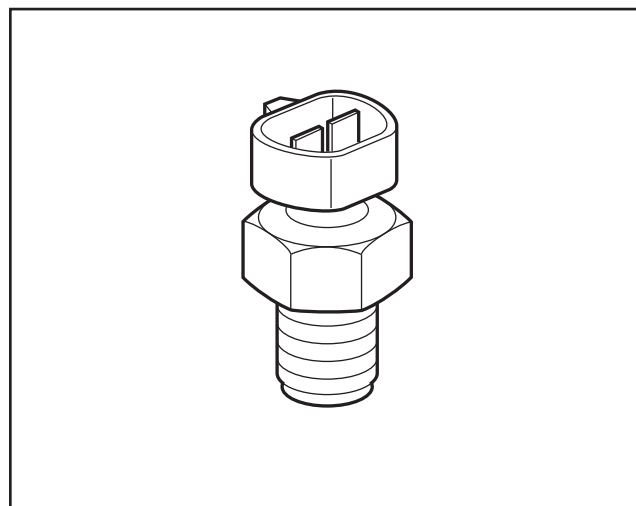
Important: Coat ECT sensor threads with PST (Pipe Sealant with Teflon) prior to installation.

1. Install the ECT sensor.

Tighten

Tighten the ECT sensor to 20 N•m (15 lb ft).

2. Reconnect the ECT electrical connector.
3. Refill the cooling system (if necessary).



Intake Air Temperature (IAT) Sensor Replacement (6.0/8.1L)

IMPORTANT: 6.0L IAT is part of the R145026B Flame Arrestor and **IS NOT** serviceable. Replace by putting a new Flame Arrestor assembly on the engine.

Removal Procedure - 8.1L ONLY

1. Turn OFF the ignition.
2. Disconnect the IAT Sensor electrical connector.
3. Remove the IAT sensor.

Installation Procedure - 8.1L ONLY

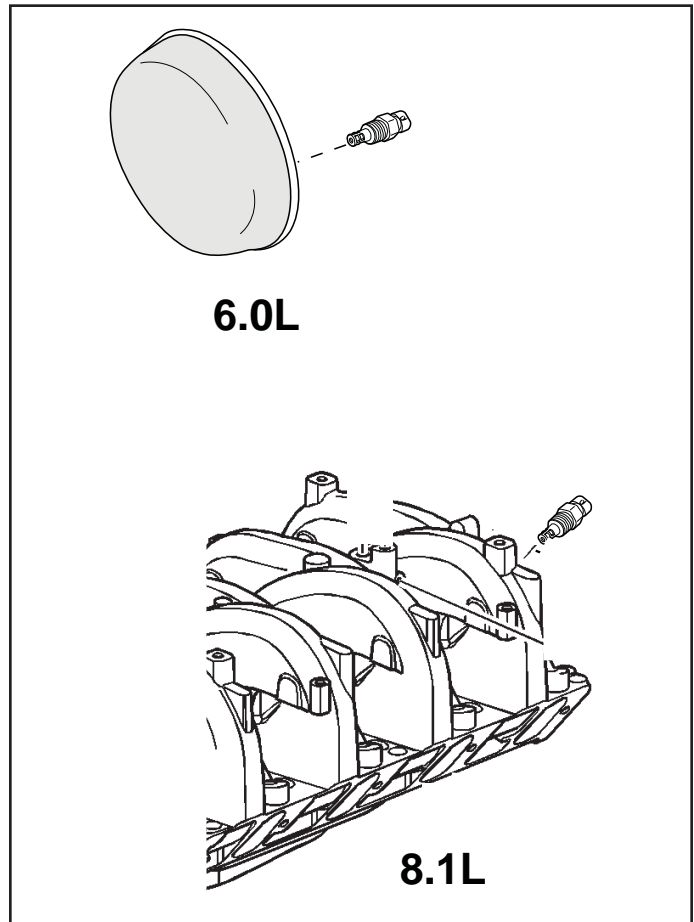
Important: Lightly coat IAT sensor threads with PST (Pipe Sealant with Teflon) prior to installation. **DO NOT** let sealant cover sensor.

1. Install the IAT sensor.

Tighten

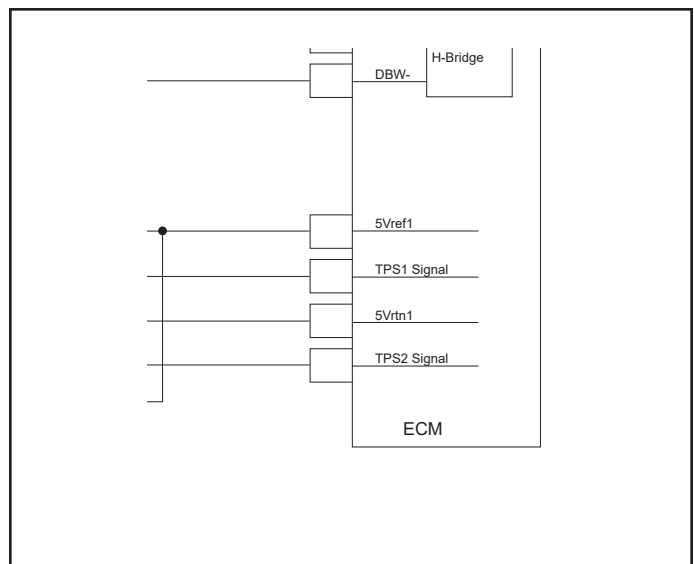
Tighten the IAT sensor to 20 N•m (15 lb ft).

2. Reconnect the IAT Sensor electrical connector.



Throttle Position Sensor (TPS)

The TPS is part of the Throttle Body assembly and is not serviceable. See the instructions in Section 3 of this manual for the Removal and Replacement of the Throttle Body Assembly.



ECM and SENSORS

Engine Oil Pressure Sensor Replacement

Notice: Care must be taken when handling the Oil Pressure sensor. Damage to the sensor will affect proper operation of the ECM-07 system.

Remove or Disconnect

1. Turn OFF the ignition.
2. Place shop towels under the Oil Pressure Sensor fitting to catch excess oil that may spill.
3. Disconnect the Oil Pressure Sensor electrical connector.
4. Remove the Oil Pressure sensor.

Installation Procedure

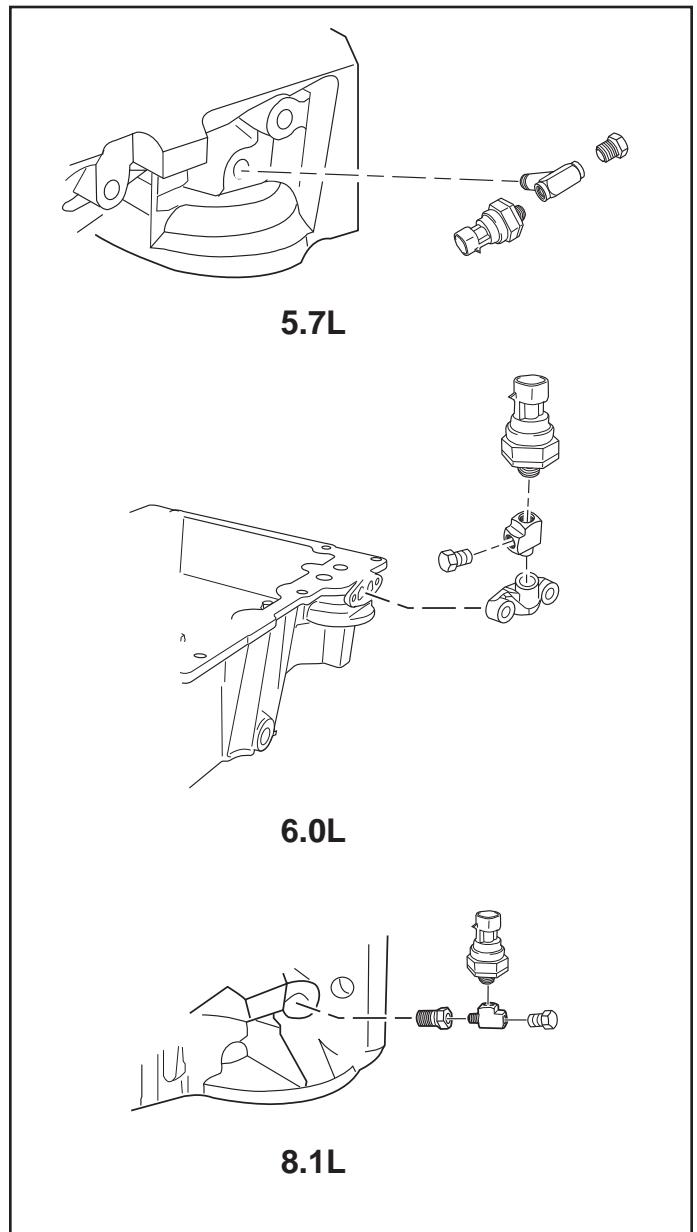
Important: Lightly coat Oil Pressure sensor threads with PST (Pipe Sealant with Teflon) prior to installation. DO NOT cover sensor port with sealant.

1. Install the Oil Pressure sensor.

Tighten

Tighten the Oil Pressure sensor to 20 N•m (15 lb ft).

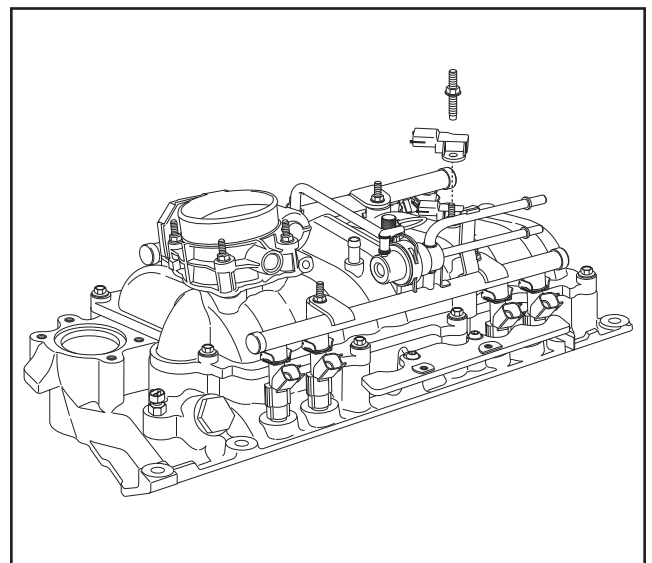
2. Reconnect the Oil Pressure Sensor electrical connector.



Manifold Absolute Pressure (MAP) / Intake Air Temperature (IAT) Sensor Replacement (5.0/5.7L)

Removal Procedure

1. Turn OFF the ignition.
2. Remove the MAP sensor retaining stud.
3. Remove the MAP sensor from the intake manifold.
4. Inspect the MAP sensor seal for wear or damage and replace as necessary.



Installation Procedure

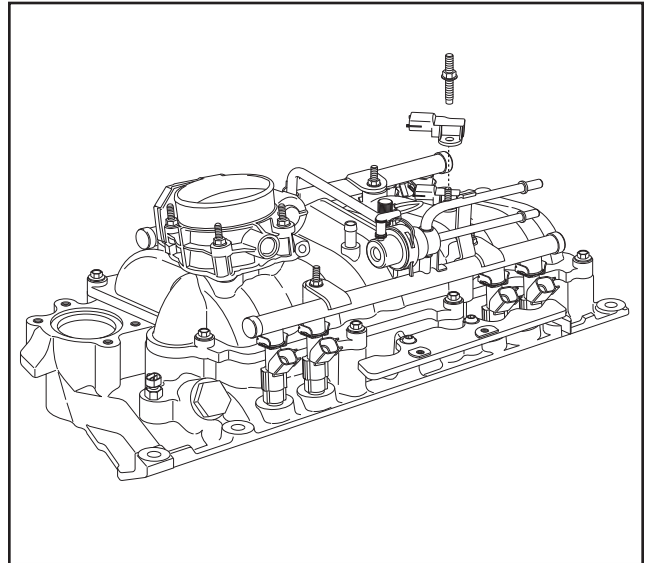
Important: Lightly coat the MAP sensor seal with rubber lubricant before installing the sensor. The lubricant should be applied with a sponge or brush. To prevent blockage, avoid dipping the sensor port directly into the lubricant.

1. Install the MAP sensor.
2. Install the MAP sensor retaining stud.

Tighten

Tighten the MAP sensor retaining stud to 12 N•m (106 lb in).

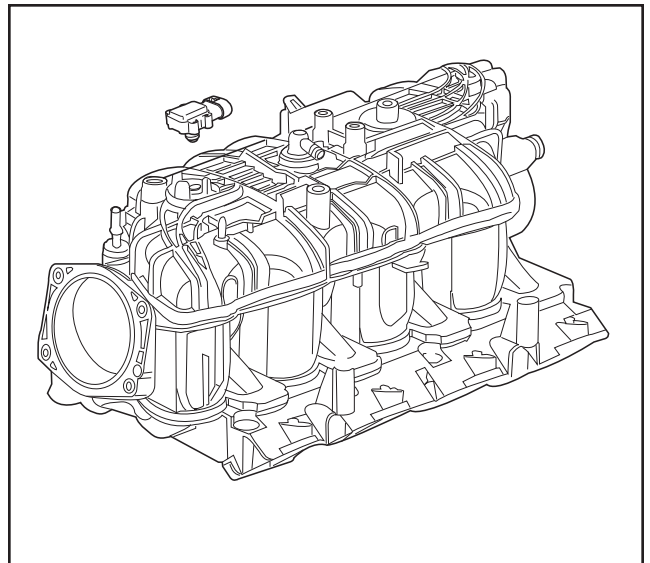
3. Connect the manifold absolute pressure (MAP) sensor electrical connector.



Manifold Absolute Pressure (MAP) Sensor Replacement (6.0L)

Removal Procedure

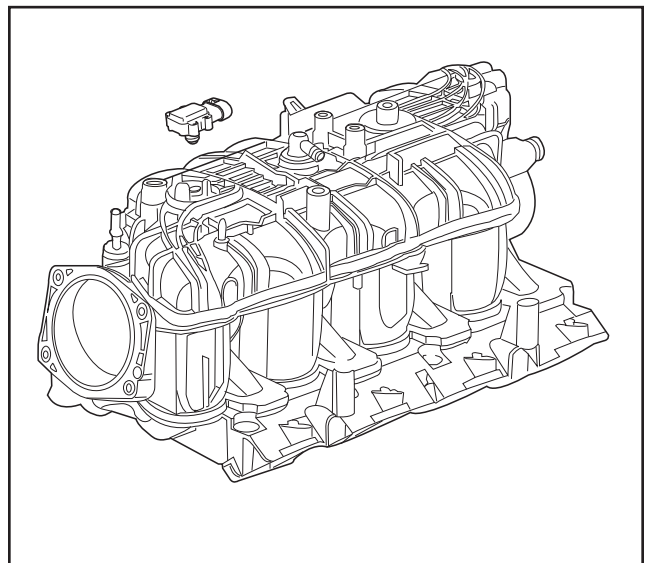
1. Turn OFF the ignition.
2. Disconnect the manifold absolute pressure (MAP) sensor electrical connector.
3. Remove the MAP sensor retaining clamp.
4. Remove the MAP sensor from the intake manifold.
5. Inspect the MAP sensor seal for wear or damage and replace as necessary.



Installation Procedure

Important: Lightly coat the MAP sensor seal with rubber lubricant before installing the sensor. The lubricant should be applied with a sponge or brush. To prevent blockage, avoid dipping the sensor port directly into the lubricant.

1. Install the MAP sensor.
2. Install the MAP sensor retaining clamp.
3. Connect the MAP sensor electrical connector.



ECM and SENSORS

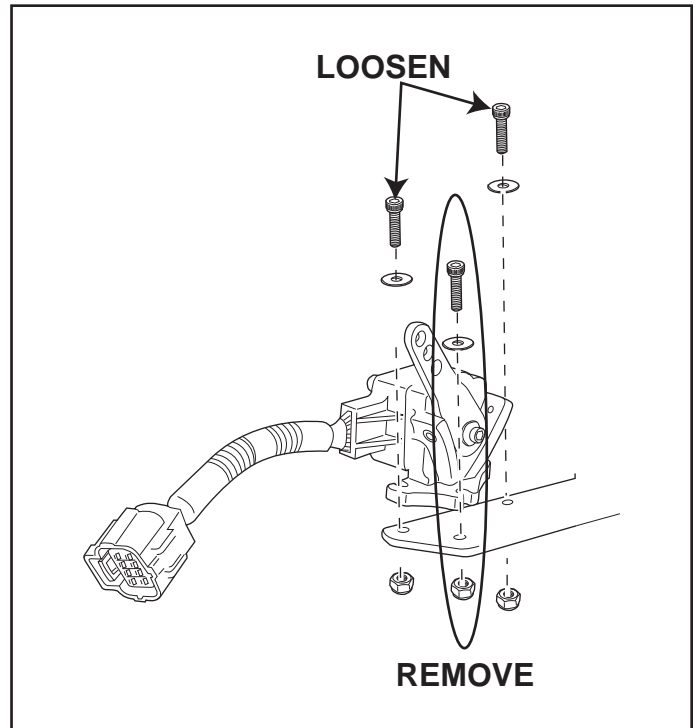
Throttle Control Position (TCP) Sensor

Tools Required:

- 9/64" Hex Key Wrench
- 11/32" Combination Wrench

Remove Procedure

1. Turn OFF the ignition.
2. Disconnect throttle cable from TCP arm.
3. Disconnect TCP electrical connector.
4. Remove TCP attaching screw (1).
5. Loosen TCP attaching screws (2).
6. Remove TCP from mounting plate



Install or Connect

1. Install TCP onto mounting bracket. Ensure flat washers are on top of the mounting feet..

Notice: New TCP Sensor Assemblies (RA119005) have been preset at the factory and should not require any adjustment.

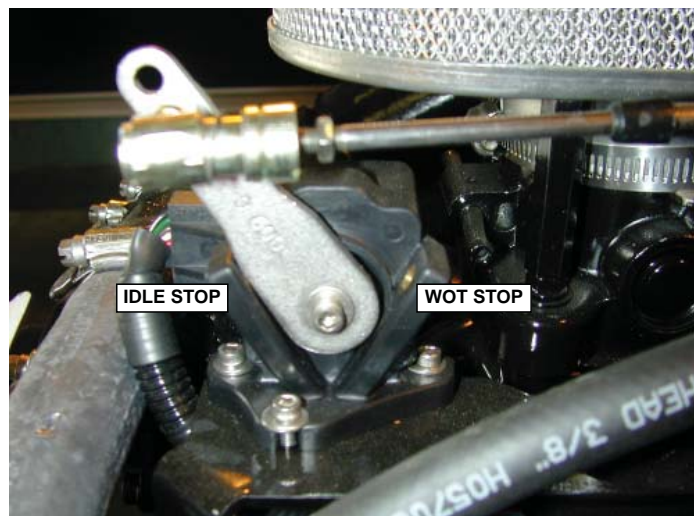
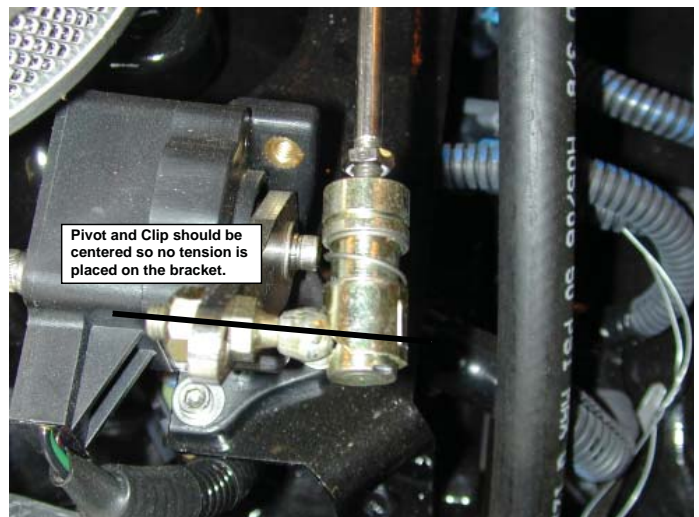
2. Install TCP attaching screw, washer, and lock nut that was previously removed.

Tighten the three retaining screws evenly. Do not overtighten. Torque to 2 - 2.5 N•m (18-22 in lb)

3. Connect TCP electrical connector.
4. Connect throttle cable to TCP arm. Verify/adjust throttle cable.

There are three critical positions that need to be checked to ensure proper throttle cable adjustment.

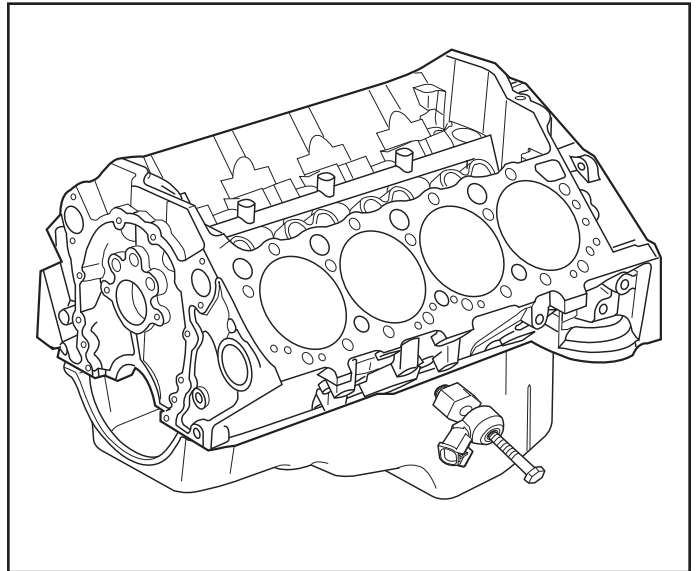
1. Throttle/shift lever in the Idle/neutral detent position - The TCP arm should be on the idle stop by its own internal spring with no additional pressure supplied by the throttle cable.
2. Throttle/Shift lever in the idle/in-gear position (both forward and reverse should be checked) - The TCP arm should be on the idle stop with no pressure applied by the throttle cable.
3. Throttle/shift lever in the wide-open-throttle position - The TCP arm should be at or just touching the wide-open-throttle stop of the TCP bracket. The throttle cable should not be pulling the arm hard into the stop.



Knock Sensor (KS) (5.0/5.7L)

Remove or Disconnect

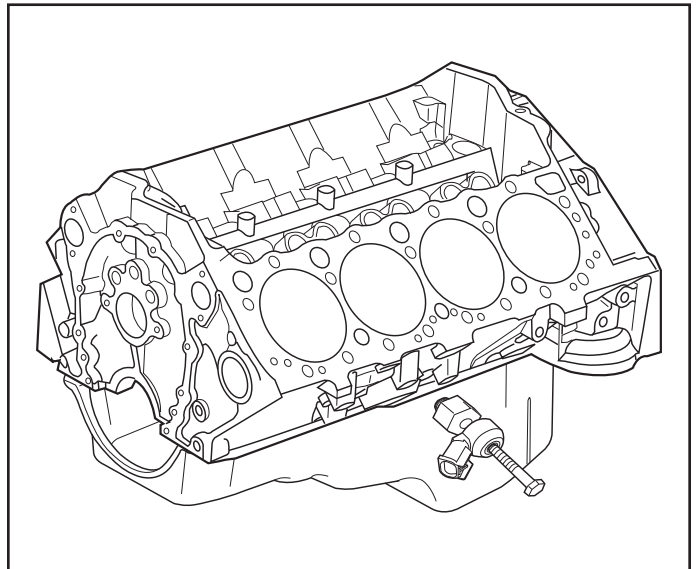
1. Turn OFF the ignition.
2. Knock sensor electrical connector.
3. Knock sensor from engine block.



Install or Connect

Important

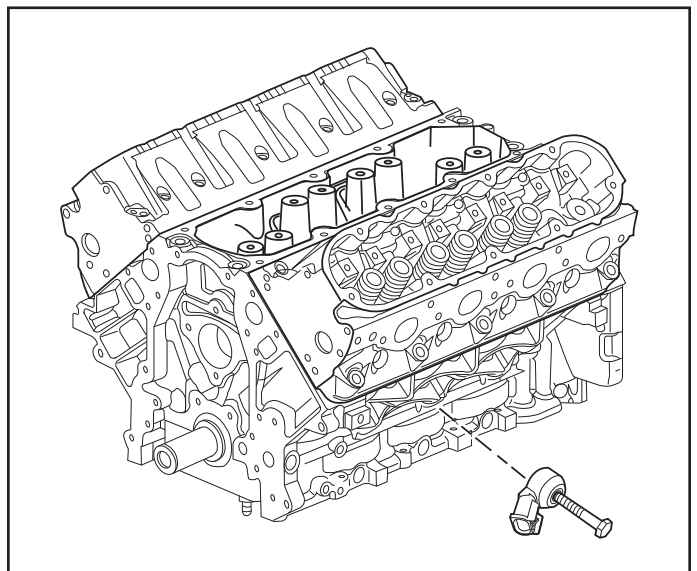
- If installing a new knock sensor, be sure to replace with an identical part number.
 - When installing knock sensor, be sure to install in the same location removed from.
 - If installing knock sensor in water jacket, use Teflon sealer.
1. Knock sensor into engine block. Be sure threads are clean. Torque to 15-22 N•m (11-16 lb ft).
 2. Knock sensor electrical connector.



Knock Sensors (KS) (6.0L)

Remove or Disconnect

1. Negative battery cable.
2. Knock sensor electrical connector.
3. Knock sensor from engine block.

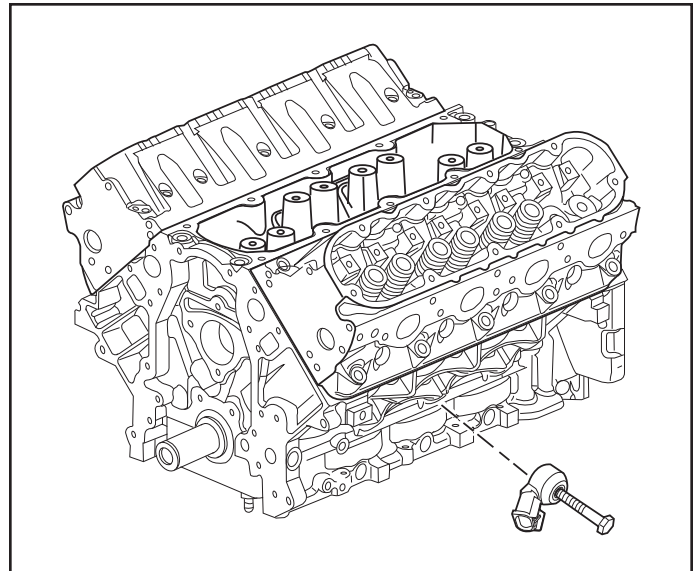


ECM and SENSORS

Install or Connect

Important

- If installing a new knock sensor, be sure to replace with an identical part number.
 - When installing knock sensor, be sure to install in the same location removed from.
 - If installing knock sensor in water jacket, use Teflon sealer.
1. Knock sensor into engine block. Be sure threads are clean. Torque to 15-22 N•m (11-16 lb ft).
 2. Knock sensor electrical connector.



Torque Specifications

Fastener Tightening Specifications

Application	N•m	Lb Ft	Lb In
ECM Mounting Screws	10-14		88-124
ECT Sensor	20	15	
MAP Sensor Attaching Screw	5-7		44-62
Oil Pressure Sensor	20	15	
IAT Sensor (8.1L)	20	15	
TCP Attaching Screws	2 - 2.5		18-22
Knock Sensors	20	15	

GCP / 4G Engine Management System

Section 3

Fuel Metering System

This section describes how the fuel metering systems operate, and provides a description of components used on the Electronic Fuel Injection equipped engines.

Contents

General Description	Page 2	On-Board Service	Page 6
Purpose.....	Page 2	Fuel Control On-Board Service.....	Page 7
Modes of Operation	Page 2	Fuel Pressure Relief Procedure.....	Page 7
Starting Mode	Page 2	Flame Arrestor	Page 7
Clear Flood Mode.....	Page 2	Throttle Body Assembly	Page 8
Run Mode.....	Page 2	Quick Connect Fitting(s) Service	
Acceleration Mode.....	Page 2	(Metal Collar)	Page 9
Fuel Cutoff Mode.....	Page 2	Fuel Rail Assembly	Page 11
Power Reduction Mode.....	Page 2	Fuel Injectors	Page 13
Fuel Metering System Components	Page 2	Fuel Pressure Regulator Assembly	Page 14
Quick-Connect Fittings.....	Page 2	Fuel Control Cell (FCC)	Page 15
Fuel Supply Components (FCC System)	Page 3	Fuel Control Cell (FCC) - Drain Water.....	Page 15
Fuel Pump Electrical Circuit.....	Page 4	Fuel Control Cell (FCC) - Element	
Fuel Rail Assembly	Page 4	Replacement.....	Page 16
Fuel Injectors.....	Page 4	Low-Pressure Fuel Pump	Page 17
Pressure Regulator Assembly	Page 5	Fuel Pump Relay	Page 17
Throttle Body Assembly	Page 5	Torque Specifications	Page 18
Idle Air Control (IAC) Valve	Page 6		
Diagnosis	Page 6		

Fuel Metering System

General Description

Gasoline Requirements



CAUTION

Fire and Explosion Hazard - Gasoline is extremely flammable and highly explosive, and, if ignited, can cause serious bodily injury or death. Careful inspection of the entire fuel system including, but not limited to, fuel tanks, fuel lines, fuel filters and all fittings is mandatory, especially after periods of storage. Replace any component that shows signs of leakage, corrosion, deterioration, swelling, hardening or softening.

WARRANTY NOTICE: Damage caused to the engine through the use of improper gasoline, low-quality or gasoline with an octane rating below the minimum requirements listed below, is considered misuse of the engine. Such damage is not covered by the PCM Marine Engines warranty.

The ignition timing set by the factory requires the use of a high-quality **lead-free** regular gasoline with the following octane specification. Some marinas may sell fuel with lead additives. Do not use leaded fuel, as it may block the fuel injectors and cause leakage.

Pump Octane Number (R+M/2) (PUMP) - 87

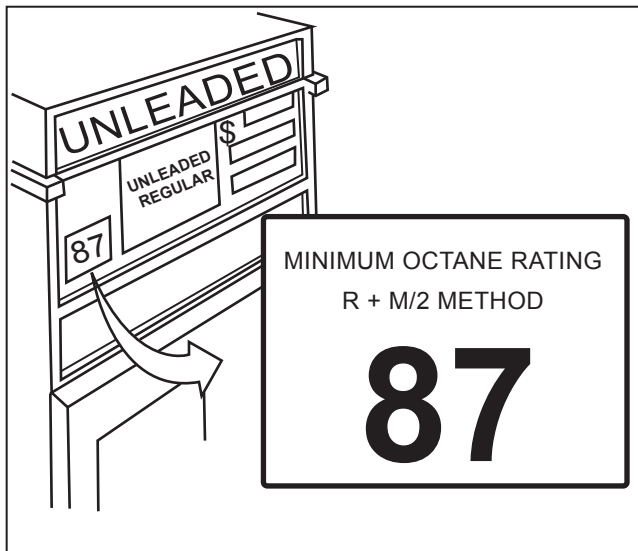


Figure 3-1 Fuel Requirements

NOTICE: Most PCM Fuel Injected engines are calibrated to operate on 87 octane fuel and maximum performance is obtained when using this fuel. Some applications may require a higher octane fuel. These particular applications will be noted.

If a slight pinging is heard during acceleration and the proper octane fuel is being used, it is considered normal. If a constant, heavy knock occurs, the engine should be evaluated by a PCM Marine Engines service technician.

Gasoline Containing Alcohol

Many brands of gasoline being distributed in the United States today contain alcohol. Two commonly used alcohol additives are Ethanol (ethyl alcohol) and Methanol (CH₃OH), also called methyl alcohol.



CAUTION

Do Not use any gasoline that contains METHANOL. This fuel is very corrosive and will create unsafe operating conditions. Serious damage will result from the continued use of fuel containing METHANOL. Any resulting engine damage will not be covered by the warranty.

Ethanol blended fuel rated E10 or less is acceptable to use in PCM Engines. Fuels rated higher than E10 SHOULD NOT BE USED. Ethanol fuels rated higher than E10 could potentially damage the engine and/or present an unsafe boating condition. Damage to the engine resulting from the use of ethanol fuel rated higher than E10 IS NOT covered by the warranty.

Ethanol, also known as ethyl alcohol or grain alcohol, is a flammable, colorless chemical compound that is added to gasoline to produce a blended fuel. The gas pump will indicate the fuel as a particular concentration of ethanol. For example, if the pump indicates the fuel is E10, that means the fuel is a blended mixture of 10% ethanol and 90% gasoline by volume. The higher the "E number" the higher the percentage of ethanol.

Gasoline containing alcohol will attract and hold moisture and may cause the following:

- The engine may operate leaner with ethanol blended fuel. This may cause hard starting and operating difficulties (vapor lock, low speed stalling)
- Corrosion of metal parts
- Excessive wear and damage to internal engine parts
- Fuel permeation through flexible fuel lines
- Deterioration of some nonmetallic materials

You will need to check with the boat manufacture to determine whether the vessel components such as the gas tank and boat fuel lines are ethanol compatible.

Most boats produced in the past 20 years have fuel tanks constructed of aluminum, stainless steel, or plastics. Since ethanol-blended fuels attract and hold moisture, ethanol content can contribute to corrosion of the tank material in aluminum fuel tanks. Corrosion material can clog fuel filters and damage injectors, carburetors, and other fuel system components. Stainless steel and plastic fuel tank materials are not affected by ethanol-blended fuels. However, ethanol-blended fuel can act as a solvent, loosening and washing old deposits or contaminates into the fuel system.

Fuel system or engine damage caused by contamination from water, foreign particles, sludge, or gums entering or forming in the fuel system is not covered by the PCM Limited Warranty.

Some boats may have fiberglass fuel tanks. Ethanol-blended fuels have been shown to act as a solvent to the surface of fiberglass fuel tanks, causing weakening of the fuel tank walls and the formation of sludge and gum in the engine fuel system and valve train. As a result, PCM does not recommend the use of ethanol-blended fuels in fuel tanks constructed of fiberglass.

The adverse effects of alcohol are more severe with Methanol and are worse with increasing alcohol content.

NOTICE: Some gasolines contain an octane-enhancing additive called methylcyclopentadienyl manganese tricarbonyl (MMT), they should not be used. These fuels may reduce spark plug life, and engine performance may be effected.

Recommendations When Using E10 Fuel

- The use of a water separating fuel filter between the fuel tank and the engine's low pressure fuel pump is recommended. The filter must be rated for use with gasoline, have a 10 micron filter element, and have a minimum rating of 50 gallons per hour. The filter must be approved for inboard installations and be installed in accordance with US Coast Guard regulations and ABYC standards. PCM Part # RA080020 meets these requirements.
- Water separating fuel filters should be checked frequently for water and contaminants in accordance with the filter manufacturers recommended service intervals. PCM Part # RA080020 is equipped with a drain that provides for water and contaminate inspection without the need for removing the filter element.
- To prevent gum formation and corrosion in the fuel system, use a commercially available fuel stabilizer, such as STA-BIL®, in the gasoline if it will be in the tank for more than two weeks or if the boat is being prepared for winter storage. After adding fuel stabilizer, the engine should be run for ten minutes to allow stabilized fuel to reach all points of the fuel system.

Purpose

The function of the fuel metering system is to deliver the correct amount of fuel to the engine under all operating conditions. Fuel is delivered to the engine by individual fuel injectors mounted in the intake manifold near each cylinder.

Modes Of Operation

The ECM looks at inputs from several sensors to determine how much fuel to give the engine. The fuel is delivered under one of several conditions, called "modes." All the "modes" are controlled by the ECM and are

described below.

Starting Mode

When the ignition switch is turned to the crank position, the ECM turns the fuel pump relay "ON," and the fuel pump builds up pressure. The ECM then checks the IAT, ECT, MAP, TCP, and TPS sensors, and determines the proper air/fuel ratio for starting. The ECM controls the amount of fuel delivered in the starting mode by changing how long the injectors are turned "ON" and "OFF." This is done by "pulsing" the injectors for very short times.

Clear Flood Mode

If the engine floods, it can be cleared by opening the throttle to 100% (wide open throttle) during cranking. The ECM then shuts down the fuel injectors so no fuel is delivered. The ECM holds this injector rate as long as the throttle stays at 100%, and the engine speed is below 300 RPM. If the throttle position becomes less than 100%, the ECM returns to the starting mode.

Run Mode

When the engine is first started and RPM is above 300 RPM, the system operates in the run mode. The ECM will calculate the desired air/fuel ratio based on these ECM inputs: RPM (TCP and TPS commanded position), IAT, ECT and MAP. Higher engine loads (MAP input) and colder engine temperatures (ECT and IAT inputs) require more fuel, or a richer air/fuel ratio.

Acceleration Mode

The ECM looks at rapid changes in TCP, TPS and MAP sensors, and provides extra fuel by increasing the injector pulse width.

Fuel Cutoff Mode

No fuel is delivered by the injector when the ignition is "OFF," to prevent dieseling. Also, injector pulses are not delivered if the ECM does not receive distributor reference pulses, which means the engine is not running. **Fuel Metering System Components**

The fuel metering system (Figure 3-1) is made up of the following parts:

- Fuel supply components (fuel tank, pump, lines, filter).
- Fuel pump electrical circuit.
- Fuel rail assembly, including fuel injectors and pressure regulator assembly.
- Throttle body assembly, including an IAC valve and TP sensor.

Quick-Connect Fittings

Quick-Connect fittings provide a simplified means of installing and connecting fuel system components. The fittings consists of a unique female connector and a compatible male pipe end. O-rings, located inside the female connector, provide the fuel seal. Integral locking tabs inside the female connector hold the fittings together.

Fuel Metering System

Fuel Supply Components (FCC System)

The Fuel Control Cell (FCC) eliminates vapor lock and air ingestion caused by fuel tank slosh, and provides the necessary filtration and water separation.

The FCC system incorporates two (2) fuel pumps to provide an uninterrupted flow of fuel to your PCM marine engine. Fuel is fed into the FCC bowl by a low-pressure, high-volume electric fuel pump. This pump flows fuel at a volume much greater than the fuel flow rate required of the high-pressure pump and engine demands. The high-pressure pump, mounted inside the FCC bowl, provides the necessary fuel pressure and volume to maintain proper engine performance. The FCC constantly has an ample supply of fuel to meet the idle, cruise and acceleration fuel requirements of the engine.

The fuel pressure regulator may be located on the fuel rail or inside the FCC bowl, controls the fuel pressure and maintains a constant pressure across the fuel delivery system. Excess fuel, not used by the engine, returns to the FCC bowl.

The fuel delivered to the engine by the FCC is filtered by a filter and water separator element, which surrounds the high pressure pump inside the FCC bowl.

As indicated above, fuel enters the FCC bowl from two (2) locations, the low-pressure pump (initial input) and the fuel pressure regulator (unused, recirculating fuel). Fuel exits the FCC bowl at two (2) locations, the high-pressure output to the fuel injection system and all excess fuel in the FCC bowl is routed back to the tank via the return line.

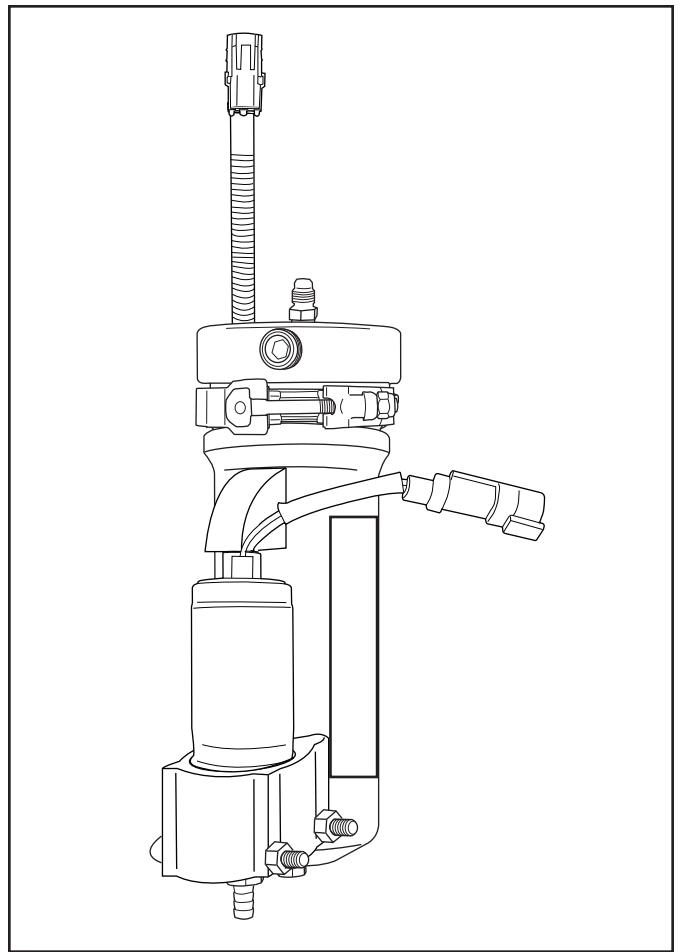


Figure 3-2 - Typical Fuel Control Cell (FCC) and Low Pressure Fuel Pump Assembly

Fuel Metering System

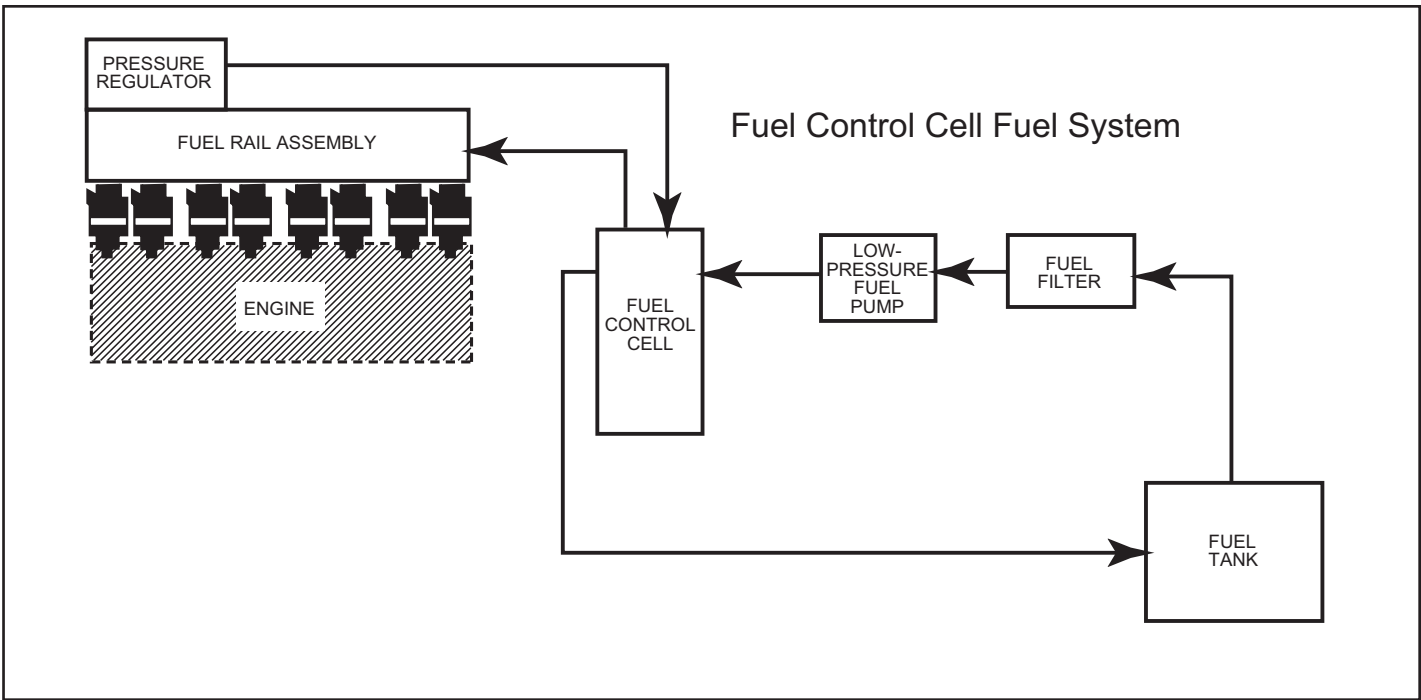
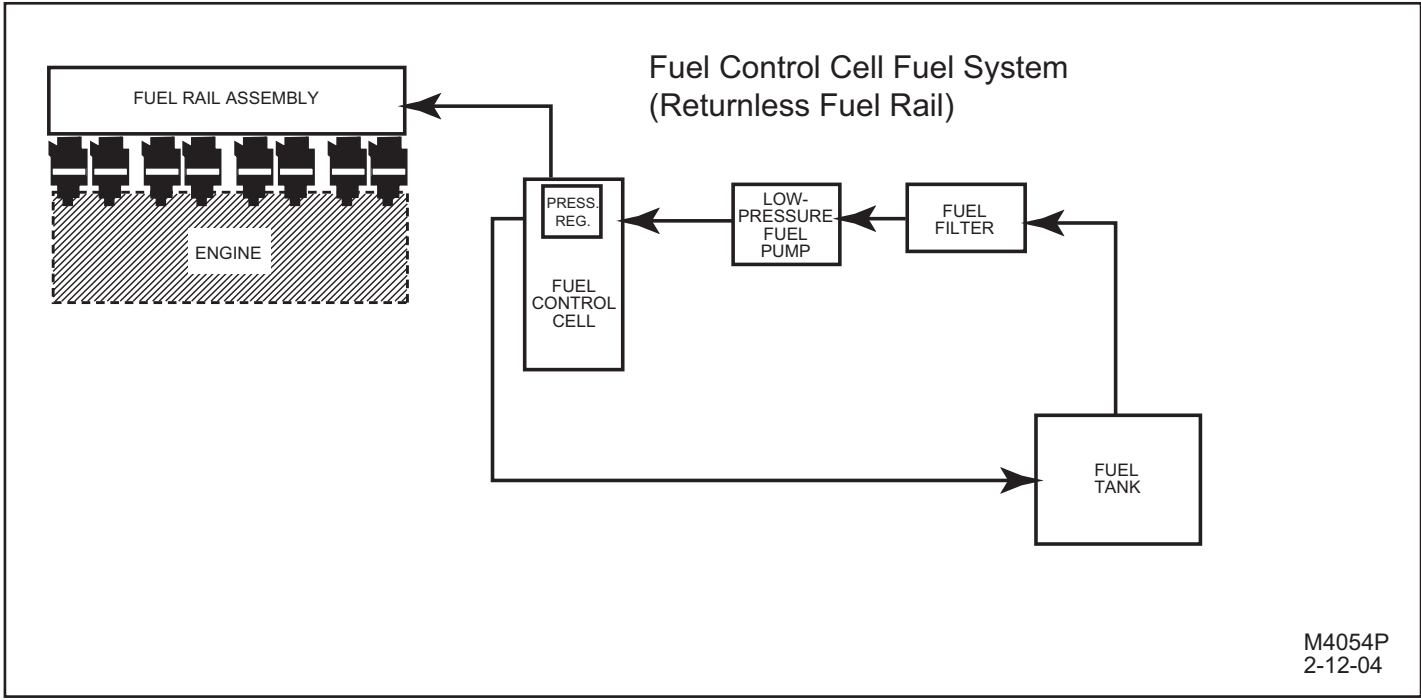


Figure 3-3 - Fuel Metering System (Typical) 5.0/5.7L



M4054P
2-12-04

Figure 3-4 - Fuel Metering System (Typical) 6.0/6.2L

Fuel Metering System

Fuel Pump Electrical Circuit

When the ignition switch is turned "ON," the ECM turns the fuel pump relay "ON" for 2-4 seconds causing the fuel pump(s) to pressurize the fuel system.

When the ignition switch is turned to the crank position, the ECM turns the fuel pump relay "ON" causing the fuel pump to run.

If the ECM does not receive ignition reference pulses (engine cranking or running), it shuts "OFF" the fuel pump relay, causing the fuel pump to stop.

An inoperative fuel pump relay will result in an "Engine Cranks But Will Not Run" condition and a possible DTC 627, 628, or 629 stored in the ECM memory.

Fuel Rail Assembly

The fuel rail (Figure 3-5) is mounted to the engine intake manifold, and performs several functions. It positions the injectors in the intake manifold, distributes fuel evenly to the injectors, and integrates the fuel pressure regulator into the fuel metering system.

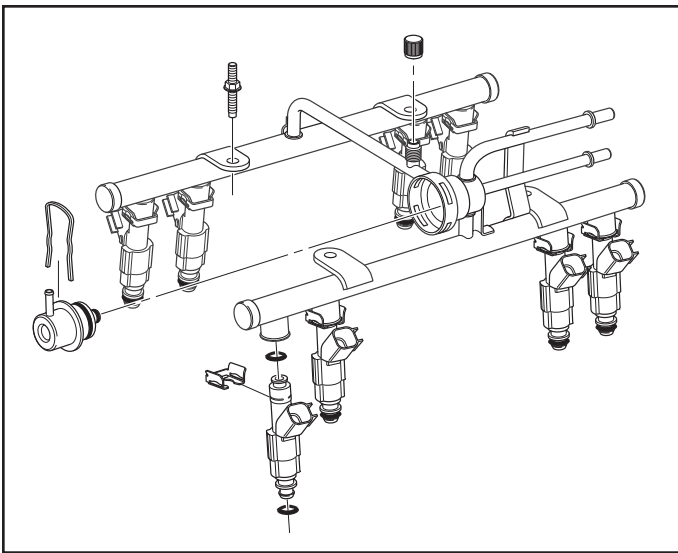


Figure 3-5 - Fuel Rail Assembly

Fuel Injectors

The fuel injector assembly is a solenoid-operated device, controlled by the ECM, that meters pressurized fuel to a single engine cylinder (Figure 3-6). The ECM energizes the injector solenoid, which opens a ball valve, allowing fuel to flow past the ball valve, and through a recessed flow director plate. The director plate has six machined holes that control the fuel flow, generating a conical spray pattern of finely atomized fuel at the injector tip. Fuel is directed at the intake valve, causing it to become further atomized and vaporized before entering the combustion chamber.

An injector that is stuck partly open would cause loss of pressure after engine shut down. Consequently, long cranking times would be noticed. Dieseling could also occur, because some fuel could be delivered to the engine after the ignition is turned "OFF." A fuel injector that does not open, may cause a "no-start" or a misfire.

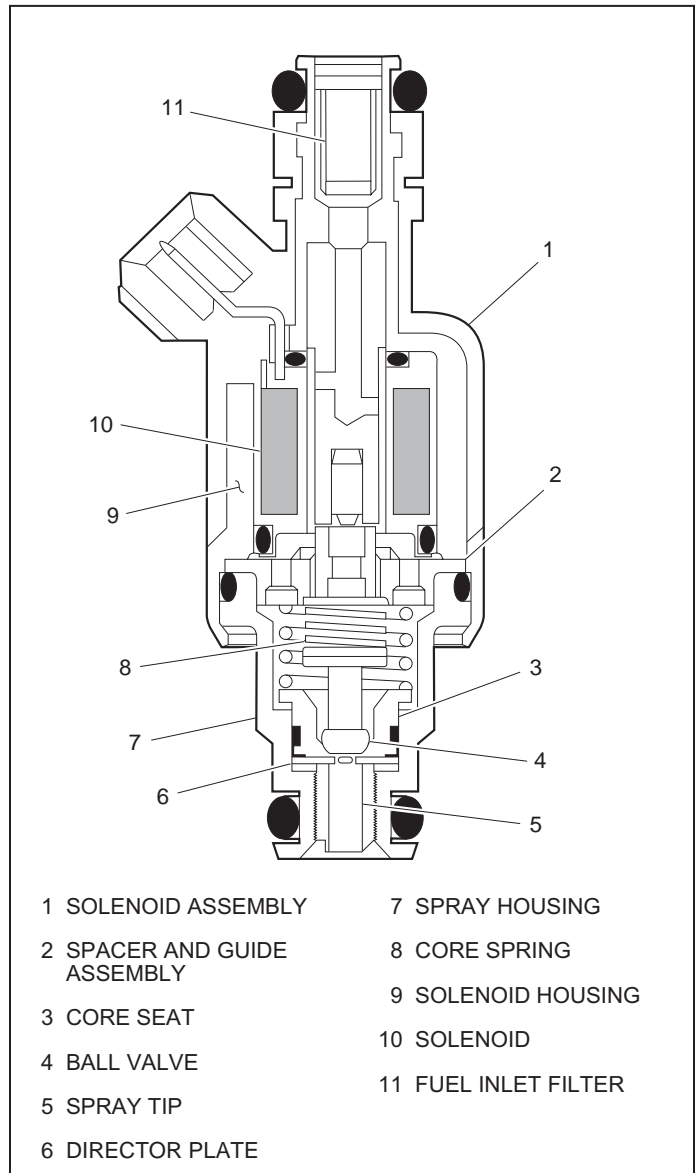
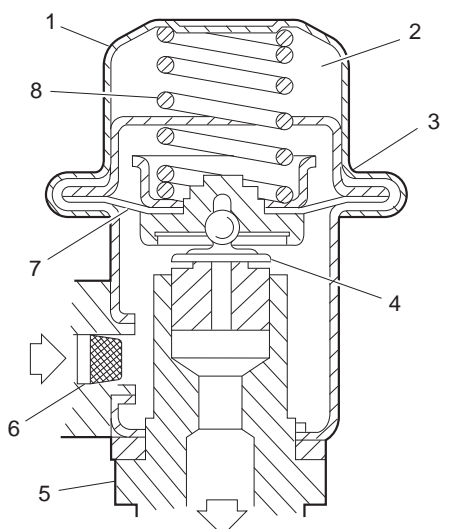


Figure 3-6 - Fuel Injector Assembly (Typical)

Pressure Regulator Assembly

The pressure regulator is a diaphragm-operated relief valve with fuel pump pressure on one side, and regulator spring pressure and intake manifold vacuum on the other side (Figure 3-7). The regulator's function is to maintain a constant pressure differential across the injectors at all times. The pressure regulator compensates for engine load by increasing fuel pressure as engine vacuum drops.

With the ignition "ON," engine "OFF" (zero vacuum), fuel pressure at the pressure test connection should be 393-427 kPa (57-62 psi) [434-469 kPa (63-68 psi) Returnless-to-Tank System]. If the pressure is too low, poor performance or a "no-start" may result. If pressure is too high, excessive odor may result.



- 1 COVER
- 2 VACUUM CHAMBER
(VACUUM SOURCE TUBE NOT SHOWN)
- 3 O - RING SEAL
- 4 FUEL PRESSURE REGULATOR VALVE
- 5 BASE ASSEMBLY
- 6 FILTER SCREEN (IF EQUIPPED)
- 7 DIAPHRAGM
- 8 SPRING

Figure 3-7 - Pressure Regulator Assembly (Typical)

Throttle Body Assembly

The throttle body assembly is attached to the intake manifold air plenum, and is used to control air flow into the engine, thereby controlling engine output (Figure 3-8). The Throttle Body contains the following components: the throttle blade, the throttle actuator motor, and the throttle position sensor (TPS) 1 and 2. The throttle body functions similar to a conventional throttle body with the following exceptions: an electric motor opens and closes the throttle valve, the throttle blade is spring loaded in both directions and the default position is slightly open, and there are 2 individual TP sensors within the throttle body assembly. The Throttle Position Sensors are used to determine the throttle plate angle. The TPS's provide the ECM with a signal voltage proportional to throttle plate movement. The TPS 1 signal voltage at closed throttle is above 4 volts and decreases as the throttle plate is opened. The TPS 2 signal voltage at closed throttle is below 1 volt and increases as the throttle plate is opened. The ECM commands the throttle plate to move based on Throttle Control Position sensor inputs and outputs commands (DBW +) to the throttle plate motor. The ECM provides 5V REF #1 supply to the throttle body for TPS signal development. If the ECM does not receive the TPS signals or detects an abnormal condition between TPS 1 and 2 the ECM will set a DTC. If the ECM no longer can determine throttle position, the ECM will command the throttle plate to the idle position regardless of commanded throttle position and TCP inputs. The operator will have idle speed only operation of the engine.

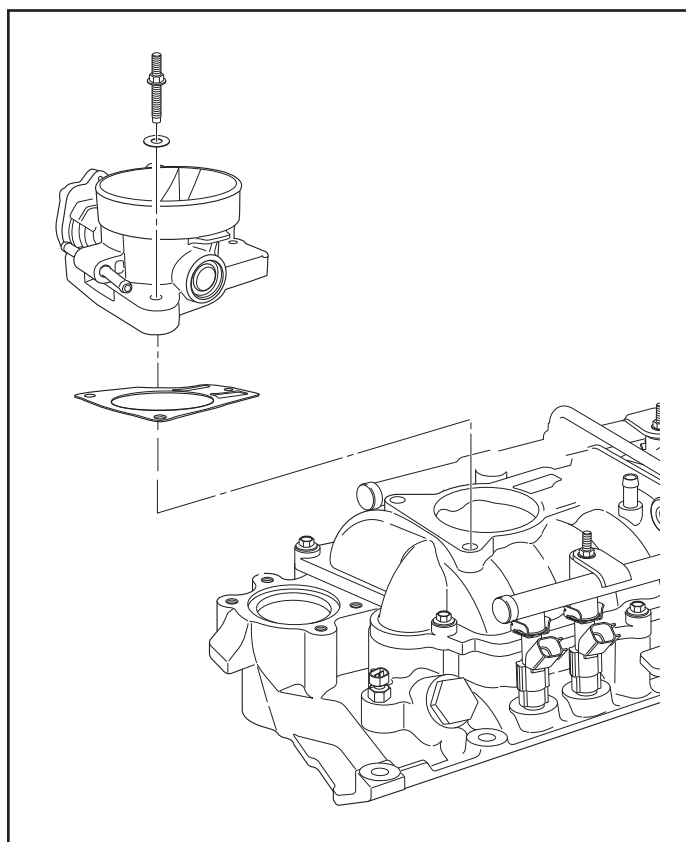


Figure 3-8 - Throttle Body Assembly

Fuel Metering System

Throttle Control Position (TCP) Sensor

The Throttle Control Position (TCP) sensor is comprised of two internal variable resistors (TCP1 and TCP2 signals) and an Idle Validation Switch (IVS). The Throttle Control Position (TCP) sensors 1 and 2 are potentiometer type sensors each with 3 circuits: a 5-volt reference circuit (5 VREF #1 = TCP1 and 5 VREF#2 = TCP2), a low reference circuit, and a signal circuit. The TCP sensors are used to determine throttle handle angle. The Idle Validation Switch indicates to the ECM that the Throttle handle has moved off idle position and TPS 1 and 2 are valid command signals. The ECM provides each TCP sensor a 5 volt reference circuit and a low reference circuit. The TCP sensors provide the ECM with signal voltage proportional to throttle handle movement. The TCP sensor 1 signal voltage at rest position is less than .5 volts and increases to above 4 volts as the throttle handle is actuated. The TCP sensor 2 signal voltage at rest position is near .25 volts and increases to more than 2 volts as the throttle handle is actuated. The TCP provides redundant signals to the ECM for throttle control. Should the TCP partially fail, you will still have full control of the throttle, but an error code will be set. TCP DTC error descriptions will indicate FPP 1 or 2 (Foot Pedal Position is a carryover term from automotive). If any two sections of the TCP fail, or the VREF#2 input is lost, this will cause the ECM to reset the throttle body to the idle position and the owner will have idle speed only.

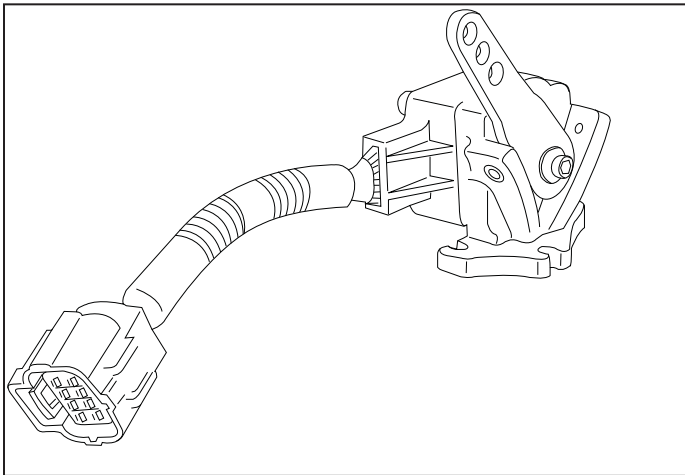


Figure 3-9 - Throttle Control Position Sensor

Fuel Pressure Gauge



CAUTION

Wrap a shop towel around the fuel pressure connection in order to reduce the risk of fire and personal injury. The towel will absorb any fuel leakage that occurs during the connection of the fuel pressure gauge. Place the towel in an approved container when the connection of the fuel pressure gauge is complete.

RT0078 Installation

1. Remove the engine cover, as required.
2. Remove the fuel rail service port cap.
3. Wrap a shop towel around the fuel rail service port.
4. Connect adapter RT0084 to the fuel rail service port.
4. Connect RT0078 to adapter RT0084.
5. Remove the shop towel from around the fuel rail service port, and place in an approved gasoline container.
6. Perform any tests and/or diagnostics as needed.

Fuel Pressure Relief



CAUTION

After you relieve the fuel system pressure, a small amount of fuel may be released when servicing the fuel lines, the fuel injection pump, or the connections. In order to reduce the risk of personal injury, cover the fuel system components with a shop towel before disconnection. This will catch any fuel that may leak out. Place the towel in an approved container when the disconnection is complete.

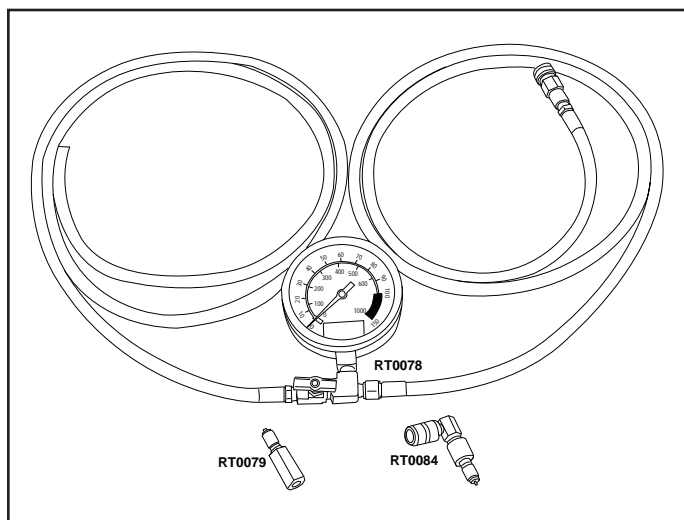
1. Perform RT0078 Installation procedure.
2. Place the hose on the RT0078 into an approved gasoline container.
3. Open the valve on the RT0078 in order to bleed any fuel from the fuel rail.
4. Close the valve on the RT0078.
5. Remove the hose on the RT0078 from the approved gasoline container.

IMPORTANT: If relieving the fuel pressure for the fuel pressure gauge removal, it is NOT necessary to proceed with the following steps.

Notice: Clean all of the following areas before performing any disconnections in order to avoid possible contamination in the system:

- The fuel pipe connections
- The hose connections
- The areas surrounding the connections

6. Wrap a shop towel around the fuel rail service port.
7. Disconnect RT0078 from adapter RT0084.



8. Disconnect adapter RT0084 from the fuel rail service port.
9. Remove the shop towel from around the fuel rail service port, and place in an approved gasoline container.
10. Install the fuel rail service port cap.
11. Install the engine cover, if required.

RT0078 Removal

1. Perform the Fuel Pressure Relief procedure.
2. Wrap a shop towel around the fuel rail service port.
3. Disconnect RT0078 from adapter RT0084.
4. Disconnect adapter RT0084 from the fuel rail service port.
5. Remove the shop towel from around the fuel rail service port, and place in an approved gasoline container.
6. Install the fuel rail service port cap.
7. Install the engine cover, if required.

Fuel Metering System

Fuel Control Cell (FCC) Replacement

Important

- Fuel pressure must be relieved before servicing the fuel pump.
- Refer to “Fuel Pressure Relief Procedure.”

Remove or Disconnect

1. Negative battery cable.
2. Fuel pump electrical connector.
3. Inlet and outlet fuel line fittings.
4. Fuel Control Cell (FCC) attaching bolts.
5. Fuel Control Cell (FCC).

Install or Connect

1. Fuel Control Cell (FCC).
2. Fuel Control Cell (FCC) attaching bolts.
3. Inlet and outlet fuel line fittings.
4. Fuel pump electrical connector.
5. Negative battery cable.

Inspect

- Turn ignition switch to the “ON” position for 2 seconds, then turn to the “OFF” position for 10 seconds. Turn the ignition switch back to the “ON” position and check for fuel leaks.

Fuel Control Cell (FCC) - Drain Water (With Engine OFF)

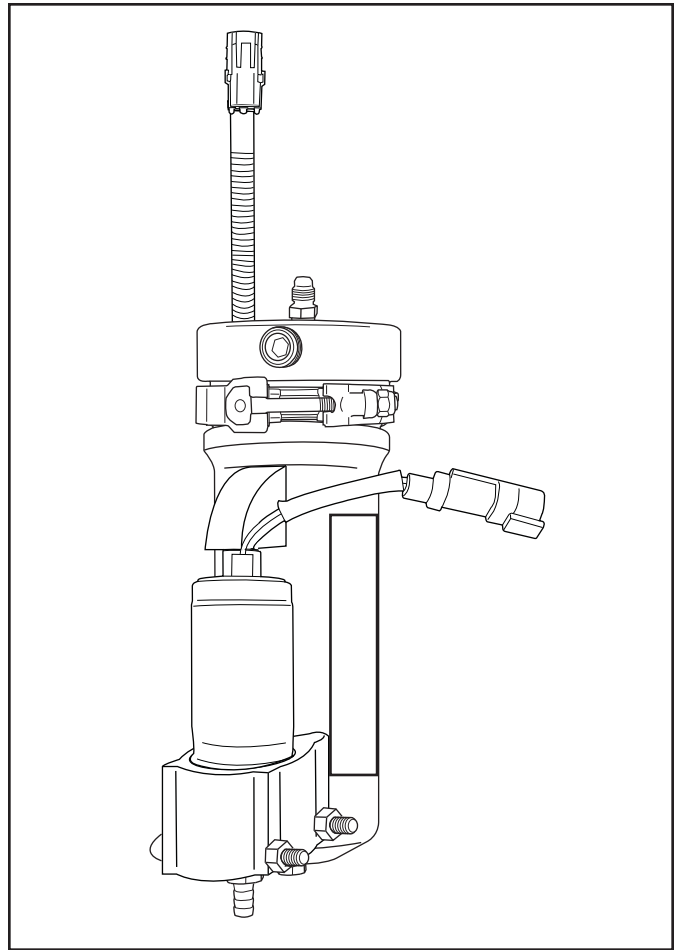
1. Disconnect the two-wire electrical harness.
2. Hold the 3/4” jam nut located at the bottom of the FCC bowl with a wrench, remove the 3/16” allen plug and drain bowl contents into a suitable container.

Caution: Both fuel, which is explosive, and water will drain from the FCC bowl.

3. Apply pipe sealant suitable for use with gasoline to the threads for the 3/16” allen plug.
4. Tighten the 3/16” allen plug while holding the 3/4” jam nut with a wrench.
5. Re-connect the two-wire electrical harness.

Inspect

- Turn ignition switch to the “ON” position for 2 seconds, then turn to the “OFF” position for 10 seconds. Cycle the ignition several times to fill the FCC bowl. Turn the ignition switch back to the “ON” position and check for fuel leaks.



Fuel Metering System

Fuel Control Cell (FCC) - Element Replacement (With Engine OFF)

1. Disconnect the two-wire electrical connectors from the FCC and the Low Pressure Fuel Pump (LPFP).
2. Disconnect the fuel supply line from the LPFP.
3. Remove the 7/16" plug, and drain the bowl contents into an approved container.

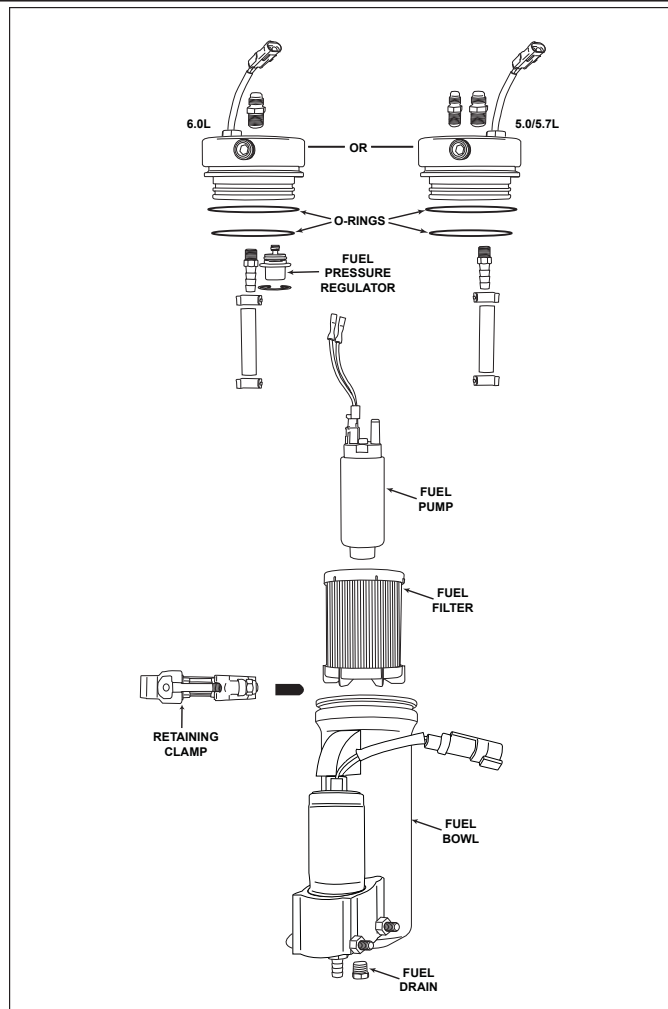
CAUTION: Both fuel and water will drain from the FCC bowl.

4. Remove the canister retaining clamp.
5. Slide the canister downward over the suspended filter element. It may be necessary to pull the unit to one side in order to remove.
6. Remove the fuel filter element from the suspended pump by gripping the fuel pump with one hand, and pulling the filter element downward with the other hand.
7. Visually inspect all internal components, i.e. hoses, wires, etc.
8. Push on new filter element (part number RP080026) over the electric fuel pump.
9. Using a pick made of soft material, such as a toothpick, remove the old O-rings from the FCC head.

CAUTION: The mounting head O-ring grooves may be damaged by using sharp steel tools to remove the O-rings.

CAUTION: Use only fuel approved O-rings (R047241) provided in RP080026 Kit. Use of non-approved O-rings may cause fuel to leak from the FCC.

10. Install the new O-rings in the same location. Lubricate the new O-rings with a fuel resistant O-ring lubricant.
11. Apply pipe sealant, suitable for use with gasoline, to the threads of the 7/16" plug.
12. Install and tighten the 7/16" plug into the canister.
13. Install the canister firmly back onto the FCC head.
14. Reinstall the retaining clamp and tighten securely.



15. Reconnect the fuel supply line to the LPFP.
16. Reconnect the two-wire electrical connectors to the FCC and the LPFP.
17. Cycle the ignition key several times to run the electric fuel pumps and fill the FCC bowl with fuel. Inspect the drain plug area for leaks. Correct any leaks prior to operating the engine.
18. Start the engine and inspect for fuel leaks. Correct any leaks prior to operating the engine any further.

DO NOT ATTEMPT TO SERVICE ANY OTHER PARTS ON THIS UNIT.

Fuel Metering System

Fuel Pressure Regulator Replacement

(In FCC)

Remove or Disconnect

Important

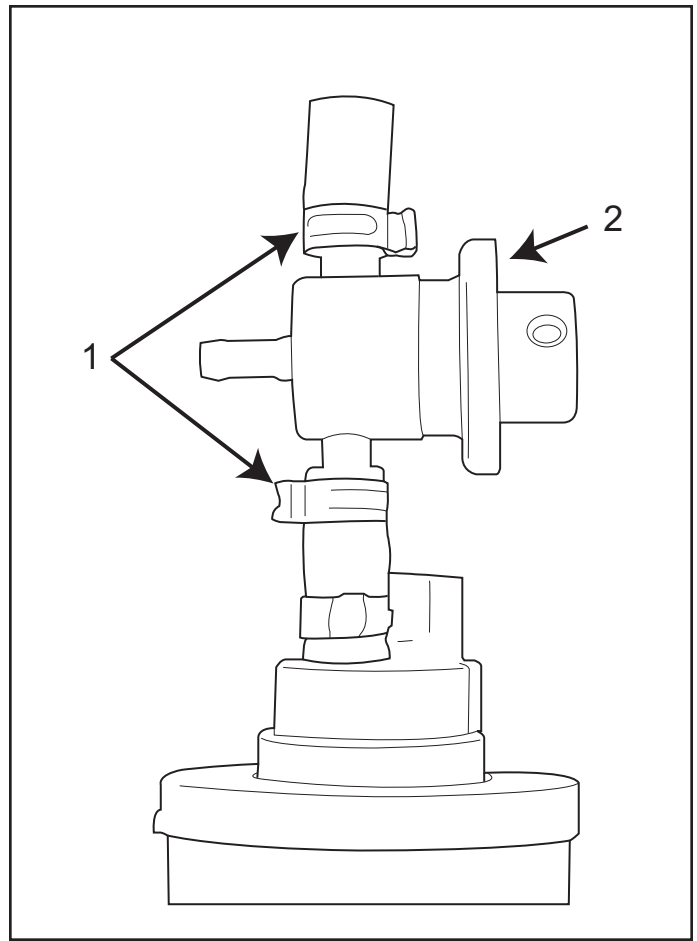
- Fuel pressure must be relieved before servicing the fuel pump.
 - Refer to “Fuel Pressure Relief Procedure.”
1. Remove the FCC bowl. Refer to Fuel Control Cell - Element Replacement steps 1-5.
 2. Remove the two clamps (1).
 3. Remove the fuel pressure regulator (2).

Install or Connect

4. Install the fuel pressure regulator (2).
5. Install two new clamps (1).
6. Push on a new filter element over the electric pump.
7. Install the FCC bowl. Refer to Fuel Control Cell - Element Replacement steps 7-12.

Inspect

- Turn ignition switch to the “ON” position for 2 seconds, then turn to the “OFF” position for 10 seconds. Cycle the ignition several times to fill the FCC bowl. Turn the ignition switch back to the “ON” position and check for fuel leaks.



Fuel Pressure Regulator - Inside FCC

Fuel Pressure Regulator Replacement

(On Fuel Rail)

Important

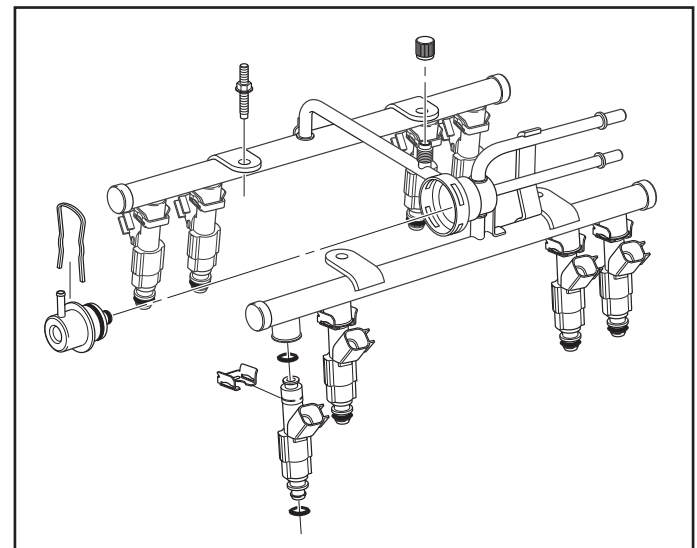
- The fuel pressure regulator is serviced as a complete assembly only.
- Fuel pressure must be relieved before servicing the fuel system.
- Refer to “Fuel Pressure Relief Procedure.”

Remove or Disconnect

1. Negative battery cable.
2. Fuel outlet line nut.
 - Use back up wrench to hold pressure regulator to keep from turning and damage.
 - Discard outlet line nut O-ring.
3. Pressure regulator attaching screw.
4. Pressure regulator from fuel rail.
5. Pressure regulator O-ring and discard.

Inspect

- The fuel input port of the pressure regulator may contain a filter screen. Inspect the screen for dirt and debris. If dirty, use a pick to remove filter screen and discard. Replace with new filter screen supplied in service package.



Fuel Pressure Regulator - On Fuel Rail

Install or Connect

1. Lubricate new fuel pressure regulator O-ring with clean engine oil and install on regulator.
2. Push pressure regulator into rail.
3. Pressure regulator attaching screw. Finger tighten only.
4. Lubricate new outlet line O-ring and install on end of line.
5. Outlet line assembly with nut to pressure regulator. Finger tighten only.
6. Torque pressure regulator attaching screw to 9.5 N•m (84 lb.in.).
7. Torque outlet line nut to 17.5 N•m (13 lb.ft.).
 - Use backup wrench to keep pressure regulator from turning and damage.
8. Negative battery cable.

Inspect

- Turn ignition switch to the “ON” position for 2 seconds, then turn to the “OFF” position for 10 seconds. Turn the ignition switch back to the “ON” position and check for fuel leaks.

Servicing the Primary Fuel Pre-Filter

The frequency of replacing the filter element is determined by the contamination level of the fuel. Replace the filter element after the first 25 hours, then every 50 hours or once a year (whichever occurs first).



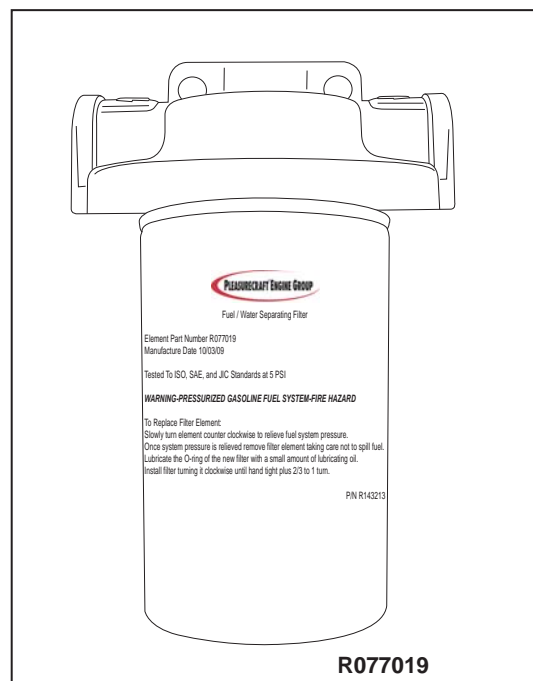
WARNING

Improper use, installation or servicing may cause an explosion or fire resulting in bodily injury, or death. This unit should only be serviced by a qualified technician. Read and follow all instructions before proceeding. Run the engine and check for fuel leaks after installation or element replacement.

Filter Element Replacement, ENGINE OFF PRIMARY FUEL PRE-FILTER #: R077019 (SPIN-ON)

NOTE: This filter may be located in various locations. Consult your boat manufacturer’s operation manual for correct location.

1. Loosen the fuel filter by spinning it counterclockwise. A filter wrench may be required.
2. Remove the filter. Ensure that the old O-ring is removed with the filter.
3. Install the new filter by spinning it on clockwise.. Ensure the new filter is installed correctly. Tighten the filter securely.
4. Start the engine and inspect for fuel leaks. Correct any leaks prior to operating the engine any further.



**This Page Was
Intentionally
Left Blank**

GCP / 4G Engine Management System

Section 4

Ignition Systems

This section will describe the Distributor Ignition (DI) System used on the 5.0L and the 5.7L engines and the Electronic Ignition (EI) used on other engines. The DI system uses a single ignition coil and a mechanical distributor. The EI system uses an ignition coil for each cylinder.

Contents

Ignition System Specifications	Page 2	Ignition Coil Replacement	Page 7
Fastener Tightening Specifications	Page 2	Spark Plug Wire Replacement	Page 7
Distributor Ignition (DI) System Description	Page 3	Spark Plug Wire Inspection	Page 8
Ignition System Overview	Page 3	Spark Plug Replacement.....	Page 9
Crankshaft Position (CKP) Sensor and Reluctor Wheel	Page 3	Spark Plug Usage	Page 9
Camshaft Position (CMP) Sensor and Reluctor Wheel	Page 4	Spark Plug Inspection.....	Page 9
Ignition Coil	Page 4	Spark Plug Visual Inspection	Page 11
Noteworthy Ignition Information	Page 5	Crankshaft Position (CKP) Sensor Replacement	Page 13
Engine Control Module (ECM)	Page 3	Camshaft Position (CMP) Sensor Replacement	Page 14
Knock Sensor (KS) System Description.....	Page 6	Setting Cam Retard.....	Page 15
Purpose.....	Page 6	Knock Sensor (KS) Replacement	Page 16
Operation	Page 6		
Normal Knock Signal	Page 6		
Abnormal Knock Signal	Page 6		

Ignition Systems

Distributor Ignition (DI) System Description Ignition System Overview

The ignition system consists of the following components or circuits:

- The 8 ignition secondary wires
- The ignition coil
- The ignition control (IC) circuit
- The camshaft position (CMP) sensor
- The camshaft reluctor wheel
- The crankshaft position (CKP) sensor
- The crankshaft reluctor wheel
- The related connecting wires
- The engine control module (ECM)

To properly control ignition timing, the ECM relies on the following information:

- Engine load, manifold pressure or vacuum
- Atmospheric, barometric, pressure
- Engine temperature
- Intake air temperature, if applicable
- Engine speed (RPM)

The ignition control utilizes the following to control spark timing functions:

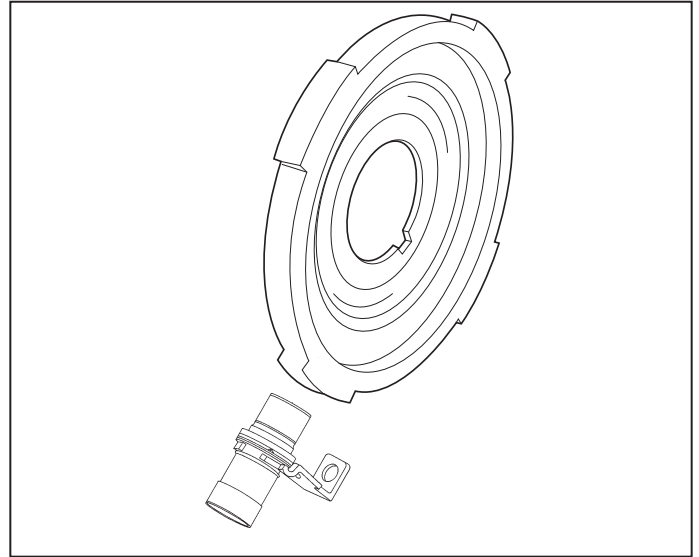
- The 4X signal - The 4X crankshaft position sensor sends a signal to the ECM. The ECM uses this signal to determine crankshaft position, or engine speed.
- The 1X signal - The 1X camshaft position sensor sends a signal to the ECM. The ECM uses this signal to quickly determine what cylinder to fire the ignition coil on.
- The ignition control (IC) circuit - The ECM uses this circuit to trigger the ignition coil.

The distributor used on the MEFI equipped engines is designed for the marine/industrial environment. The base plate of the distributor is equipped with two special vents to prevent any fuel vapors from igniting. With the high voltage produced by the distributor, a special material is used for the distributor cap and rotor. It is a thermoplastic, injection-molded, glass-reinforced polyester. This material provides the dielectric and insulation property needed, and also prevents carbon tracking.

Distributors with separate coils are used on the MEFI engines. The ignition coil connects to the distributor cap through a high tension wire.

There is no scheduled maintenance or periodic lubrication required. Engine oil lubricates the lower bushing and the upper bushing is pre-lubricated and sealed.

Crankshaft Position (CKP) Sensor and Reluctor Wheel



The crankshaft position (CKP) sensor is a magneto resistive type sensor. The CKP sensor works in conjunction with a 4X reluctor wheel. The reluctor wheel is mounted on the front of the crankshaft. The CKP sensor outputs a 4X signal for spark control, tachometer output and fuel control. All CKP signals are output as a digital waveform.

The 5.7L, right-hand rotation, uses a different crankshaft reluctor wheel than a normal, left-hand rotation engine.

Electronic Ignition (EI) System Description

Ignition System Overview

The ignition system consists of the following components or circuits:

- The 8 ignition secondary wires
- The 8 ignition coils
- The 8 ignition control (IC) circuits
- The camshaft position (CMP) sensor
- The camshaft reluctor wheel
- The crankshaft position (CKP) sensor
- The crankshaft reluctor wheel
- The related connecting wires
- The engine control module (ECM)

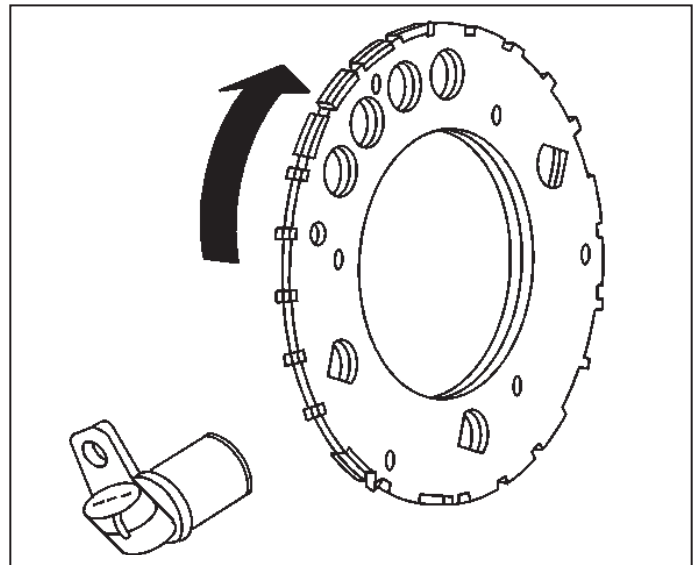
To properly control ignition timing, the ECM relies on the following information:

- Engine load, manifold pressure or vacuum
- Atmospheric, barometric, pressure
- Engine temperature
- Intake air temperature
- Engine speed (RPM)

The ignition control utilizes the following to control spark timing functions:

- The 24X signal - The 24X crankshaft position sensor sends a signal to the ECM. The ECM uses this signal to determine crankshaft position, or engine speed.
- The 1X signal - The 1X camshaft position sensor sends a signal to the ECM. The ECM uses this signal to quickly determine what cylinder to fire the ignition coil on.
- The ignition control (IC) circuits - The ECM uses these circuits to trigger the ignition coils.

Crankshaft Position (CKP) Sensor and Reluctor Wheel

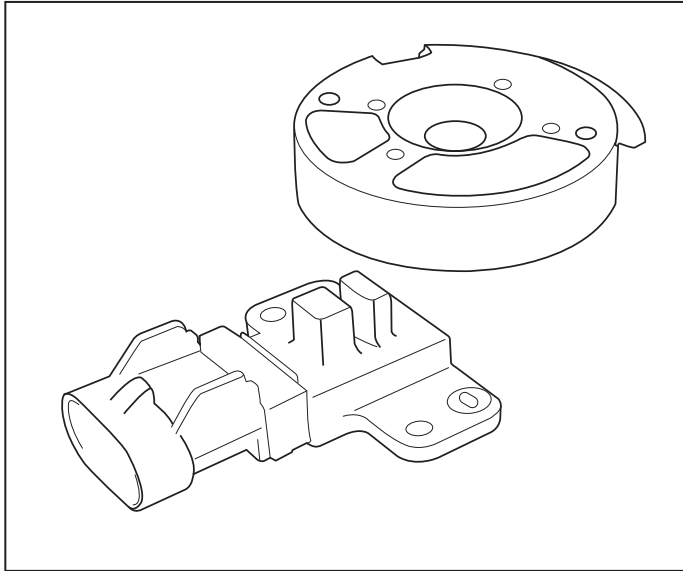


The crankshaft position (CKP) sensor is a magneto resistive type sensor. The CKP sensor works in conjunction with a 24X reluctor wheel. The reluctor wheel is mounted on the rear of the crankshaft. The 24X reluctor wheel uses 2 different width notches that are 15 degrees apart. This pulse width encoded pattern allows cylinder position identification within 90 degrees of crankshaft rotation. In some cases, this can be achieved within 45 degrees of crankshaft rotation. The reluctor wheel also has dual track notches that are 180 degrees out of phase. This design allows for quicker starts and accuracy. The CKP sensor also outputs a 4X signal for spark control, tachometer output and fuel control. All CKP signals are output as a digital waveform.

Ignition Systems

Camshaft Position (CMP) Sensor and Reluctor Wheel (DI Systems)

The camshaft position (CMP) sensor works in conjunction with a 1X reluctor wheel mounted inside the distributor housing. The CMP is used to determine the top dead center position of cylinder #1, and will synchronize with the 4X CKP sensor signal for quicker starting. The CMP signals are output as a digital waveform.

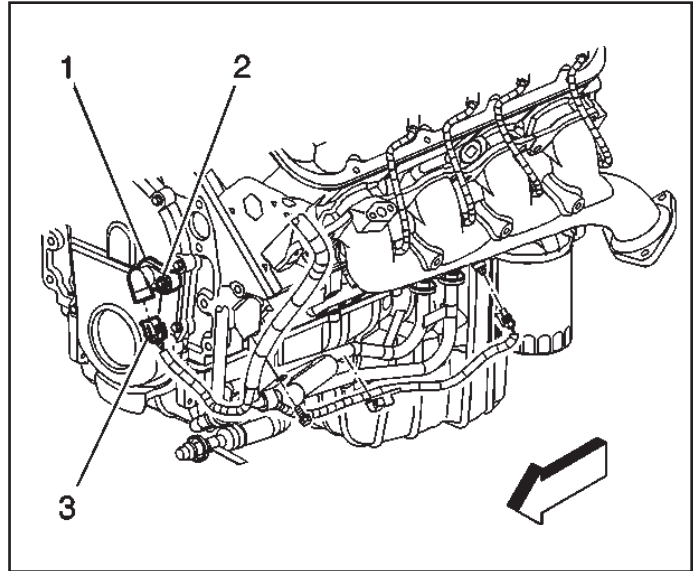


The DI ignition system may require the distributor to be readjusted if it is moved for any reason. In the past, the distributor would be rotated to adjust ignition timing. The ignition timing on this engine is not adjustable. Moving the distributor will NOT change ignition timing at all. The ignition timing is determined and controlled by the ECM. However, if the distributor is not positioned properly, driveability problems will exist.

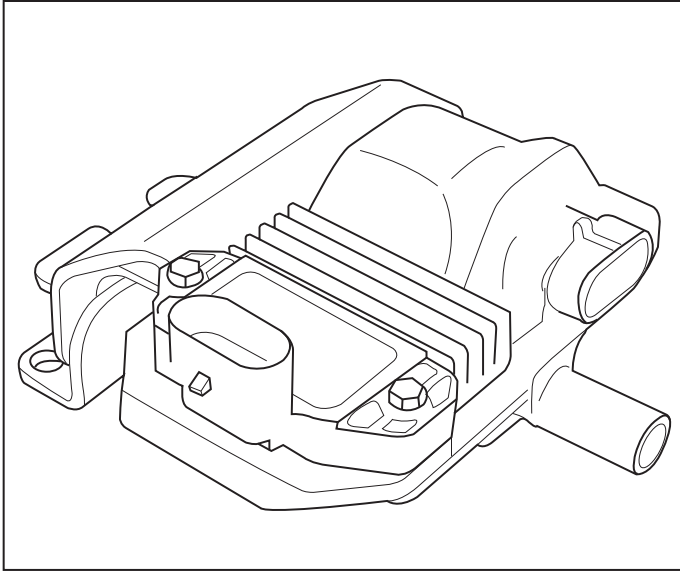
In order to properly set the distributor position, a scan tool MUST be used. There is a parameter on the data stream called iCam Retard. iCam retard must be set to 43-47 degrees, or driveability problems will exist.

Camshaft Position (CMP) Sensor and Reluctor Wheel (EI Systems)

The camshaft position (CMP) sensor works in conjunction with a 1X reluctor wheel mounted at the rear of the camshaft. The CMP is used to determine the top dead center position of cylinder #1, and will synchronize with the 24X CKP sensor signal for quicker starting. The CMP signals are output as a digital waveform.



Ignition Coil (DI Systems)

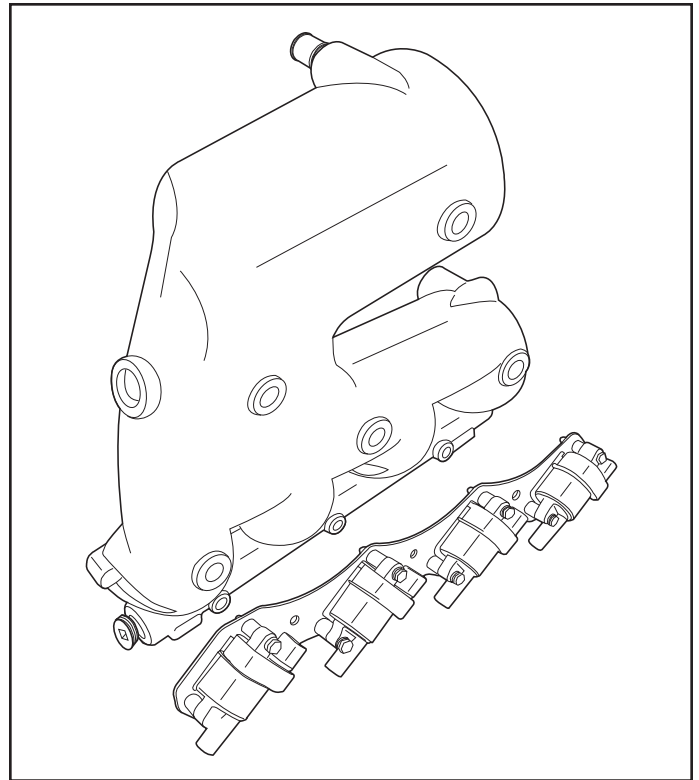


The design construction of the ignition coil affects its output. The DI system ignition coil was designed to produce greater spark voltage, longer spark and operate at higher RPM. The DI system coil has the secondary winding wrapped around the primary winding, and the primary winding is wrapped around the iron core. The coil is not oil filled, the windings are covered in an epoxy compound for protection against moisture and arc over.

There is an iron laminated square frame around the coil windings. This is to increase magnetic flux path and store energy to produce higher secondary spark voltage. The coil's mounting bracket is attached to ground.

The coil generates a high secondary voltage (up to 35,000 volts) when the primary circuit is broken. A secondary high tension wire connects from the top post of the coil to the center post of the distributor cap. There is one 2-wire connector on the coil that is used for battery voltage input and the trigger signal from the IC module.

Ignition Coils (EI Systems)



The ignition system on this engine features a multiple coil configuration and is known as coil near plug.

The 8 ignition coils are individually mounted near each cylinder and are fired sequentially. There is an ignition control (IC) circuit for each ignition coil. The 8 ignition control circuits are connected to the ECM. The ECM triggers each ignition coil individually and makes all timing decisions. The ignition coils are supplied with the following circuits:

- The ignition voltage circuit
- The ignition control circuit
- The ground circuit
- The reference low circuit

The ignition voltage circuits also supply the power for the fuel injectors. Each coil is serviced separately.

This system puts out very high ignition energy for plug firing. Less energy is lost to ignition wire resistance because the ignition wires are much shorter than in a conventional ignition system.

Ignition Systems

Knock Sensor (KS) System Description

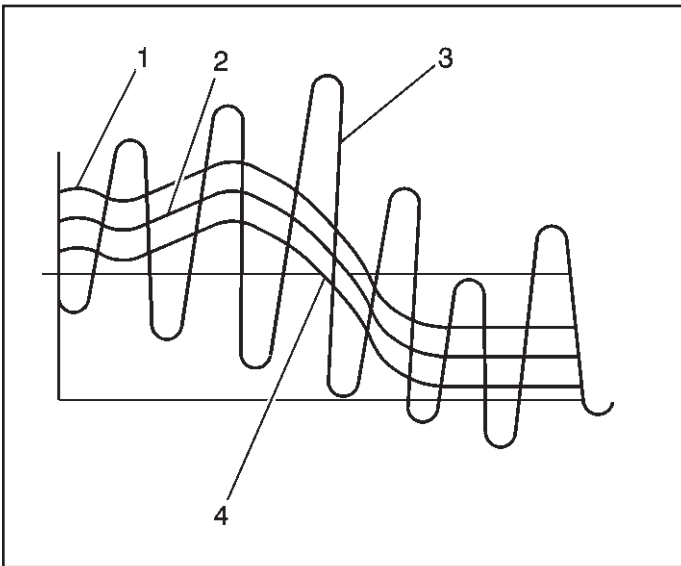
Purpose

To control spark knock (detonation), a knock sensor (KS) system is used. This system is designed to retard spark timing when excessive spark knock is detected in the engine. The KS system allows the engine to use maximum spark advance for optimal driveability and fuel economy under all operating conditions.

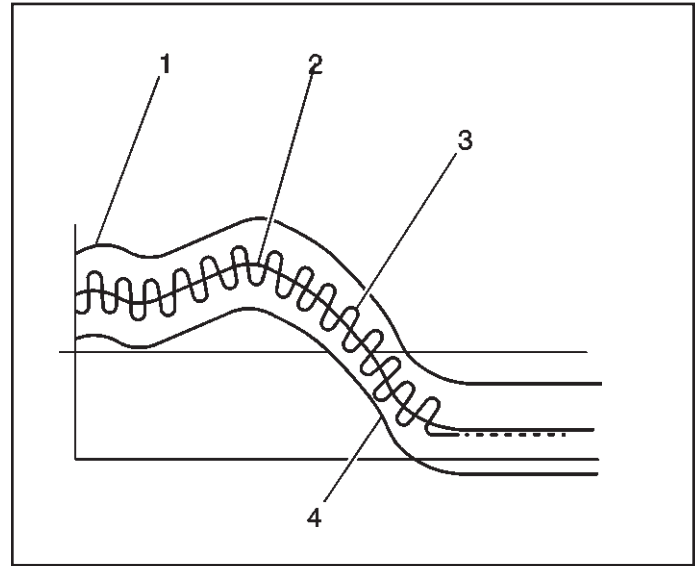
Operation

The ECM uses a knock sensor to detect abnormal vibration in the engine (detonation/spark knock). Mounted on the engine block, the knock sensor produces an AC voltage signal at all engine speeds and loads. The ECM then adjusts the spark timing based on the amplitude and frequency of the KS signal. The ECM uses the KS signal to calculate an average voltage. Then, the ECM assigns a voltage range above and below the average voltage value. The ECM checks the KS and related wiring by comparing the actual knock signal to the assigned voltage range. A normal KS signal should vary outside the assigned voltage range as shown in the NORMAL KS figure. If the ECM detects a KS signal within the assigned voltage range as shown in the ABNORMAL KS figure, the applicable DTC will set.

Normal Knock Sensor Signal



Abnormal Knock Sensor Signal



Legend

1. Upper fail region
2. Knock sensor calculated average
3. Knock sensor signal
4. Lower fail region

A diagnostic trouble code (DTC) may set for the following conditions or faults:

- The ECM malfunctions in a manner which will not allow the ECM to run a diagnostic of the KS circuit.
- The KS signal is within the assigned voltage range.
- The KS signal is not present.
- The Knock Sensor is improperly torqued.

Noteworthy Ignition Information

There are important considerations to point out when servicing the ignition system. The following noteworthy information will list some of these to help the technician in servicing the ignition system.

- The ignition coils secondary voltage output capabilities are very high - more than 40,000 volts. Avoid body contact with ignition high voltage secondary components when the engine is running or personal injury may result.
- The 4X or 24X crankshaft position (CKP) sensor is the most critical part of the ignition system. If the sensor is damaged so that the pulses are not generated, the engine does not start.
- The CKP sensor clearance is very important. If the interrupter ring is bent or damaged in any way, the CKP sensor may be destroyed. Extreme care must be exercised during removal and installation procedures.
- The ignition timing is not adjustable. Moving the distributor on DI Systems changes the "Cam Retard." Cam Retard MUST be set within specifications or a driveability problem will exist.
- Be careful not to damage the secondary ignition wires or boots when servicing the ignition system. Rotate each boot in order to dislodge the boot from the plug or coil/cap tower before pulling the boot from the spark plug or the coil/cap tower.

Engine Control Module (ECM)

The ECM is responsible for maintaining proper spark and fuel injection timing for all driving conditions. To provide optimum driveability and emissions, the ECM monitors input signals from the additional following components in calculating ignition control (IC) spark timing:

- The engine coolant temperature (ECT) sensor
- The intake air temperature (IAT) sensor
- The throttle position (TP) sensor
- The manifold absolute pressure (MAP) sensor

Ignition Systems

Setting Cam Retard

Important: Moving the distributor DOES NOT adjust ignition timing. Ignition timing is completely computer controlled. However, a parameter called “Cam Retard” must be within specifications or driveability problems will exist.

1. Connect laptop, using Diacom (PCM p/n RT0086) in order to read CAN BUS data.
2. Start the engine.
3. Look at the “Cam Retard” parameter.

Notice: Cam Retard MUST be set to proper specification.

4. If the Cam Retard is not within specification, loosen the distributor hold down bolt.
5. Rotate distributor until specification can be achieved.
Tighten
Tighten the distributor hold down bolt to 25 N·m (18 lb ft).



CAM Retard Specifications

Application	Engine Management System	Serial Number Range	CAM Retard Specification (Degrees)
5.0/5.7L	MEFI 4/4B	430000 - 469999	43 - 47
5.0/5.7L	GCP	470000 - 485993	Production 0 - 4 (See SUP2009-01) 6 - 8
5.0/5.7L	GCP / 4G	485994 - Present	14 - 16
5.0/5.7L CES	GCP / 4G	480000 - Present	14 - 16

Ignition System Specifications

Application	Specifications	
	Metric	English
Firing Order (DI Systems)	1-8-4-3-6-5-7-2	
Firing Order (EI Systems)	1-8-7-2-6-5-4-3	
Spark Plug Wire Resistance	10,000 ohms per foot	
Spark Plug Torque	15 N·m	11 lb ft
Spark Plug Gap (R030010, R030009)	1.52 mm	.060 in
Spark Plug Gap (R030011, R030012)	1.02 mm	.040 in
Spark Plug Type (5.0/5.7L)	R030010	
Spark Plug Type (6.0L)	R030011	
Spark Plug Type (6.2L)	R030012	
Spark Plug Type (8.1L)	R030009	

Fastener Tightening Specifications

Application	Specifications	
	Metric	English
Camshaft Position (CMP) Sensor Bolt	9 N·m	72 lb in
Crankshaft Position (CKP) Sensor Bolt	9 N·m	72 lb in
Distributor Hold Down Bolt	25 N·m	18 lb ft
Distributor Cap Bolts	2.4 N·m	21 lb in
Engine Control Module (ECM) Mounting Screws	10-14 N·m	88-124 lb in
Ignition Coil Attaching Bolts	12 N·m	106 lb in
Knock Sensor (KS)	20 N·m	15 lb ft

**This Page Was
Intentionally
Left Blank**

GCP / 4G Engine Management System

Section 5

Diagnostics

This section will describe the Distributor Ignition (DI) System used on the 5.0L and the 5.7L engines. The DI system uses a single ignition coil and a mechanical distributor. The section explains the individual components of the Distributor Ignition System. Electronic Ignition System is explained in Section 4B.

Contents

Ignition System Specifications	Page 2	Ignition Coil Replacement	Page 7
Fastener Tightening Specifications	Page 2	Spark Plug Wire Replacement	Page 7
Distributor Ignition (DI) System Description	Page 3	Spark Plug Wire Inspection	Page 8
Ignition System Overview	Page 3	Spark Plug Replacement.....	Page 9
Crankshaft Position (CKP) Sensor and Reluctor Wheel	Page 3	Spark Plug Usage	Page 9
Camshaft Position (CMP) Sensor and Reluctor Wheel	Page 4	Spark Plug Inspection.....	Page 9
Ignition Coil	Page 4	Spark Plug Visual Inspection	Page 11
Noteworthy Ignition Information	Page 5	Crankshaft Position (CKP) Sensor Replacement	Page 13
Engine Control Module (ECM)	Page 3	Camshaft Position (CMP) Sensor Replacement	Page 14
Knock Sensor (KS) System Description.....	Page 6	Setting Cam Retard.....	Page 15
Purpose.....	Page 6	Knock Sensor (KS) Replacement	Page 16
Operation	Page 6		
Normal Knock Signal	Page 6		
Abnormal Knock Signal	Page 6		

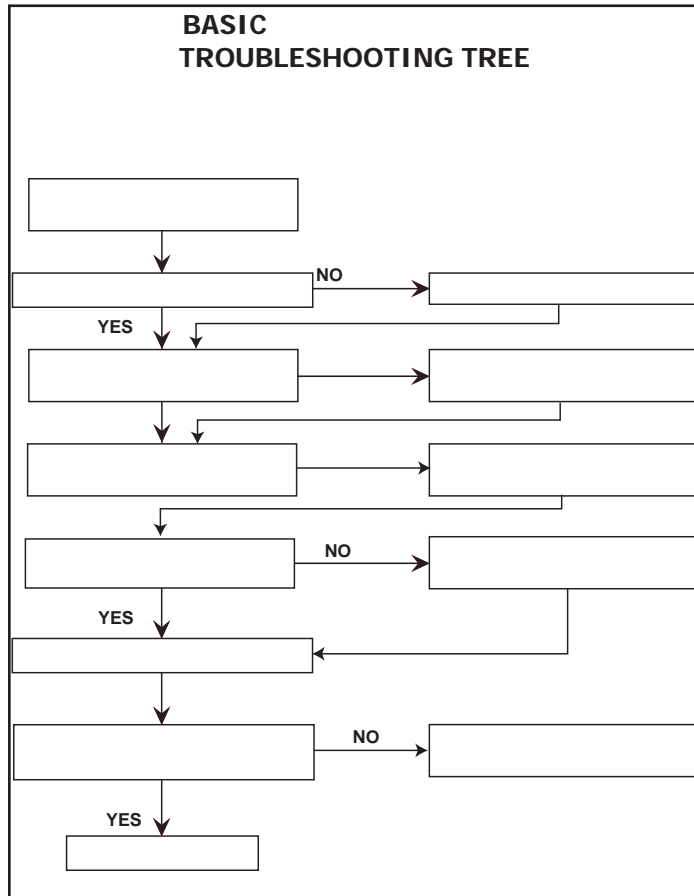
Diagnostics

Abbreviations

4G	4th Generation ECM	PWM	Pulse Width Modulated
AL	Adaptive Learn	RAM	Random Access Memory
BP	Barometric Pressure	RPM	Revolutions Per Minute
CAN	Controller Area Network	SPN	Suspect Parameter Number
CGL	Check Gauges Lamp	Tach	Tachometer
CL	Closed Loop	TCP	Throttle Control Position (Handle)
DBW	Drive-By-Wire	TDC	Top Dead Center
DMM	Digital Multi-Meter (high impedance)	TPS	Throttle Position Sensor (Throttle Body)
DST	Diagnostic Scan Tool	VDC	Voltage, Direct Current
DTC	Diagnostic Trouble Code	Vsw	Switched, Ignition Voltage
DVOM	Digital Voltage and Ohm Meter (high impedance)		
ECM	Engine Control Module		
ECT	Engine Coolant Temperature		
EGO	Exhaust Gas Oxygen Sensor, typically heated		
EMWT	Exhaust Manifold Water Temperature		
ETC	Electronic Throttle Control		
FMI	Failure Mode Indicator		
FO	Firing Order		
FP	Fuel Pressure		
FPP	Foot Pedal Position		
GCP	Global Controller Platform		
HEGO	Heated Exhaust Gas Oxygen Sensor (same as HO2S)		
HO2S	Heated Oxygen Sensor (same as HEGO)		
IAT	Intake Air Temperature		
IVS	Idle Validation Switch		
LED	Light Emitting Diode		
MAP	Manifold Absolute Pressure		
MIL	Malfunction Indicator Lamp		
OBD	On-Board Diagnostics		
OEM	Original Equipment Manufacture		
PC	Personal Computer		
PFI	Port Fuel Injection		
PGN	Parameter Group Number		

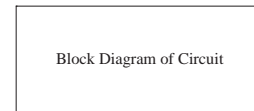
OVERVIEW

This manual is intended to be used as an aid for customers troubleshooting GCP / 4G drivability problems. This manual defines the diagnostics and recommended troubleshooting procedures associated with a GCP / 4G controlled engine. Troubleshooting trees are provided to aid in this process. Three types of trees are used throughout this manual.



The Basic Troubleshooting Tree used provides test and instruction for a trouble condition. It is most often accompanied by an explanation of the tests and decision branches.

DTC XXXX- Diagnostic Condition



- *External Hardware Input/Output*- This identifies the hardware that either sends an input to the ECM or is driven by and ECM output.
- *Check Condition*- This defines what condition to troubleshoot the fault condition.
- *Fault Condition(s)*- This identifies the condition(s) that set the fault.
- *Corrective Action(s)*- This identifies the *RECOMMENDED* corrective action(s) that the ECM is generally programmed to perform. In some instances, the calibration engineer(s) may choose to perform a different action.
- Emissions or Non-emissions related fault

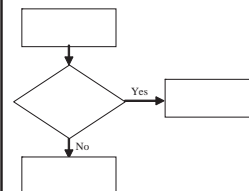
Text to identify the circuit of interest and its use for control.

Text to describe the conditions that cause the fault to set.

There will be two types of diagnostic trees used for GCP / 4G faults. The first will provide a block diagram of the ECM and circuit it controls. This diagram will be accompanied by the pin out from the ECM to the device for point to point testing.

DTC XXXX- Diagnostic Condition

Note: Helpful tips used to aid troubleshooting



Diagnostic Aids

- Tip #1
- Tip #2 ...

The second diagnostic tree will provide you with the test and instructions for the suspect circuit.

OVERVIEW

This manual is intended to be used as an aid for customers troubleshooting GCP / 4G drivability problems. This manual defines the diagnostics and recommended troubleshooting procedures associated with a GCP / 4G controlled engine. Troubleshooting trees are provided to aid in this process. Three types of trees are used throughout this manual.

Diagnostics

INTRODUCTION

Since the conception of the internal combustion engine there have been three absolutes that are required to make an engine run:

- **FUEL**
- **SPARK**, and
- **AIR**.

While there have been significant advances in the engine management systems, those three absolutes remain, fuel, spark, and air are required to make the engine run. Simply, successful troubleshooting of a drivability problem is accomplished by isolating the problem to one of these three areas, then repair the source of the problem.

With each generation of improvement in the engine management system, troubleshooting, maintaining, tune ups, and repair have become much easier to accomplish.

BASIC TROUBLESHOOTING APPROACH

Start by taking a 'systems' approach to the engine. Proper engine operation depends on numerous systems and components functioning together. This of course, makes any one system dependant upon the proper operation of all the other systems. The common thread through all the systems is the Main Electrical System. If you do not have the proper system voltage and ground, none of the other engine systems can function properly.

When troubleshooting a GCP / 4G Engine Management System it is necessary that:

- o the Main Engine Electrical System Components,
- o the Engine Fuel System Components,
- o the Engine Cooling System Components, and
- o the Engine Mechanical Components,

are all functioning as designed prior to troubleshooting the GCP / 4G System. The Drivability Checklist is designed to help you insure that requirement is met.

Refer to Figure 2-1 and 2-2 for the relationship between the Basic Troubleshooting Approach and the Drivability Checklist. Successful problem diagnosis requires the following approach be applied to all reported problems. There are seven basic steps to troubleshooting a problem, and these steps are the basis for the Drivability Checklist.

1. Obtain a detailed description of the problem.
2. Check for Service Bulletins.
3. Perform a detailed visual inspection.
4. Verify the problem.
5. Perform the GCP / 4G System Check
6. Isolate and Repair the problem
7. Clear the ECM of Codes and Verify the problem has been corrected.

Using the Drivability Checklist will help you stay focused on the task at hand. Do all the steps, and in the order provided for every drivability problem encountered.

Most GCP / 4G circuit failures cause stored codes which have a diagnostic and repair procedure designed to resolve the problem causing the code.

Analyzing and resolving GCP / 4G and non-GCP / 4G problems are made easier using the Drivability Checklist. Especially when a code is cleared, does not reoccur but, a problem is still present.

Problems which do not set codes must be resolved using the symptom present. Some symptoms are easily recognized – “the engine overheated”; other symptoms can be vague, one person’s description of hesitation may be another person’s stumble. In these cases, you are dealing with conditions where the engine/boat package is no longer performing as it once did. Using the Drivability Checklist will help resolve these problems more readily.

THE DRIVABILITY CHECKLIST

The seven checks of the Basic Troubleshooting Tree are the basis for the Drivability Checklist, Figure 2-3. These seven steps can be applied to every problem that you encounter. Let’s take a closer look at the seven steps of the Drivability Checklist.

NOTE: For illustrative purposes each step presumes the problem has not been resolved. Therefore, you proceed to the next step. In actual troubleshooting if any step corrects the problem there would be no reason to proceed further, you would verify your repair, Step 7 of the Drivability Checklist, and return the boat to its owner.

1. Obtain a clear, concise description of the problem.

Whenever possible, interrogate the owner/operator and find out the conditions leading up to, and under which the problem occurred. Information related to recent service on the engine or recent unexpected or abnormal events can greatly aid you in your troubleshooting effort.

Often, an owner/operator provides only information about the symptom that is currently present. Find out if any recent work was performed on the engine, such as a broken belt or failed raw water pump impeller.

Has someone already tried to correct the current problem?

Have any new accessories been added recently?

Did the problem occur shortly after the last time he refueled?

Did the problem occur after a recent repair such as a hull repair where the underwater gear was replaced?

As you can see, there are numerous questions that could be asked based on the symptom and the owner/operator’s responses. Some of the more important questions to ask

BASIC TROUBLESHOOTING APPROACH

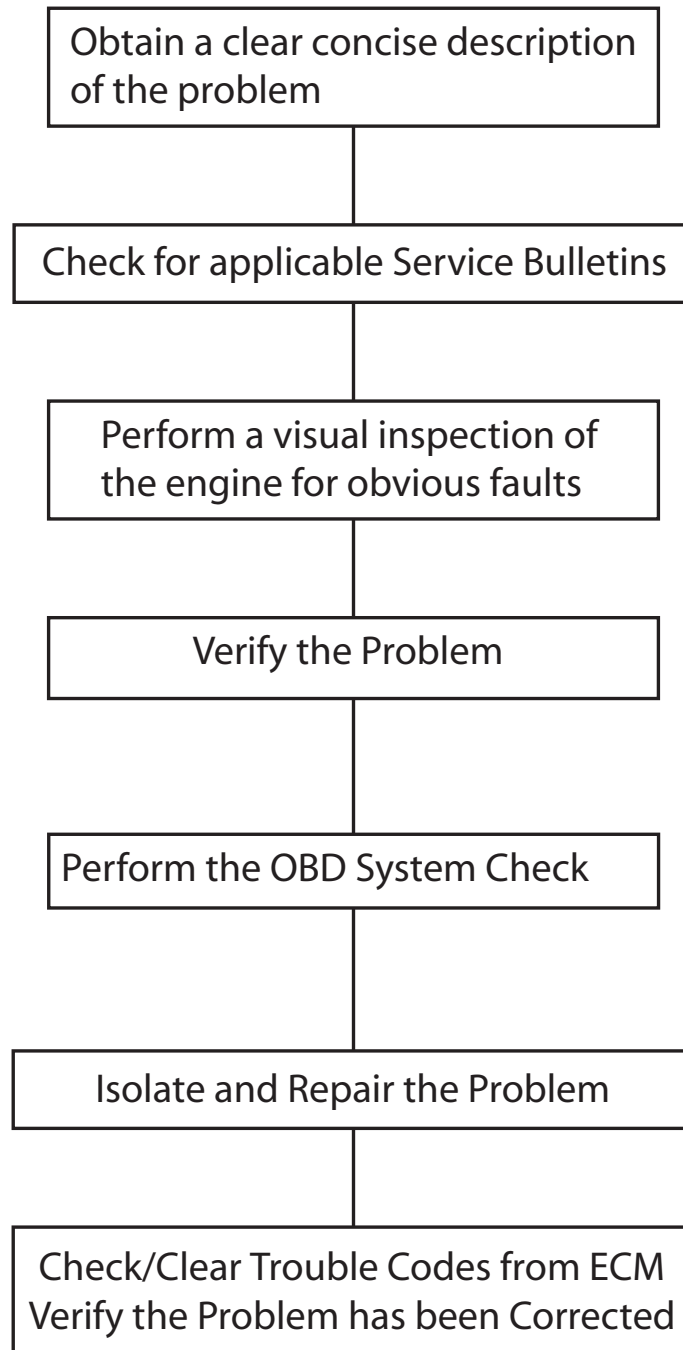


Figure 2-1 Basic Troubleshooting Approach Tree

Diagnostics

DRIVABILITY CHECKLIST TROUBLESHOOTING TREE

STEP 1

Obtain a clear concise description of the problem

STEP 2

Check for applicable Service Bulletins

BULLETINS

Perform Service Bulletin Action

STEP 3

NONE

Perform a visual inspection of the engine for obvious faults

FAULTS

Corrective action performed based on obvious faults found.

STEP 4

NONE

Verify the Problem - First Look

Perform 'Verify the Problem' Troubleshooting Tree

STEP 5

Perform the OBD System Check Troubleshooting Tree

NO CODE

STEP 6A

Perform Drivability Checklist - Step 6A - Troubleshooting Tree.

STEP 6

CODE

Isolate and Repair the Problem

STEP 7

Check/Clear Trouble Codes from ECM. Verify the Problem has been Corrected

NO

Call PCM Warranty Services
803-345-0050 ext. 107

YES

Return to the owner.

Figure 2-2 Drivability Checklist Troubleshooting Tree

are detailed on the Drivability Checklist, Figure 2-3, Step 1.

1. Obtain a clear concise description of the problem. Based on the symptom you receive from the owner/operator you may already know where to begin your troubleshooting. Many symptoms provide you that quick and easy insight to the problem. Some examples would be:

- o Over or Under Temperature problems – troubleshoot the Cooling System.
- o Various electrical issues such as no or slow cranking, dead battery, low or high voltage reading at the dash, etc. – troubleshoot the Main Electrical System.
- o Malfunction Indicator Lamp or *Check Engine Lamp is lit on the dash – troubleshoot the GCP / 4G system.

NOTE: The Malfunction Indicator Lamp or Check Engine Lamp normally lights when the ECM stores a code. Some boat manufacturers utilize a Check Engine Lamp to indicate faults other than stored codes. Check your boat owners manual for each application.

Remember to closely follow the Drivability Checklist so a problem or cause of a problem is not overlooked. You may have an idea which system has failed or where the problem may be from the owner/operator's description, but the **cause** of the problem may be overlooked by skipping steps. The cause of an over heat, dead battery, or no start condition, for example, may be addressed by a Service Bulletin or corrected during a thorough Visual Inspection.

2. Check for applicable Service Bulletins. Before you begin work on an engine, always check for Service Bulletins that may apply to the engine being serviced. Service Bulletins should be performed prior to proceeding with any troubleshooting procedure.

Record your engine serial and model numbers and engine hours on the Drivability Checklist, Figure 2-3, Step 2. This information is necessary to locate applicable Service Bulletins. With very little time and effort the reported symptom may be identified as exactly what a Service Bulletin corrects. Always check for Service Bulletins before proceeding with any other procedure.

3. Perform a Visual Inspection of the engine for obvious faults. One of the most important, yet least performed functions when troubleshooting is a *detailed* visual inspection. Always, visually and physically inspect the engine hose connections - coolant, vacuum, exhaust, and fuel, and the wiring harness and connections for any that may be loose, broken, or corroded.

Pay close attention to the power and ground connections for corrosion and/or accessory devices added in. Improperly added accessories can adversely affect engine operation. Inspect the engine and its assemblies for signs of damage or failure. Visually inspect for signs of arcing, fluid leaks, excessive water in the bilge, cracked or

damaged assemblies, and signs of excessive heat such as melted or deformed parts and discolored paint.

Typically when you perform a visual inspection you are looking for obvious conditions that could cause the reported symptom. If an over heat is reported you look for discolored paint and other heat related damage. When you have a performance issue reported; include the often overlooked inspections of the boat, for conditions that may affect performance such as hull damage or growth, damaged underwater gear, and if the correct propeller is installed.

Referring to the Drivability Checklist, Figure 2-3, Step 3. There are a number of inspections listed, such as damage from excessive heat, fluid leaks, fluid levels, etc. Most of the inspections listed are items easily seen as faults. When you have performance issues, such as a loss of power, RPM, or starting problems, be sure to include in your inspection a check of the ignition wires and spark plugs to include:

- o Proper routing of the plug wires,
- o Correct firing order,
- o Removal of each spark plug to include cylinder inspection for fluids, and
- o Inspection of spark plugs for fouling, gap, broken or cracked insulators and the correct type, size, reach, and heat range for the engine.

Be alert as you perform the visual inspection, you may repair the reported problem by reconnecting a wiring connector or cleaning the corrosion away from a power or ground terminal of the battery.

Samples of some observations that would need immediate attention before attempting to run the engine are:

- o **Slow Cranking, Hard to Start, or No Crank** – *Be sure to do your visual inspection of the spark plugs and cylinders for evidence of fluids.* This condition may have been caused by a Fuel System failure, Cooling System failure, water ingestion, Engine Mechanical System failure, or a Main Electrical System failure. If fluids are present, **Do Not** attempt to start or run the engine until the cause of the condition is corrected. Serious engine damage may occur.
- o **Melted, skinned, or burnt wiring** – You will need to repair the wiring. The condition of the wiring may have been caused by a Cooling System failure or a Main Electrical System failure.
- o **Oil level excessively high on the dipstick** – This may indicate a foreign liquid in the oil or an over-fill condition exists. Investigate and correct a high oil level condition before proceeding. Symptoms of too much oil in the crankcase include:

Diagnostics

- a loss of power,
- a loss of top end rpm, or
- a possible low oil pressure reading.

- o **Evidence of excessive water in the bilge** – A rust/water line on the starter/engine block is usually a good indication; if the water is not still covering these items. Multiple electrical issues may remain. Most common is a failed starter, but high water may short out the battery and other electrical devices. It may have been ingested into the engine causing a mechanical failure. And as mentioned above, you may have water in the engine oil or transmission.

The result of a good visual inspection will help you determine where you will concentrate your troubleshooting efforts.

4. Verify the problem - 'Taking the Engine's Pulse'. Just as a doctor would take your temperature and blood pressure on a visit, you must have your tools available when you are diagnosing a 'sick' engine. To verify the problem, you will connect your Diacom scan tool and Fuel Pressure gauge to the engine to begin your test to verify the problem. You should also have your Digital Multi-Meter (DMM) available.

Always verify, for yourself, that the problem you are about to troubleshoot is the same problem reported to you in Step 1 of the Drivability Checklist. Verifying the problem may require you to water test the boat, and then try to recreate the conditions under which the failure occurred.

Refer to Figure 2-3, Step 4. Step 4 of the Drivability Checklist is comprised of a series of checks leading up to verifying the reported problem.

Figure 2-4 is a trouble tree for Step 4 of Drivability Checklist. This step tests multiple systems therefore, a trouble tree is provide so you can 'branch' to the appropriate system when an action expected does not occur. This step will be discussed in more detail following this overall checklist discussion.

5. Perform the GCP / 4G System Check. The GCP / 4G System Check is an organized approach to identifying a problem created by an electronic engine control system malfunction. This check verifies the following:

- o The ECM power and ground circuits.
- o The ECM can communicate with the scan tool.
- o The ECM will allow the engine to start and continue to run.
- o The ECM has or has not stored Diagnostic Trouble Codes (DTC).

If DTC's are present, the GCP / 4G System Check will direct you to the next procedure you need to perform.

Details of the GCP / 4G System Check will be covered in the GCP / 4G diagnostic section.

6. Isolate and Repair the Problem. Sometimes easier said than done. Utilize your resources. Obtain the service manual for the problem you have encountered. Follow the procedures exactly as they are written. Do Not skip any steps. If you have reached a point in your testing where you have:

- o Checked all the components in a system,
- o Properly completed the Drivability Checklist procedures through Step 5,
- o Completed Step 5, and did not find codes or found and corrected code related problems but, the symptom is still present or the code returned,
- o An engine that starts and runs but still exhibits a symptom, and
- o Any unresolved problem.

You need to **STOP** and refer to Figure 2-2, the Drivability Checklist, Step 6A. Step 6A is designed to check for a variety of problems known to affect drivability.

Refer to Figure 2-6, this is a Troubleshooting Tree for Step 6A of the Drivability Checklist. This trouble tree follows the items listed under Step 6A on the Drivability Checklist.

7. Verify your repair action has corrected the problem. Once you have completed a repair action, clear any codes from the ECM. If codes return after repairs are made or you had multiple codes listed in the ECM's memory return to Step 6, Isolate and Repair the Problem, and perform the procedure and repair action for the remaining code(s). Steps 6 and 7 will have to be performed for each stored code until the system is repaired and tests normally. Always retest to verify the engine is operating normally.

The original problem may have been caused by another system or event; ensure that you have corrected both the cause and the original problem. When you verify your repair action, be sure to test **With the boat in the water**, and:

- 1) Run the boat a minimum of two (2) minutes to verify that no codes reset, and then
- 2) Run the boat long enough to verify your repair has corrected the problem.

PCM DRIVABILITY CHECKLIST

ENGINE SERIAL NUMBER: _____

Date: _____ **Dealership Name:** _____

Technician's Name: _____ **Technician's Contact Phone #:** _____

Owner/Operator Name: _____

Person Reporting the problem (if different from owner/operator): _____

Service Writer or Person that took the problem report: _____

1) PROBLEM OR SYMPTOM: _____

Who first observed the symptom? _____ When did the symptom first occur? _____

Any recent change or service work prior to symptom occurring - replaced belts or impeller, major engine or boat repairs, recently refueled, etc.? _____ Has someone, other than yourself, tried to

correct the current symptom? _____ If yes, what work was done? _____

Accessories Added Recently? _____ Is the symptom currently present? _____

Special conditions (if any) required to duplicate the symptom: _____

Use an additional sheet of paper if more space is required for symptoms or descriptions.

2) CHECK FOR SERVICE UPDATES:

ENGINE SERIAL NUMBER: _____ **ENGINE MODEL NUMBER:** _____ **ENGINE HOURS:** _____

HULL NUMBER: _____

ENGINE: None Apply: ___ Performed: _____

BOAT: None Apply: ___ Performed: _____

3) VISUAL INSPECTION:

Inspection	YES	NO
Evidence of an over-heat:		
Engine Harness connectors connected properly:		
Physical Damage - wiring, connectors, assemblies, and Remove Spark Plugs and inspect for fluids.		
Corrosion:		
Hull-clean and free of excessive growth:		

Inspection	YES	NO
Evidence of or Excessive Water in the Bilge:		
Fluid levels checked:		
Leaking Fluids:		
Firing order correct:		
Correct size propellers installed:		
Underwater gear is undamaged:		
Accessories added? If yes, check items		

4) VERIFY THE PROBLEM

	YES	NO	
Does the engine start and continue to run?	go to 3 below	go to 1 below	
1) Key-ON-Engine-OFF (KOEO)	YES	NO	Fuel Press.
Both Fuel Pumps run 2-4 seconds:			
Fuel Pressure near wot specification - when pumps run:			
2) Key-ON-Engine-Running (KOER)	YES	NO	Fuel Press.
Engine cranks:			
Fuel Pressure near wot specification - engine cranking:			
Engine Starts and continues to run:		go to (3) Water Test	
3) WATER TEST	YES	NO	Fuel Press.
Verify reported symptom:			
Fuel Pressure - idle:			
Fuel Pressure - under load, @ WOT:			

Check Accessories Added:

- Heater
- Shower
- Hot Water Tank
- Flush Kit
- Multi-Function Display
- Synchronizer
- After-Market Stereo Equipment
- After-Market Depth/Fish Finder
- After-Market Navigational Equipment, such as GPS, Radar, Sonar, Auto-pilot systems
- After-Market Radio Equipment
- Lights
- Other - (please list)

4A) Revised or additional symptom found?: _____

Figure 2-3 Drivability Checklist

Diagnostics

PCM DRIVABILITY CHECKLIST

5) PERFORM THE OBD SYSTEM CHECK

CODE(S) PRESENT: _____ DIAGNOSTIC PROCEDURE USED: _____ **Continue to Step 6**

6) ISOLATE AND REPAIR THE PROBLEM.

Were you able to isolate and repair the problem? If **YES**, continue to **Step 7**.

If **NO**, complete the Drivability Checklist for No Codes, step 6A below. If the problem is still not resolved, then call for factory technical assistance.

6A) NO CODES - ENGINE RUNS - DRIVABILITY SYMPTOM STILL PRESENT

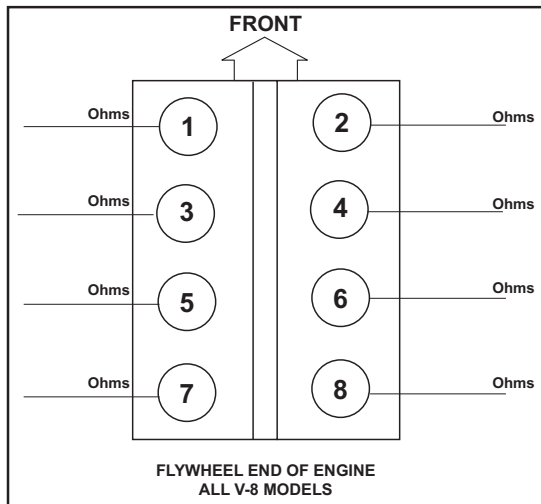
Inspection or Check	YES	NO
1) Review Steps 1 thru 5:		
2) Inspect fuel for contamination:		
3) Electrically isolate engine from boat:		
4) Powertrain is aligned:		
5) Remove and Inspect Distributor Cap and Rotor (5.0/5.7L only):		
6) Check & record Ignition wire resistance:		
7) Remove and Inspect each spark plug:		
8) Perform a Compression Check on all 8 cylinders: Record below.		

Inspection or Check	YES	NO
WATER TEST		
9) Verify CAM Retard** (5.0/5.7L only):		
10) Performance verified against a similar boat w/same engine. package, if available		
11) Perform the Diacom Power Balance Check; under load, @ 1600-1800rpm:		
12) Perform the harness 'Wiggle Test':		
13) Diacom recording-Pre-Delivery test:		

7) VERIFY REPAIR HAS CORRECTED THE PROBLEM. Check for and clear all codes from the ECM memory. **Water test the boat.** Run the engine for a minimum of two (2) minutes, then verify that no codes have returned. Continue with your water test long enough to verify that the problem has been corrected.

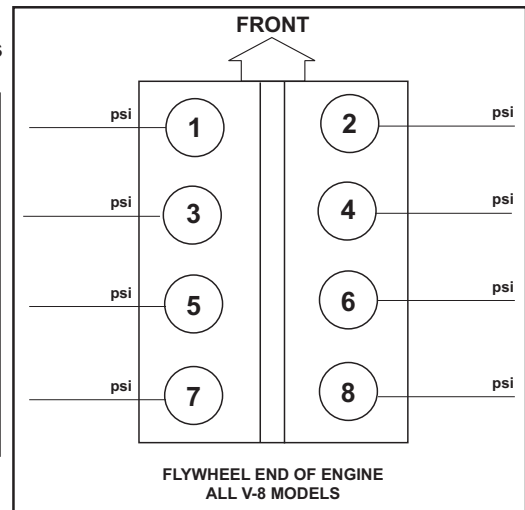
** CAM Retard - '02 thru '06 = 43-47 degrees

'07 - SN 485993 = 0 - 4 degrees/CES and SN 485994 ↑ = 15 ± 2 degrees

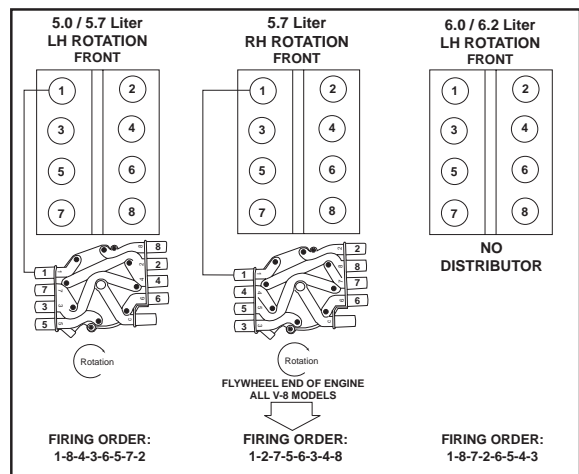


IGNITION WIRE RESISTANCE CHECK
Less than 10,000 ohms/ft

COMPRESSION PRESSURE:
5.0/5.7L - 130-215 psi
6.0L - 130-215 psi
6.2L - 130-215 psi
Lowest pressure should be within 70% of highest pressure.
Minimum cylinder pressure - 100 psi.



COMPRESSION CHECK



REFERENCES:

Master Engine Specification Sheets

L510030 - GCP / 4G Diagnostic Service Manual

L510015 - 5.0/5.7L Engine Mechanical Service Manual

L510016 - 6.0L Engine Mechanical Service Manual

PCM Premier Dealer Website - All the Latest Publications

Figure 2-3 Drivability Checklist

Drivability Checklist

Step 4 - Verify the problem

Refer to Figure 2-2. As you progress through the Drivability Checklist you can see that each step could go to a new troubleshooting tree or system for repair and correction of the owner provided symptom. As was previously discussed, there are certain symptoms or observations that require immediate attention prior to this step.

Figure 2-4 is a trouble tree for Step 4 of Drivability Checklist. As you can see from Figure 2-4, if an action performed fails you may have a new branch to follow to troubleshoot and repair the problem.

We want to verify the problem before you go for a water test and verify the problem. You are going to need your senses, sight, hearing, and touch as much as you will need your tools, the Digital Multi-Meter (DMM), Diacom and Fuel Pressure Gauge, while performing these checks. This will be your first look at the various engine systems, working together, with a focus on troubleshooting the problem. Within a few minutes of testing, you may know the direction of your troubleshooting efforts.

NOTE: For illustrative purposes each test presumes the problem has not been resolved. Therefore, you proceed to the next step. In actual troubleshooting if any step corrects the problem there would be no reason to proceed further, you would verify your repair, Step 7 of the Drivability Checklist, and return the boat to its owner.

o **IMPORTANT:** Review your owner provided symptom. Remember, some symptoms or observations require immediate attention. Ensure you have checked for Service Bulletins and performed a thorough Visual Inspection. As an example, if you have a slow or no crank condition you would perform your Visual Inspection to include the spark plugs and cylinders for fluids, then perform the Main Electrical System Troubleshooting which includes System Power and Starter circuit troubleshooting. Figures 2-7 through 2-11 are the trouble trees for the Main Electrical System and Starter troubleshooting these will be discussed in detail under the Main Electrical section.

1. START the engine.

If the engine starts and continues to run you know you have fuel, spark and air. You have verified the boat to engine electrical interface, system power and grounds, battery, system fuses, all three system relays, fuel pump operation, and the ECM is functioning to start and run the engine. Your next step is the **Water Test**.

o For other conditions, long crank, hard start, no start, stalling, etc., you will branch off to the No Start Troubleshooting Tree, Figure 2-5.

The No Start Troubleshooting Tree, incorporates the **Key-On-Engine-Off (KOEO) test** and other checks to

determine the condition of the engine's Electrical, Fuel, and GCP / 4G/08 systems. Each check is designed to get you to another troubleshooting tree to isolate the system and cause of the problem as quickly as possible.

2. **Place the ignition switch in the Key-ON-Engine-OFF (KOEO) position.** Ensure the boat's safety lanyard is properly connected and the shift lever is in the neutral position. You should listen, feel and observe that the following actions take place:

- o **Both fuel pumps run for 2-4 seconds.** Listen for each fuel pump and place your hand on each pump to verify that it is indeed running. Diacom may be used to cycle the fuel pumps, as necessary. If either or both fuel pumps fail to operate, you would branch to the Key-ON-Engine-OFF- Fuel Pump(s) Do Not Run - Troubleshooting Tree, Figure 2-12.
- o **Observe the Fuel Pressure Gauge; fuel pressure should rise to near the wide-open-throttle (WOT) specification while the fuel pumps run.** If the pumps run but fuel pressure is not to specification, you would branch to the Fuel Pressure Out-of-Range Troubleshooting Tree, Figure 2-13.

NOTE: The Fuel Pump and Pressure troubleshooting trees will be covered in detail under the Fuel System section.

You learn a lot about the engine systems when you turn the ignition ON. The simple action of turning the key to the ON position has allowed you to check several engine systems simultaneously - Electrical, Fuel, and GCP / 4G/08. If the actions described previously occur, then you have verified the:

- o Boat's Ignition Switch,
- o Boat's Safety Lanyard circuit,
- o Low and High Pressure Fuel pumps,
- o Relay - Fuel Pump,
- o 100A Engine Harness Fuse, ECM, VSW, and Fuel Pump Fuses,
- o ECM powered up and functioned to turn on the fuel pumps,
- o Battery voltage is at least 9.6 vdc*, and
- o Power and ground circuits and related components are functioning.

NOTE: *The ECM may not power up if the battery voltage is less than 9.6 vdc.

3. **Engine cranking test.** Do Not turn the key to

Diagnostics

“OFF” between the Key-ON-Engine-OFF test and this test.

Place the ignition switch in the START position, for 25-30 seconds, to crank or roll over the engine. You should observe the following actions:

NOTE: Normal starter cranking RPM is 150-200 RPM. This can be observed on the Diacom display. If normal cranking RPM is not achieved, troubleshoot the starter for a slow crank condition.

- o The engine cranks or rolls over for at least 25-30 seconds,
- o The Fuel Pressure Gauge reading should rise to the same level observed during the Key-On-Engine-Off test. Fuel pressure rising is your indication that the fuel pumps are running.
- o **IF** the engine does not start or starts and stalls, the fuel pumps should run for 2-4 seconds after the key is released from the START position. If the fuel pumps do not run for 2-4 seconds after the key is released, the ECM did not turn the fuel pumps on.

Refer to Figure 2-5. You would branch off and begin your checks with the Ignition fuse. Based on your result you may go on to do a System Power Check or Check the ECM for codes.

NOTE: Turning the key to the ‘START’ position resets the ECM which enables the fuel pumps for 2-4 seconds for prime. If the engine is failing to start, be sure to crank the engine for 5 seconds. You are checking to see if the ECM is receiving the Crankshaft Position Sensor (CKP) and Camshaft Position Sensor (CMP) signals which enable the fuel and ignition circuits. It is the CKP signal that causes the pumps to run for 2-4 seconds after you stop cranking the engine. Cranking for 5 seconds will ensure that a CMP, CKP, MAP (BP), or other code will be stored for a defective device. For troubleshooting, utilize the Diacom scan tool to observe Battery Voltage and Fuel Pump Output status while the engine cranks.

The action of turning the key “ON” then to the “START” position has allowed you to verify more of the operational capability of the three engine systems - Electrical, Fuel, and GCP / 4G/08/08. The additional circuit and component functions verified are:

- o Main Electrical System – all of the Starter Circuit to include the starter relay, transmission neutral safety switch, starter, the associated power and grounds, the boat’s ignition and safety lanyard circuits, and the Battery meets the minimum system voltage requirements,
- o GCP / 4G/08 System – if the fuel pumps run for 2-4 seconds after the key is released from the START position, the Crank Sensor signal is presumed to be present at the ECM enabling the ignition circuits and Fuel System.

Performing the No Start Troubleshooting Tree, typically, will get you back to the point where the engine will be running. You would complete Step 4 of the Drivability Checklist by water testing the boat. During the Water Test, you will be verifying two things:

4. WATER TEST

- (1) Verify the fuel pressure at WOT and under load.

If fuel pressure is correct you have verified the fuel system all the way to the injectors. If the fuel pressure is incorrect, this may be the cause of your symptom, and you would go to the Fuel Pressure Out-Of-Range Troubleshooting Tree.

Remember, it is absolutely essential to verify fuel pressure under load, at wide-open-throttle. This is the only reading that verifies the integrity of the fuel system.

- (2) Verify the reported symptom/problem.

You will verify or revise the reported symptom, then proceed with the checklist to Step 5, the GCP / 4G/08 System Check.

Refer to Figure 2-4, you can see that if an action failed we would go to another branch on the trouble tree.

Should the engine crank normally but fail to start; you would branch off to the No Start Troubleshooting Tree, as we have discussed. From that tree you may branch into the Fuel System, Main Electrical System, or GCP / 4G System based on your test results.

STEP 4
- VERIFY THE PROBLEM -

IMPORTANT:
 FOR A **REPORTED** OVERHEAT OR MAIN ELECTRICAL SYSTEM PROBLEM, SUCH AS BATTERY, STARTER OR CHARGE SYSTEM PROBLEMS - **STOP!**
 PERFORM OVERHEAT TROUBLESHOOTING OR MAIN ELECTRICAL SYSTEM TROUBLESHOOTING FIRST.

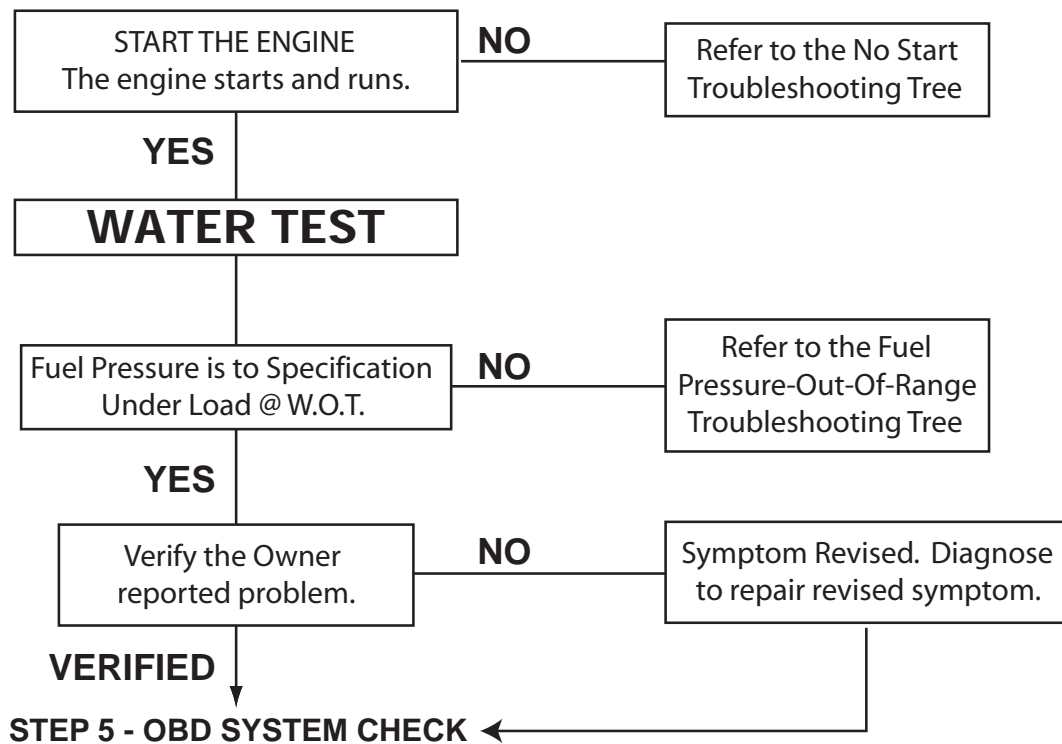
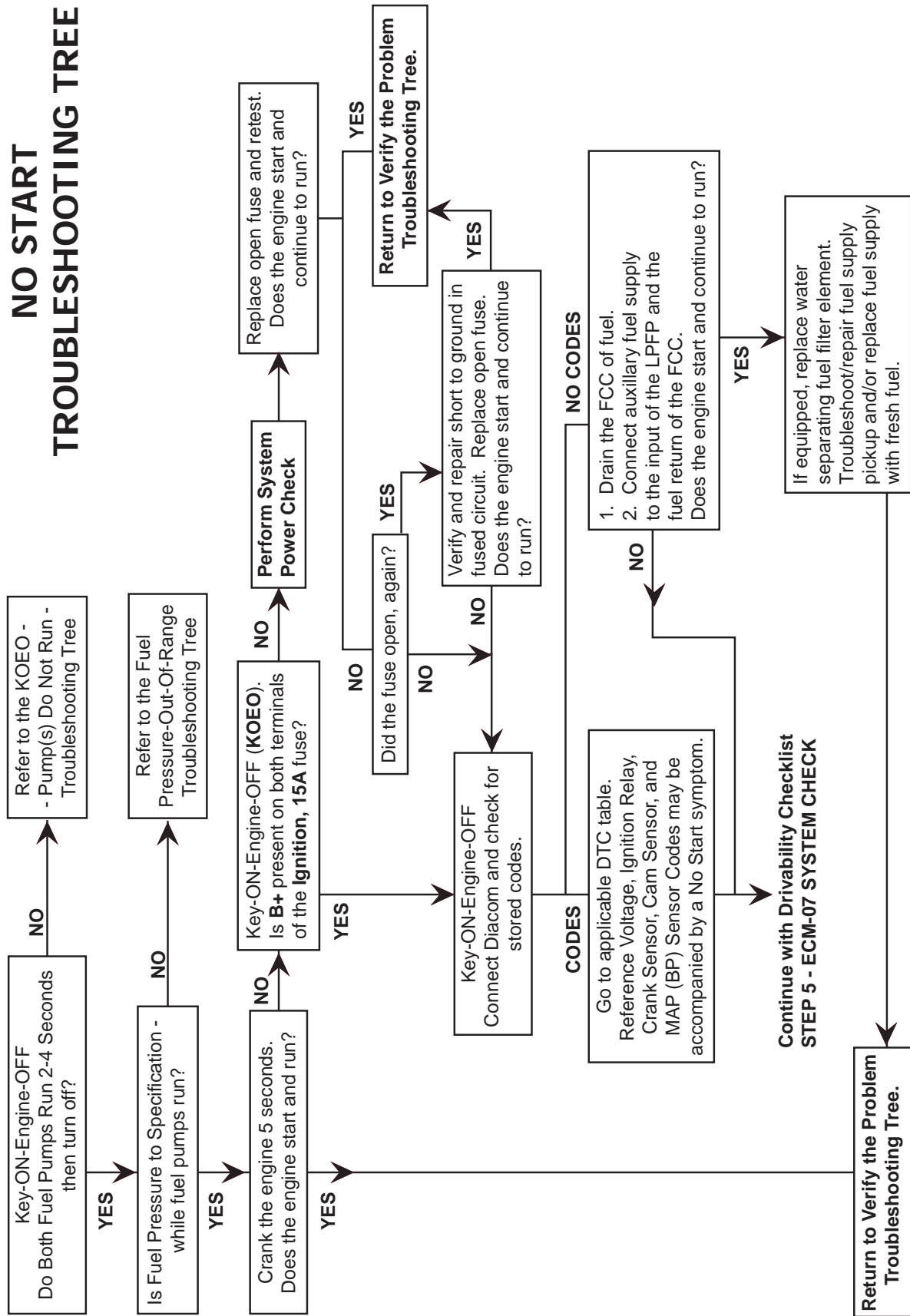


Figure 2-4 Verify the Problem

NO START TROUBLESHOOTING TREE



IMPORTANT:

USE THIS TROUBLESHOOTING TREE FOR THE CONDITION WHERE THE ENGINE CRANKS NORMALLY, BUT WILL NOT START AND CONTINUE TO RUN. USE THE MAIN ELECTRICAL SYSTEM TROUBLESHOOTING TREES FOR SLOW CRANK OR NO CRANK TO TROUBLESHOOT STARTER ISSUES.

Figure 2-5 No Start Troubleshooting Tree

Drivability Checklist

Step 6 - Isolate and Repair the Problem.

Refer to Figure 2-6, The Drivability Checklist - No Codes Troubleshooting Tree, for Step 6A of the Drivability Checklist, Figure 2-3. This trouble tree follows the items listed under Step 6A on the Drivability Checklist. The first check is to review the data collected as you performed the first 5 steps of the checklist.

- o Review the symptom information the owner/operator provided when you questioned him/her on recent events or service.
- o Recheck the engine model and serial number.
- o Recheck the Service Updates.
- o Review your Visual Inspection.
- o Recheck for accessories added.
- o Review Step 4 "Verify The Problem".
- o Run another check for GCP / 4G/08 codes.

If a problem is found, correct that problem before proceeding. If you skipped any portion of the first 5 steps go back and perform those checks or inspections. After you verify that all steps, 1-5, have been properly completed and the results properly analyzed, proceed to step 6A-2.

Refer to Figure 2-3, Step 6A-2. An extremely important test is to verify the quality of the fuel in the boat. Sample the gasoline for water, diesel fuel, and other contaminants. This can be done by draining the FCC fuel bowl into an approved container for inspection.

If fuel system contamination is present or you suspect bad fuel, connect your auxiliary fuel tank to the engine, drain the FCC, and retest the boat. If performance returns to normal, you know you have a fuel quality and/or fuel availability problem. This test analyzes two problems fuel quality and fuel availability at the same time. Be careful not to misinterpret the results.

Remember, proper fuel pressure verifies the components of the fuel system not the quality of the fuel. Always inspect for fuel quality and utilize your auxiliary fuel tank to confirm your findings.

Step 6A-3, is to electrically isolate the engine from the boat. This is done using the RT0091 Test Switch. With the boat harness disconnected and the test switch in place you can operate the engine independent from the boat. Clear codes (if present) and retest. If the engine operates normally, you will have to troubleshoot and repair the boat wiring or systems that were interfering with proper engine operation.

With the increased sophistication in electronics, both engine and boat, it is not unusual for a boat system or wiring to interfere with proper engine operation. Typically, the source of the problem will be a loose or broken connection in the battery, ignition or ground circuits.

Step 6A-4, is to verify proper powertrain alignment. Improper powertrain alignment may affect boat and engine performance. The powertrain cannot be properly aligned if there is damage to the strut or shaft. When you performed the Visual Inspection, Step 3 of the Drivability Checklist, you should have inspected the boat for environmental factors that may cause a loss of engine or boat performance. If you did not perform those inspections do so before performing this step.

Steps 6A-5 – 6A-9, of Figure 2-2, are a series of inspections involving the ignition circuits.

Step 6A-5 - On 5.0/5.7L engines only, remove the distributor cap and inspect the cap and rotor for abnormal conditions.

Step 6A-6 - Check and record the resistance of each spark plug wire. Ignition wire resistance should not be greater than 10,000 ohms per foot. Record the results in the space provided on the Drivability Checklist, Figure 2-3. Leave the plug wires disconnected.

Step 6A-7 - Remove each spark plug and inspect for abnormal conditions such as:

- wrong type, size, reach, or heat range of the spark plug installed,
- improper gap,
- fouling, or
- physical damage.

Step 6A-8 - With all eight spark plugs removed, perform a compression check on all 8 cylinders. Record the results of the compression check in the space provided on the Drivability Checklist. Re install the spark plugs and ensure the ignition wires are all connected and routed properly.

Step 6A-9 - For 5.0/5.7L engines only, with the engine running at idle, verify CAM Retard is between 0-4 degrees using your Diacom scan tool. Adjust as required to set to the proper specification.

Steps 6A-10 – 6A-13 are made with the boat in the water.

Step 6A-10 - Whenever practical, if another boat of similar size, with the same engine package, is available, use it to verify and compare engine parameters for performance issues.

Step 6A-11 - Perform a Power Balance Test on the engine. The Power Balance Test is accessed using your Diacom scan tool. For best results, perform this test with the engine under load, running between 1600 - 1800 RPMs. This test can isolate a coil/ignition module circuit and/or fuel injector circuit problem to a specific cylinder. You would then troubleshoot the cylinder which failed this check.

NOTE: The Diacom Power Balance Test will be discussed in more detail in the GCP / 4G/08 Section, Section 6, under Diacom Test Features.

Step 6A-12 - Perform the engine harness "Wiggle Test".

Diagnostics

With the engine running, start at the boat/engine harness 2 and 8 pin connectors and wiggle the harness. Move forward along the starboard side wiggling the harness at sensor, injector and coil connections. Then repeat for the port side of the harness. A change in engine operation indicates a wiring defect in the area where the wires were wiggled. Repair wiring or connections as required.

Step 6A-13 - The final test to perform is to record the Pre-Delivery Inspection test run. Review this Diacom data file against similar new engine Pre-Delivery Diacom recordings. Look for data that is out of range versus new engine data. Troubleshoot and repair circuits that read out of range. File this test and all relative information in the customer's service and/or sales file(s).

Completing the steps on your Drivability Checklist, through step 6A, will locate most symptomatic problems. Be sure to record all your findings as you perform the Drivability Checklist. If you have completed the Drivability Checklist through Step 6A, and have not found and resolved the problem:

STOP - call the PCM Technical Service Department for assistance. PCM Warranty and Service Department: **803-345-0050**.

Have your completed Drivability Checklist and Diacom recording readily available, then call the PCM Technical Service Department for assistance. You may be requested to fax or e-mail a copy of the checklist to the Technical Service Department during your discussion with the factory service representative.

STEP 6A DRIVABILITY CHECKLIST - NO CODES

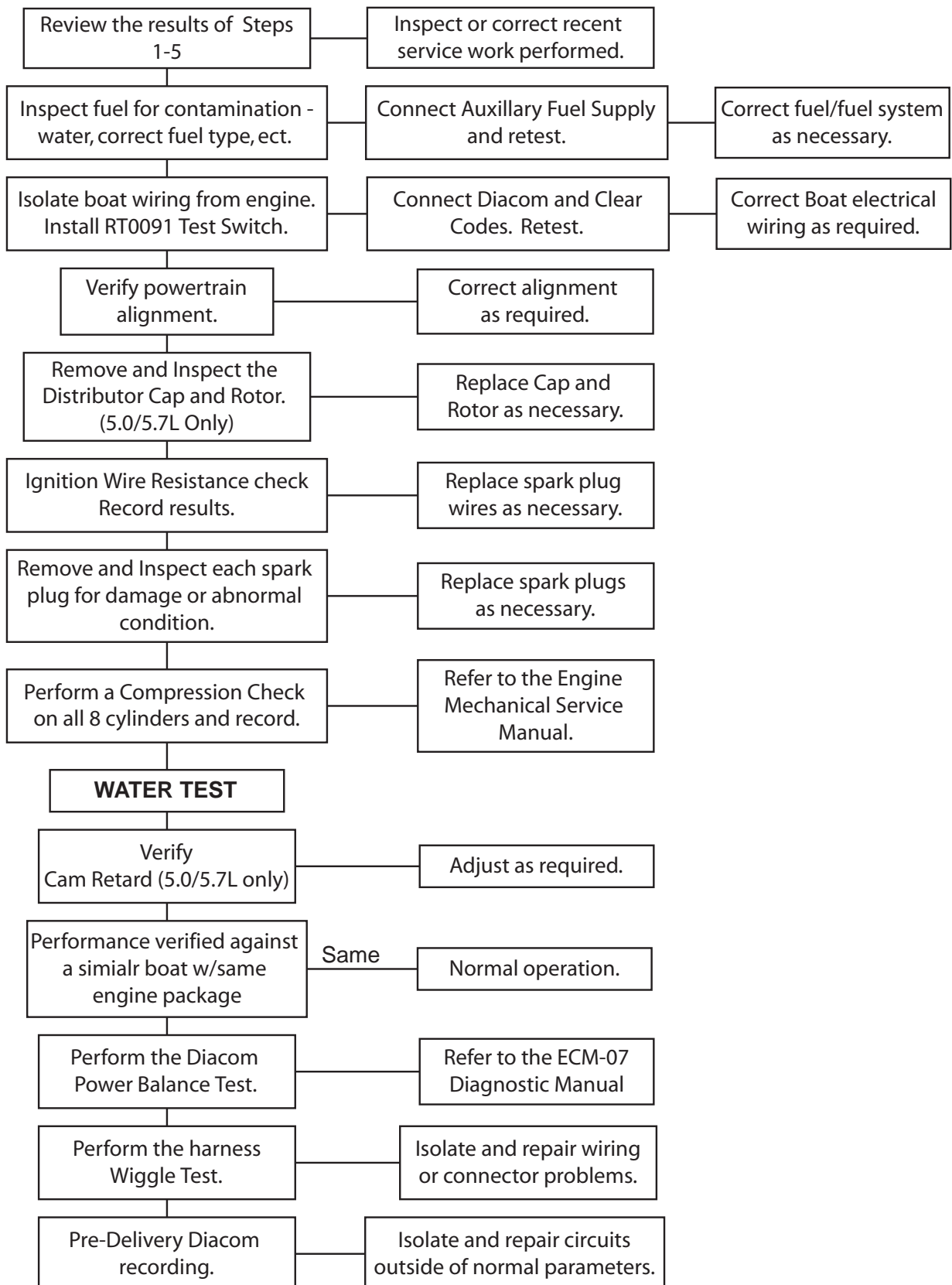


Figure 2-6 Drivability Checklist - No Codes

MAIN ELECTRICAL SYSTEM TROUBLESHOOTING TREE

Dead Battery, Charge System Problems,
No Crank, Slow Crank or any problem
related to the main system power.

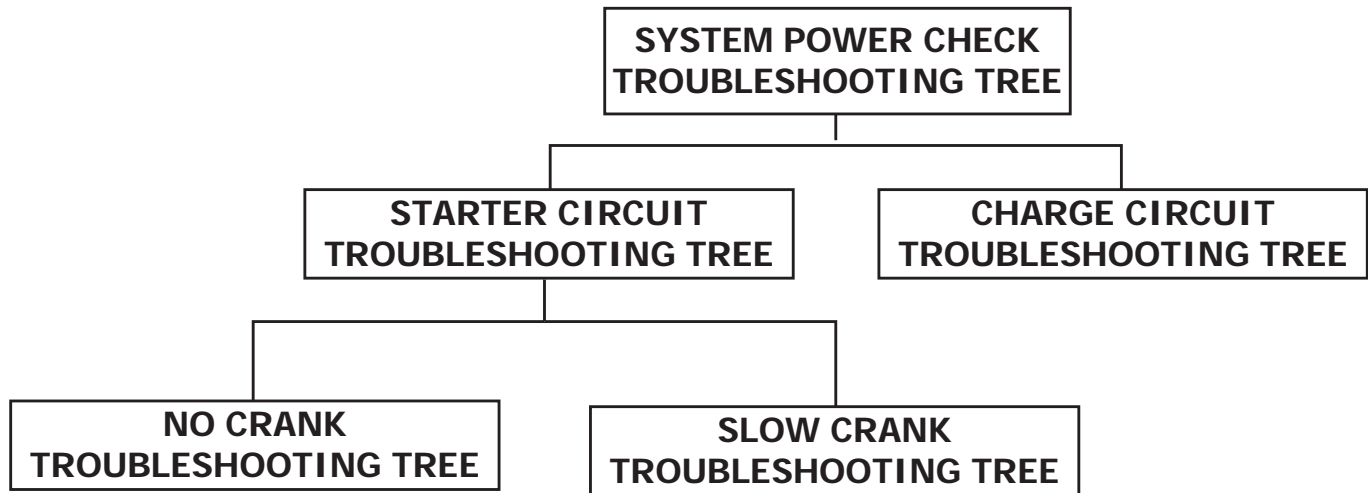


Figure 2-7 Main Electrical System Troubleshooting Tree

SYSTEM POWER CHECK TROUBLESHOOTING TREE

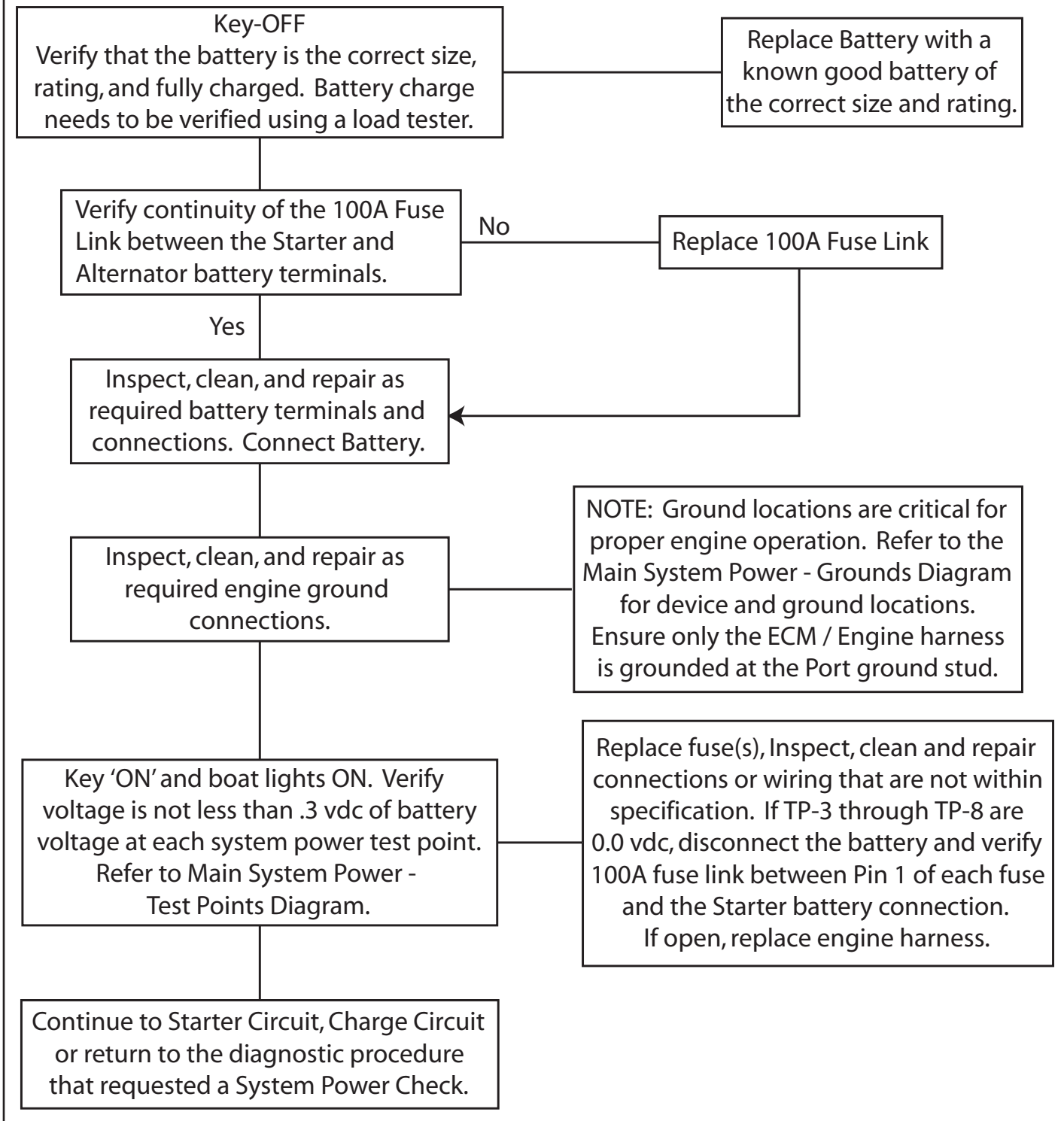


Figure 2-8 System Power Troubleshooting Tree

Diagnostics

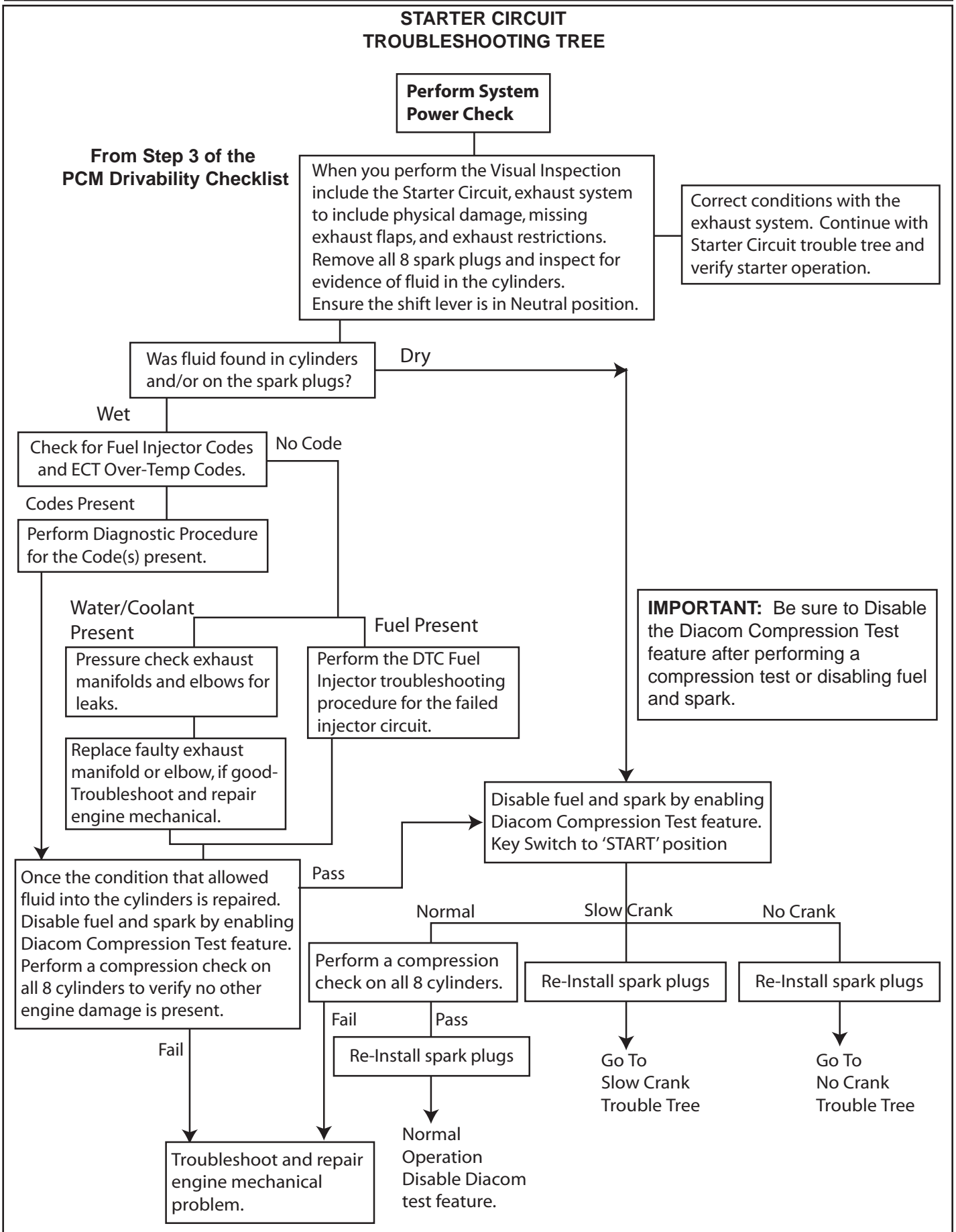
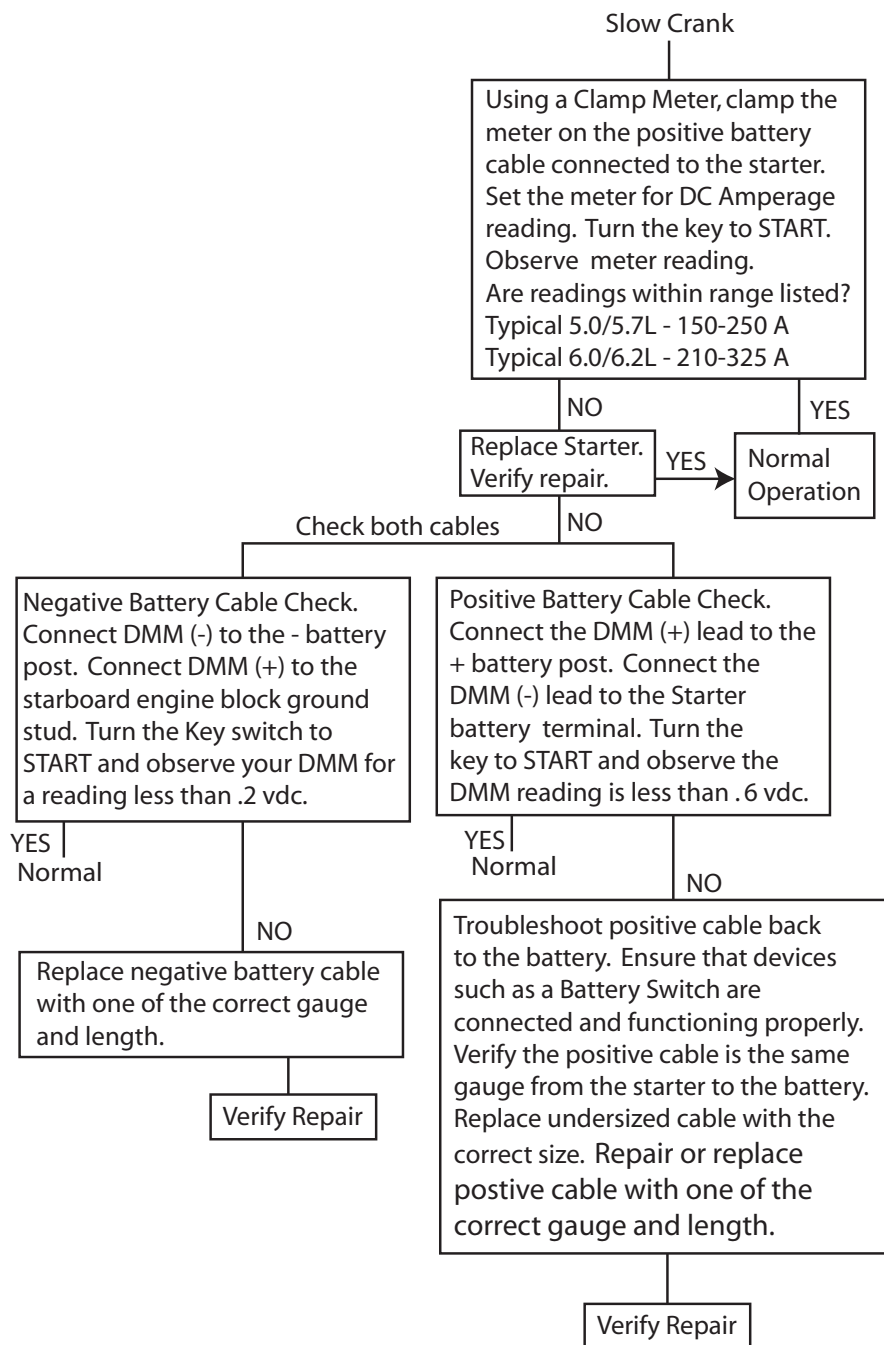


Figure 2-9 Starter Circuit Troubleshooting Tree

STARTER CIRCUIT TROUBLESHOOTING TREE SLOW CRANK CONDITION



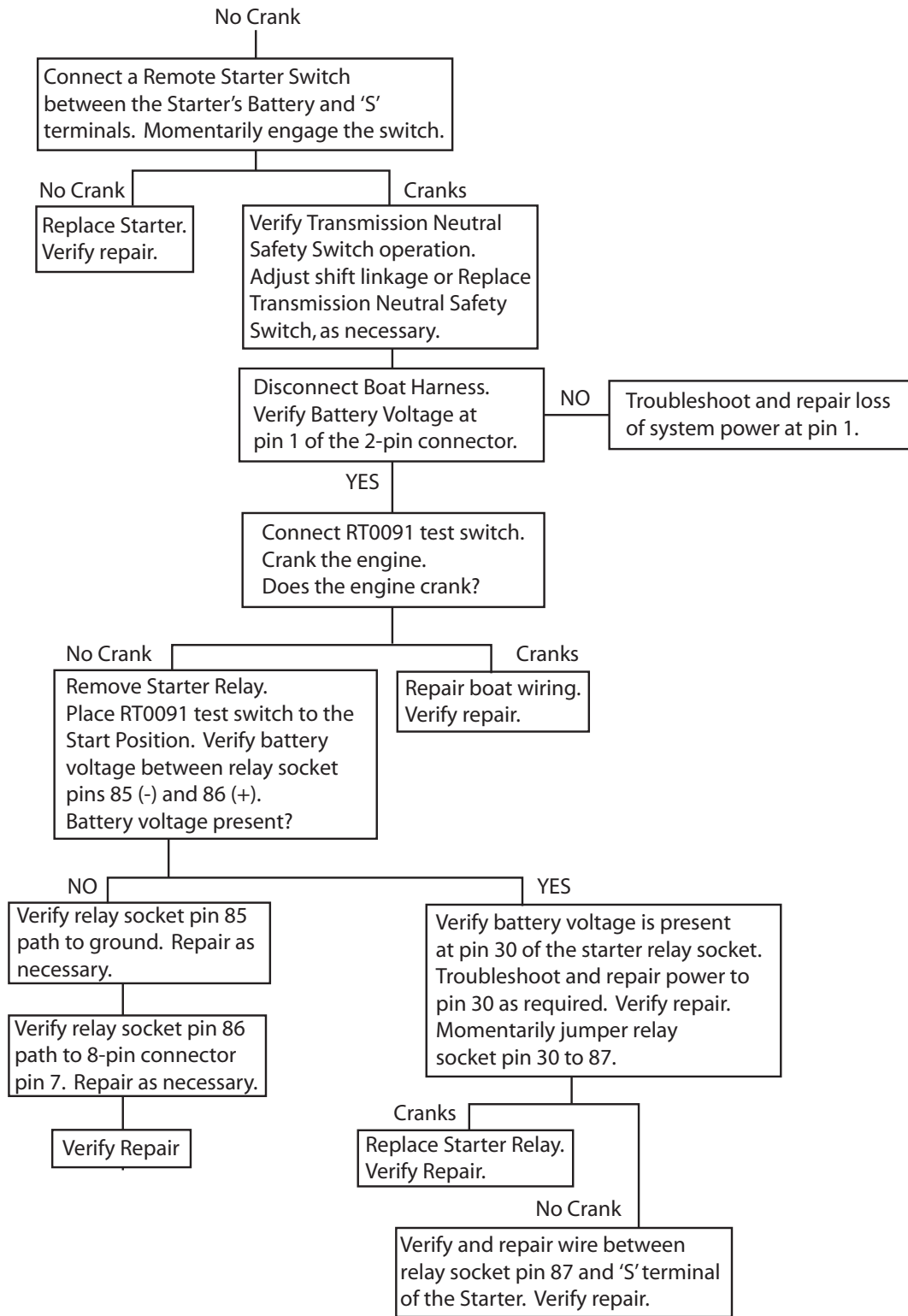
***** IMPORTANT *****

When you have completed your troubleshooting and repair of the starter, be sure to disable the Diacom Compression Test feature, then verify the engine starts and runs.

Figure 2-10 Starter Circuit - Slow Crank

Diagnostics

STARTER CIRCUIT TROUBLESHOOTING TREE NO CRANK CONDITION

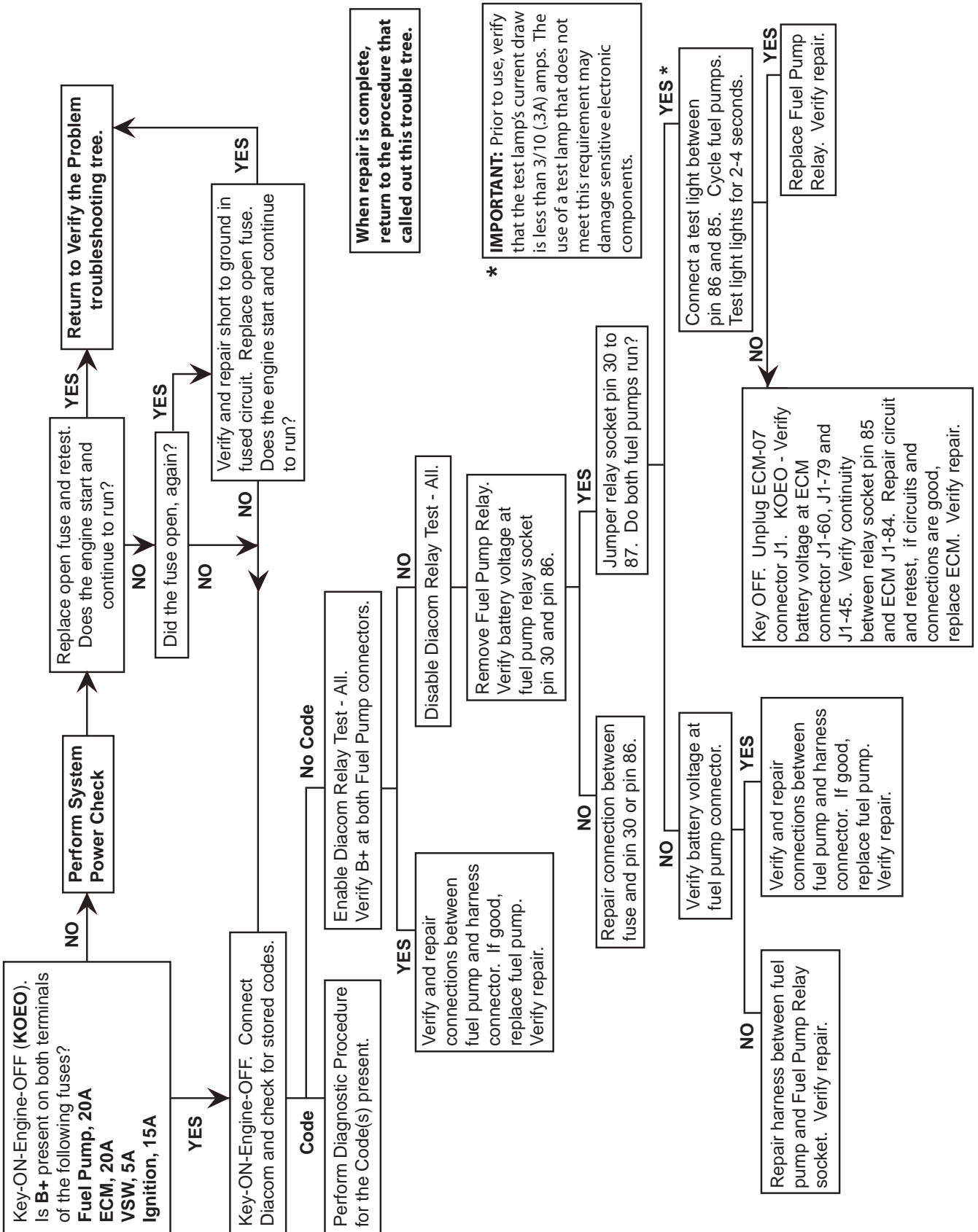


***** IMPORTANT *****

When you have completed your troubleshooting and repair of the starter, be sure to disable Diacom Compression Test feature, then verify the engine starts and runs.

Figure 2-11 Starter Circuit - No Crank

KEY-ON-ENGINE-OFF - FUEL PUMP(S) DON'T RUN - TROUBLESHOOTING TREE



When repair is complete, return to the procedure that called out this trouble tree.

*** IMPORTANT:** Prior to use, verify that the test lamp's current draw is less than 3/10 (.3A) amps. The use of a test lamp that does not meet this requirement may damage sensitive electronic components.

Figure 2-12 Fuel System - Fuel Pump(s) Do Not Run

KEY-ON-ENGINE-OFF FUEL PRESSURE OUT OF RANGE - PUMPS RUN

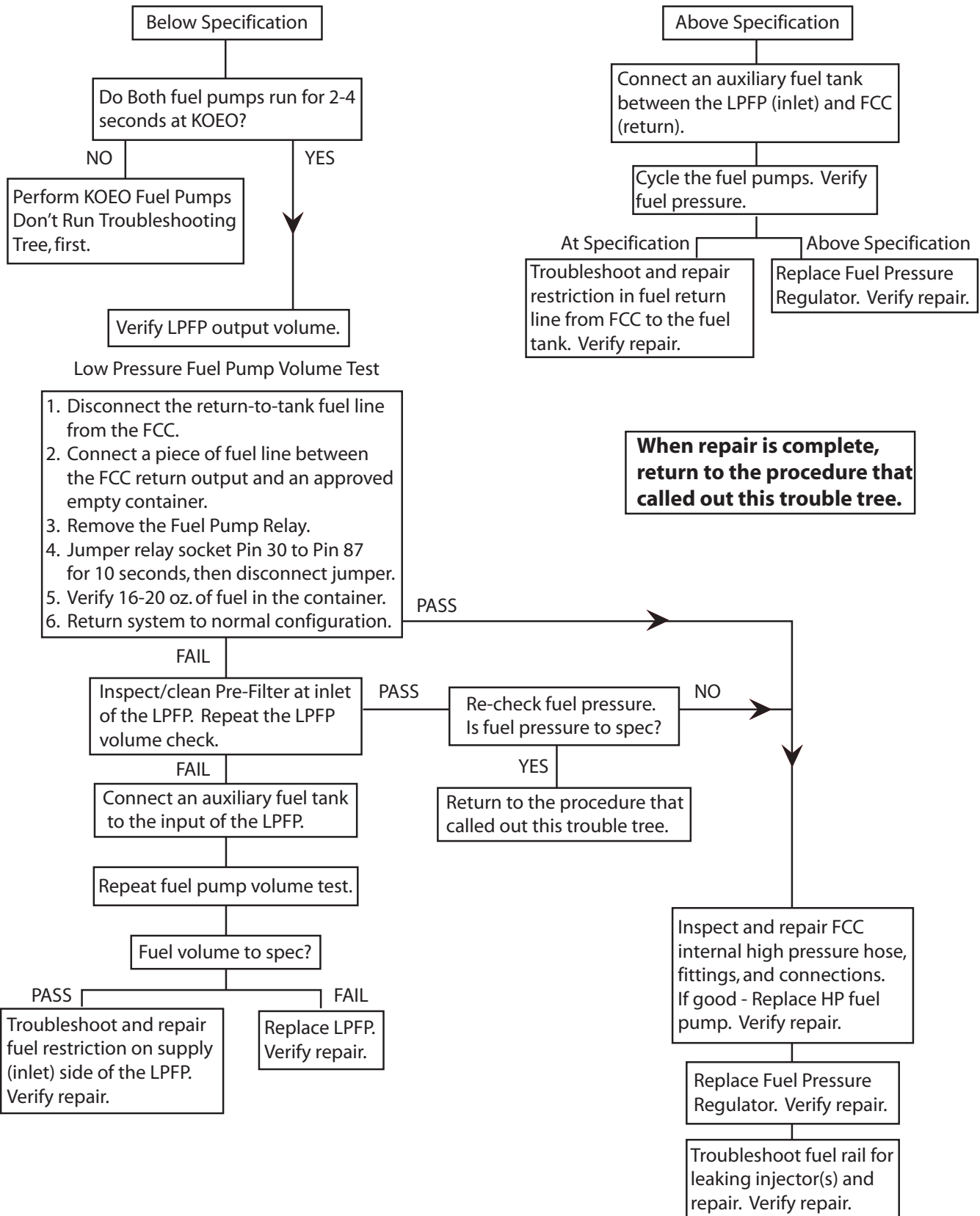


Figure 2-13 Fuel System - Fuel Pressure Out-Of-Range

Diagnostics

Diagnostic Trouble Code (DTC)	Suspect Parameter Number (SPN)	Failure Mode Identifier (FMI)	Fault Description
DTC 107	106	4	MAP voltage low
DTC 108	106	16	MAP pressure high
DTC 1087	94	1	Secondary Fuel Pressure Low Pressure
DTC 1088	94	0	Secondary Fuel Pressure High Pressure
DTC 11	520800	7	Distributor Position Error
DTC 111	105	15	IAT higher than expected stage 1
DTC 1111	515	16	RPM above fuel rev limit level
DTC 1112	515	0	RPM above spark rev limit level
DTC 1113	515	31	RPM higher than expected
DTC 112	105	4	IAT voltage low
DTC 1121	91	31	FPP1/2 simultaneous voltages out-of-range (redundancy lost)
DTC 1122	520199	11	FPP1/2 do not match each other or IVS (redundancy lost)
DTC 113	105	3	IAT voltage high
DTC 1155	4236	0	Closed-loop gasoline bank1 high
DTC 1156	4236	1	Closed-loop gasoline bank1 low
DTC 1157	4238	0	Closed-loop gasoline bank2 high
DTC 1158	4238	1	Closed-loop gasoline bank2 low
DTC 116	110	15	ECT higher than expected stage 1
DTC 117	110	4	ECT voltage low
DTC 118	110	3	ECT voltage high
DTC 121	51	1	TPS1-2 lower than expected
DTC 122	51	4	TPS1 voltage low
DTC 123	51	3	TPS1 voltage high
DTC 127	105	0	IAT higher than expected stage 2
DTC 129	108	1	BP pressure low
DTC 1311	1323	11	Cylinder 1 misfire detected
DTC 1312	1324	11	Cylinder 2 misfire detected
DTC 1313	1325	11	Cylinder 3 misfire detected
DTC 1314	1326	11	Cylinder 4 misfire detected
DTC 1315	1327	11	Cylinder 5 misfire detected
DTC 1316	1328	11	Cylinder 6 misfire detected
DTC 1317	1329	11	Cylinder 7 misfire detected
DTC 1318	1330	11	Cylinder 8 misfire detected
DTC 1325	731	15	Knock retard at limit

Diagnostic Trouble Code (DTC)	Suspect Parameter Number (SPN)	Failure Mode Identifier (FMI)	Fault Description
DTC 134	3217	5	EGO1 open / lazy
DTC 140	3256	5	EGO3 open / lazy
DTC 1411	441	3	EMWT1 voltage high
DTC 1412	442	3	EMWT2 voltage high
DTC 1413	441	4	EMWT1 voltage low
DTC 1414	442	4	EMWT2 voltage low
DTC 1415	441	15	EMWT1 higher than expected stage 1
DTC 1416	442	15	EMWT2 higher than expected stage 1
DTC 1417	441	0	EMWT1 higher than expected stage 2
DTC 1418	442	0	EMWT2 higher than expected stage 2
DTC 1421	1385	3	ERWT1 voltage high
DTC 1422	1386	3	ERWT2 voltage high
DTC 1423	1385	4	ERWT1 voltage low
DTC 1424	1386	4	ERWT2 voltage low
DTC 1425	1385	15	ERWT1 higher than expected stage 1
DTC 1426	1386	15	ERWT2 higher than expected stage 1
DTC 1427	1385	0	ERWT1 higher than expected stage 2
DTC 1428	1386	0	ERWT2 higher than expected stage 2
DTC 154	3227	5	EGO2 open / lazy
DTC 1542	704	4	AUX analog Pull-Up/Down 1 low voltage (Transmission Temp.)
DTC 16	636	8	Crank and/or cam could not synchronize during start
DTC 160	3266	5	EGO4 open / lazy
DTC 1611	1079	31	Sensor supply voltage 1 and 2 out-of-range
DTC 1612	629	31	Microprocessor failure - RTI 1
DTC 1613	629	31	Microprocessor failure - RTI 2
DTC 1614	629	31	Microprocessor failure - RTI 3
DTC 1615	629	31	Microprocessor failure - A/D
DTC 1616	629	31	Microprocessor failure - Interrupt
DTC 1639	924	5	PWM5 open or short to ground - CAM Phaser Circuit
DTC 1640	924	3	PWM5 short to power - CAM Phaser Circuit
DTC 1673	1634	13	Calibration configuration error
DTC 1674	1634	2	Internal processor hardware ID failure
DTC 171	4237	0	Adaptive-learn gasoline bank1 high
DTC 172	4237	1	Adaptive-learn gasoline bank1 low

Diagnostics

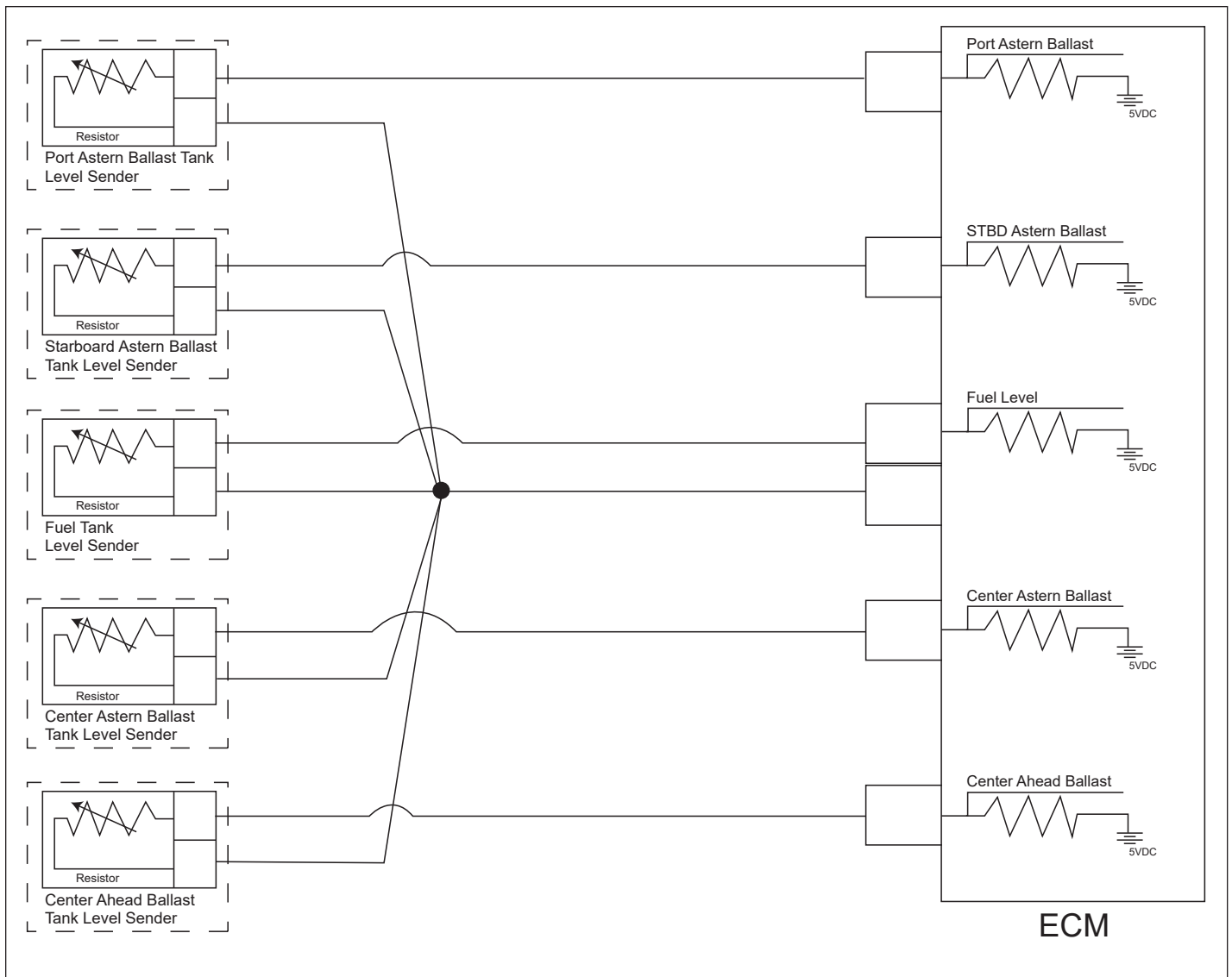
Diagnostic Trouble Code (DTC)	Suspect Parameter Number (SPN)	Failure Mode Identifier (FMI)	Fault Description
DTC 174	4239	0	Adaptive-learn gasoline bank2 high
DTC 175	4239	1	Adaptive-learn gasoline bank2 low
DTC 2111	51	7	Unable to reach lower TPS
DTC 2112	51	7	Unable to reach higher TPS
DTC 2115	91	0	FPP1 higher than IVS
DTC 2116	29	0	FPP2 higher than IVS
DTC 2120	520199	11	FPP1 invalid voltage and FPP2 disagrees with IVS (redundancy lost)
DTC 2121	91	18	FPP1-2 lower than expected
DTC 2122	91	3	FPP1 voltage high
DTC 2123	91	4	FPP1 voltage low
DTC 2125	520199	11	FPP2 invalid voltage and FPP1 disagrees with IVS (redundancy lost)
DTC 2126	91	16	FPP1-2 higher than expected
DTC 2127	29	4	FPP2 voltage low
DTC 2128	29	3	FPP2 voltage high
DTC 2130	558	5	IVS stuck at-idle, FPP1/2 match
DTC 2131	558	6	IVS stuck off-idle, FPP1/2 match
DTC 2135	51	31	TPS1/2 simultaneous voltages out-of-range
DTC 2139	91	1	FPP1 lower than IVS
DTC 2140	29	1	FPP2 lower than IVS
DTC 217	110	0	ECT higher than expected stage 2
DTC 219	515	15	RPM higher than max allowed govern speed
DTC 221	51	0	TPS1-2 higher than expected
DTC 222	3673	4	TPS2 voltage low
DTC 2229	108	0	BP pressure high
DTC 223	3673	3	TPS2 voltage high
DTC 2295	94	4	Secondary fuel pressure low voltage
DTC 2296	94	3	Secondary fuel pressure high voltage
DTC 236	102	2	TOP sensor high voltage
DTC 237	102	4	TOP sensor low voltage
DTC 238	102	3	TOP sensor active
DTC 2428	173	0	EGT temperature high
DTC 261	651	5	Injector 1 open or short to ground
DTC 2618	645	4	Tach output ground short
DTC 2619	645	3	Tach output short to power

Diagnostic Trouble Code (DTC)	Suspect Parameter Number (SPN)	Failure Mode Identifier (FMI)	Fault Description
DTC 262	651	6	Injector 1 coil shorted
DTC 264	652	5	Injector 2 open or short to ground
DTC 265	652	6	Injector 2 coil shorted
DTC 267	653	5	Injector 3 open or short to ground
DTC 268	653	6	Injector 3 coil shorted
DTC 270	654	5	Injector 4 open or short to ground
DTC 271	654	6	Injector 4 coil shorted
DTC 273	655	5	Injector 5 open or short to ground
DTC 274	655	6	Injector 5 coil shorted
DTC 276	656	5	Injector 6 open or short to ground
DTC 277	656	6	Injector 6 coil shorted
DTC 279	657	5	Injector 7 open or short to ground
DTC 280	657	6	Injector 7 coil shorted
DTC 282	658	5	Injector 8 open or short to ground
DTC 283	658	6	Injector 8 coil shorted
DTC 301	1323	31	Cylinder 1 emissions/catalyst damaging misfire
DTC 302	1324	31	Cylinder 2 emissions/catalyst damaging misfire
DTC 303	1325	31	Cylinder 3 emissions/catalyst damaging misfire
DTC 304	1326	31	Cylinder 4 emissions/catalyst damaging misfire
DTC 305	1327	31	Cylinder 5 emissions/catalyst damaging misfire
DTC 306	1328	31	Cylinder 6 emissions/catalyst damaging misfire
DTC 307	1329	31	Cylinder 7 emissions/catalyst damaging misfire
DTC 308	1330	31	Cylinder 8 emissions/catalyst damaging misfire
DTC 3104	3104	5	IMV loop open or short to ground
DTC 3105	3105	6	IMV coil short or short to power
DTC 326	731	2	Knock1 excessive or erratic signal
DTC 327	731	4	Knock1 sensor open or not present
DTC 331	520197	2	Knock2 excessive or erratic signal
DTC 332	520197	4	Knock2 sensor open or not present
DTC 336	636	2	CRANK input signal noise
DTC 337	636	4	Crank signal loss
DTC 341	723	2	CAM input signal noise
DTC 342	723	4	Loss of CAM input signal
DTC 420	3050	11	Catalyst inactive on gasoline (Bank 1)

Diagnostics

Diagnostic Trouble Code (DTC)	Suspect Parameter Number (SPN)	Failure Mode Identifier (FMI)	Fault Description
DTC 430	3051	11	Catalyst inactive on gasoline (Bank 2)
DTC 502	84	8	Roadspeed input loss of signal
DTC 521	100	0	Oil pressure sender high pressure
DTC 522	100	4	Oil pressure sender low voltage
DTC 523	100	3	Oil pressure sender high voltage
DTC 524	100	1	Oil pressure low
DTC 562	168	17	Vbat voltage low
DTC 563	168	15	Vbat voltage high
DTC 601	628	13	Microprocessor failure - FLASH
DTC 604	630	12	Microprocessor failure - RAM
DTC 606	629	31	Microprocessor failure - COP
DTC 627	1348	5	Fuel pump relay coil open
DTC 628	1347	5	Fuel-pump high-side open or short to ground
DTC 629	1347	6	Fuel-pump high-side short to power
DTC 642	1079	4	Sensor supply voltage 1 low
DTC 643	1079	3	Sensor supply voltage 1 high
DTC 650	1213	5	MIL open
DTC 652	1080	4	Sensor supply voltage 2 low
DTC 653	1080	3	Sensor supply voltage 2 high
DTC 685	1485	5	Power relay coil open
DTC 686	1485	4	Power relay ground short
DTC 687	1485	3	Power relay coil short to power
DTC 87	94	1	Primary Fuel Pressure Low Pressure
DTC 88	94	0	Primary Fuel Pressure High Pressure
DTC 8901	3221	31	UEGO1 internal processor fault
DTC 8902	3222	3	UEGO1 heater supply high voltage
DTC 8903	3222	4	UEGO1 heater supply low voltage
DTC 8904	3221	3	UEGO1 cal resistor voltage high
DTC 8905	3221	4	UEGO1 cal resistor voltage low
DTC 8906	3056	3	UEGO1 return voltage shorted high
DTC 8907	3056	4	UEGO1 return voltage shorted low
DTC 8908	3218	3	UEGO1 pump voltage shorted high
DTC 8909	3218	4	UEGO1 pump voltage shorted low
DTC 8910	3217	3	UEGO1 sense cell voltage high

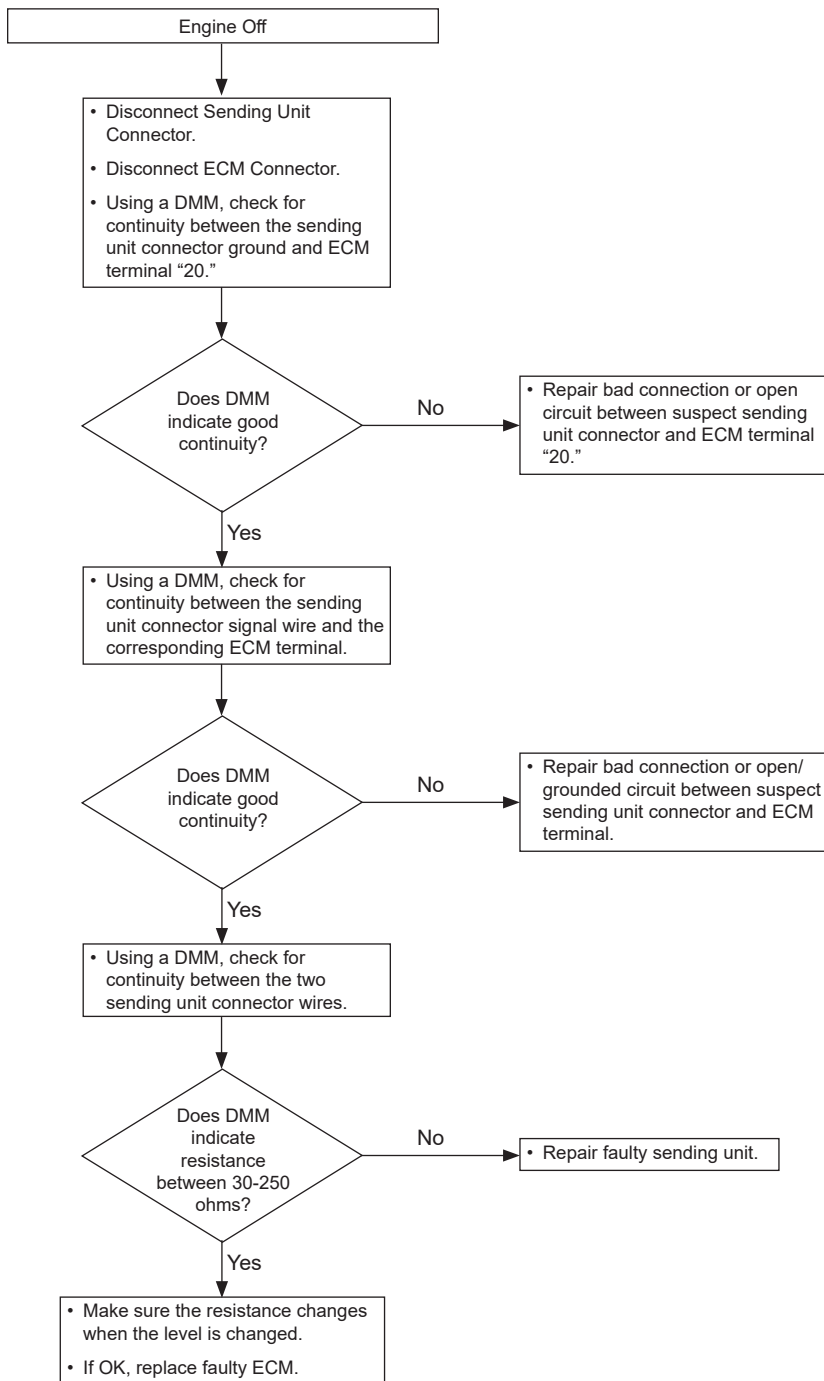
Diagnostic Trouble Code (DTC)	Suspect Parameter Number (SPN)	Failure Mode Identifier (FMI)	Fault Description
DTC 8911	3217	4	UEGO1 sense cell voltage low
DTC 8912	3225	3	UEGO1 pump voltage at high drive limit
DTC 8913	3225	4	UEGO1 pump voltage at low drive limit
DTC 8914	3222	10	UEGO1 sense cell slow to warm up
DTC 8915	3225	10	UEGO1 pump cell slow to warm up
DTC 8916	3222	0	UEGO1 sense cell impedance high
DTC 8917	3225	0	UEGO1 pump cell impedance high
DTC 8918	3225	1	UEGO1 pump cell impedance low
DTC 8919	67049	31	UEGO2 internal processor fault
DTC 8920	67050	3	UEGO2 heater supply high voltage
DTC 8921	67051	4	UEGO2 heater supply low voltage
DTC 8922	67052	3	UEGO2 cal resistor voltage high
DTC 8923	67053	4	UEGO2 cal resistor voltage low
DTC 8924	67054	3	UEGO2 return voltage shorted high
DTC 8925	67055	4	UEGO2 return voltage shorted low
DTC 8926	67056	3	UEGO2 pump voltage shorted high
DTC 8927	67057	4	UEGO2 pump voltage shorted low
DTC 8928	67058	3	UEGO2 sense cell voltage high
DTC 8929	67059	4	UEGO2 sense cell voltage low
DTC 8930	67060	3	UEGO2 pump voltage at high drive limit
DTC 8931	67061	4	UEGO2 pump voltage at low drive limit
DTC 8932	67062	10	UEGO2 sense cell slow to warm up
DTC 8933	67063	10	UEGO2 pump cell slow to warm up
DTC 8934	67064	0	UEGO2 sense cell impedance high
DTC 8935	67065	0	UEGO2 pump cell impedance high
DTC 8936	67066	1	UEGO2 pump cell impedance low
DTC 8937	3222	4	UEGO1 heater open / ground short
DTC 8938	3222	3	UEGO1 heater short to power
DTC 8940	3232	4	UEGO2 heater open / ground short
DTC 8941	3232	3	UEGO2 heater short to power
DTC 91	94	4	Primary fuel pressure low voltage
DTC 92	94	3	Primary fuel pressure high voltage



- Ballast Level / Fuel Level - LINC System
- *Check Condition* - None
- *Fault Condition* - None

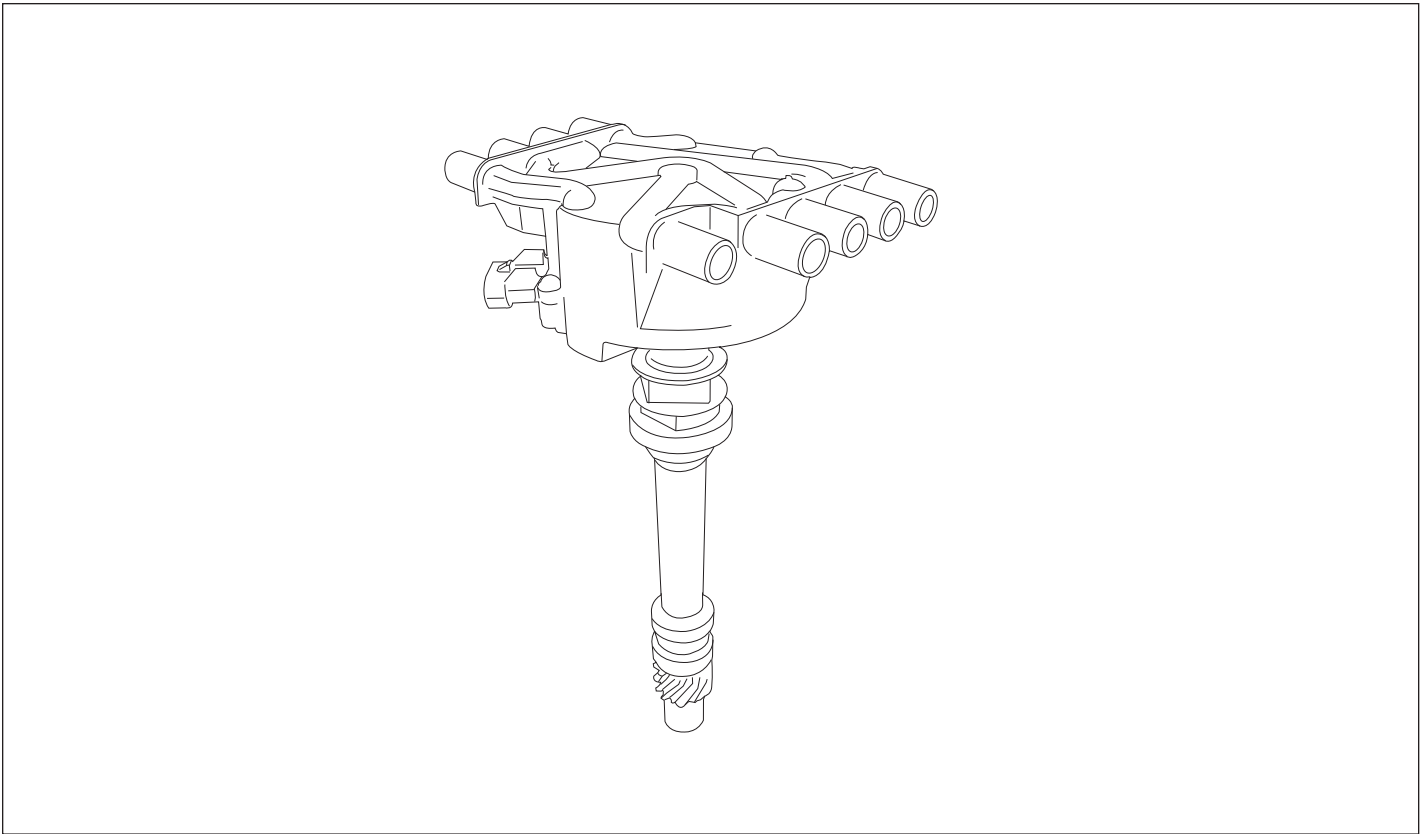
On some models, the fuel level and/or ballast tank levels are inputs to the ECM. The ECM converts the data and outputs a percentage level on the CAN BUS. Faults to these circuits do not set diagnostic trouble codes. The following chart will aid in determining the fault within one of these level circuits.

Ballast Tank Level / Fuel Level Diagnostics



Diagnostics

DTC 0011 - Distributor Alignment Error - 5.0/5.7L Engines Only / Cam Position Error SPN - 520800; FMI - 7

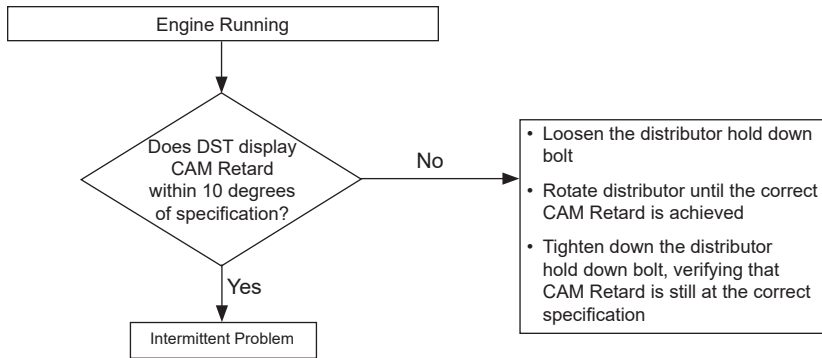


- Distributor Alignment (Position) Error / Cam Position Error
- *Check Condition* - Engine Running
- *Fault Condition* - Engine distributor position is greater than 10 degrees from specification
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning
- Emissions related fault

The camshaft position sensor is a magnetic sensor installed in the distributor on 5.0/5.7L engines adjacent to a “coded” trigger wheel. The sensor-trigger wheel combination is used to determine cam position (with respect to TDC cylinder #1 compression).

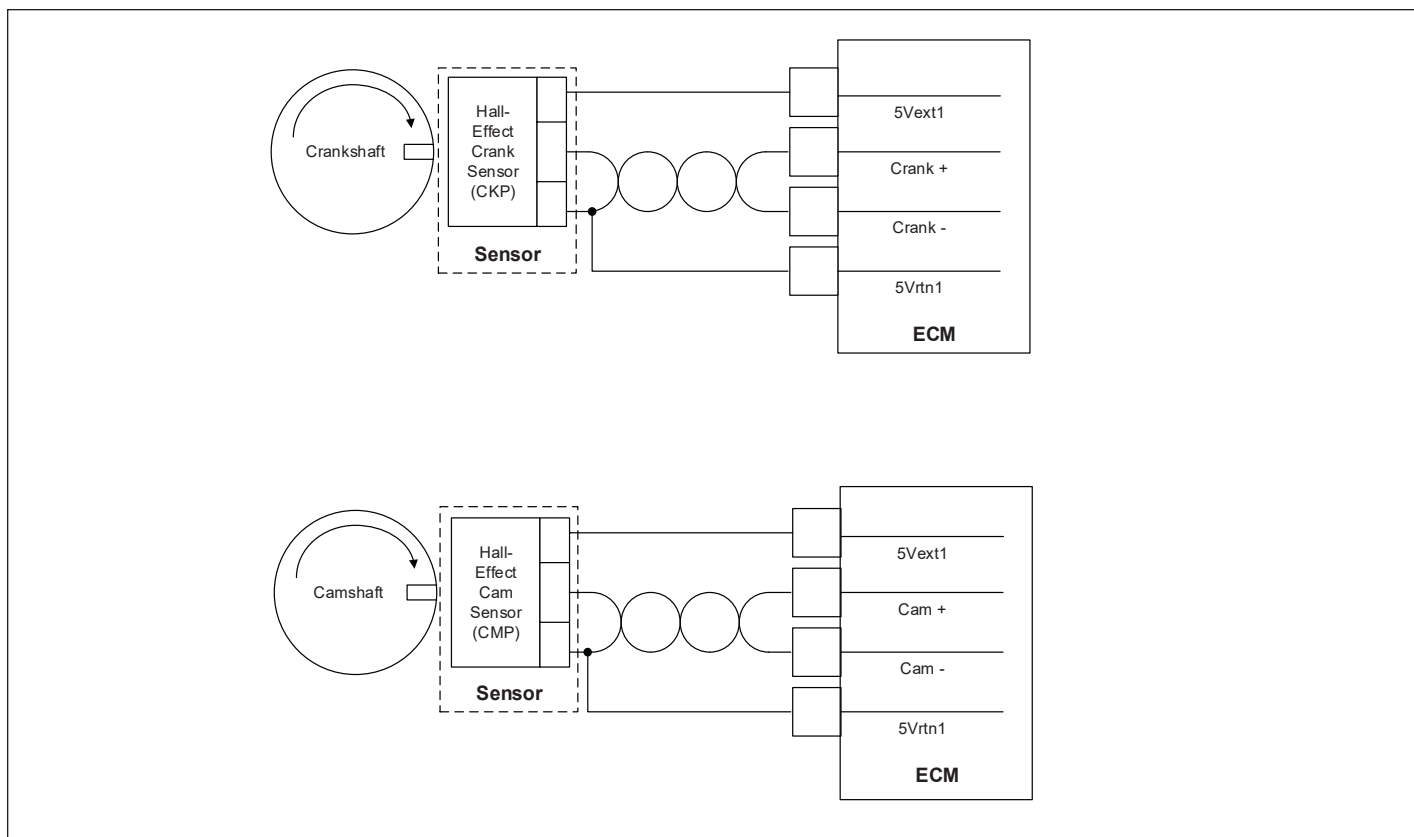
The cam position, or distributor alignment, must be within 10 degrees of specification. If this position is off by more than the 10 degrees, the MIL will be illuminated and some ignition “cross firing” may occur at certain RPM and load conditions.

DTC 0011 - Distributor Alignment Error - 5.0/5.7L Engines Only / Cam Position Error SPN - 520800; FMI - 7



Diagnostics

DTC 0016 - Crank and/or Cam Could Not Synchronize During Start SPN - 636; FMI - 8



- Crankshaft Position Sensor/Camshaft Position Sensor
- *Check Condition* - Engine Cranking or Running
- *Fault Condition* - Engine rotates without crank and/or cam synchronization
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Emissions related fault

The crankshaft position sensor is a magnetic sensor installed in the engine block adjacent to a “coded” trigger wheel located on the crankshaft. The sensor-trigger wheel combination is used to determine crankshaft position (with respect to TDC cylinder #1 compression) and the rotational engine speed. Determination of the crankshaft position and speed is necessary to properly activate the ignition, fuel injection, and throttle governing systems for precise engine control.

The camshaft position sensor is a magnetic sensor installed in the engine block or valve train adjacent to a “coded” trigger wheel located on or off of the camshaft. The sensor-trigger wheel combination is used to determine cam position (with respect to TDC cylinder #1 compression). Determination of the camshaft position is necessary to identify the stroke (or cycle) of the engine to properly activate the fuel injection system and ignition (for coil-on-plug engines) for precise engine control.

The ECM must see a valid crankshaft position and camshaft position signal properly aligned during cranking before it can synchronize the injection and ignition systems to initiate starting. If engine speed > 90 RPM and the crank and cam can not synchronize within 4.0 cranking revs, this fault will set. Typically, this fault will result in an engine that will not start or run.

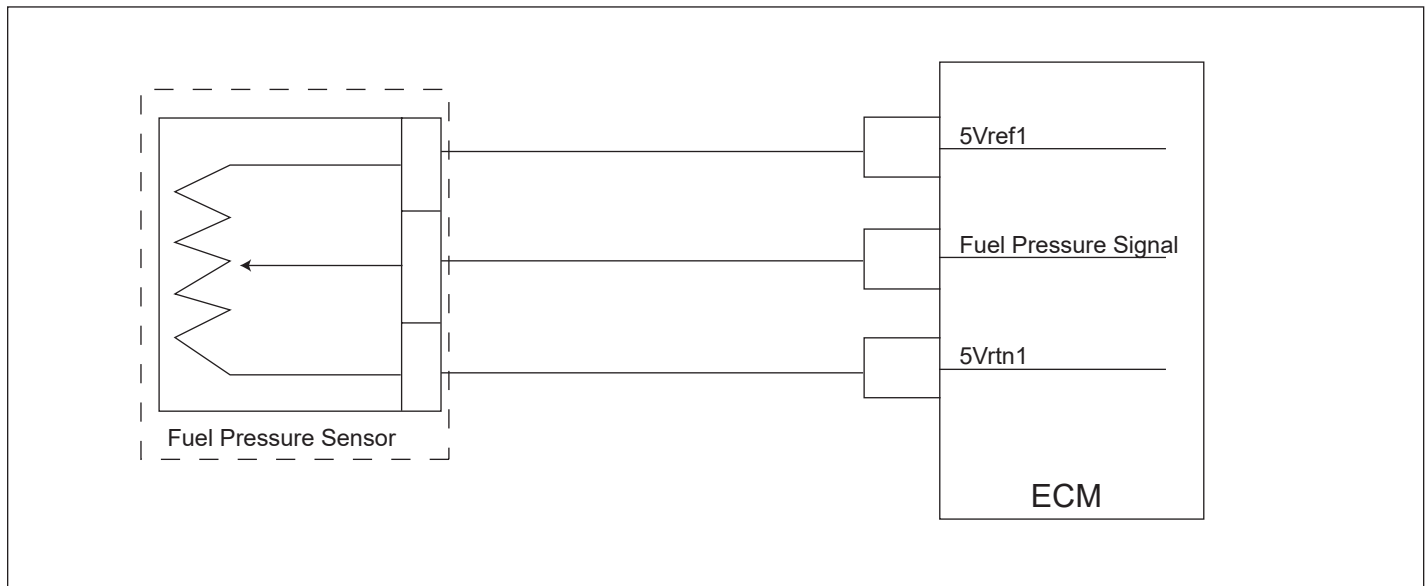
DTC 0016 - Crank and/or Cam Could Not Synchronize During Start SPN - 636; FMI - 8

Diagnostic Aids

- Check that crankshaft and/or camshaft position sensor(s) are securely connected to the harness
- Check that crankshaft and/or camshaft position sensor(s) are securely installed into engine block
- Check crankshaft and/or camshaft position sensor(s) circuit(s) wiring for an open circuit

Diagnostics

DTC 0087 - Primary Fuel Pressure Low Pressure SPN - 94; FMI - 1



- Primary Fuel Pressure Sensor
- *Check Condition* - Engine Running
- *Fault Condition (Direct Injection)* - Engine run time greater than 10 seconds and Target Fuel Pressure minus Actual Fuel Pressure is greater than 20 bar.
- *Fault Condition (Non-Direct Injection)* - Engine run time greater than 10 seconds and Fuel Pressure is less than 55 psi.
- *Corrective Action(s)* - Illuminate MIL, disable adaptive learn and closed loop fueling correction.
- Emissions related fault

The Primary Fuel Pressure sensor is the high pressure fuel rail pressure on direct injection engines. This value can range from 40 to 150 bar and varies based on RPM.

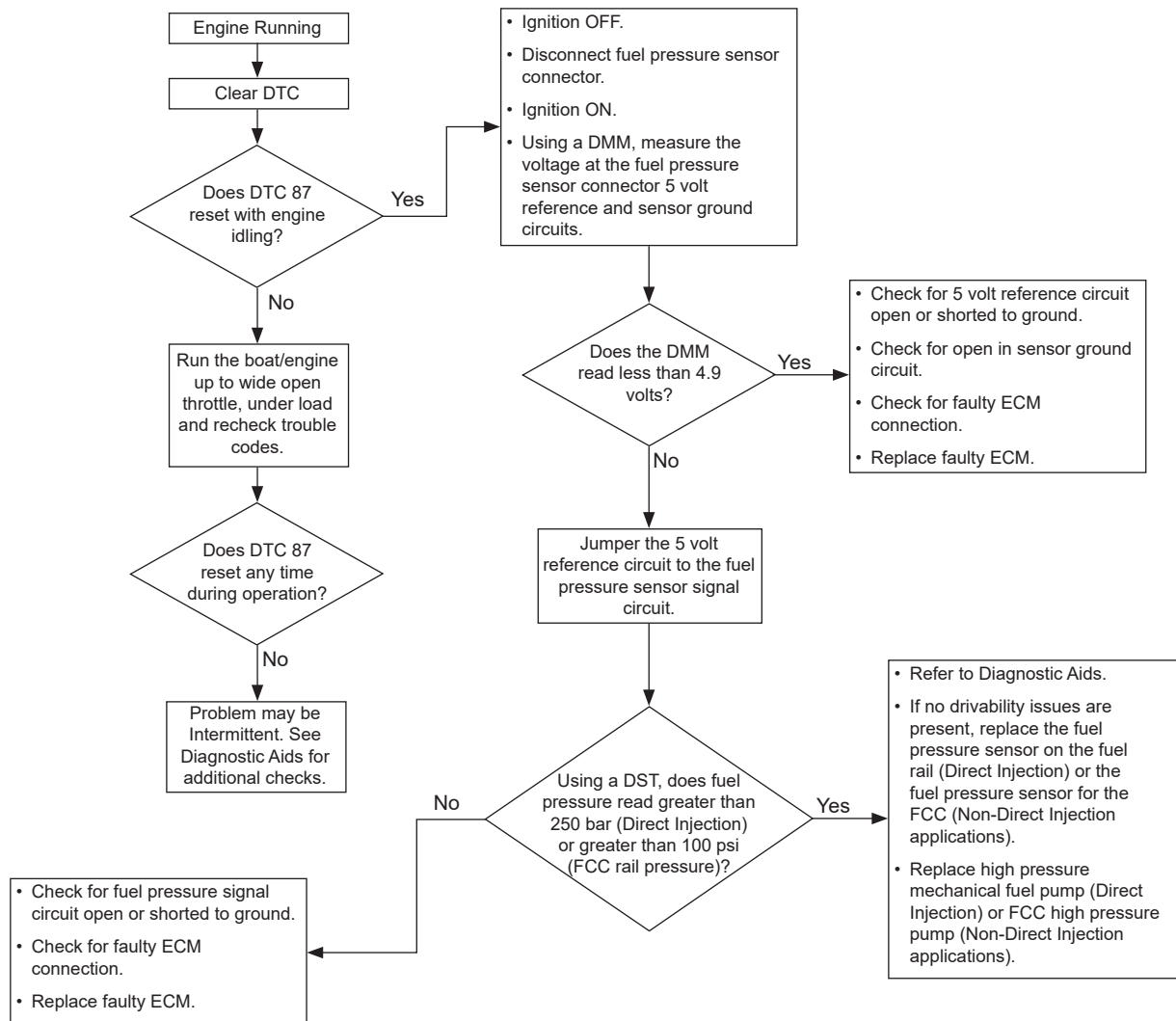
The Primary Fuel Pressure sensor on a non-direct injection engine is Fuel Control Cell fuel pressure. This value is steady between 59-62 psi. This value does not vary with RPM.

This fault will set when the fuel pressure sensor is indicating a fuel pressure lower than expected.

Diagnostic Aids

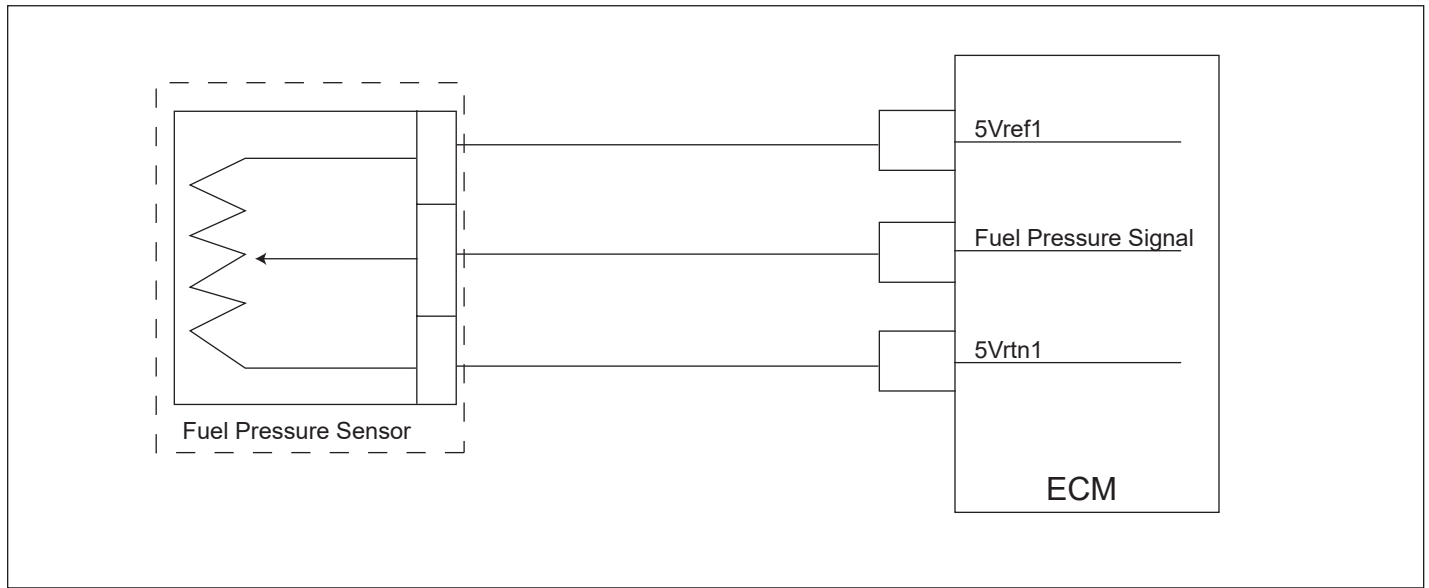
- Check the fuel filters for restrictions. Replace fuel filters as necessary.
- Check for fuel line restrictions, loose fittings or deteriorated fuel lines. Correct any problems found.
- Check fuel pressure sensor circuit wiring for a bad connection causing an intermittent problem. Correct any problems found.

DTC 0087 - Primary Fuel Pressure Low Pressure SPN - 94; FMI - 1



Diagnostics

DTC 0088 - Primary Fuel Pressure High Pressure SPN - 94; FMI - 0



- Primary Fuel Pressure Sensor
- *Check Condition* - Engine Running
- *Fault Condition (Direct Injection)* - Engine run time greater than 10 seconds and Actual Fuel Pressure minus Target Fuel Pressure is greater than 20 bar.
- *Fault Condition (Non-Direct Injection)* - Engine run time greater than 10 seconds and Fuel Pressure is more than 70 psi.
- *Corrective Action(s)* - Illuminate MIL, disable adaptive learn and closed loop fueling correction.
- Emissions related fault

The Primary Fuel Pressure sensor is the high pressure fuel rail pressure on direct injection engines. This value can range from 40 to 150 bar and varies based on RPM.

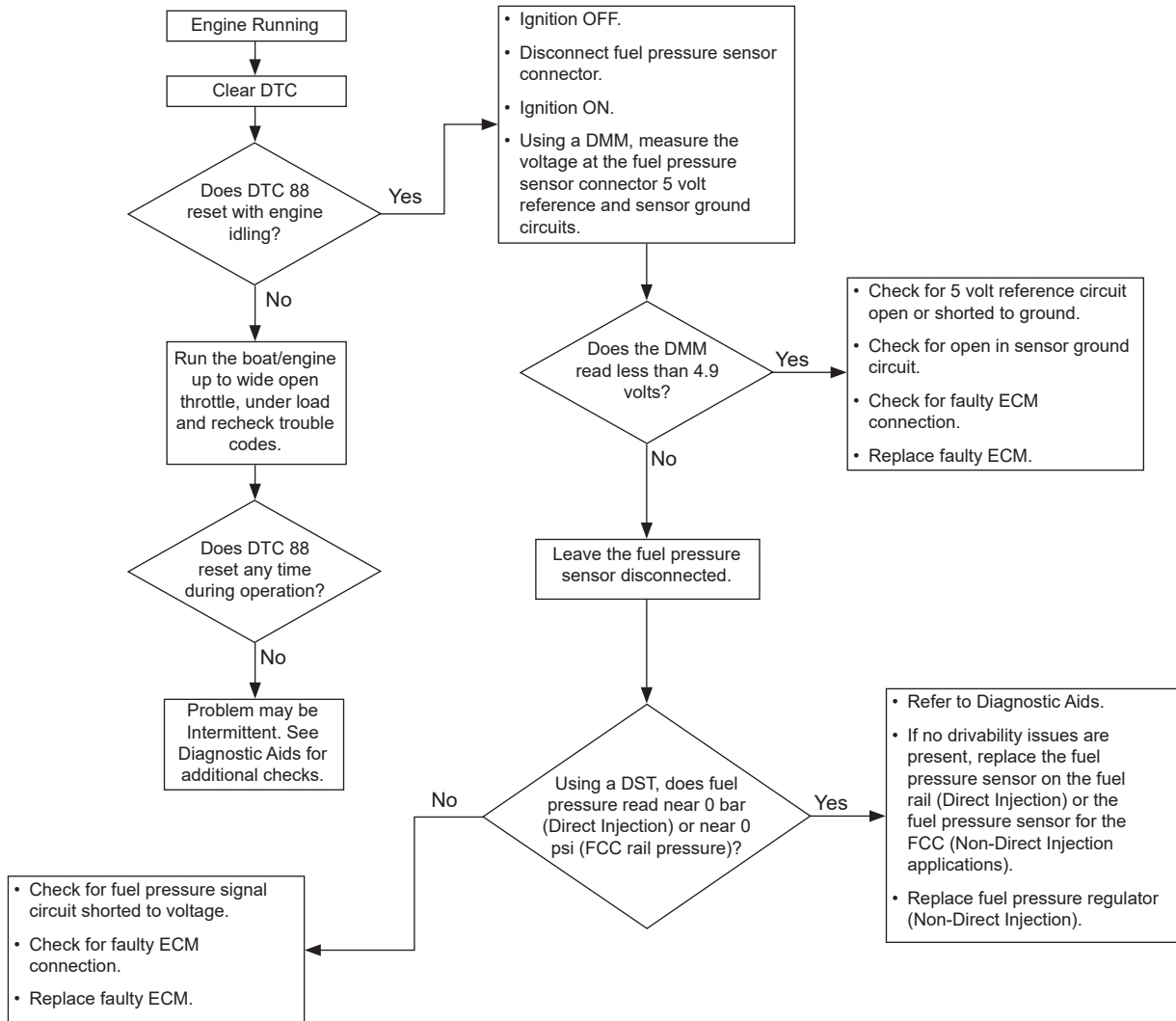
The Primary Fuel Pressure sensor on a non-direct injection engine is Fuel Control Cell fuel pressure. This value is steady between 59-62 psi. This value does not vary with RPM.

This fault will set when the fuel pressure sensor is indicating a fuel pressure higher than expected.

Diagnostic Aids

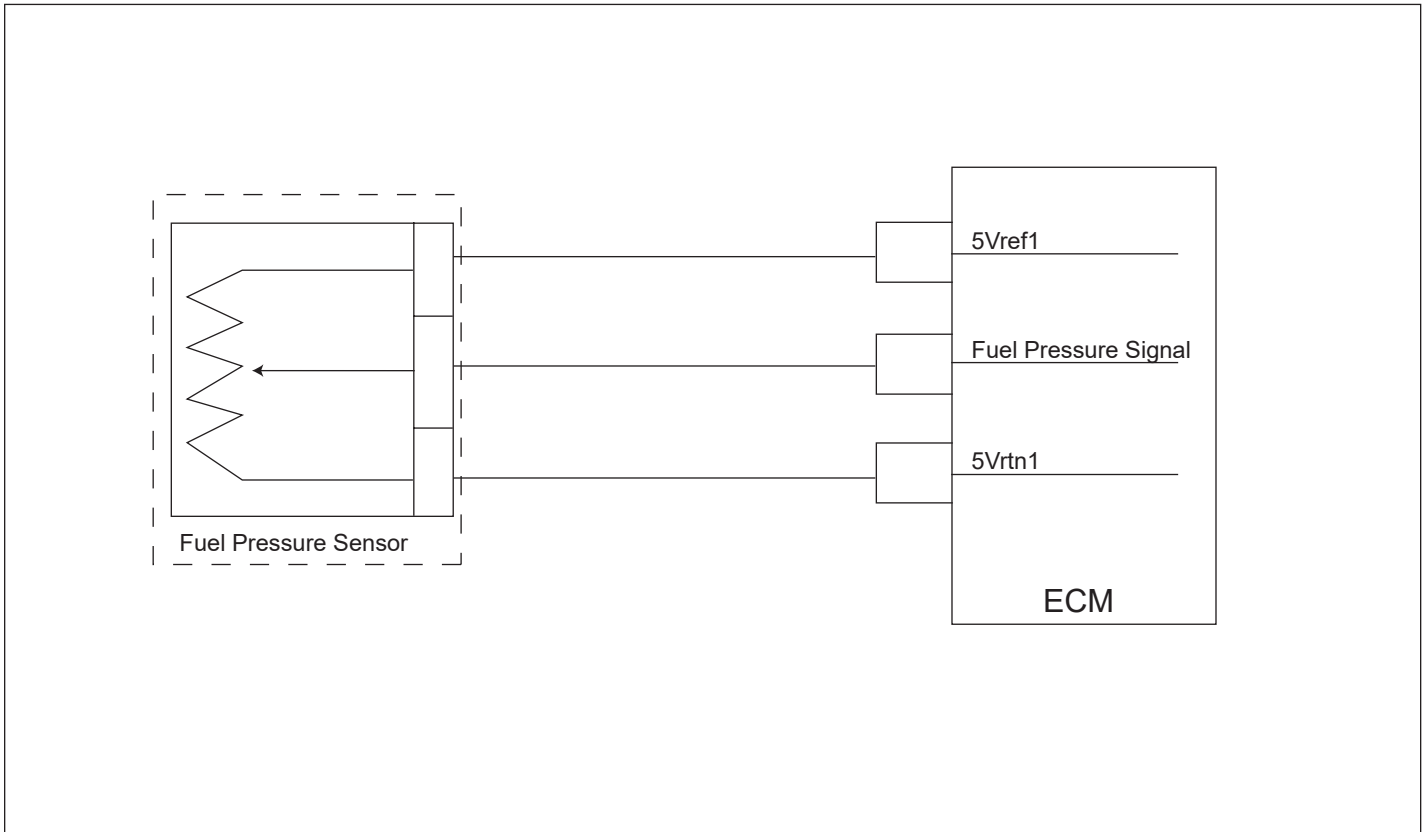
- Check the fuel filters for restrictions. Replace fuel filters as necessary.
- Check for fuel return line restrictions, loose fittings or deteriorated fuel lines. Correct any problems found.
- Check fuel pressure sensor circuit wiring for a bad connection causing an intermittent problem. Correct any problems found.

DTC 0088 - Primary Fuel Pressure High Pressure SPN - 94; FMI - 0



Diagnostics

DTC 0091 - Primary Fuel Pressure Sensor Circuit Low Voltage SPN - 94; FMI - 4



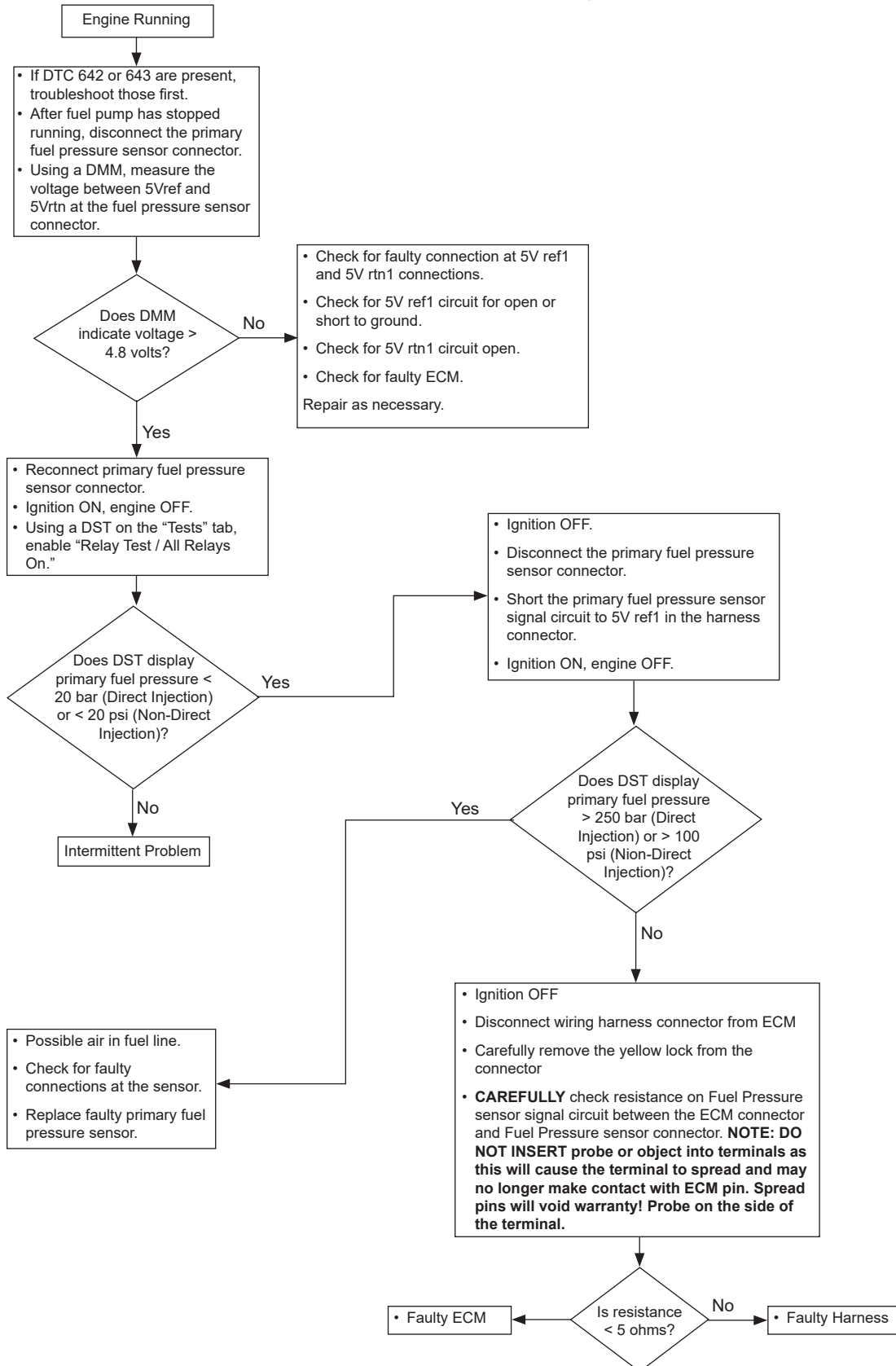
- Primary Fuel Pressure Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Primary Fuel Pressure sensor voltage < 0.20 volts
- *Corrective Action(s)* - Illuminate MIL, disable adaptive learn and closed loop fueling correction.
- Emissions related fault

The Primary Fuel Pressure sensor is the high pressure fuel rail pressure on direct injection engines. This value can range from 40 to 150 bar and varies based on RPM.

The Primary Fuel Pressure sensor on a non-direct injection engine is Fuel Control Cell fuel pressure. This value is steady between 59-62 psi. This value does not vary with RPM.

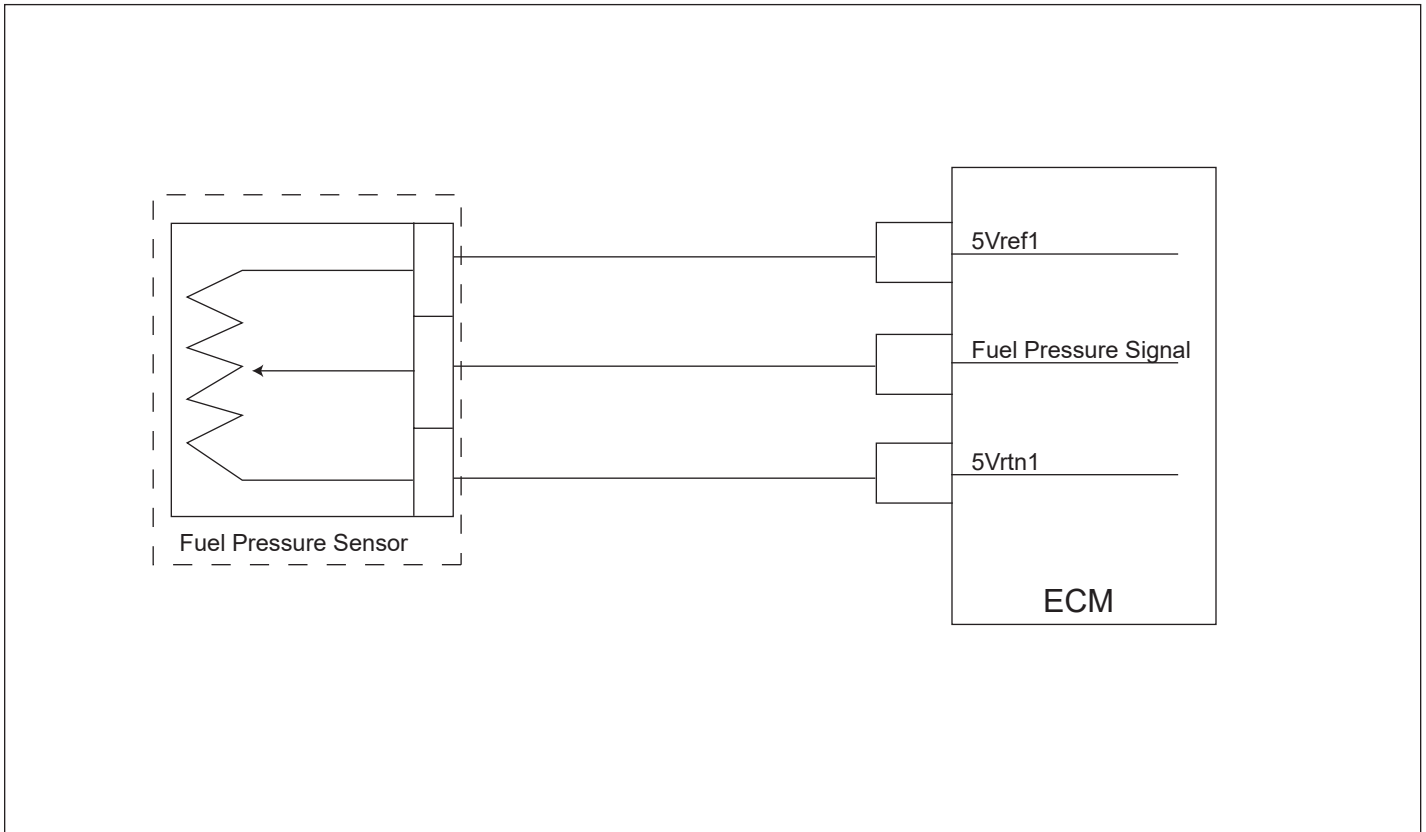
This fault will set when the fuel pressure sensor circuit voltage is less than 0.20 volts.

DTC 0091 - Primary Fuel Pressure Sensor Circuit Low Voltage SPN - 94; FMI - 4



Diagnostics

DTC 0092 - Primary Fuel Pressure Sensor Circuit High Voltage SPN - 94; FMI - 3



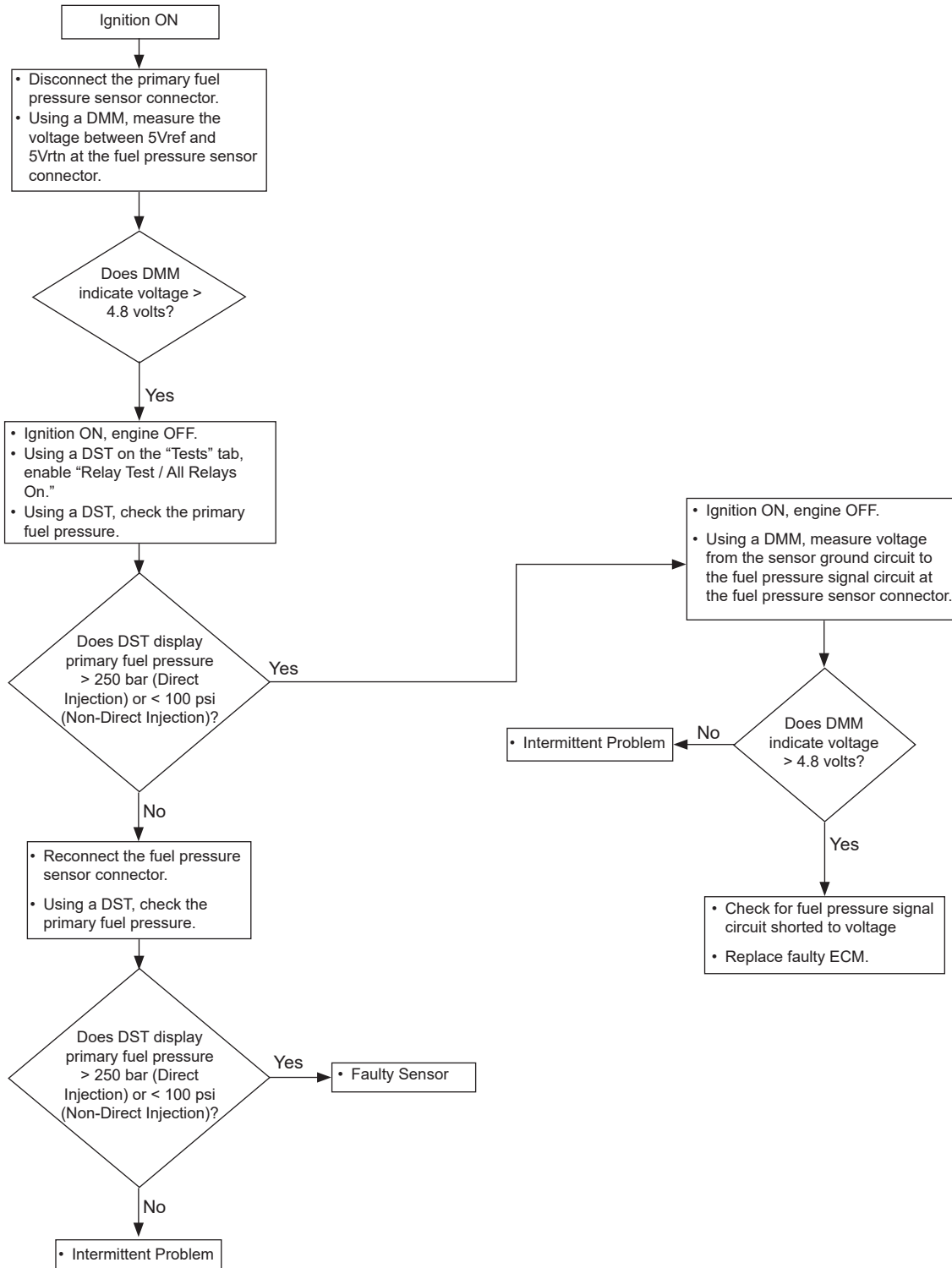
- Primary Fuel Pressure Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Primary Fuel Pressure sensor voltage > 4.80 volts
- *Corrective Action(s)* - Illuminate MIL, disable adaptive learn and closed loop fueling correction.
- Emissions related fault

The Primary Fuel Pressure sensor is the high pressure fuel rail pressure on direct injection engines. This value can range from 40 to 150 bar and varies based on RPM.

The Primary Fuel Pressure sensor on a non-direct injection engine is Fuel Control Cell fuel pressure. This value is steady between 59-62 psi. This value does not vary with RPM.

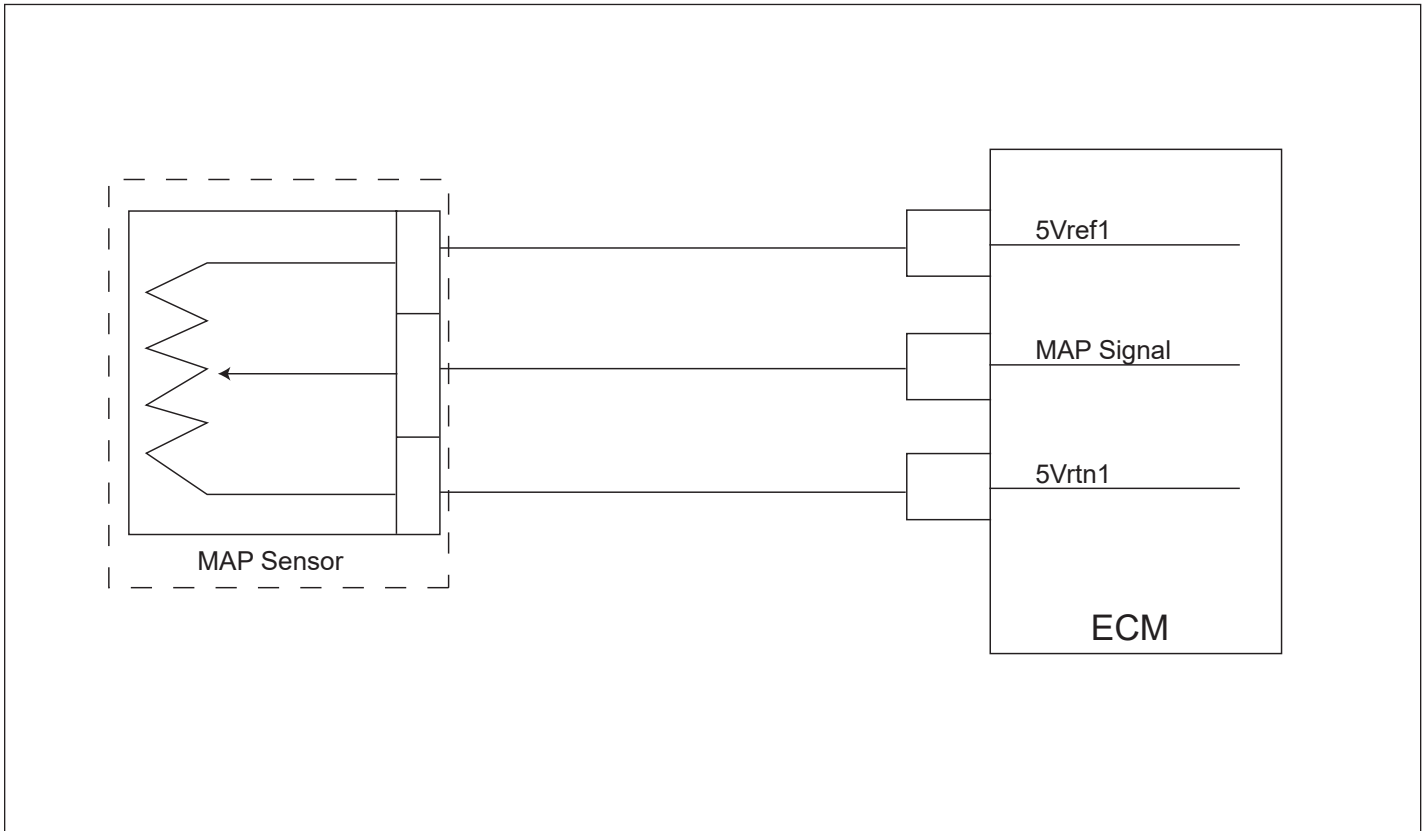
This fault will set when the fuel pressure sensor circuit voltage is greater than 4.80 volts.

DTC 0092 - Primary Fuel Pressure Sensor Circuit High Voltage SPN - 94; FMI - 3



Diagnostics

DTC 0107 - MAP Sensor Circuit Low Voltage SPN - 106; FMI - 4



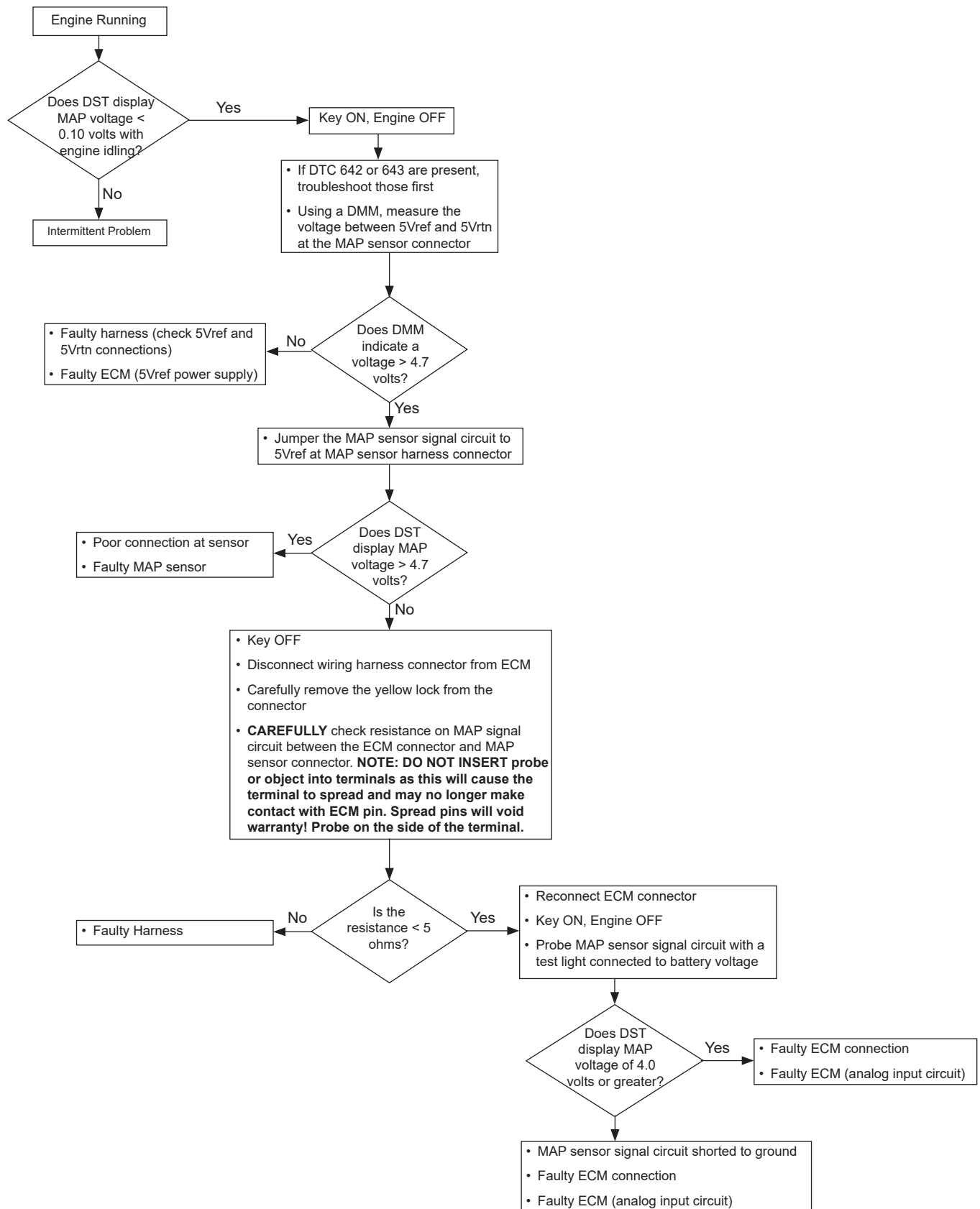
- Manifold Absolute Pressure Sensor
- *Check Condition* - Engine Cranking or Running
- *Fault Condition* - MAP sensor voltage feedback less than 0.10 volts when throttle position is greater than 2.0% and engine speed is less than 7000 RPM.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, recommend power derate 1, disable adaptive learn fueling correction for key-cycle, or any combination thereof as defined in calibration.
- Emissions related fault

The Manifold Absolute Pressure sensor is a pressure transducer connected to the intake manifold. It is used to measure the pressure of air in the manifold prior to induction into the engine. The pressure reading is used in conjunction with other inputs to determine the rate of airflow to the engine, which thereby determines the required fuel flow rate.

This fault will set when the MAP sensor voltage feedback is sensed as lower than 0.10 volts. In many cases, this condition is caused by the MAP sensor being disconnected from the engine harness, an open-circuit or short-to-ground of the MAP circuit in the wire harness, a loss of sensor reference voltage, or a failure of the sensor. When this fault occurs, the ECM operates in a limp home mode in which an estimated MAP based on TPS feedback is used to fuel the engine. Recommended corrective actions include setting power derate 1, disabling adaptive learn for the remainder of the key-on cycle with closed-loop remain enabled, and outputting a warning to the user.

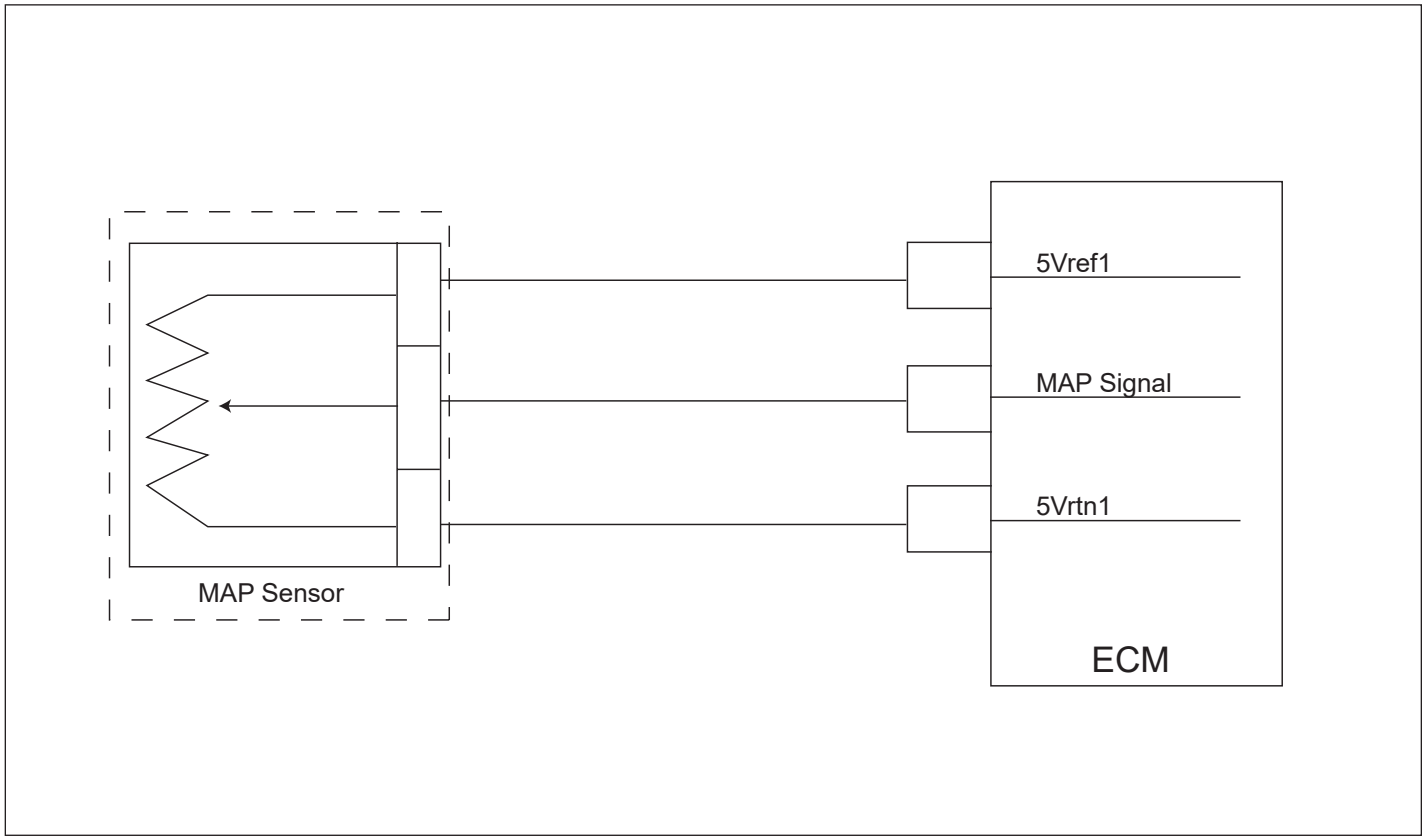
If the MAP sensor is integrated in a TMAP sensor and an IAT High Voltage fault (DTC 113) is also present, the sensor is likely disconnected from the wire harness.

DTC 0107 - MAP Sensor Circuit Low Voltage SPN - 106; FMI - 4



Diagnostics

DTC 0108 - MAP Sensor Circuit High Pressure SPN - 106; FMI - 16

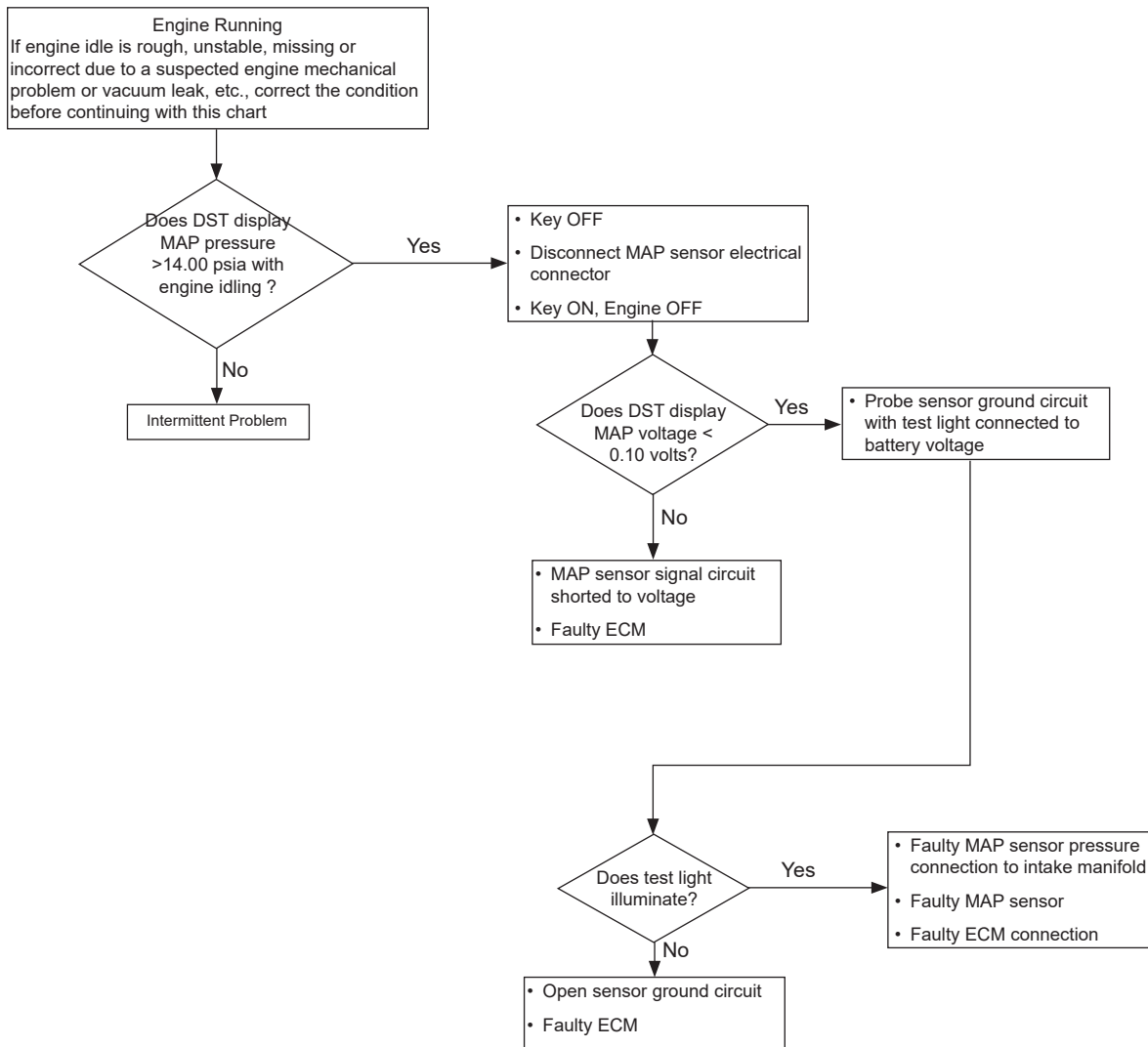


- Manifold Absolute Pressure Sensor
- *Check Condition* - Engine Cranking or Running
- *Fault Condition* -MAP is higher than 14.00 psia when throttle position is less than 10% and engine speed is greater than 1800 RPM.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, or any combination thereof as defined in calibration. Power derate is sometimes used with this fault.
- Emissions related fault

The Manifold Absolute Pressure sensor is a pressure transducer connected to the intake manifold. It is used to measure the pressure of air in the manifold prior to induction into the engine. The pressure reading is used as an index for spark, fuel, base fuel, etc. and is used in conjunction with other inputs to determine the airflow rate to the engine. The air flow rate in conjunction with the base fuel command determines the fuel flow rate.

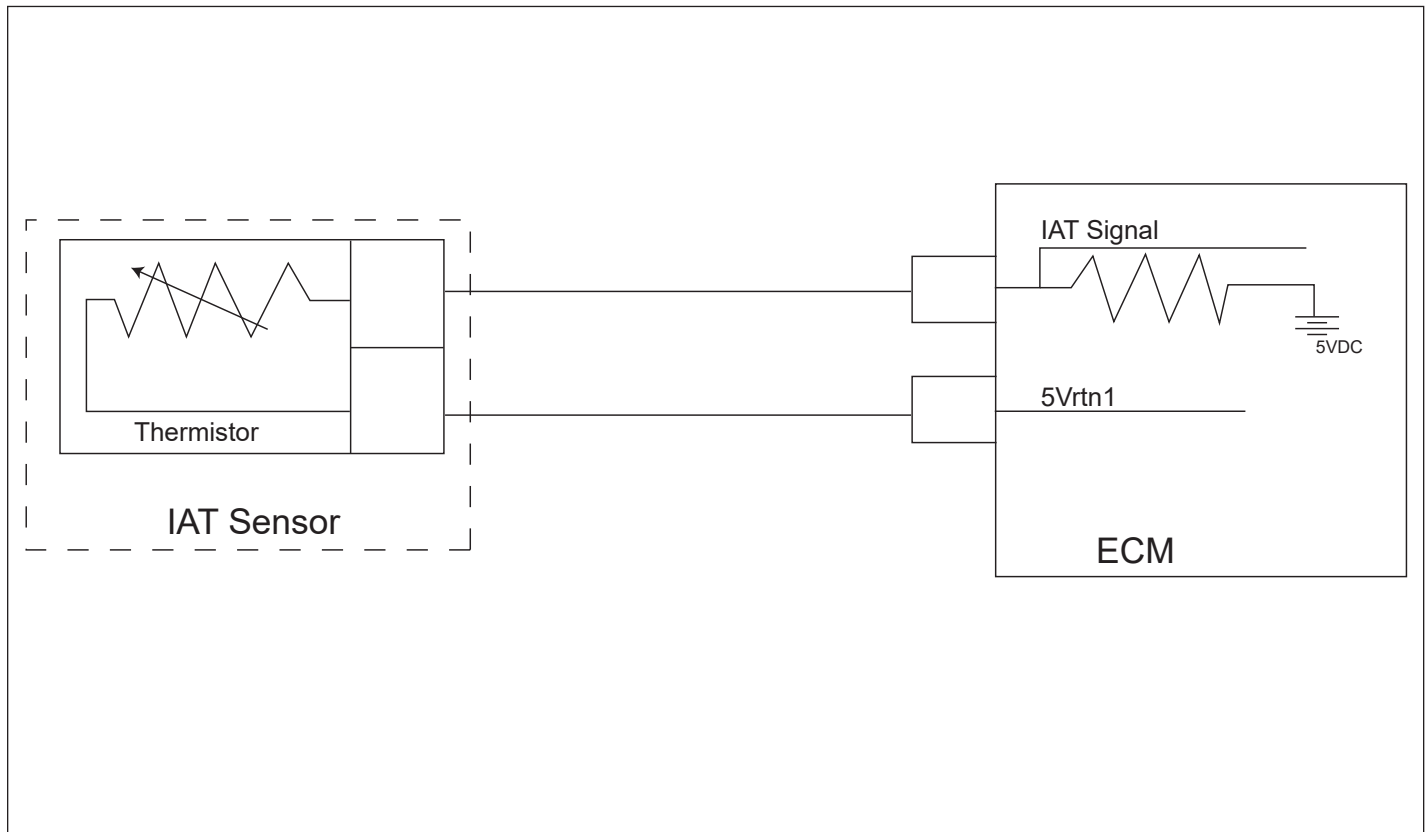
This fault will set when the MAP reading is higher than it should be for the given TPS, and RPM. When the fault is set the engine will typically operate in a "limp home" mode using an estimated MAP based on TPS feedback. It is recommended that Adaptive Learn be disabled to prevent improper learning and population of the table. In addition, power derate is sometimes used.

DTC 0108 - MAP Sensor Circuit High Pressure SPN - 106; FMI - 16



Diagnostics

DTC 0111 - IAT Higher Than Expected Stage 1 SPN - 105; FMI - 15



- Intake Air Temperature Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Intake Air Temperature greater than 200 degrees F at an operating condition greater than 1500 RPM.
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction while fault is active, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to detonation.
- Non-emissions related fault

The Intake Air Temperature sensor is a thermistor (temperature sensitive resistor) located in the intake manifold of the engine. It is used to monitor incoming air and the output, in conjunction with other sensors, is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.

The Manifold Air Temperature is a calculated value based mainly on the IAT sensor at high airflow and influenced more by the ECT/CHT at low airflow. It is used to monitor incoming air and the output, in conjunction with other sensors, is used to determine the airflow to the engine, and ignition timing.

This fault will set if the Intake Air Temperature is greater than 200 degrees F and the operating condition is at a speed greater than 1500 RPM.

DTC 0111 - IAT Higher Than Expected Stage 1 SPN - 105; FMI - 15

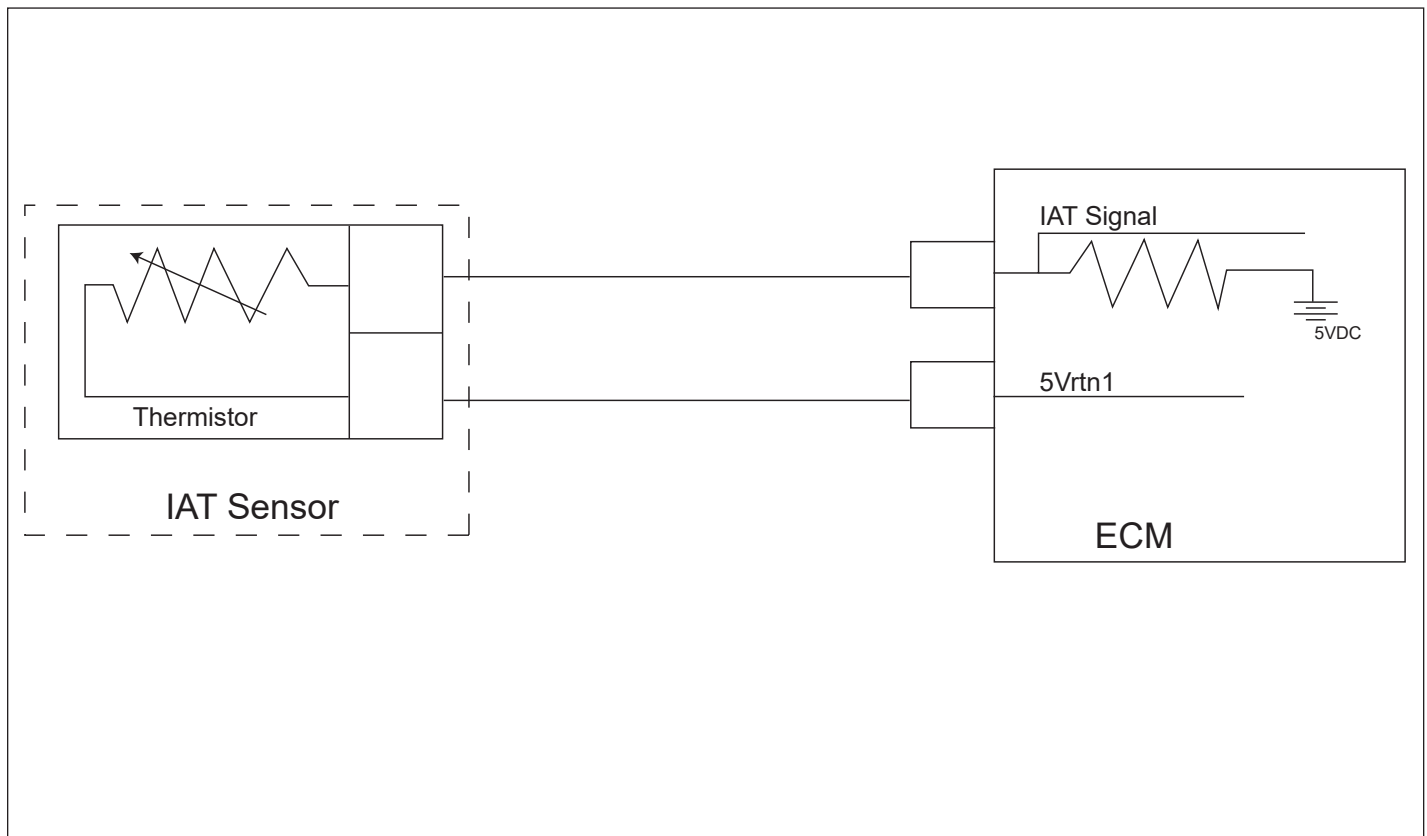
Diagnostic Aids

- This fault will set when inlet air is hotter than normal. The most common cause of high inlet air temperature is a result of a problem with routing of the inlet air. Ensure inlet plumbing sources are external, is cool, and is not too close to the exhaust at any point.
- Inspect the inlet air system for cracks or breaks that may allow unwanted underhood air to enter the engine.
- If no problem is found, replace the IAT sensor with a known good part and retest.

Diagnostics

DTC 0112 - IAT Sensor Circuit Low Voltage

SPN - 105; FMI - 4



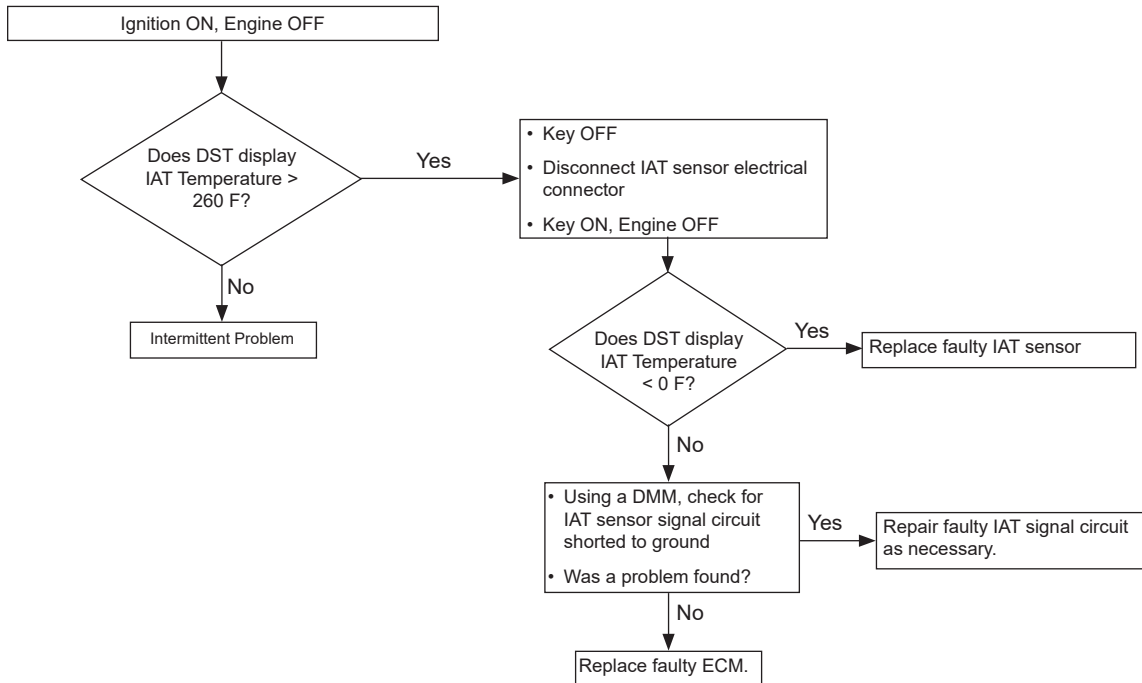
- Intake Air Temperature Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - IAT sensor voltage less than 0.050 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination thereof as defined in calibration. Recommend power derate 1/2 to reduce possible detonation and engine damage due to high intake charge temperatures that can not be sensed.
- Non-emissions related fault

The Intake Air Temperature sensor is a thermistor (temperature sensitive resistor) located in the intake manifold of the engine. It is used to monitor incoming air and the output, in conjunction with other sensors, is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.

The Manifold Air Temperature is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT at low airflow. It is used to monitor incoming air and the output, in conjunction with other sensors, is used to determine the airflow to the engine.

This fault will set if the signal voltage is less than 0.050 volts. The ECM will use a default value for the IAT sensor in the event of this fault.

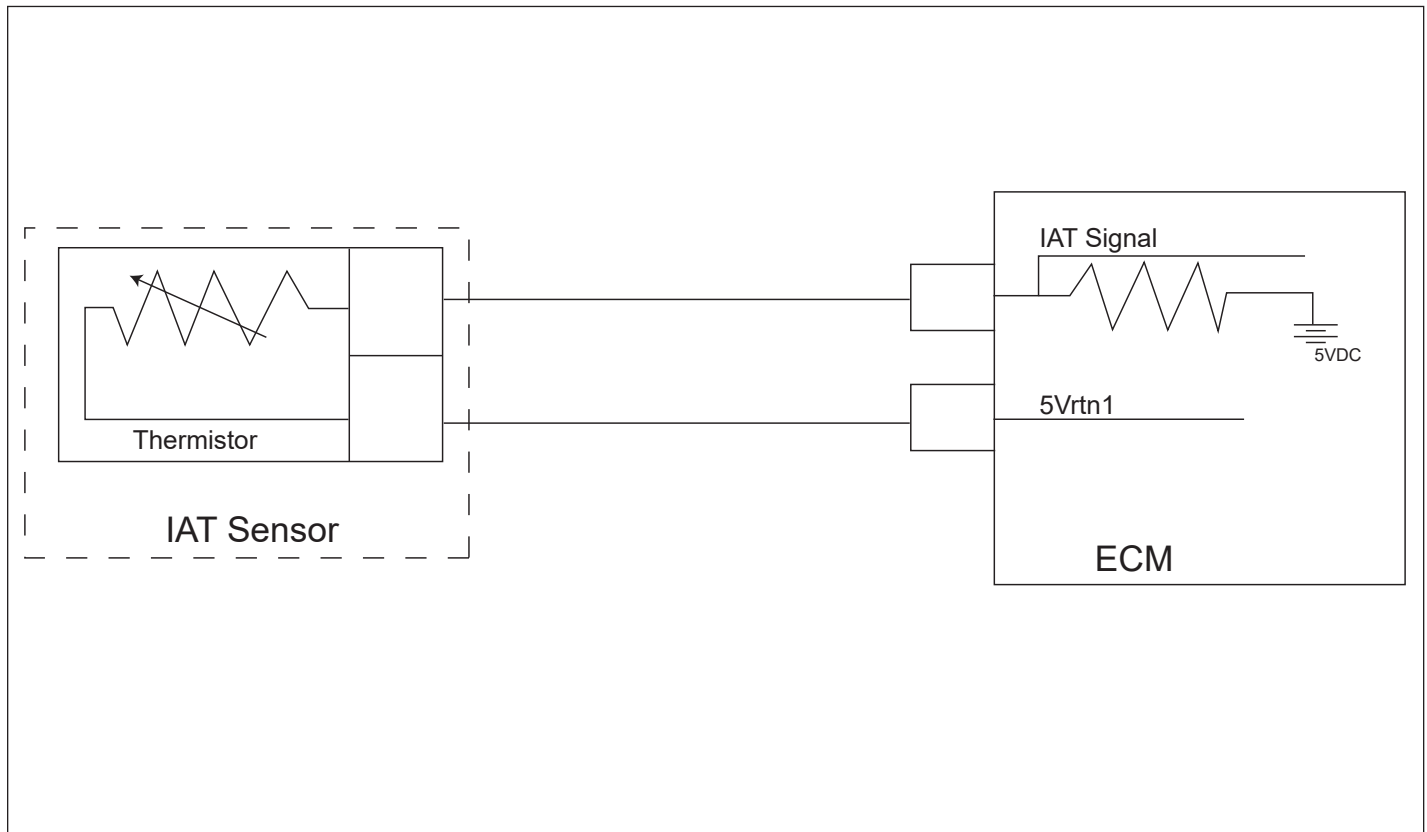
DTC 0112 - IAT Sensor Circuit Low Voltage SPN - 105; FMI - 4



Diagnostics

DTC 0113 - IAT Sensor Circuit High Voltage

SPN - 105; FMI - 3



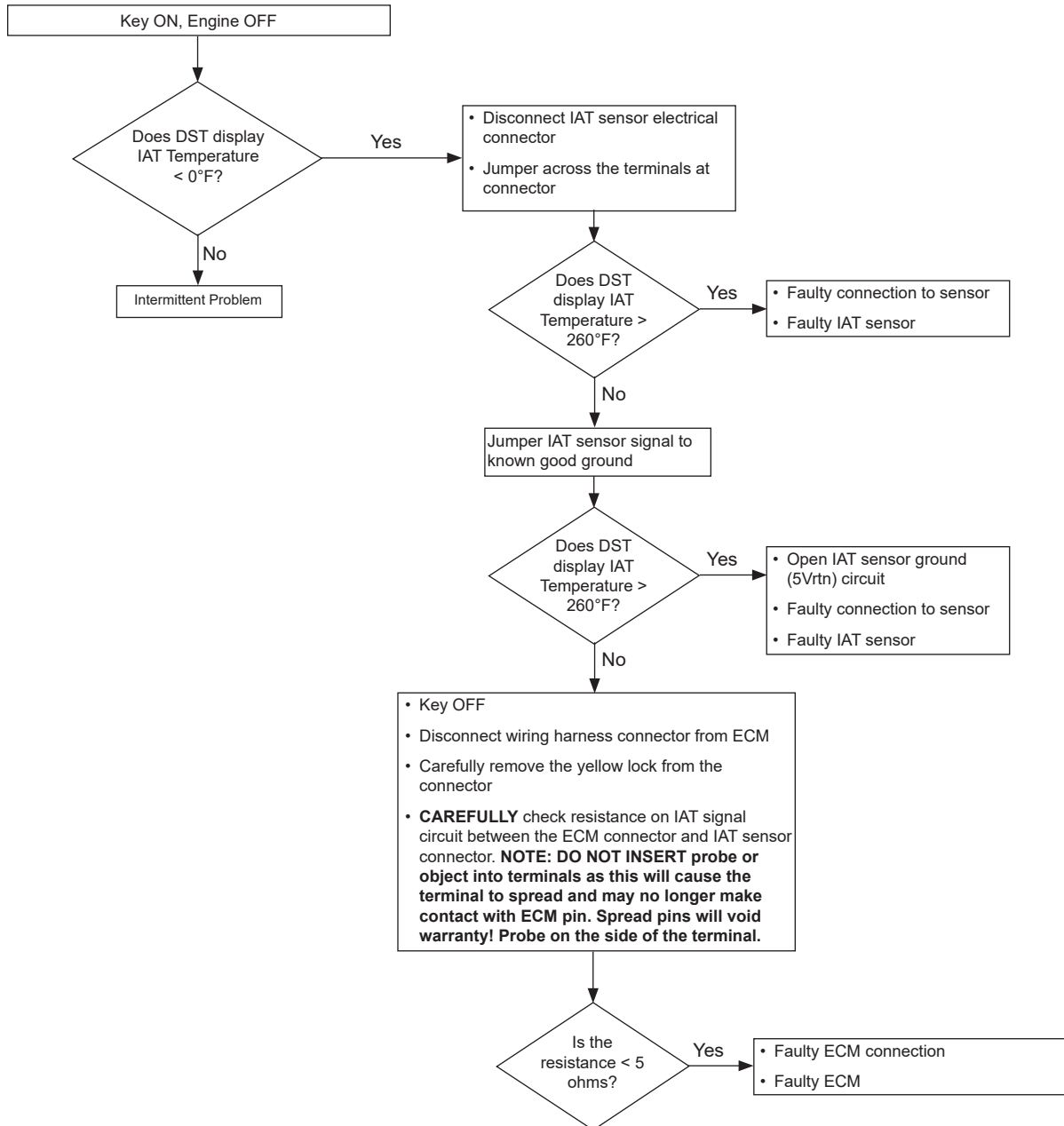
- Intake Air Temperature Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - IAT sensor voltage greater than 4.95 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction during active fault, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to detonation.
- Non-emissions related fault

The Intake Air Temperature sensor is a thermistor (temperature sensitive resistor) located in the intake manifold of the engine. It is used to monitor incoming air and the output, in conjunction with other sensors, is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.

The Manifold Air Temperature is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT at low airflow. It is used to monitor incoming air and the output, in conjunction with other sensors, is used to determine the airflow to the engine.

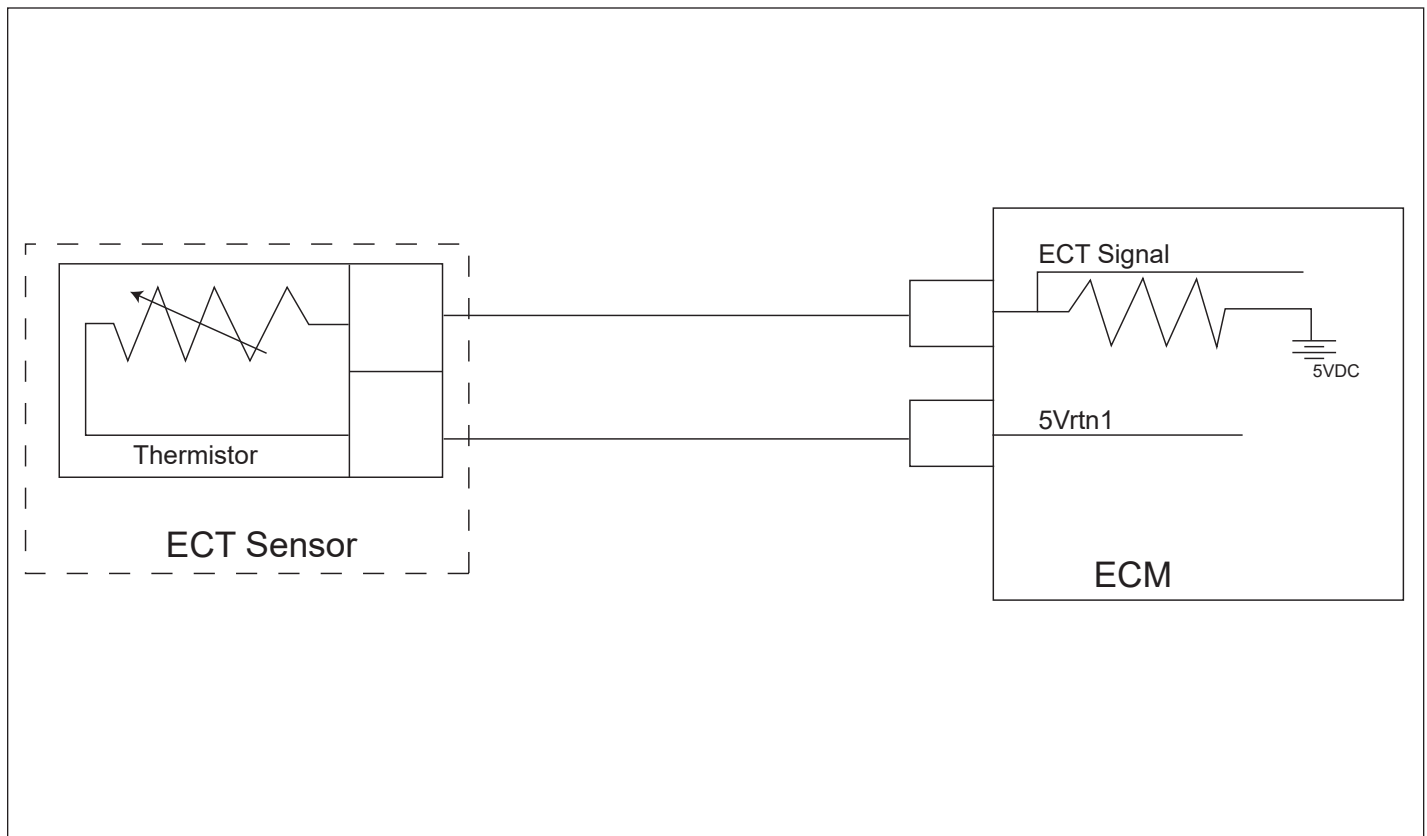
This fault will set if the signal voltage is higher than 4.95 volts anytime the engine is running. In many cases, this condition is caused by the IAT sensor being disconnected from the engine harness, an open-circuit or short-to-power of the IAT circuit in the wire harness, or a failure of the sensor. The ECM will use a default value for the IAT sensor in the event of this fault.

DTC 0113 - IAT Sensor Circuit High Voltage SPN - 105; FMI - 3



Diagnostics

DTC 0116 - ECT Higher Than Expected Stage 1 SPN - 110; FMI - 15



- Engine Coolant Temperature Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Engine Coolant Temperature reading greater than 200 degrees F when operating at a speed greater than 600 RPM
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault. Recommend a power derate 1/2 and/or a low rev limit to protect engine from possible damage.
- Non-emissions related fault

The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. This is used for engine airflow calculation, ignition timing control, to enable certain features, and for engine protection. The ECM provides a voltage divider circuit so when the sensor reading is cool the sensor reads higher voltage, and lower when warm.

This fault will help protect the engine in the event of over temperature. When the coolant exceeds 200 deg. F and engine RPM exceeds 600 RPM for 60 seconds this fault will set.

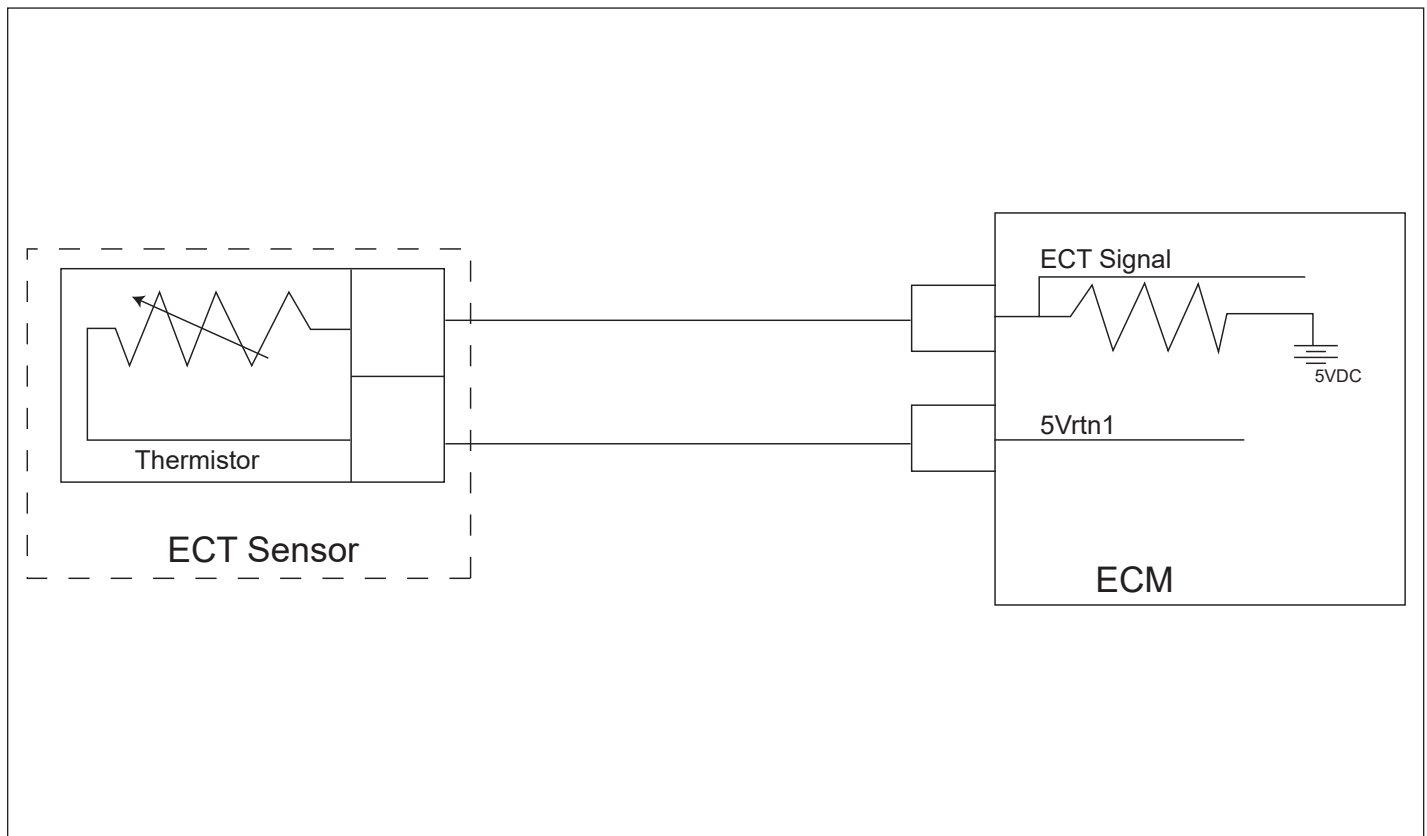
DTC 0116 - ECT Higher Than Expected Stage 1 SPN - 110; FMI - 15

Diagnostic Aids

- If the “ECT High Voltage” fault is also present, follow the troubleshooting procedures for that fault as it may have caused “ECT Higher Than Expected 1.”
- Check that the heat exchanger has a proper amount of ethylene glycol/water and that the heat exchanger is not leaking
- Ensure that there is no trapped air in the cooling path
- Inspect the cooling system (radiator and hoses) for cracks and ensure connections are leak free
- Check that the raw water pickup is not blocked/restricted by debris and that the hose is tightly connected
- Check that the thermostat is not stuck closed
- Check that the raw water pump/impeller is tact and that it is not restricted

Diagnostics

DTC 0117 - ECT Sensor Circuit Low Voltage SPN - 110; FMI - 4

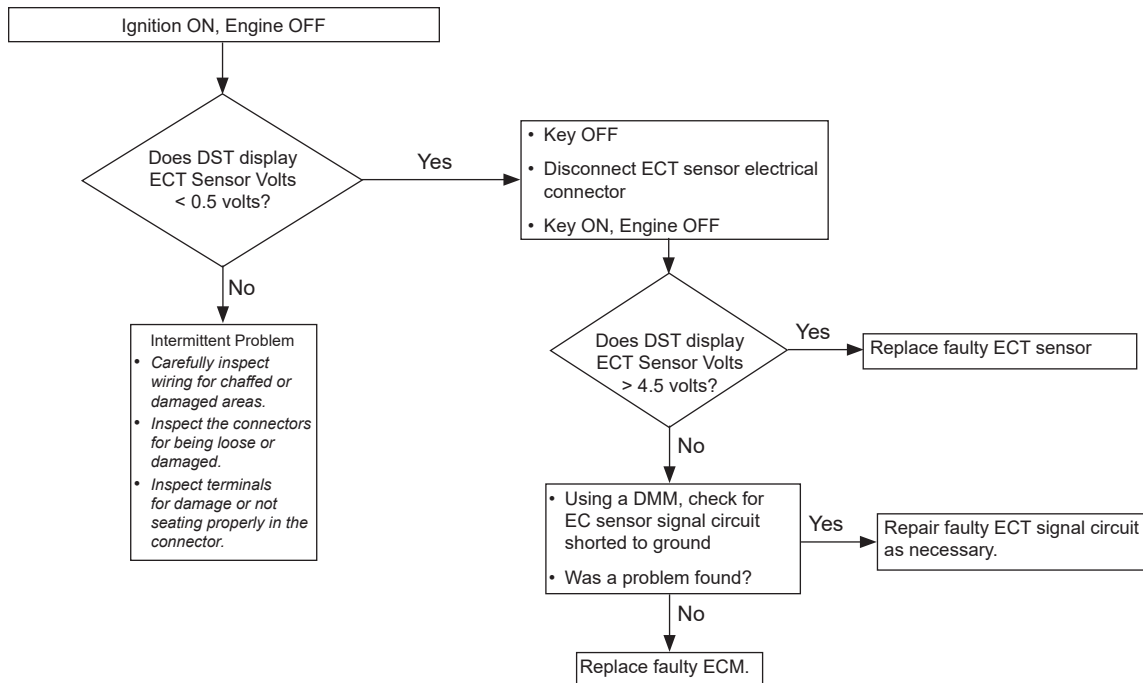


- Engine Coolant Temperature Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - ECT sensor voltage less than 0.050 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to the inability to sense temperature.
- Non-emissions related fault

The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. This is used for engine airflow calculation, ignition timing control, to enable certain features, and for engine protection. The ECM provides a voltage divider circuit so when the sensor reading is cool the sensor reads higher voltage, and lower when warm.

This fault will set if the signal voltage is less than 0.050 volts. The ECM will use a default value for the ECT sensor in the event of this fault.

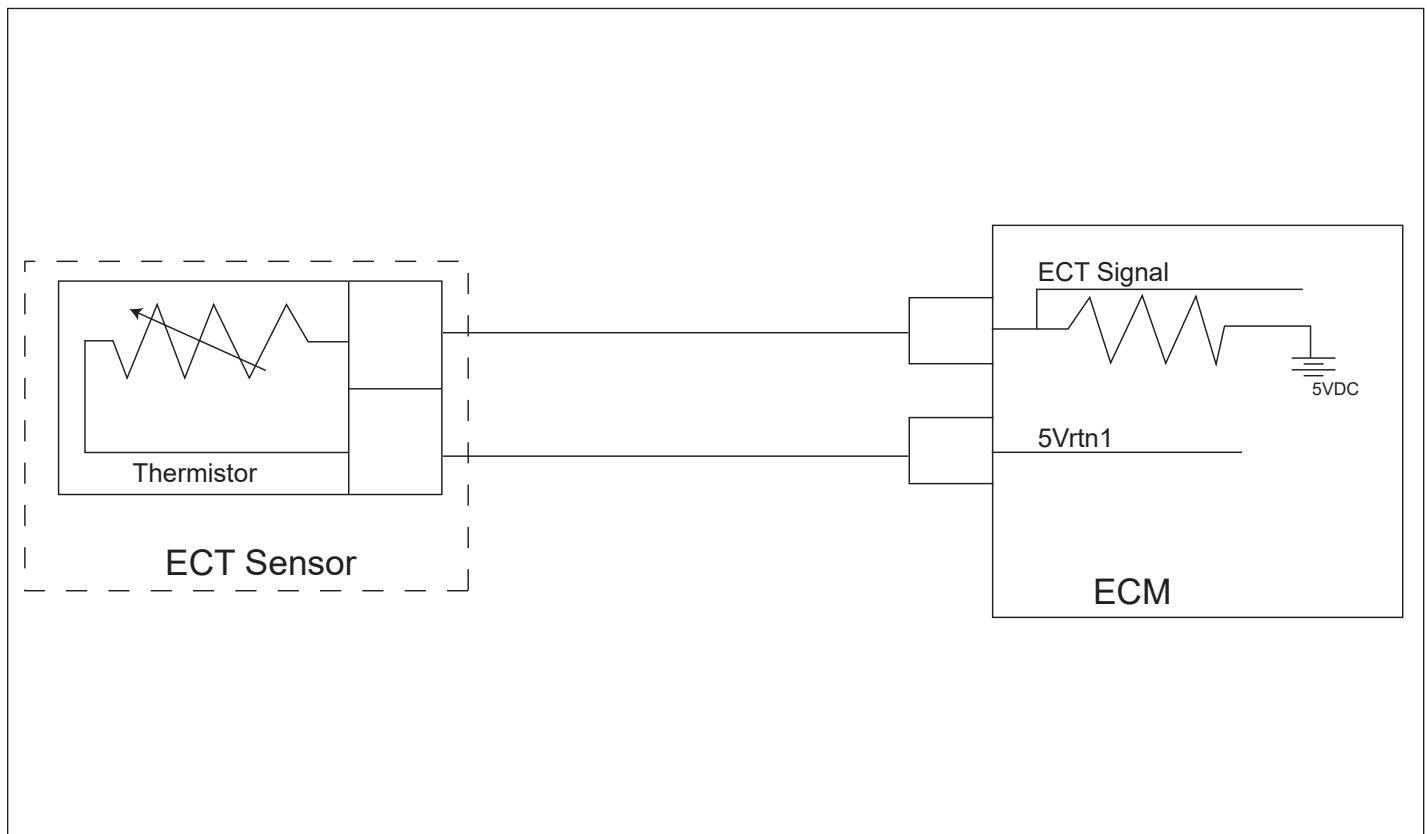
DTC 0117 - ECT Sensor Circuit Low Voltage SPN - 110; FMI - 4



Diagnostics

DTC 0118 - ECT Sensor Circuit High Voltage

SPN - 110; FMI - 3

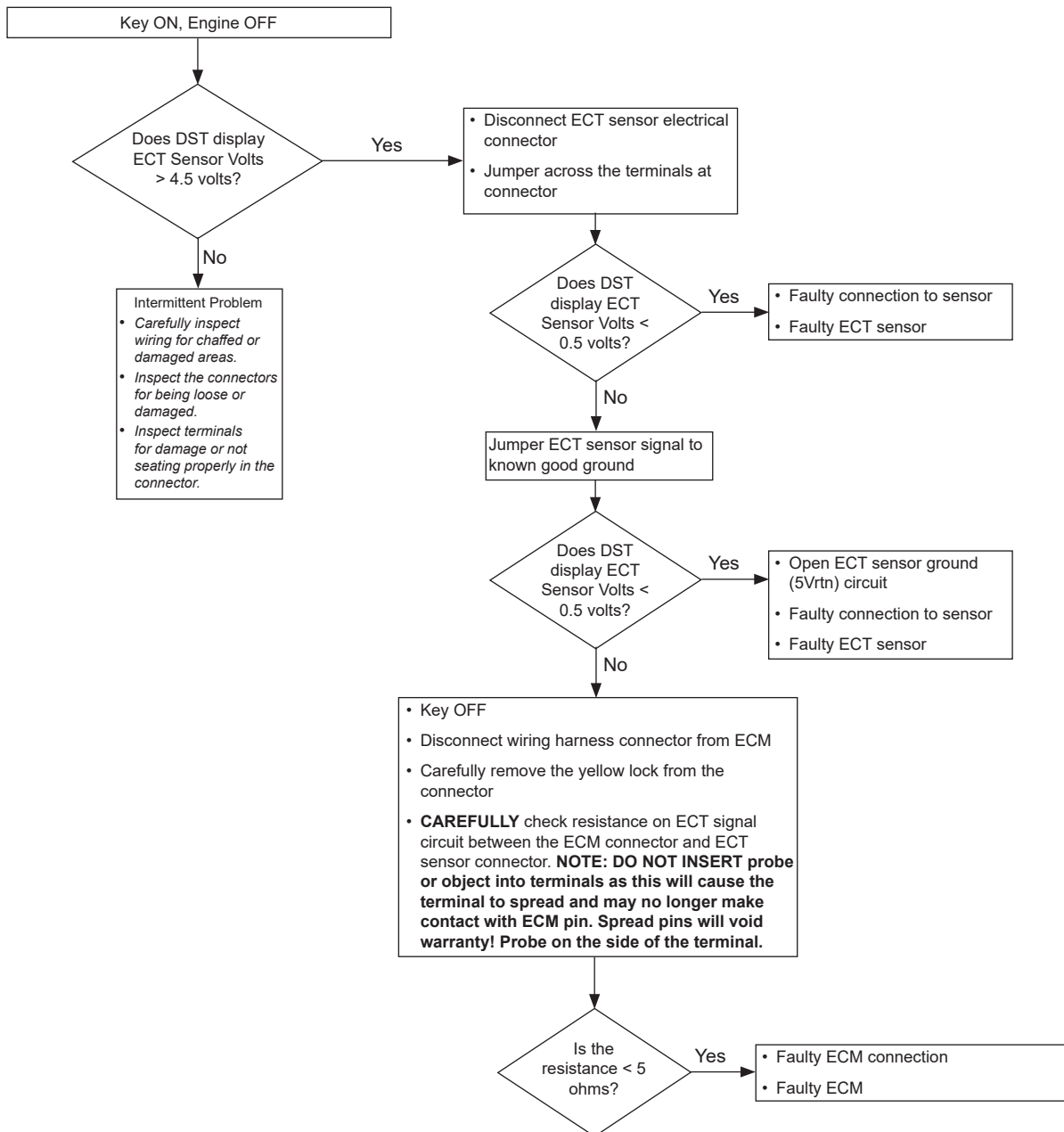


- Engine Coolant Temperature Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - ECT sensor voltage higher than 4.95 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to the inability to sense temperature.
- Non-emissions related fault

The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. This is used for engine airflow calculation, ignition timing control, to enable certain features, and for engine protection. The ECM provides a voltage divider circuit so when the sensor reading is cool the sensor reads higher voltage, and lower when warm.

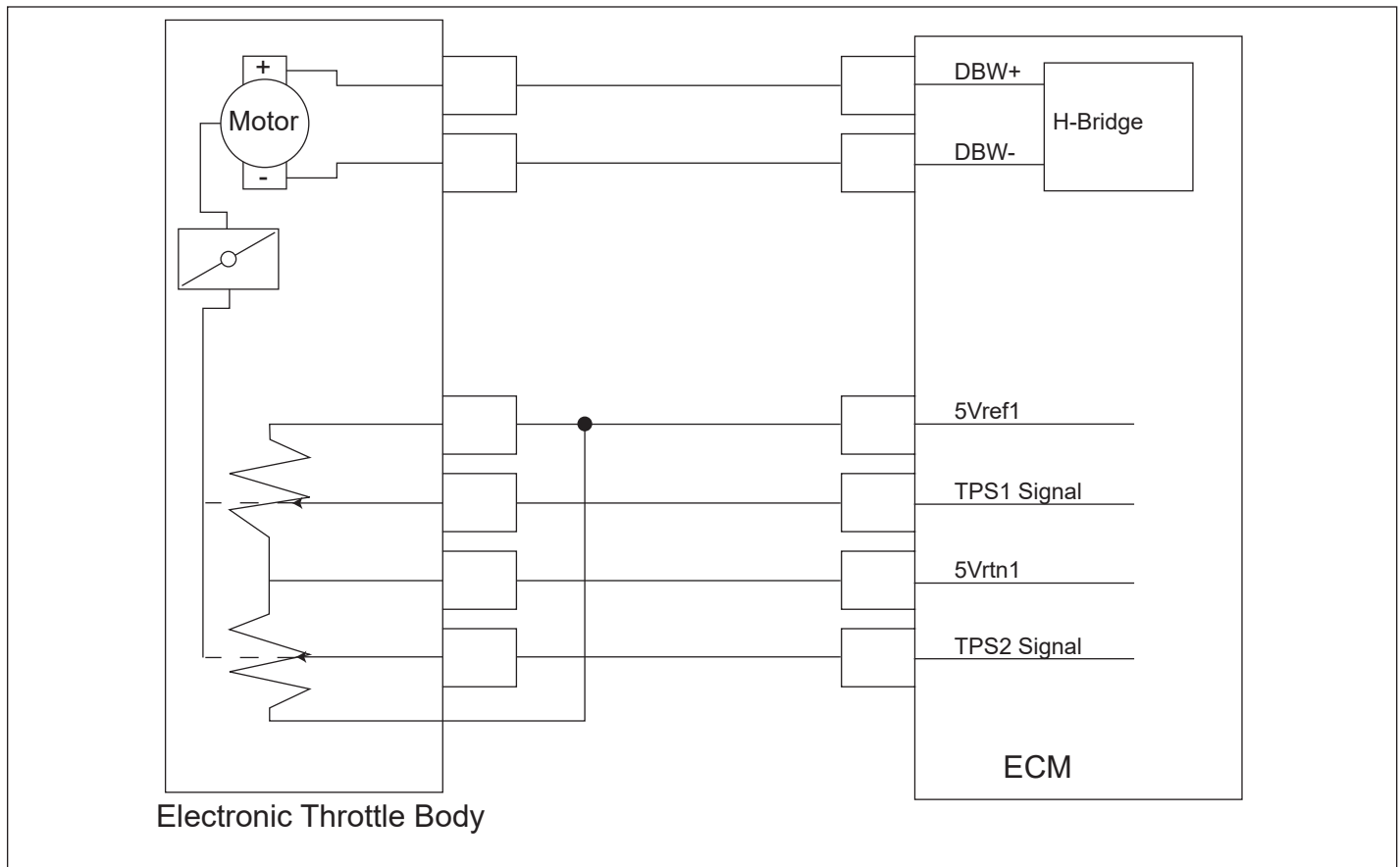
This fault will set if the signal voltage is higher than 4.95 volts. In many cases, this condition is caused by the ECT sensor being disconnected from the engine harness, an open-circuit or short-to-power of the ECT circuit in the wire harness, or a failure of the sensor. The ECM will use a default value for the ECT sensor in the event of this fault.

DTC 0118 - ECT Sensor Circuit High Voltage SPN - 110; FMI - 3



Diagnostics

DTC 0121 - TPS1 % Lower Than TPS2 % SPN - 51; FMI - 1



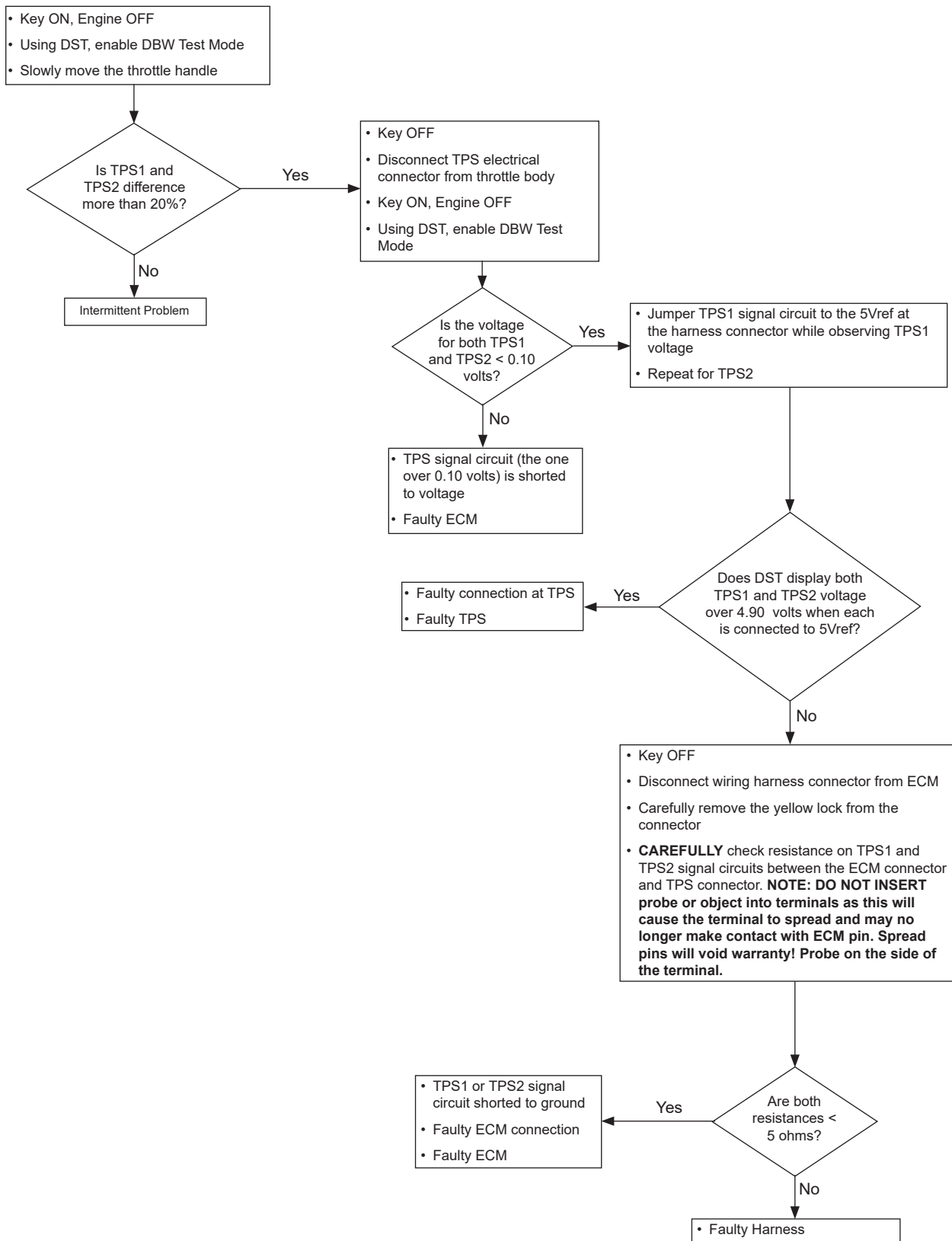
- Throttle Body - Throttle Position Sensor 1 & 2 (electronic throttle body only)
- *Check Condition* - Key-On, Engine Cranking, or Running
- *Fault Condition* - TPS1 lower than TPS2 by 20%
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions related fault

The throttle controls the airflow through the engine, directly affecting the power output of the engine. When the throttle is electronically controlled in an Electronic Throttle Body it can be used to control the idle stability and limit engine speed based on operating conditions.

The Throttle Position Sensor uses a variable resistor and voltage divider circuit to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In an Electronic Throttle Body multiple position feedback sensors (usually two counteracting potentiometers/hall-effects) are used to perform speed governing with improved safety and redundancy.

This fault will set if TPS1 % is lower than TPS2 % by 20%. At this point the throttle is considered to be out of specification, or there is a problem with the TPS signal circuit. During this active fault, an audible/visual alert device is activated and either an engine shutdown should be triggered or throttle control is set to use the higher of the two feedback signals for control in combination with a low rev limit and/or power derate.

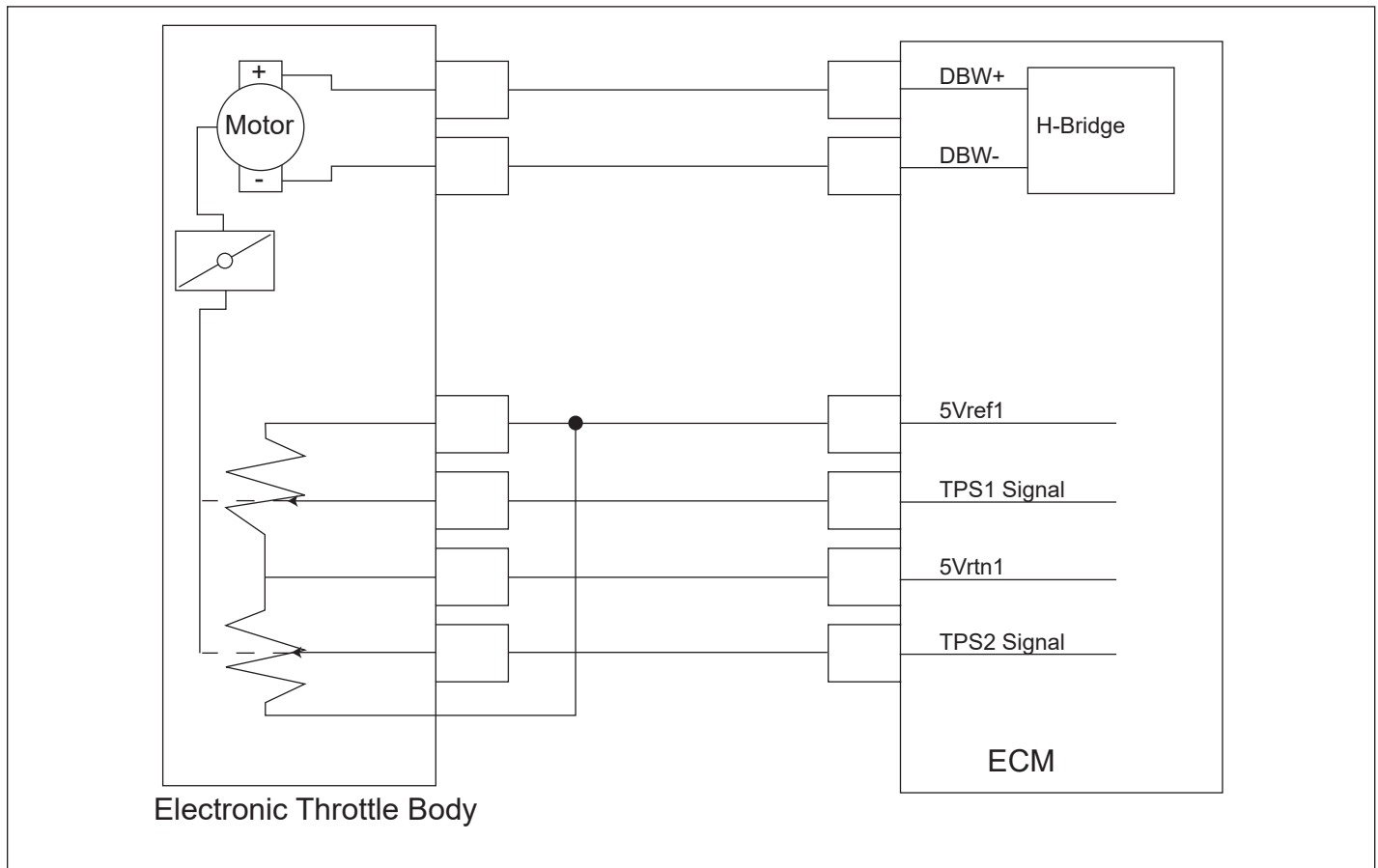
DTC 0121 - TPS1 % Lower Than TPS2 % SPN - 51; FMI - 1



Diagnostics

DTC 0122 - TPS1 Signal Circuit Voltage Low

SPN - 51; FMI - 4



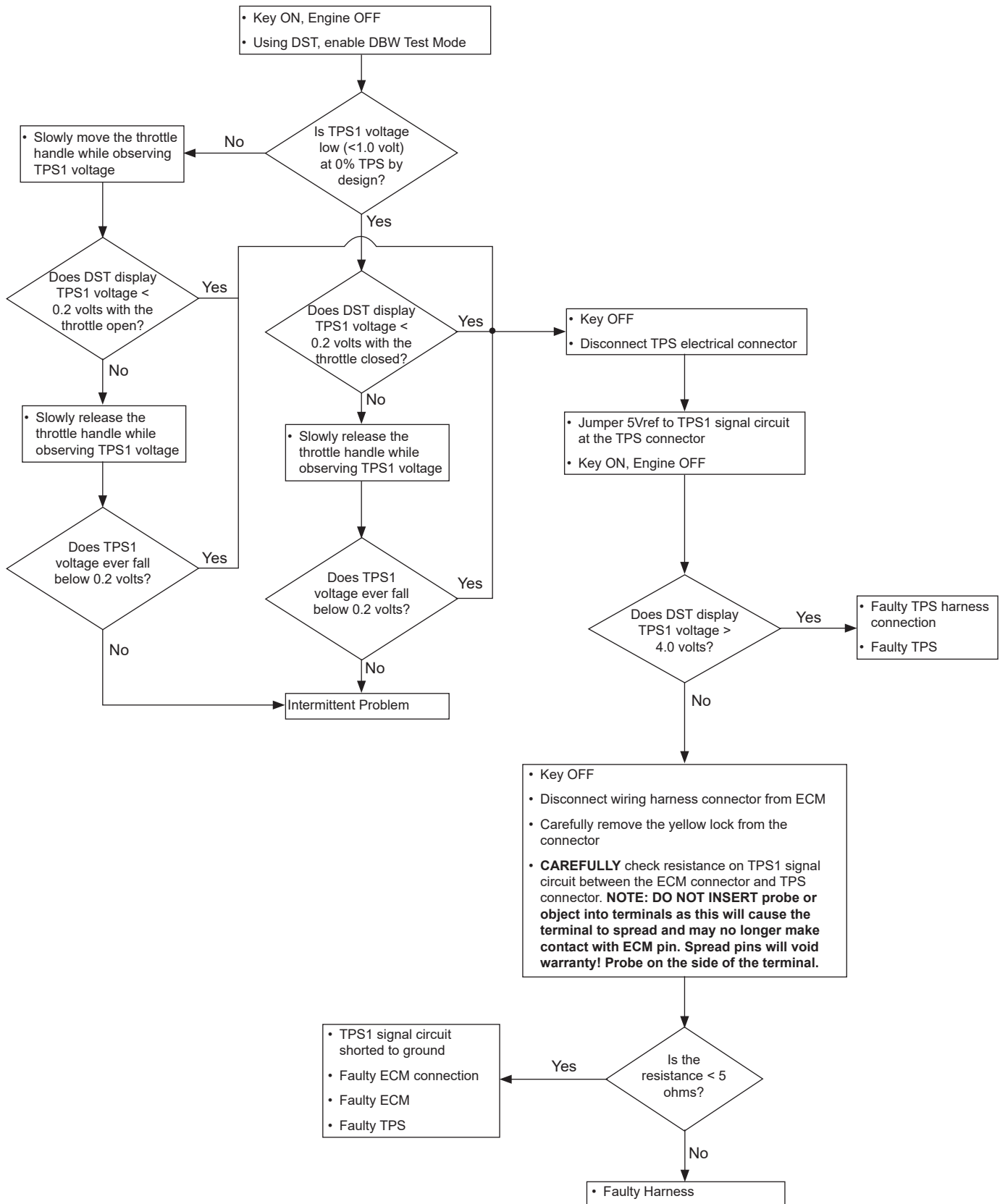
- Throttle Body - Throttle Position Sensor 1
- *Check Condition* - Key On, Engine Cranking or Running
- *Fault Condition* - TPS1 sensor voltage lower than 0.20 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions related fault

The throttle controls the airflow through the engine, directly affecting the power output of the engine. When the throttle is electronically controlled in an Electronic Throttle Body it can be used to control the idle stability and limit engine speed based on operating conditions.

The Throttle Position Sensor uses a variable resistor and voltage divider circuit to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In an Electronic Throttle Body multiple position feedback sensors (usually two counteracting potentiometers/hall-effects) are used to perform speed governing with improved safety and redundancy.

This fault will set if TPS1 voltage is lower than 0.20 volts at any operating condition while the engine is cranking or running. In many cases, this condition is caused by the TPS sensor being disconnected from the engine harness, an open-circuit or short-to-ground of the TPS circuit in the wire harness, or a failure of the sensor. This fault should be configured to trigger an engine shutdown and the engine will not start with this fault active.

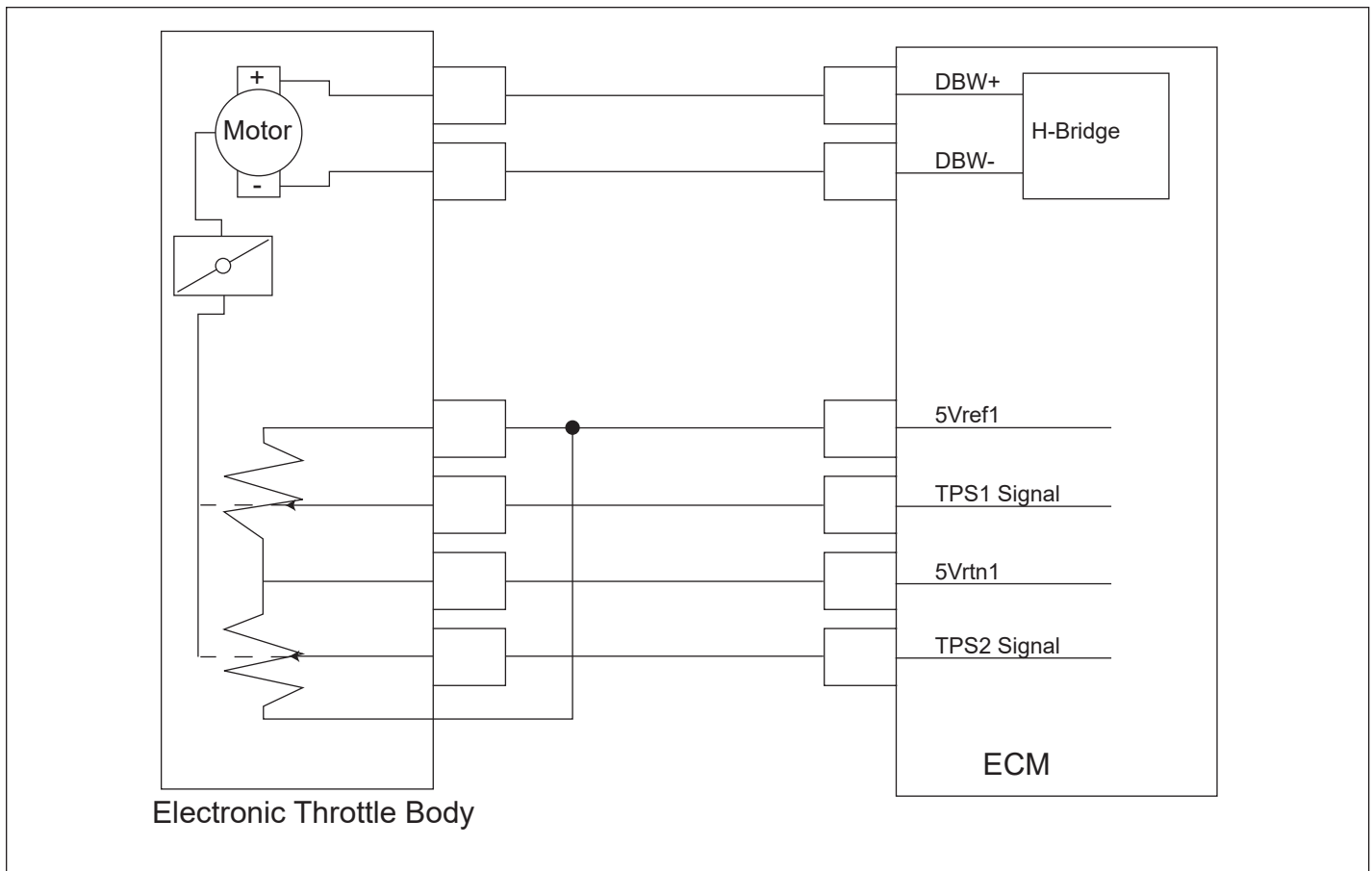
DTC 0122 - TPS1 Signal Circuit Voltage Low SPN - 51; FMI - 4



Diagnostics

DTC 0123 - TPS1 Signal Circuit Voltage High

SPN - 51; FMI - 3



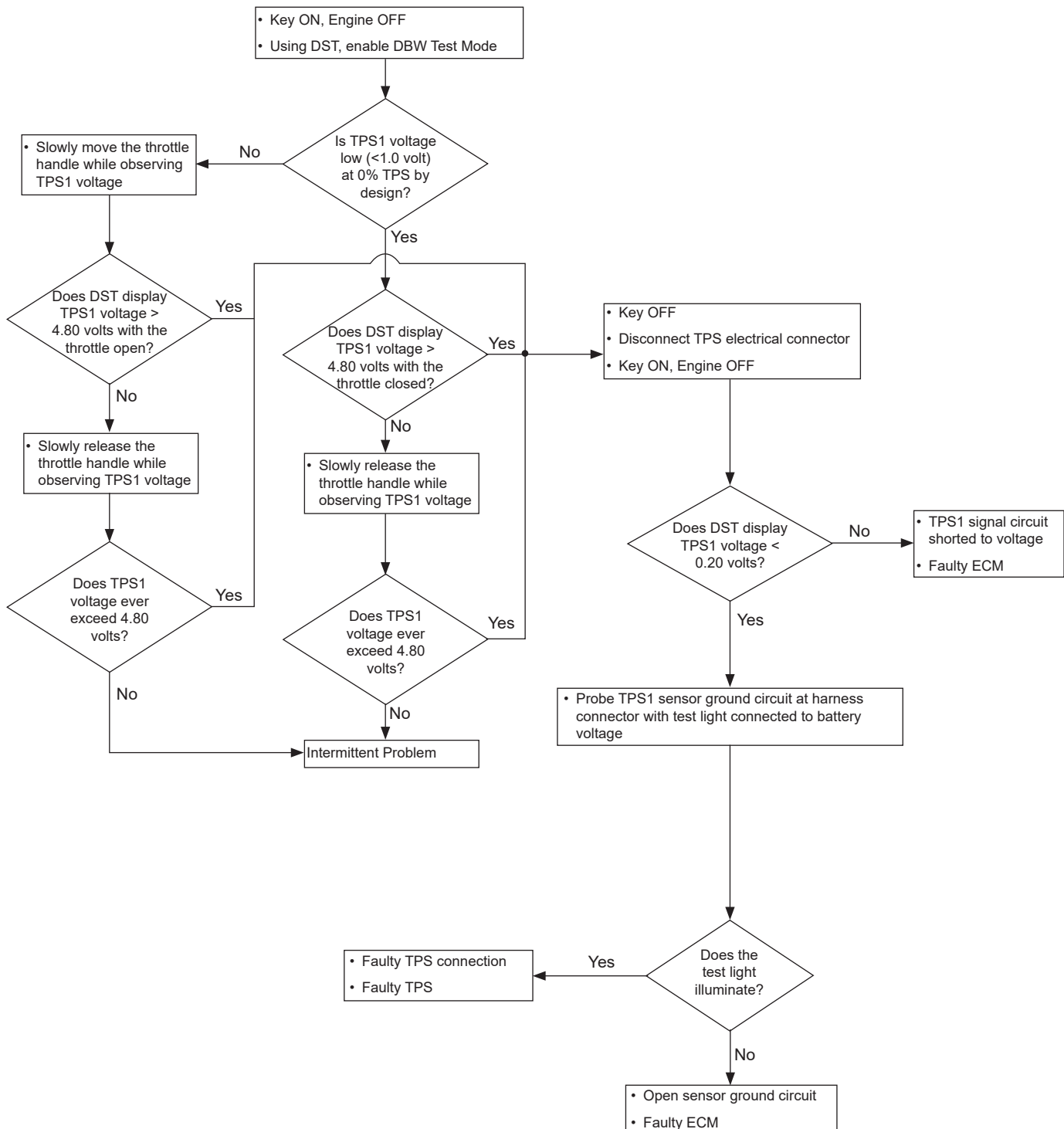
- Throttle Body - Throttle Position Sensor 1
- *Check Condition* - Key On, Engine Cranking or Running
- *Fault Condition* - TPS1 sensor voltage higher than 4.80 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions related fault

The throttle controls the airflow through the engine, directly affecting the power output of the engine. When the throttle is electronically controlled in an Electronic Throttle Body it can be used to control the idle stability and limit engine speed based on operating conditions.

The Throttle Position Sensor uses a variable resistor and voltage divider circuit to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In an Electronic Throttle Body multiple position feedback sensors (usually two counteracting potentiometers/hall-effects) are used to perform speed governing with improved safety and redundancy.

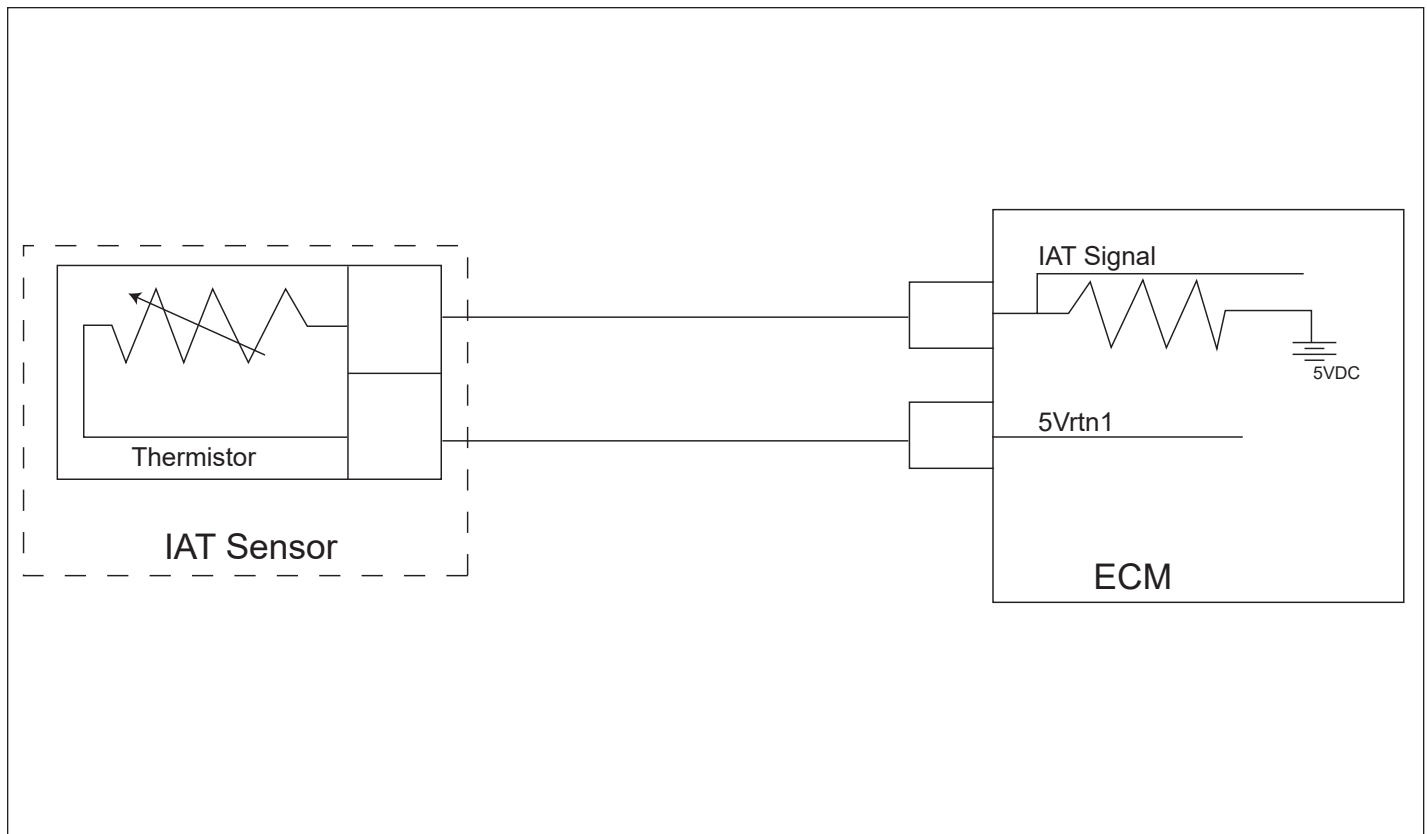
This fault will set if TPS1 voltage is higher than 4.80 volts. In many cases, this condition is caused by a short-to-power of the TPS circuit in the wire harness or a failure of the sensor. This fault should be configured to trigger an engine shutdown and the engine will not start with this fault active.

DTC 0123 - TPS1 Signal Circuit Voltage High SPN - 51; FMI - 3



Diagnostics

DTC 0127 - IAT Higher Than Expected Stage 2 SPN - 105; FMI - 0



- Intake Air Temperature Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Intake Air Temperature greater than 210 degrees F at an operating condition greater than 1500 RPM.
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction while fault is active, or any combination thereof as defined in calibration.
- Non-emissions related fault

The Intake Air Temperature sensor is a thermistor (temperature sensitive resistor) located in the intake manifold of the engine. It is used to monitor incoming air and the output, in conjunction with other sensors, is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.

The Manifold Air Temperature is a calculated value based mainly on the IAT sensor at high airflow and influenced more by the ECT/CHT at low airflow. It is used to monitor incoming air and the output, in conjunction with other sensors, is used to determine the airflow to the engine, and ignition timing.

This fault will set if the Intake Air Temperature is greater than 210 degrees F and the operating condition is at a speed greater than 1500 RPM.

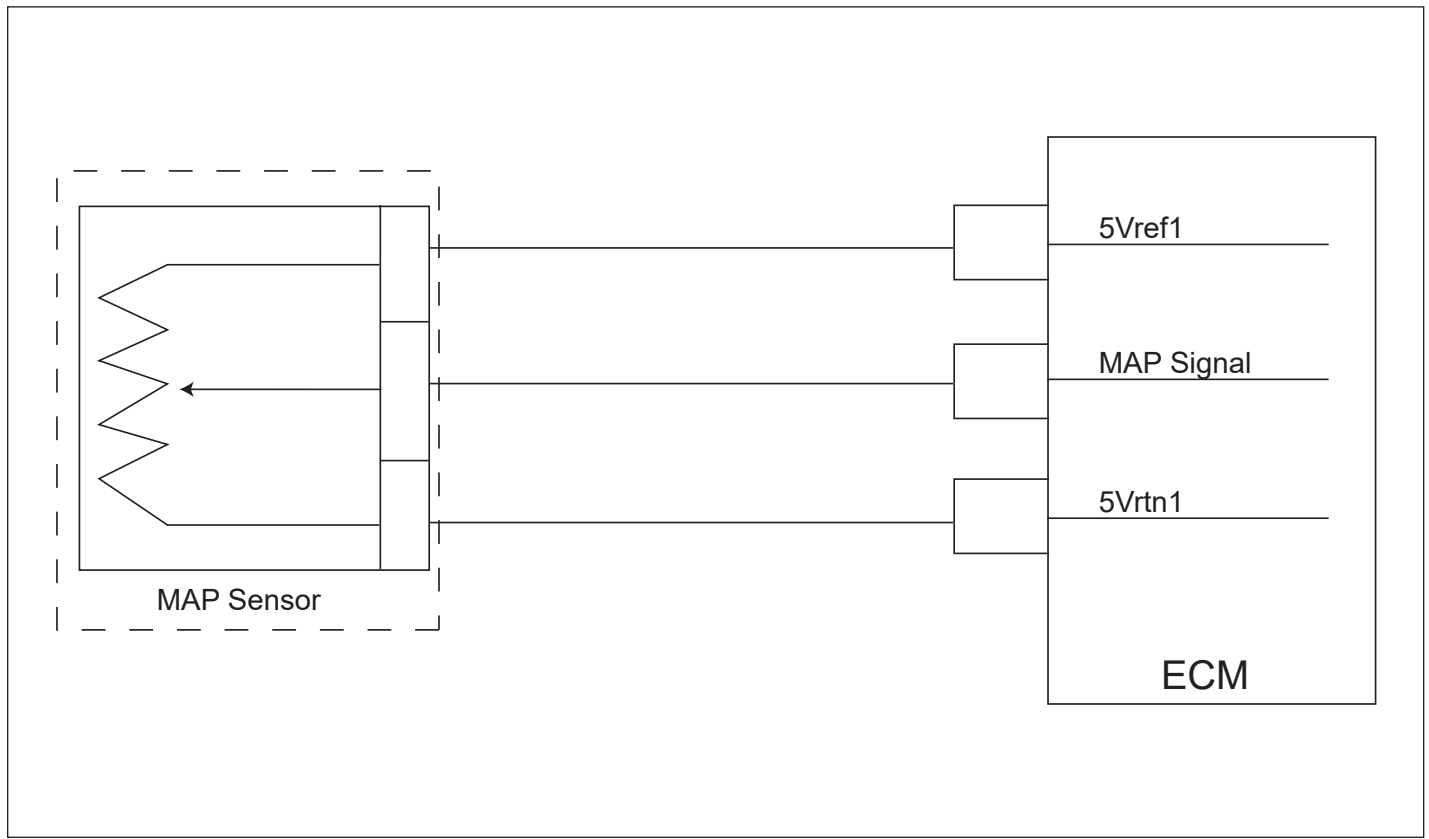
DTC 0127 - IAT Higher Than Expected Stage 2 SPN - 105; FMI - 0

Diagnostic Aids

- This fault will set when inlet air is hotter than normal. The most common cause of high inlet air temperature is a result of a problem with routing of the inlet air. Ensure inlet plumbing sources are external, is cool, and is not too close to the exhaust at any point.
- Inspect the inlet air system for cracks or breaks that may allow unwanted underhood air to enter the engine.
- If no problem is found, replace the IAT sensor with a known good part and retest.

Diagnostics

DTC 0129 - Barometric Pressure - Low Pressure SPN - 108; FMI - 1

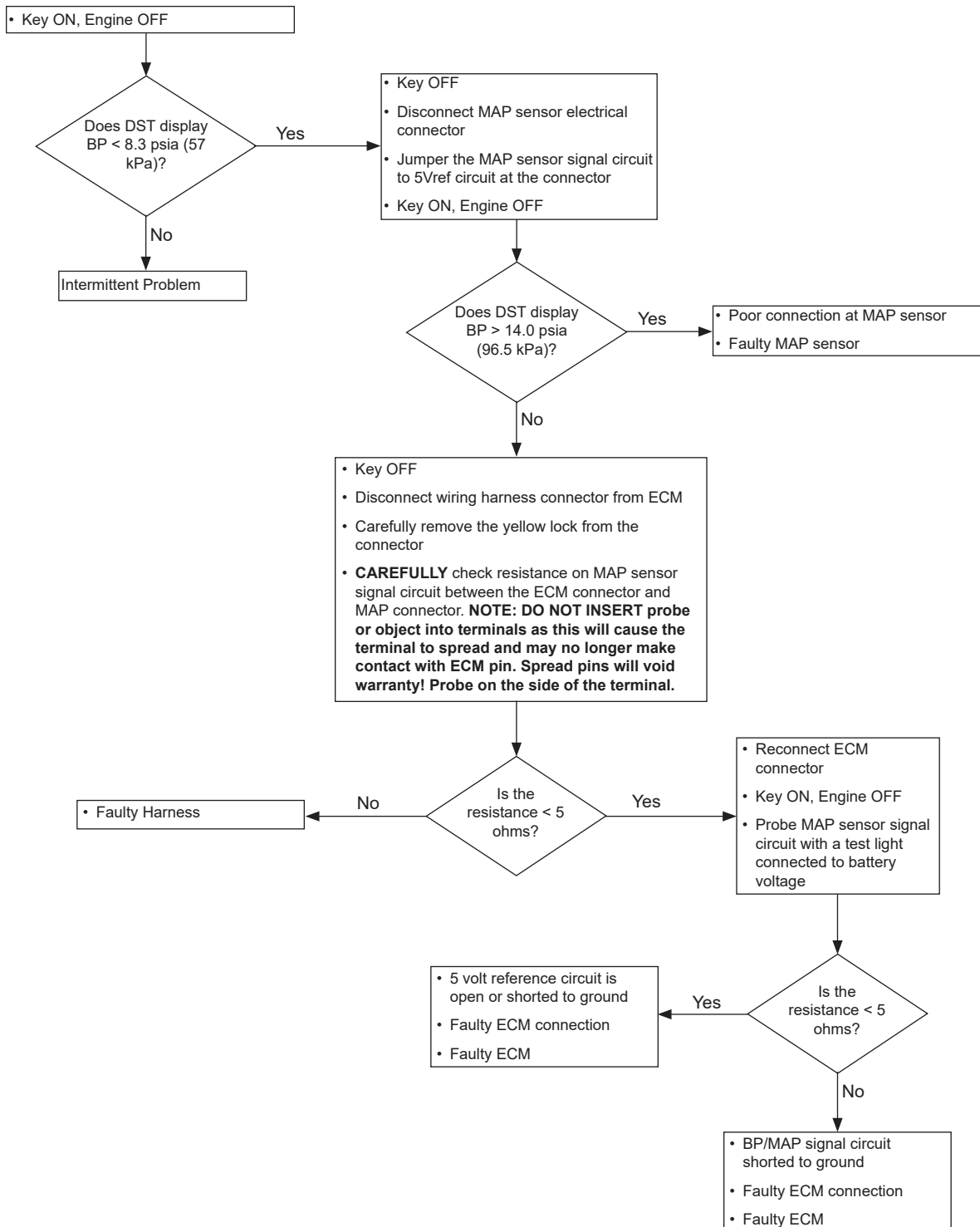


- Barometric Pressure
- *Check Condition* - Key On, Engine Off or after BP estimate during low-speed/high load operation
- *Fault Condition* - Barometric Pressure is less than 8.30 psia
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle
- Emissions related fault

Barometric Pressure is estimated from the MAP sensor at key-on and in some calibrations during low speed/high load operation as defined in the engine's calibration. The barometric pressure value is used for fuel and airflow calculations and equivalence ratio targets based on altitude.

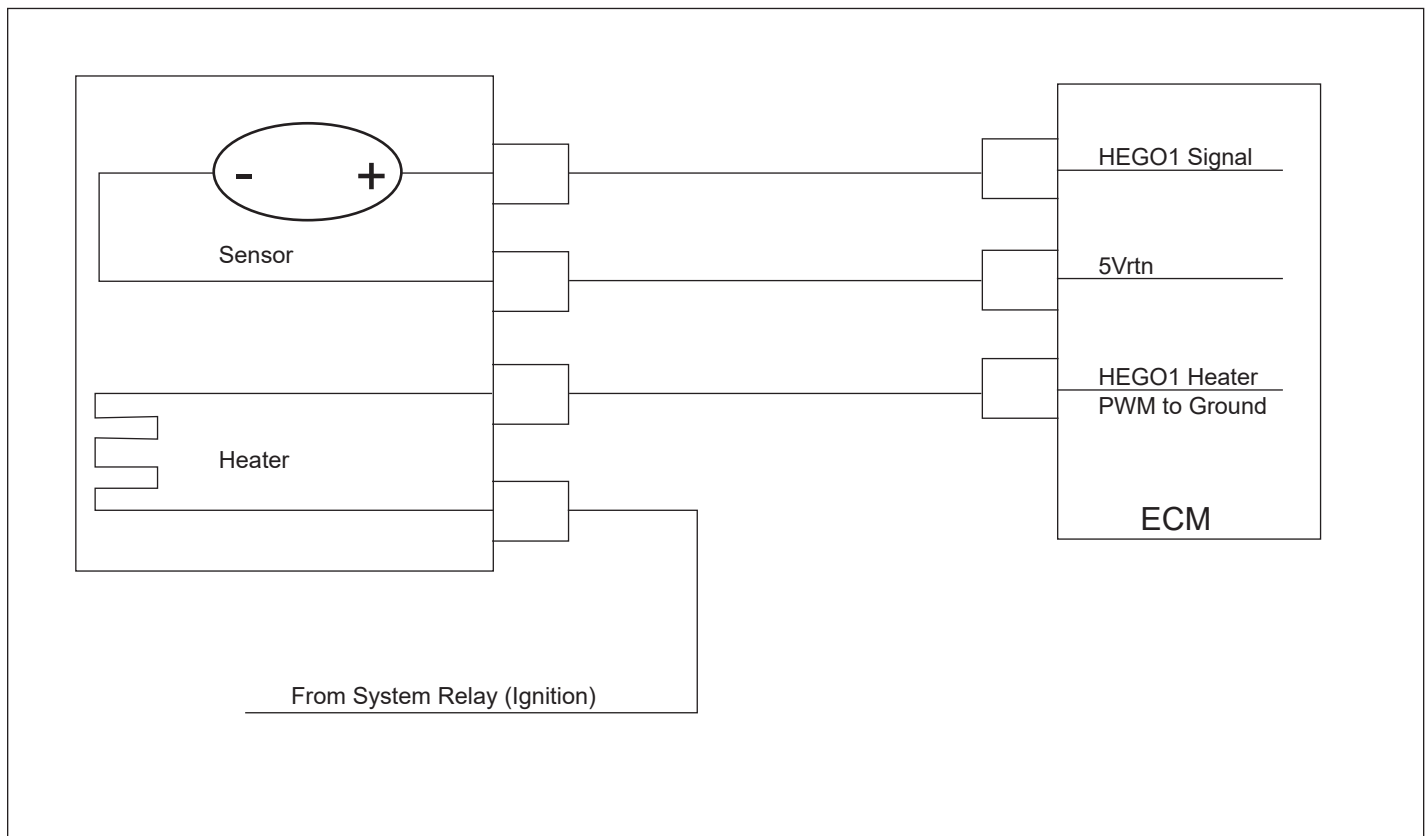
This fault sets if the barometric pressure is lower than 8.30 psia as defined in the diagnostic calibration.

DTC 0129 - Barometric Pressure - Low Pressure SPN - 108; FMI - 1



Diagnostics

DTC 0134 - Heated Exhaust Gas Oxygen 1 (HEGO1) Sensor Circuit Open/Lazy SPN - 3217; FMI - 5

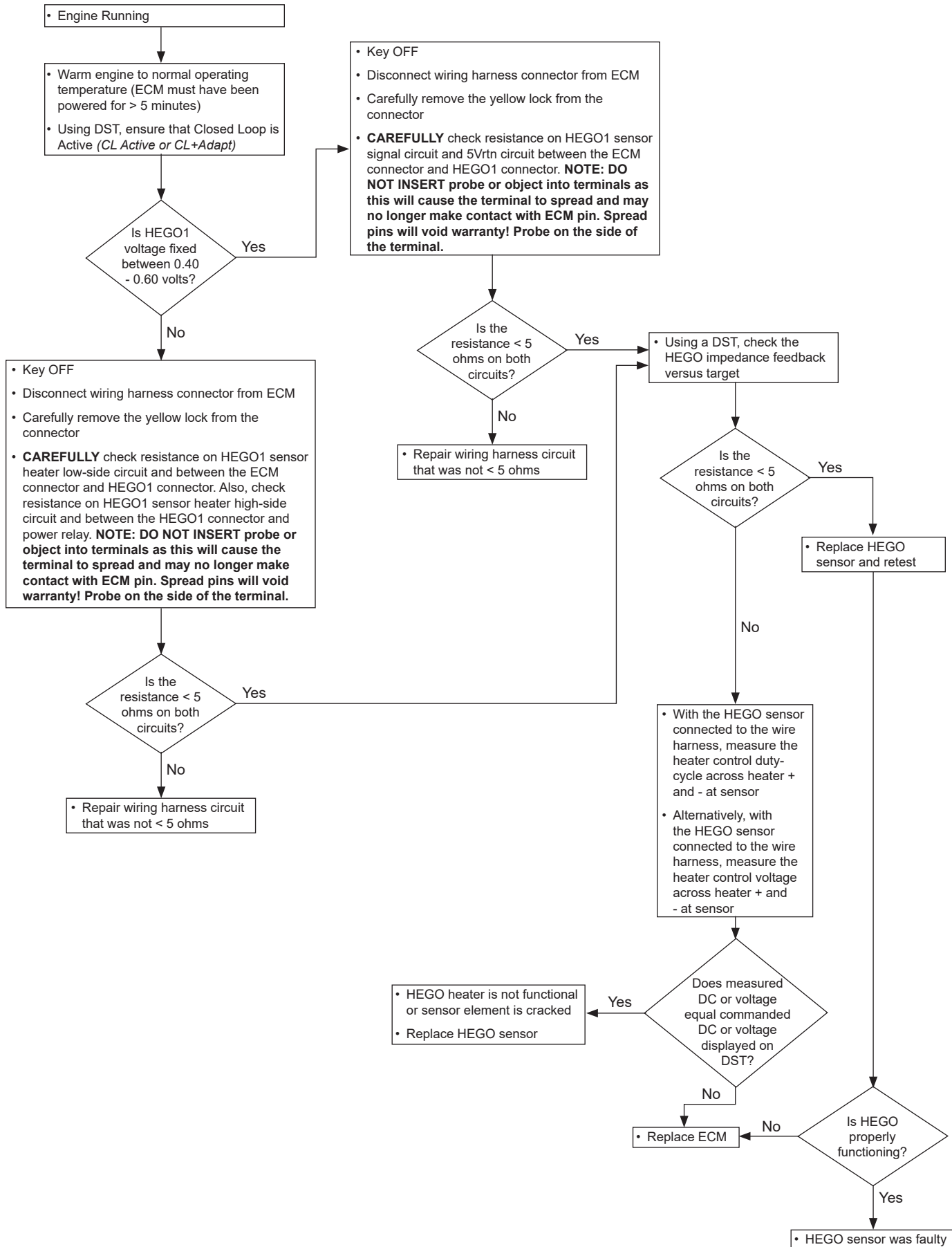


- Heated Exhaust Gas Oxygen Sensor (Bank 1-Sensor 1/Bank 1-Before Catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - HEGO cold longer than 120 seconds
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The HEGO sensor is a switching-type sensor about stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either “CL Active” or “CL + Adapt” control modes.

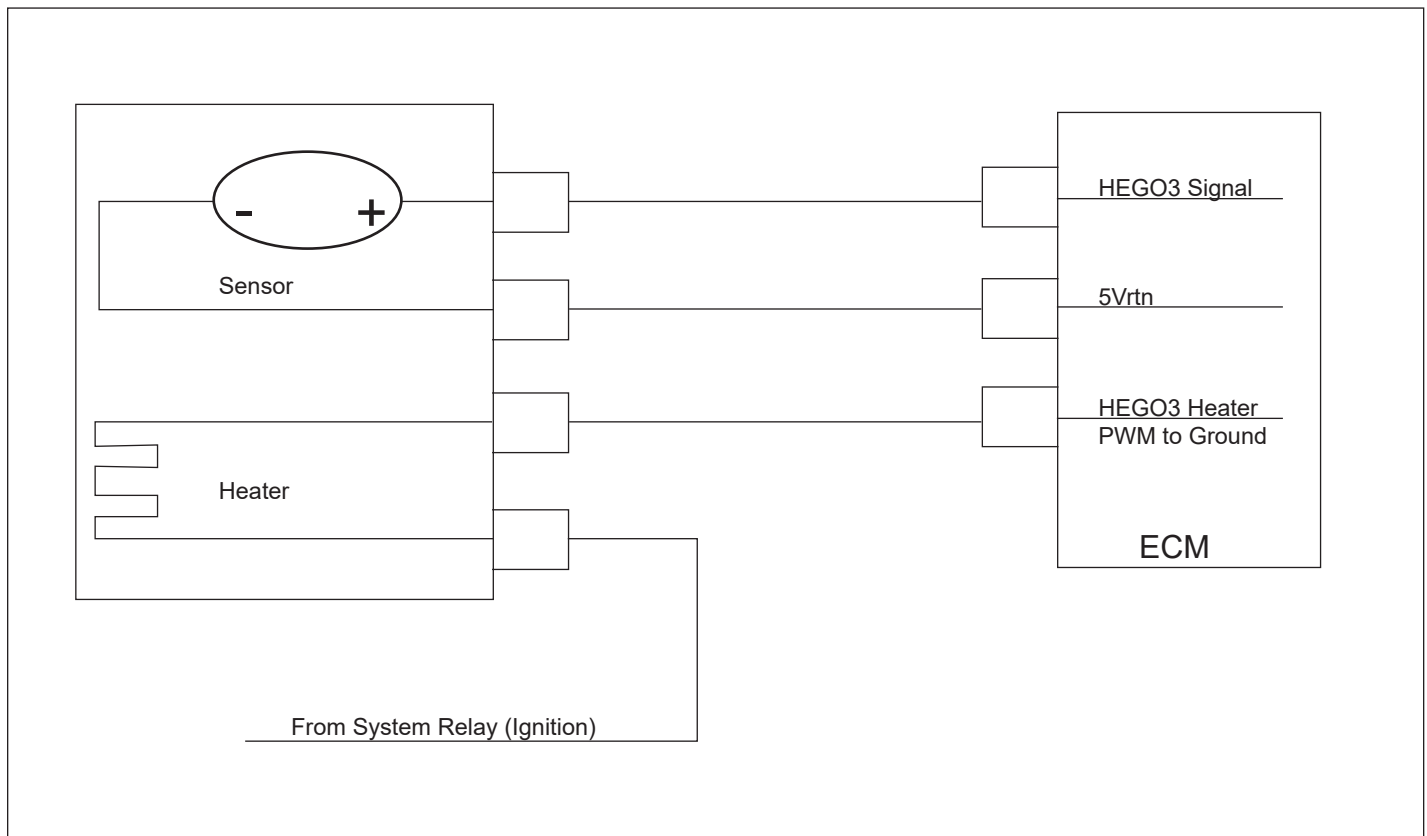
This fault will set if the sensor element is cold, non-responsive, or inactive for 120 seconds as defined in the diagnostic calibration. Cold, non-responsive, or inactive are determined based on two criteria 1) a measurement of the feedback sense element (zirconia) to determine its temperature or 2) a lack of change in sensor feedback. This fault should disable closed-loop when it is active and adaptive learn for the key-cycle.

DTC 0134 - Heated Exhaust Gas Oxygen 1 (HEGO1) Sensor Circuit Open/Lazy SPN - 3217; FMI - 5



Diagnostics

DTC 0140 - Heated Exhaust Gas Oxygen 3 (HEGO3) Sensor Circuit Open/Lazy SPN - 3256; FMI - 5

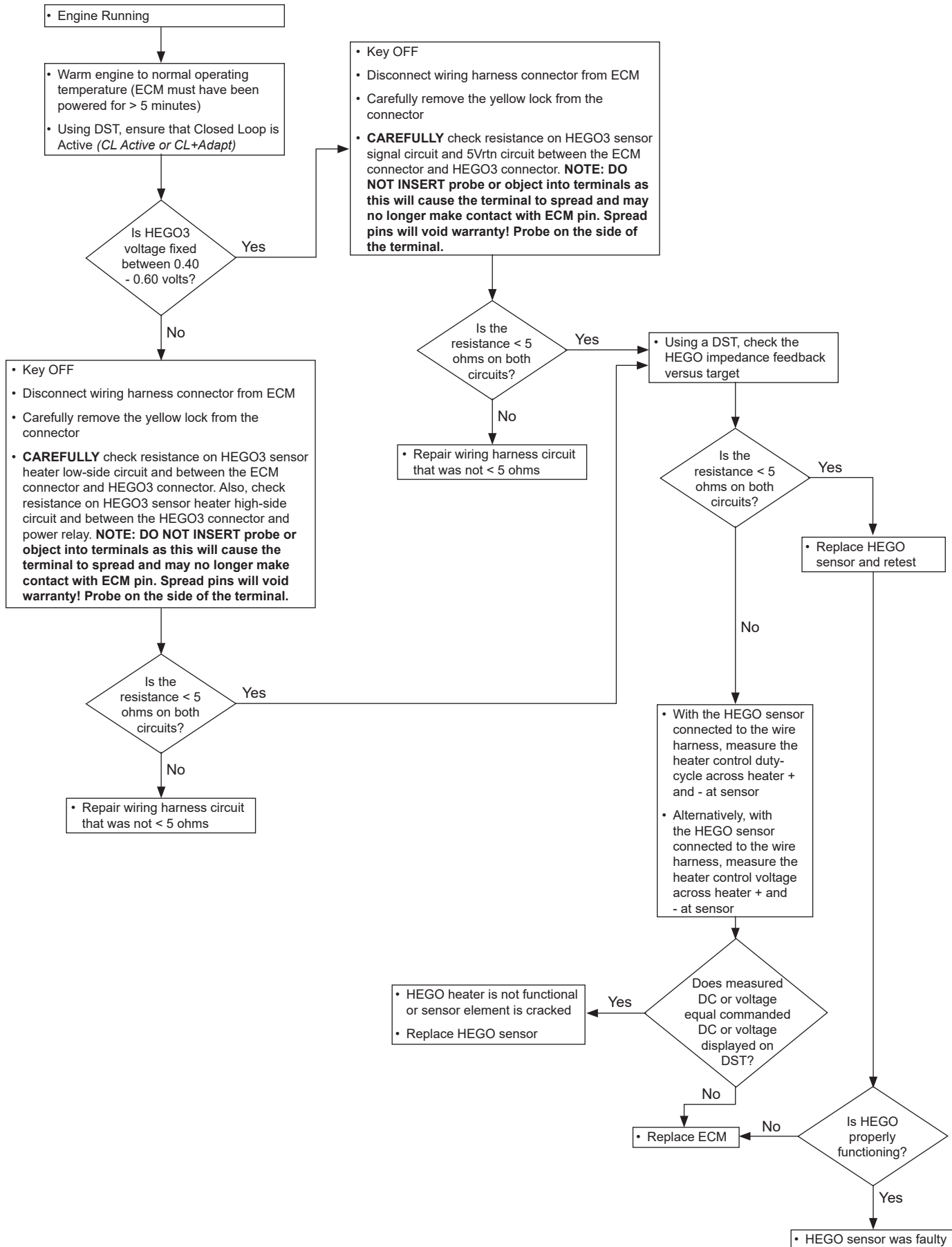


- Heated Exhaust Gas Oxygen Sensor (Bank 1-Sensor 3/Bank 1-After Catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - HEGO cold longer than 120 seconds
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The HEGO sensor is a switching-type sensor about stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted using the Closed Loop multiplier and then "learned" with the Adaptive multiplier. The multipliers only update when the system is in either "CL Active" or "CL + Adapt" control modes.

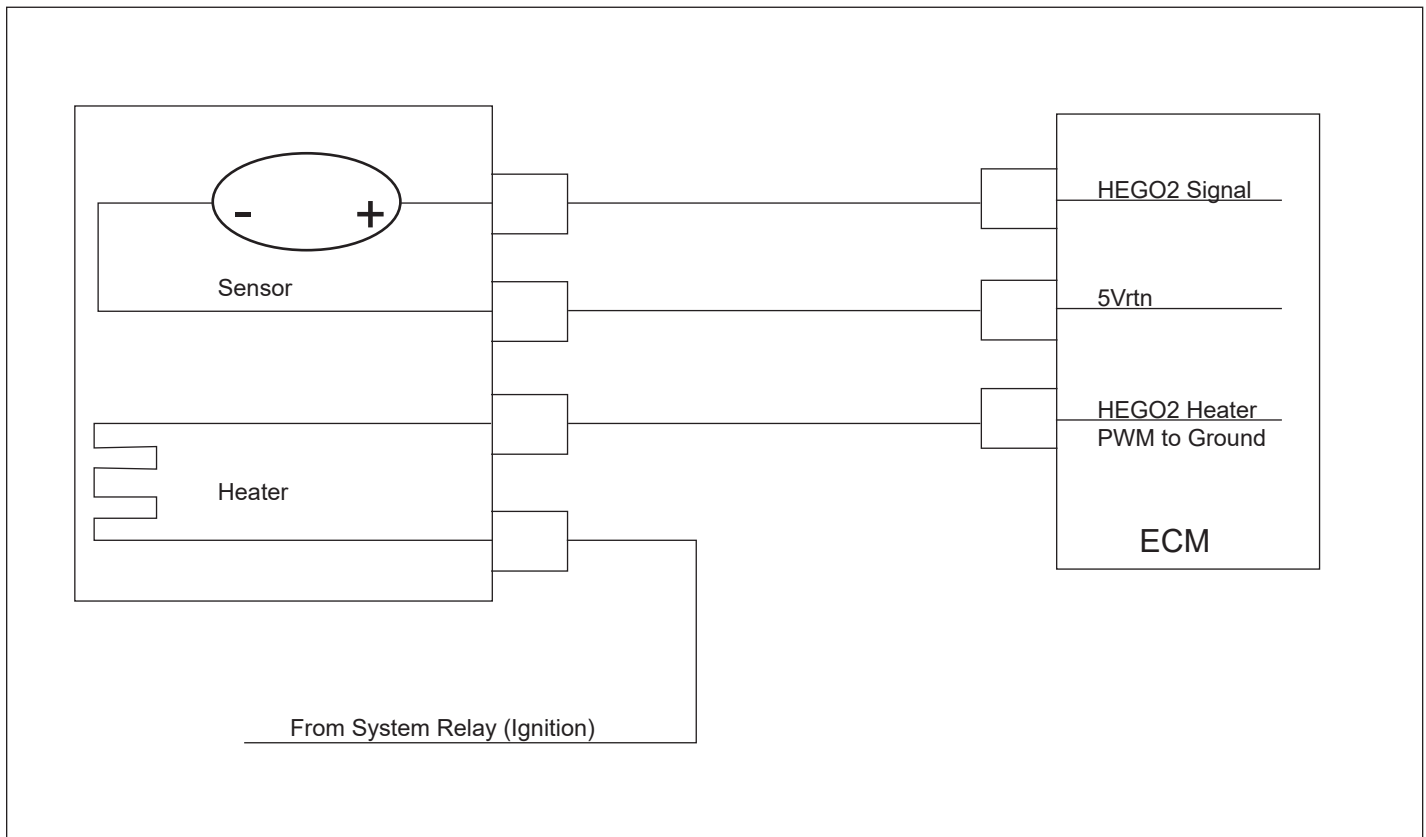
This fault will set if the sensor element is cold, non-responsive, or inactive for 120 seconds as defined in the diagnostic calibration. Cold, non-responsive, or inactive are determined based on two criteria 1) a measurement of the feedback sense element (zirconia) to determine its temperature or 2) a lack of change in sensor feedback. This fault should disable closed-loop when it is active and adaptive learn for the key-cycle.

DTC 0140 - Heated Exhaust Gas Oxygen 3 (HEGO3) Sensor Circuit Open/Lazy SPN - 3256; FMI - 5



Diagnostics

DTC 0154 - Heated Exhaust Gas Oxygen 2 (HEGO2) Sensor Circuit Open/Lazy SPN - 3227; FMI - 5

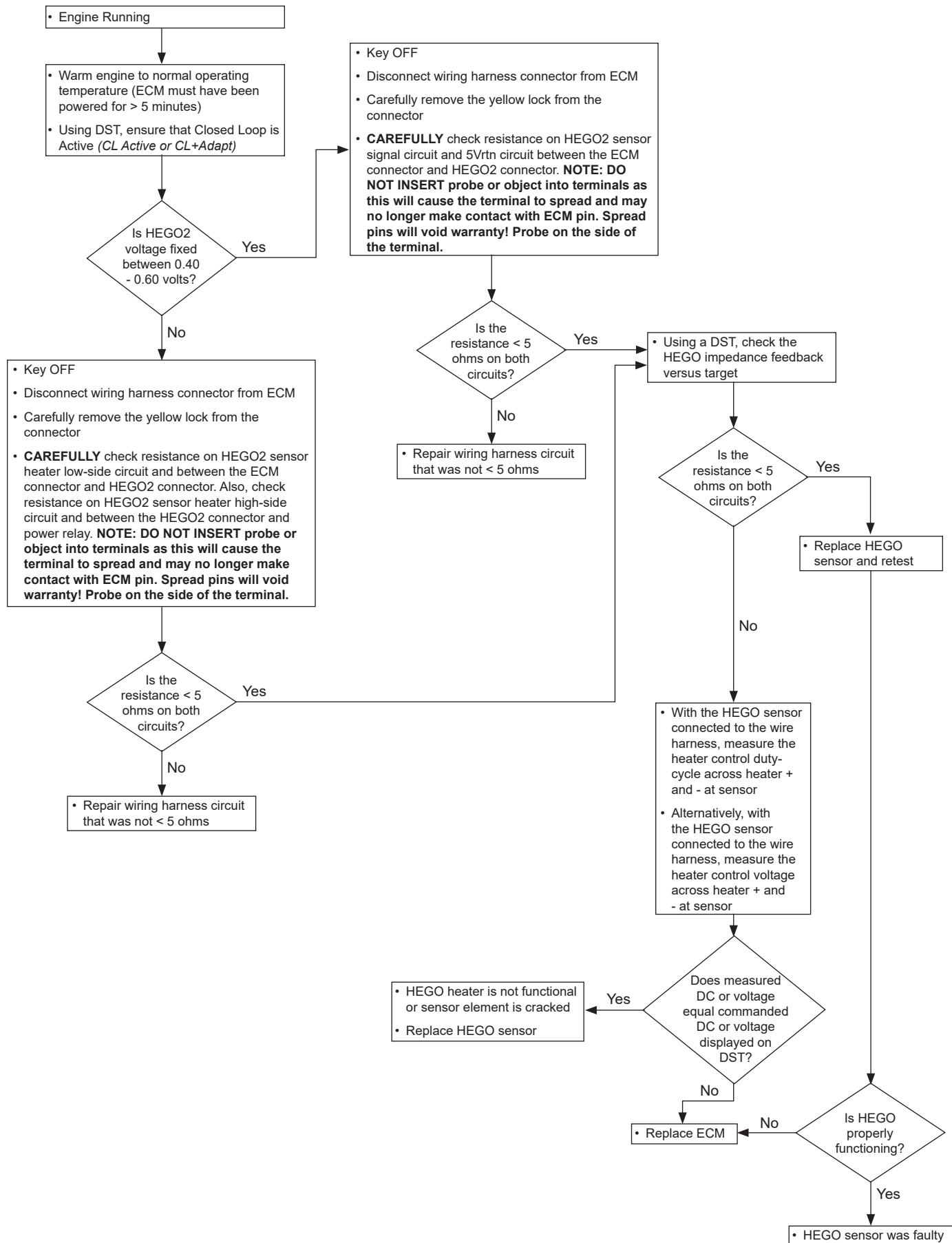


- Heated Exhaust Gas Oxygen Sensor (Bank 2-Sensor 2/Bank 2-Before Catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - HEGO cold longer than 120 seconds
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The HEGO sensor is a switching-type sensor about stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either “CL Active” or “CL + Adapt” control modes.

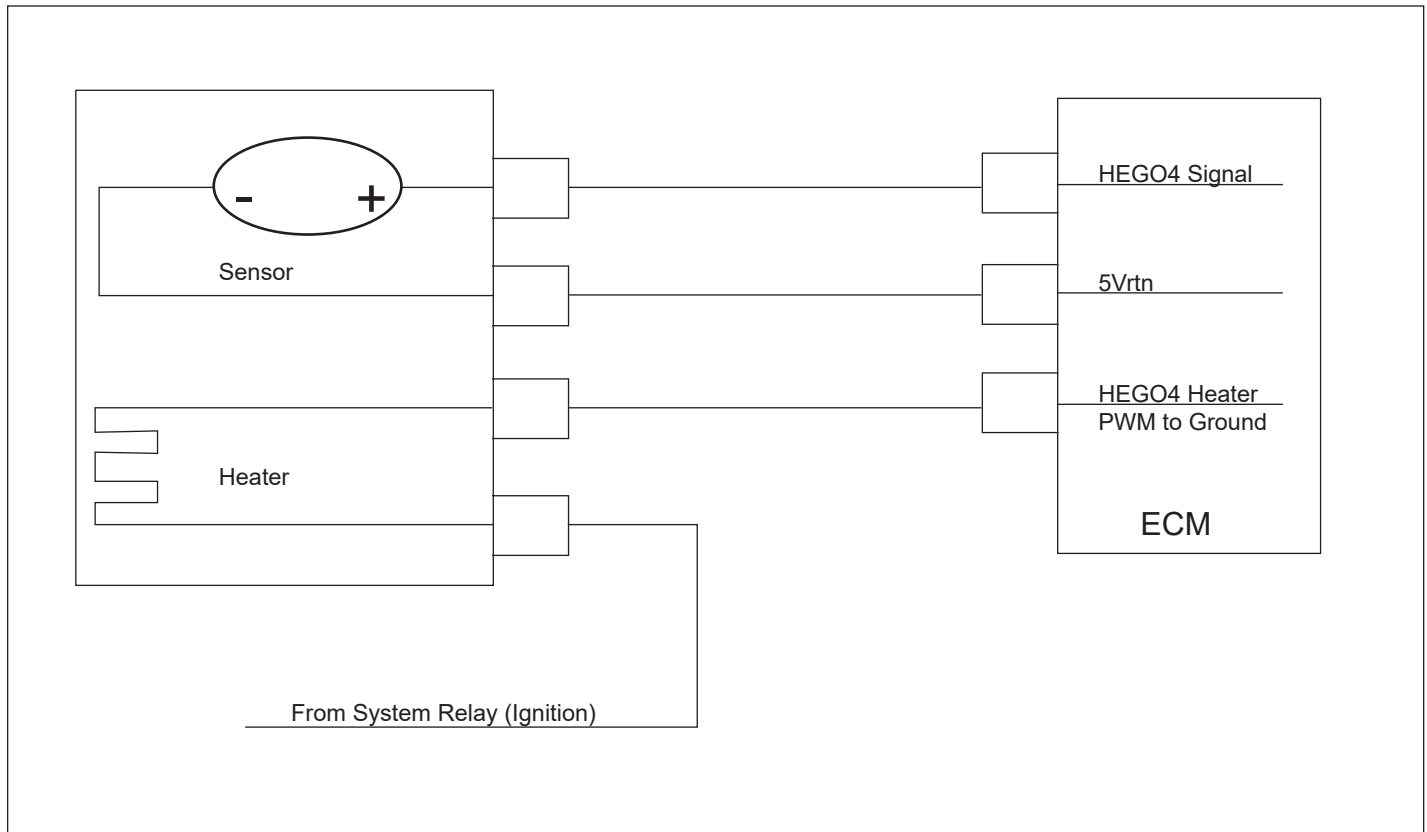
This fault will set if the sensor element is cold, non-responsive, or inactive for 120 seconds as defined in the diagnostic calibration. Cold, non-responsive, or inactive are determined based on two criteria 1) a measurement of the feedback sense element (zirconia) to determine its temperature or 2) a lack of change in sensor feedback. This fault should disable closed-loop when it is active and adaptive learn for the key-cycle.

DTC 0154 - Heated Exhaust Gas Oxygen 2 (HEGO2) Sensor Circuit Open/Lazy SPN - 3227; FMI - 5



Diagnostics

DTC 0160 - Heated Exhaust Gas Oxygen 4 (HEGO4) Sensor Circuit Open/Lazy SPN - 3266; FMI - 5

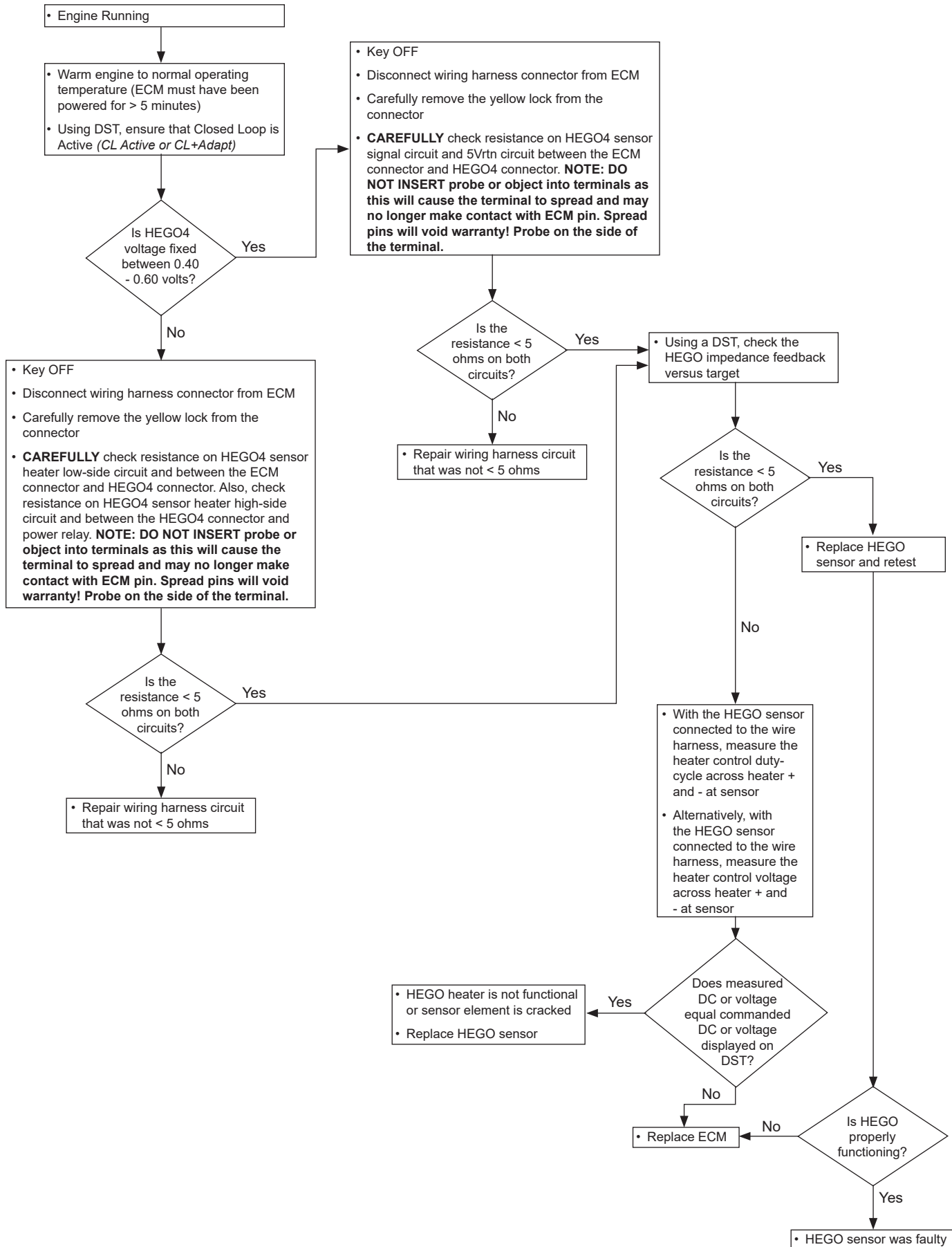


- Heated Exhaust Gas Oxygen Sensor (Bank 2-Sensor 4/Bank 2-After Catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - HEGO cold longer than 120 seconds
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The HEGO sensor is a switching-type sensor about stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either “CL Active” or “CL + Adapt” control modes.

This fault will set if the sensor element is cold, non-responsive, or inactive for 120 seconds as defined in the diagnostic calibration. Cold, non-responsive, or inactive are determined based on two criteria 1) a measurement of the feedback sense element (zirconia) to determine its temperature or 2) a lack of change in sensor feedback. This fault should disable closed-loop when it is active and adaptive learn for the key-cycle.

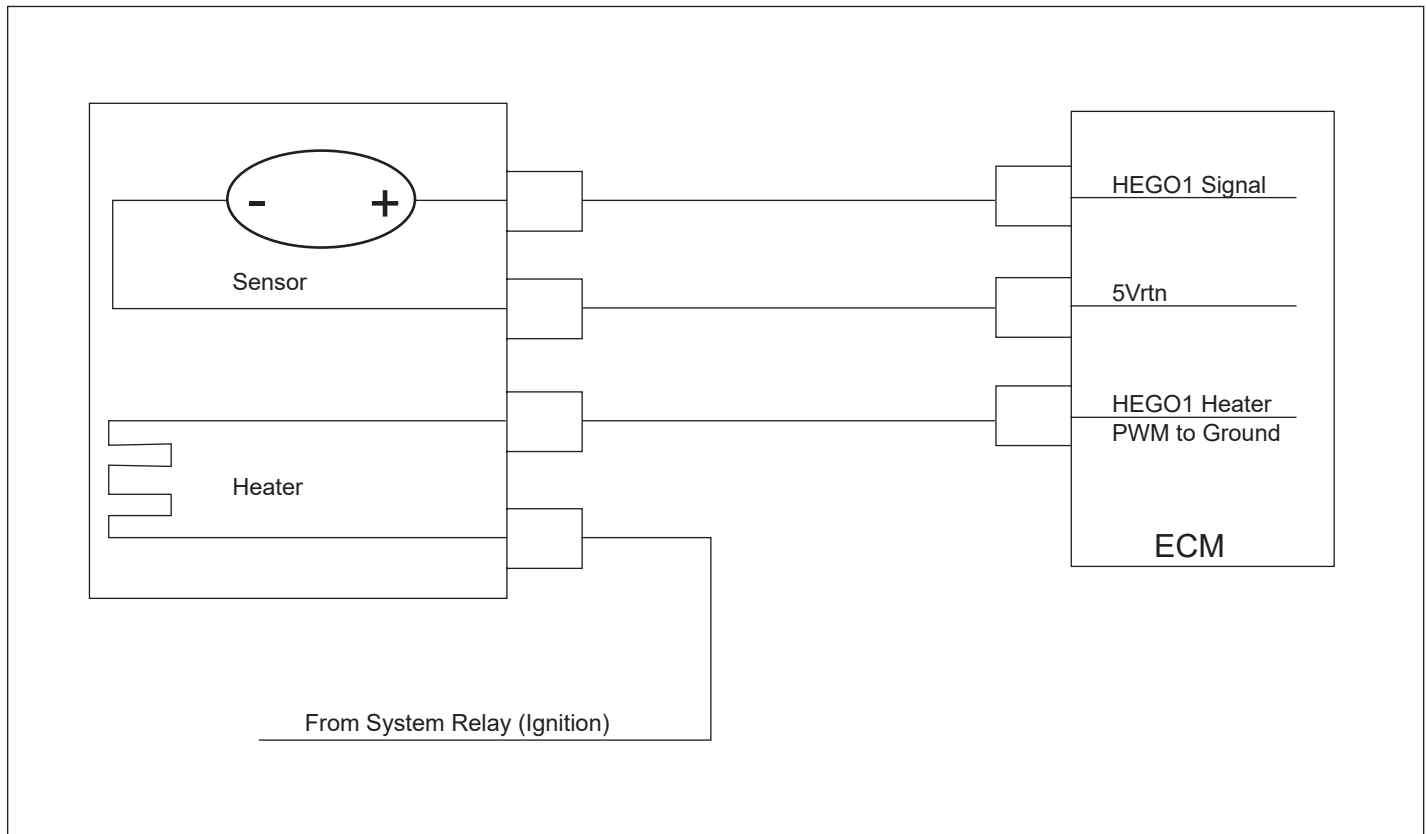
DTC 0160 - Heated Exhaust Gas Oxygen 4 (HEGO4) Sensor Circuit Open/Lazy SPN - 3266; FMI - 5



Diagnostics

DTC 0171 - Adaptive-Learn Bank 1 High

SPN - 4237; FMI - 0



- Heated Exhaust Gas Oxygen Sensor (Bank 1-Sensor 1/Bank 1-Before Catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Bank 1 adaptive fuel multiplier higher than 30%
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and possibly disable closed-loop fueling correction during active fault .
- Emissions related fault

The HEGO sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either “CL Active” or “CL + Adapt” control modes. The purpose of the Adaptive Learn fuel multiplier is to adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation.

This fault sets if the Adaptive multiplier exceeds 30%, indicating that the engine is operating lean (excess oxygen) and requires more fuel than allowed by corrections. Often high positive fueling corrections are a function of one or more of the following conditions: 1) exhaust leaks upstream or near the HEGO sensor, 2) reduced fuel supply pressure to the fuel injection system, 3) a non-responsive HEGO sensor, and/or 3) an injector that is stuck closed. This fault should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

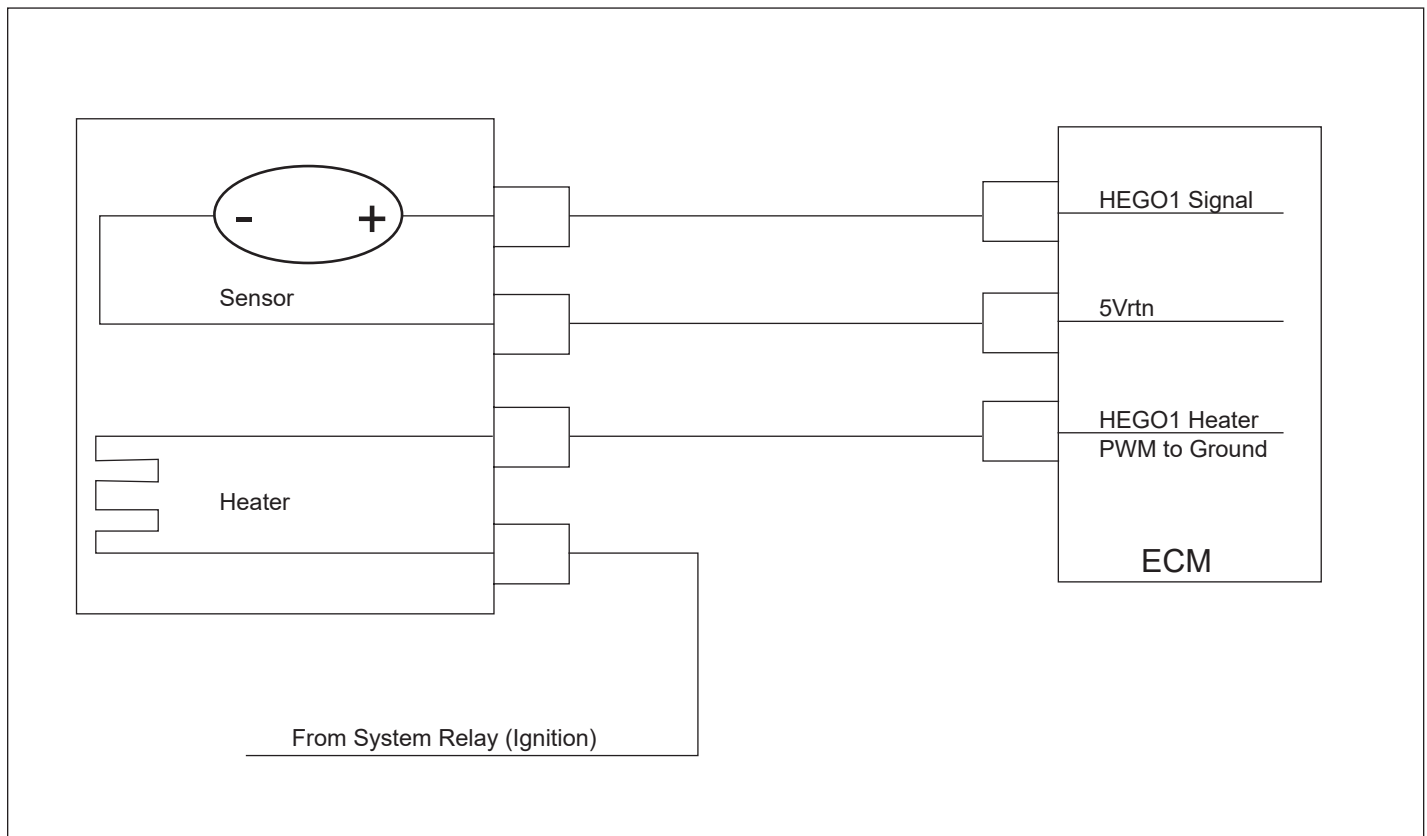
DTC 0171 - Adaptive-Learn Bank 1 High SPN - 4237; FMI - 0

Diagnostic Aids

- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- Vacuum Leaks - Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at light load.
- Injectors - System will be lean if an injector driver or driver circuit fails. The system will also be lean if an injector fails in a closed manner or is dirty.
- Fuel Pressure - System will be lean if fuel pressure is too low. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- Air in Fuel - If the fuel return hose/line is too close to the fuel supply pickup in the fuel tank, air may become entrapped in the pump or supply line causing a lean condition and driveability problems.
- Exhaust Leaks - If there is an exhaust leak, outside air can be pulled into the exhaust and past the HEGO sensor causing a false lean condition.
- Fuel Quality - A drastic variation in fuel quality may cause the system to be lean including oxygenated fuels.
- System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- If all tests are OK, replace the HEGO sensor with a known good part and retest.

Diagnostics

DTC 0172 - Adaptive-Learn Bank 1 Low SPN - 4237; FMI - 1



- Heated Exhaust Gas Oxygen Sensor (Bank 1-Sensor 1/Bank 1-Before Catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Bank 1 adaptive fuel multiplier lower than -30%
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and possibly disable closed-loop fueling correction during active fault .
- Emissions related fault

The HEGO sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either “CL Active” or “CL + Adapt” control modes. The purpose of the Adaptive Learn fuel multiplier is to adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation.

This fault sets if the Adaptive multiplier is lower than -30%, indicating that the engine is operating rich (excess fuel) and requires less fuel than allowed by corrections. Often high negative fueling corrections are a function of one or more of the following conditions: 1) high fuel supply pressure to the fuel injection system, 2) a non-responsive HEGO sensor, and/or 3) an injector that is stuck open. This fault should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

DTC 0172 - Adaptive-Learn Bank 1 Low SPN - 4237; FMI - 1

Diagnostic Aids

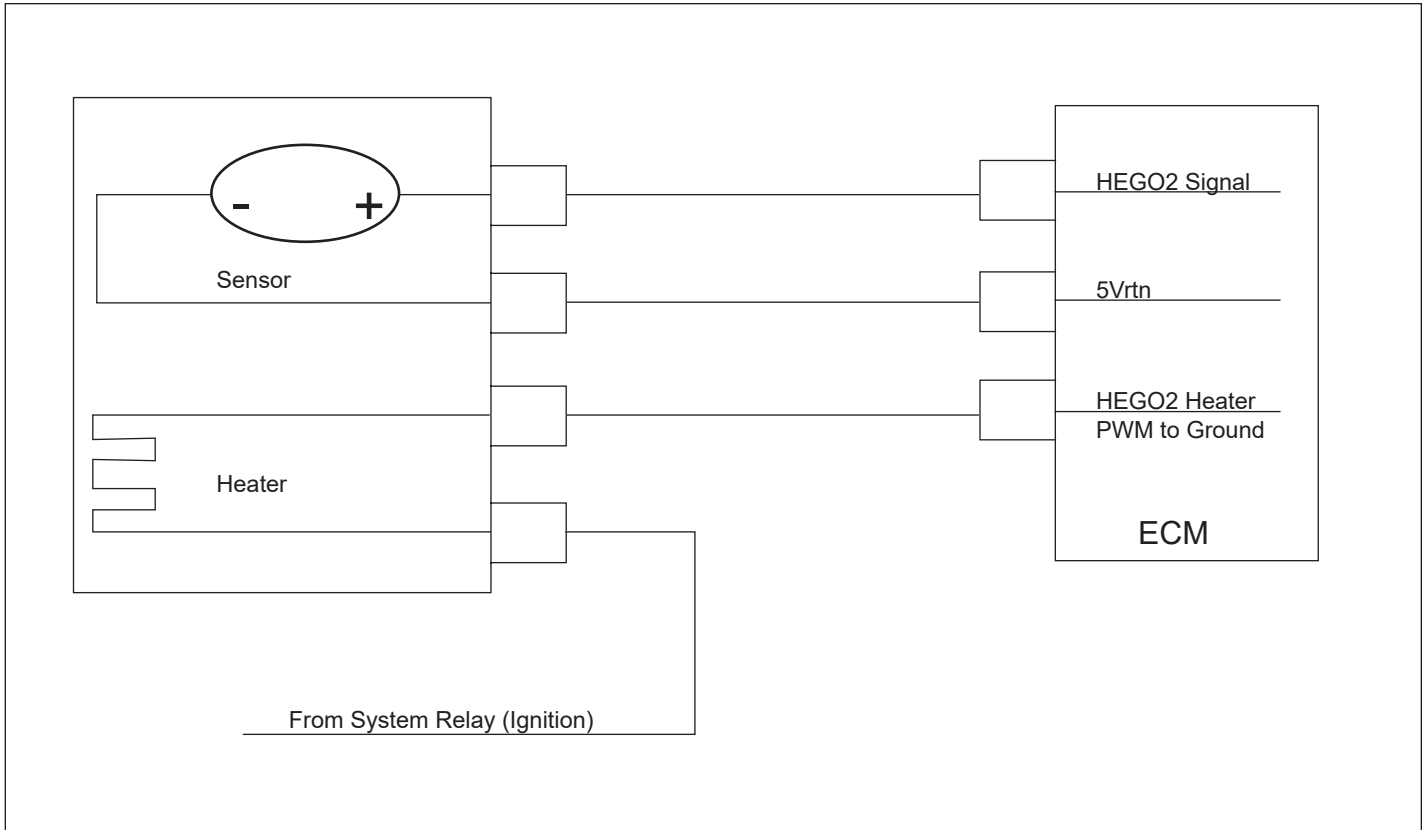
NOTE: If any other DTCs are present, diagnose those first.

- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- Injectors - System will be rich if an injector driver or driver circuit fails shorted-to-ground. The system will also be rich if an injector fails in an open.
- Fuel Pressure - System will be rich if fuel pressure is too high. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- If all tests are OK, replace the HEGO sensor with a known good part and retest

Diagnostics

DTC 0174 - Adaptive-Learn Bank 2 High

SPN - 4239; FMI - 0



- Heated Exhaust Gas Oxygen Sensor (Bank 2-Sensor 3/Bank 2-Before Catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Bank 2 adaptive fuel multiplier higher than 30%
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and possibly disable closed-loop fueling correction during active fault .
- Emissions related fault

The HEGO sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either “CL Active” or “CL + Adapt” control modes. The purpose of the Adaptive Learn fuel multiplier is to adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation.

This fault sets if the Adaptive multiplier exceeds 30%, indicating that the engine is operating lean (excess oxygen) and requires more fuel than allowed by corrections. Often high positive fueling corrections are a function of one or more of the following conditions: 1) exhaust leaks upstream or near the HEGO sensor, 2) reduced fuel supply pressure to the fuel injection system, 3) a non-responsive HEGO sensor, and/or 3) an injector that is stuck closed. This fault should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

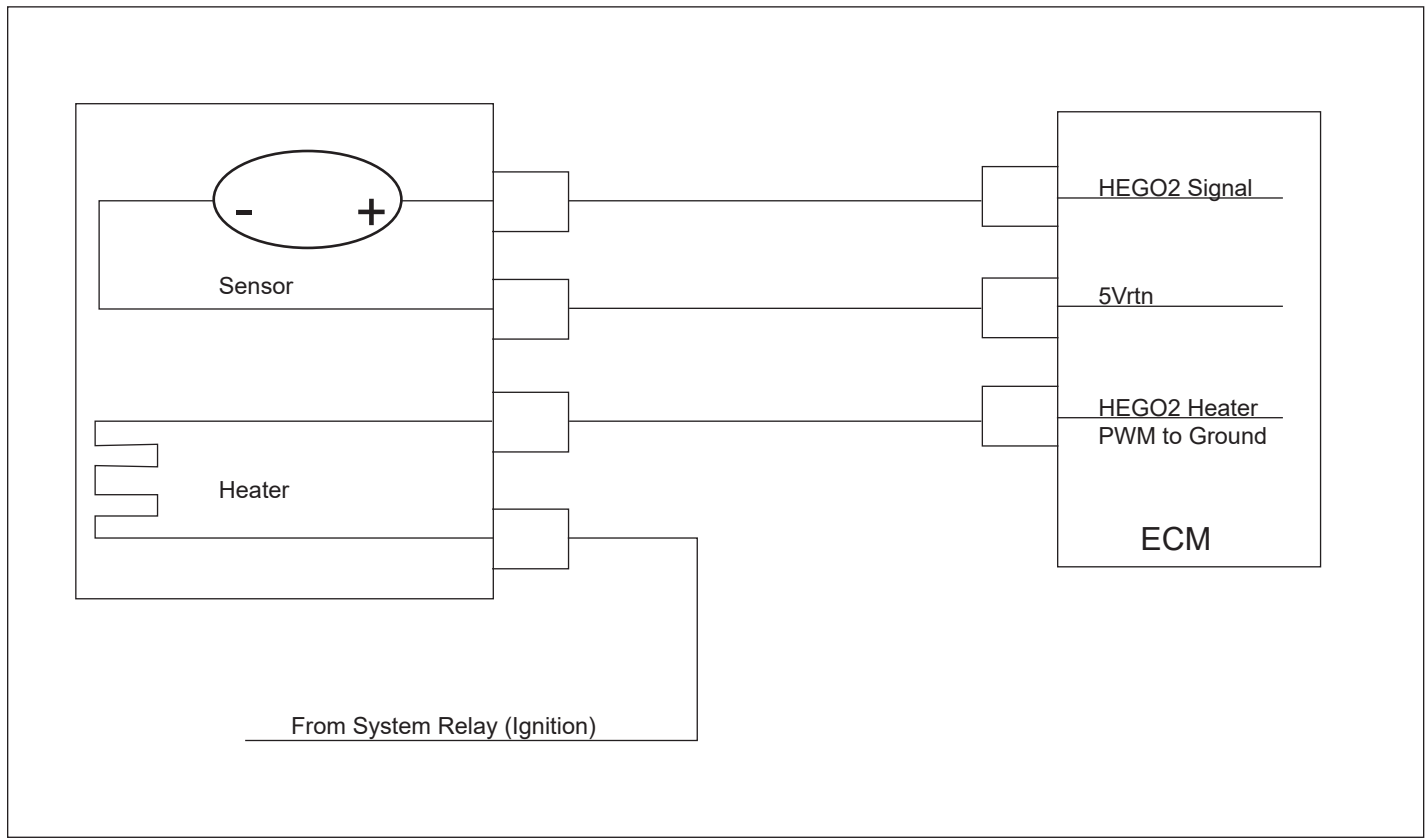
DTC 0174 - Adaptive-Learn Bank 2 High SPN - 4239; FMI - 0

Diagnostic Aids

- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- Vacuum Leaks - Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at light load.
- Injectors - System will be lean if an injector driver or driver circuit fails. The system will also be lean if an injector fails in a closed manner or is dirty.
- Fuel Pressure - System will be lean if fuel pressure is too low. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- Air in Fuel - If the fuel return hose/line is too close to the fuel supply pickup in the fuel tank, air may become entrapped in the pump or supply line causing a lean condition and driveability problems.
- Exhaust Leaks - If there is an exhaust leak, outside air can be pulled into the exhaust and past the HEGO sensor causing a false lean condition.
- Fuel Quality - A drastic variation in fuel quality may cause the system to be lean including oxygenated fuels.
- System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- If all tests are OK, replace the HEGO sensor with a known good part and retest.

Diagnostics

DTC 0175 - Adaptive-Learn Bank 2 Low SPN - 4239; FMI - 1



- Heated Exhaust Gas Oxygen Sensor (Bank 2-Sensor 3/Bank 2-Before Catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Bank 2 adaptive fuel multiplier lower than -30%
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and possibly disable closed-loop fueling correction during active fault .
- Emissions related fault

The HEGO sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either “CL Active” or “CL + Adapt” control modes. The purpose of the Adaptive Learn fuel multiplier is to adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation.

This fault sets if the Adaptive multiplier is lower than -30%, indicating that the engine is operating rich (excess fuel) and requires less fuel than allowed by corrections. Often high negative fueling corrections are a function of one or more of the following conditions: 1) high fuel supply pressure to the fuel injection system, 2) a non-responsive HEGO sensor, and/or 3) an injector that is stuck open. This fault should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

DTC 0175 - Adaptive-Learn Bank 2 Low SPN - 4239; FMI - 1

Diagnostic Aids

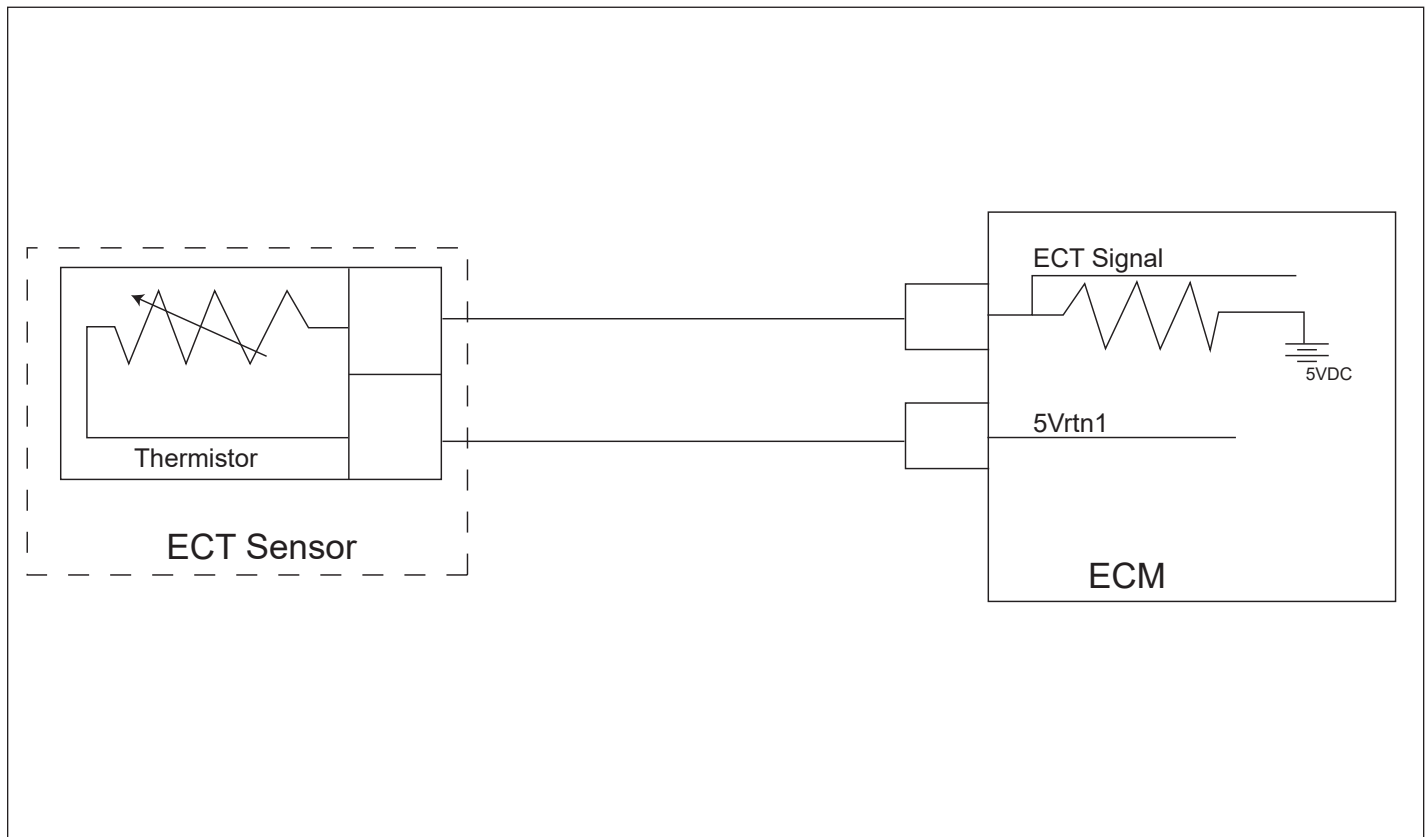
NOTE: If any other DTCs are present, diagnose those first.

- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- Injectors - System will be rich if an injector driver or driver circuit fails shorted-to-ground. The system will also be rich if an injector fails in an open.
- Fuel Pressure - System will be rich if fuel pressure is too high. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- If all tests are OK, replace the HEGO sensor with a known good part and retest

Diagnostics

DTC 0217 - ECT Higher Than Expected Stage 2

SPN - 110; FMI - 0



- Engine Coolant Temperature Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Engine Coolant Temperature reading greater than 210 degrees F when operating at a speed greater than 600 RPM
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault. Recommend a power derate 1/2 and/or a low rev limit to protect engine from possible damage.
- Non-emissions related fault

The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. It is used for engine airflow calculation, ignition timing control, to enable certain features, and for engine protection. The ECM provides a voltage divider circuit so when the sensor reading is cool the sensor reads higher voltage, and lower when warm.

This fault will help protect the engine in the event of over temperature. When the coolant exceeds 210 deg. F and engine RPM exceeds 600 RPM for the latch time this fault will set.

DTC 0217 - ECT Higher Than Expected Stage 2 SPN - 110; FMI - 0

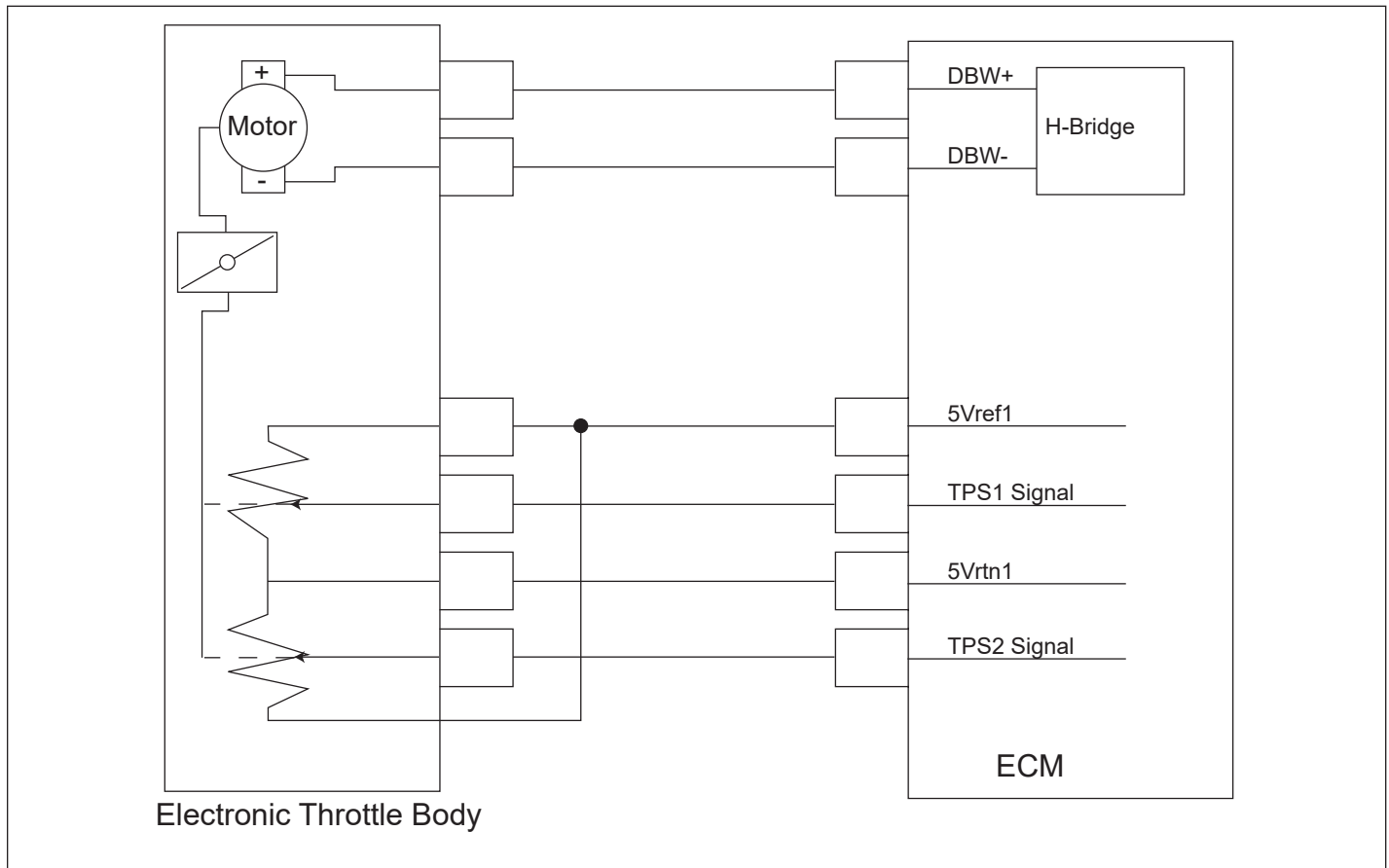
Diagnostic Aids

- If the “ECT High Voltage” fault is also present, follow the troubleshooting procedures for that fault as it may have caused “ECT Higher Than Expected 1.”
- Check that the heat exchanger has a proper amount of ethylene glycol/water and that the heat exchanger is not leaking
- Ensure that there is no trapped air in the cooling path
- Inspect the cooling system (radiator and hoses) for cracks and ensure connections are leak free
- Check that the raw water pickup is not blocked/restricted by debris and that the hose is tightly connected
- Check that the thermostat is not stuck closed
- Check that the raw water pump/impeller is tact and that it is not restricted

Diagnostics

DTC 0219 - RPM Higher Than Max Allowed Governed Speed

SPN - 515; FMI - 15



- Max Govern Speed Override- Crankshaft Position Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Engine speed greater than the max gov override speed as defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, reduce throttle to limit speed. Recommend closed loop and adaptive learn fueling correction remains active during fault.
- Non-emissions related fault

This fault will set anytime the engine RPM exceeds the limit set in the diagnostic calibration for the latch time or more. This speed overrides any higher max governor speeds programmed by the user. This fault is designed to help prevent engine or equipment damage.

The throttle will be lowered in order to govern the engine to the speed set in the diagnostic calibration.

DTC 0219 - RPM Higher Than Max Allowed Governed Speed SPN - 515; FMI - 15

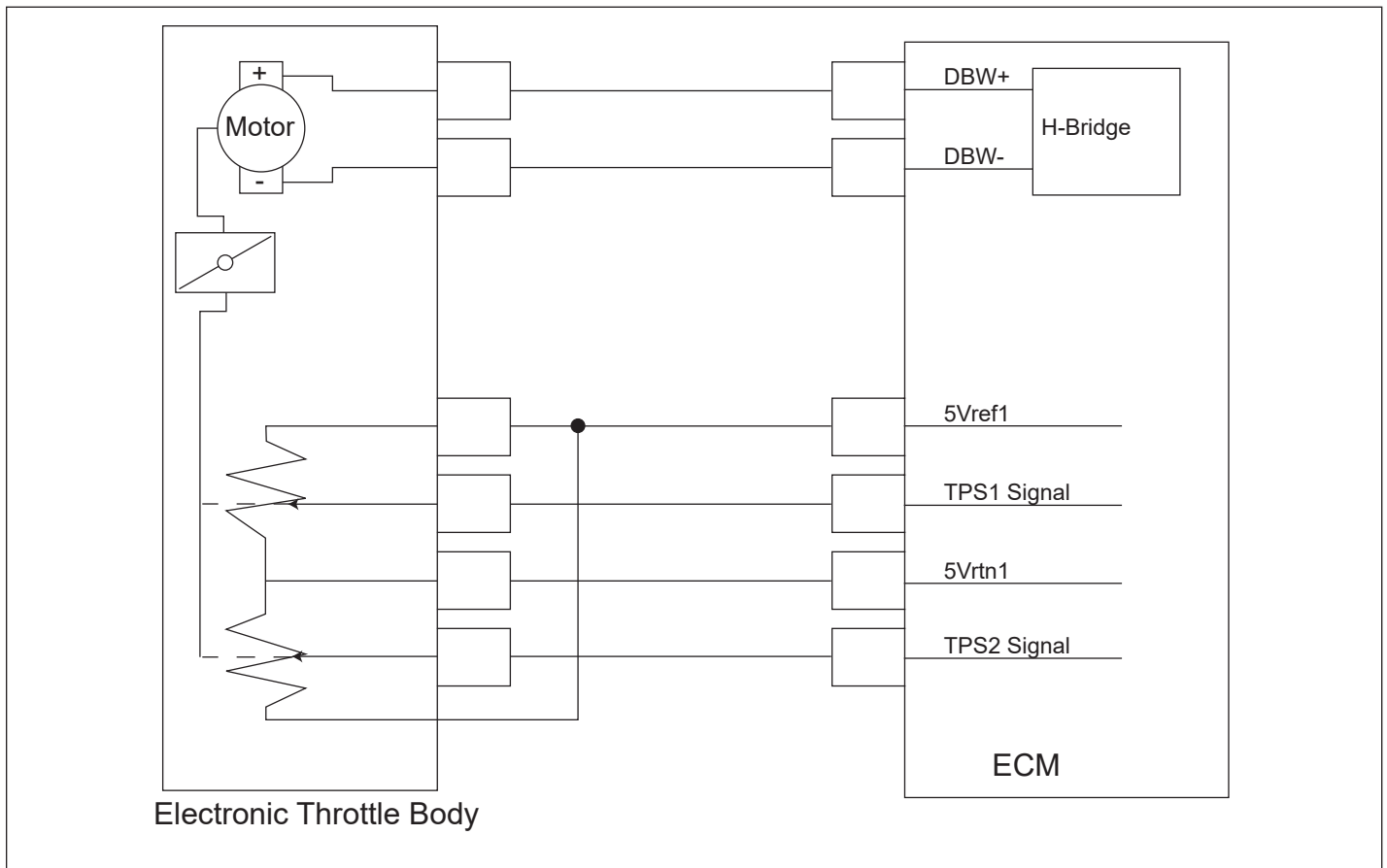
Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- Ensure that no programmed governor speeds exceed the limit set in the diagnostic calibration for Max Gov Override Speed
- Check mechanical operation of the throttle
- Check the engine intake for large air leaks downstream of the throttle body

Diagnostics

DTC 0221 - TPS1 % Higher Than TPS2 % SPN - 51; FMI - 0



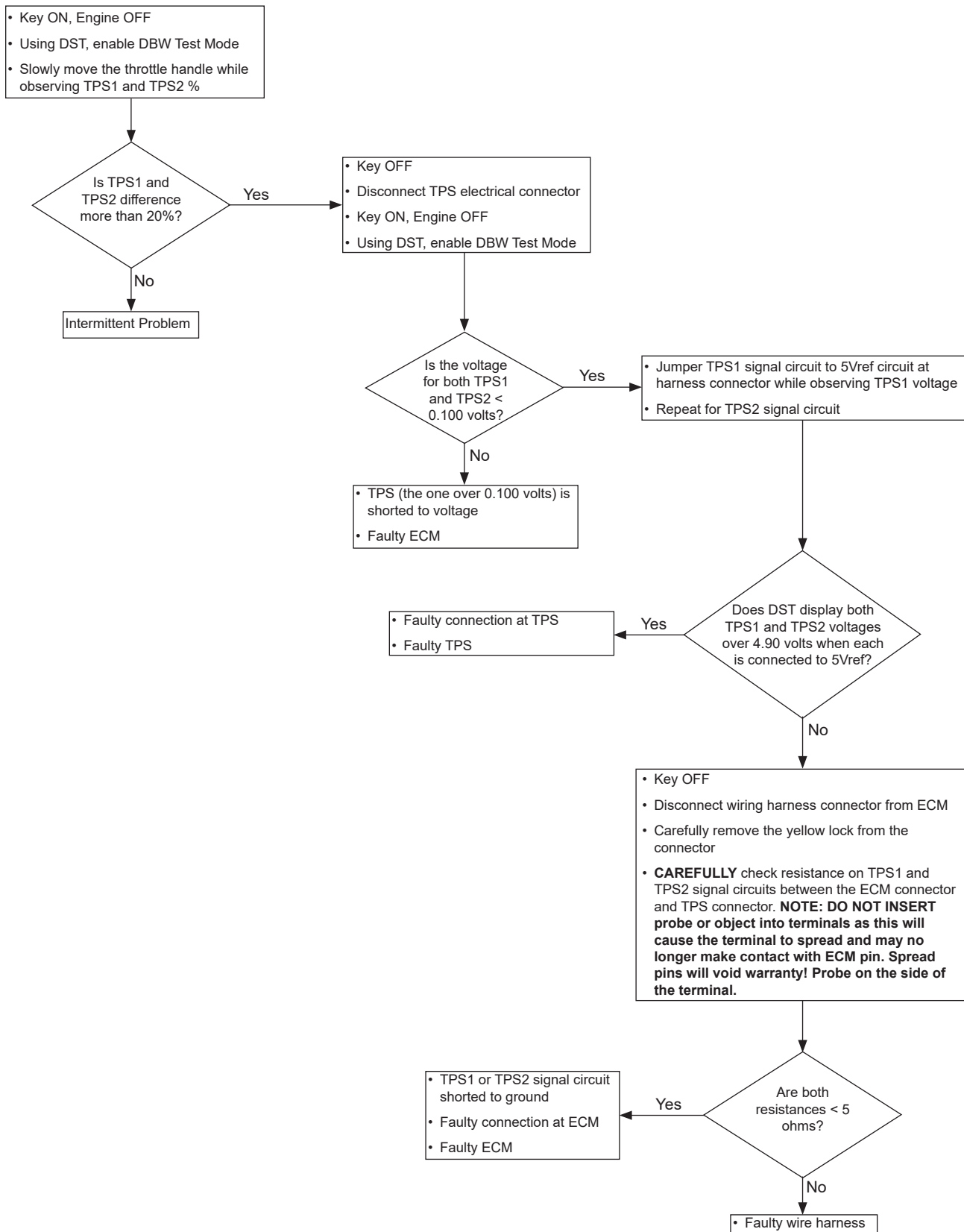
- Throttle Body-Throttle Position Sensor 1 & 2 (electronic throttle body only)
- *Check Condition* - Key-On, Engine Cranking, or Running
- *Fault Condition* - TPS1 higher than TPS2 by 20%
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions related fault

The throttle controls the airflow through the engine, directly affecting the power output of the engine. When the throttle is electronically controlled in an Electronic Throttle Body it can be used to control the idle stability and limit engine speed based on operating conditions.

The Throttle Position Sensor uses a variable resistor and voltage divider circuit to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In an Electronic Throttle Body multiple position feedback sensors (usually two counteracting potentiometers/hall-effects) are used to perform speed governing with improved safety and redundancy.

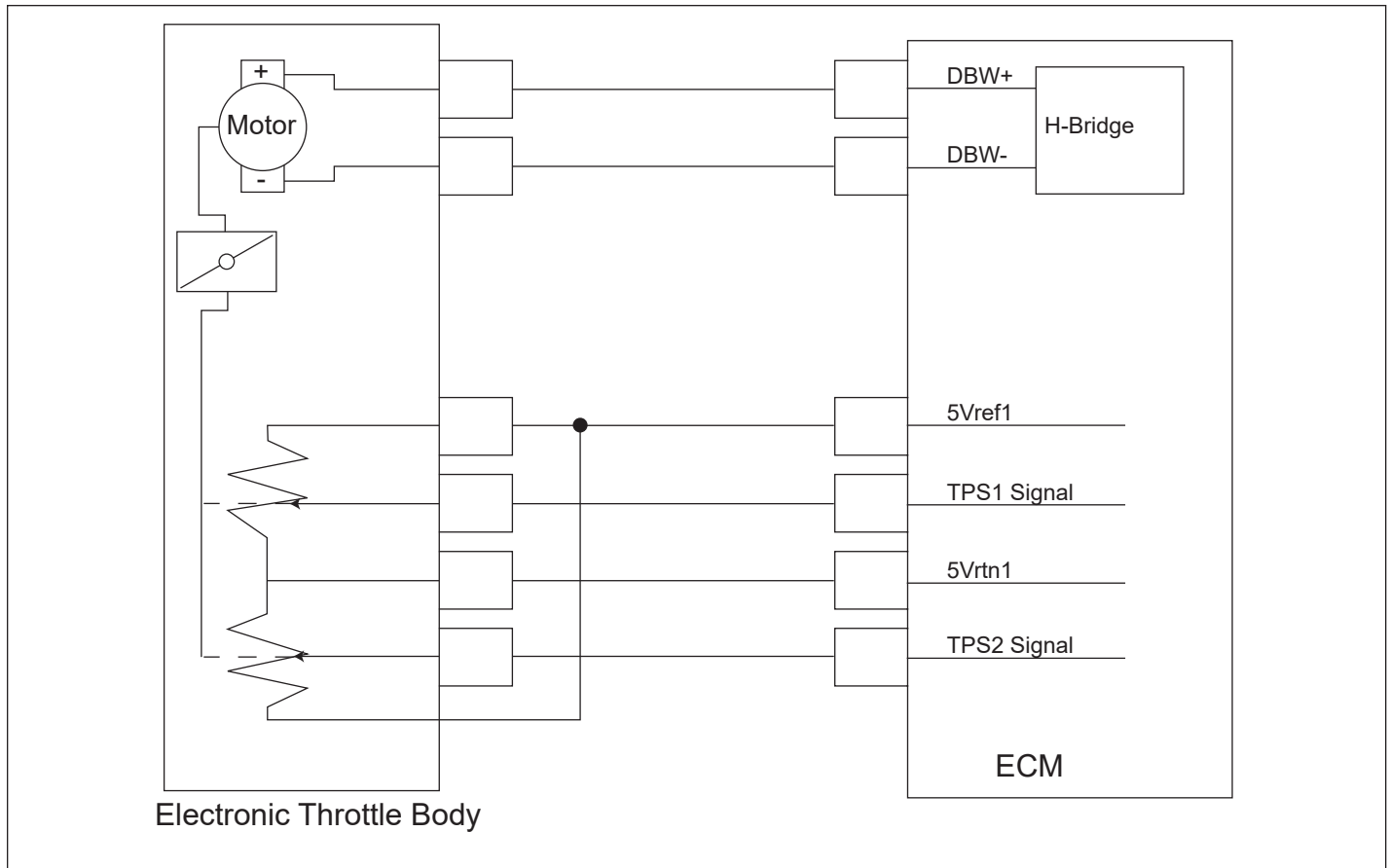
This fault will set if TPS1 % is higher than TPS2 % by 20%. At this point the throttle is considered to be out of specification, or there is a problem with the TPS signal circuit. During this active fault, an audible/visual alert device is activated and either an engine shutdown should be triggered or throttle control is set to use the higher of the two feedback signals for control in combination with a low rev limit and/or power derate.

DTC 0221 - TPS1 % Higher Than TPS2 % SPN - 51; FMI - 0



Diagnostics

DTC 0222 - TPS2 Signal Circuit Voltage Low SPN - 3673; FMI - 4



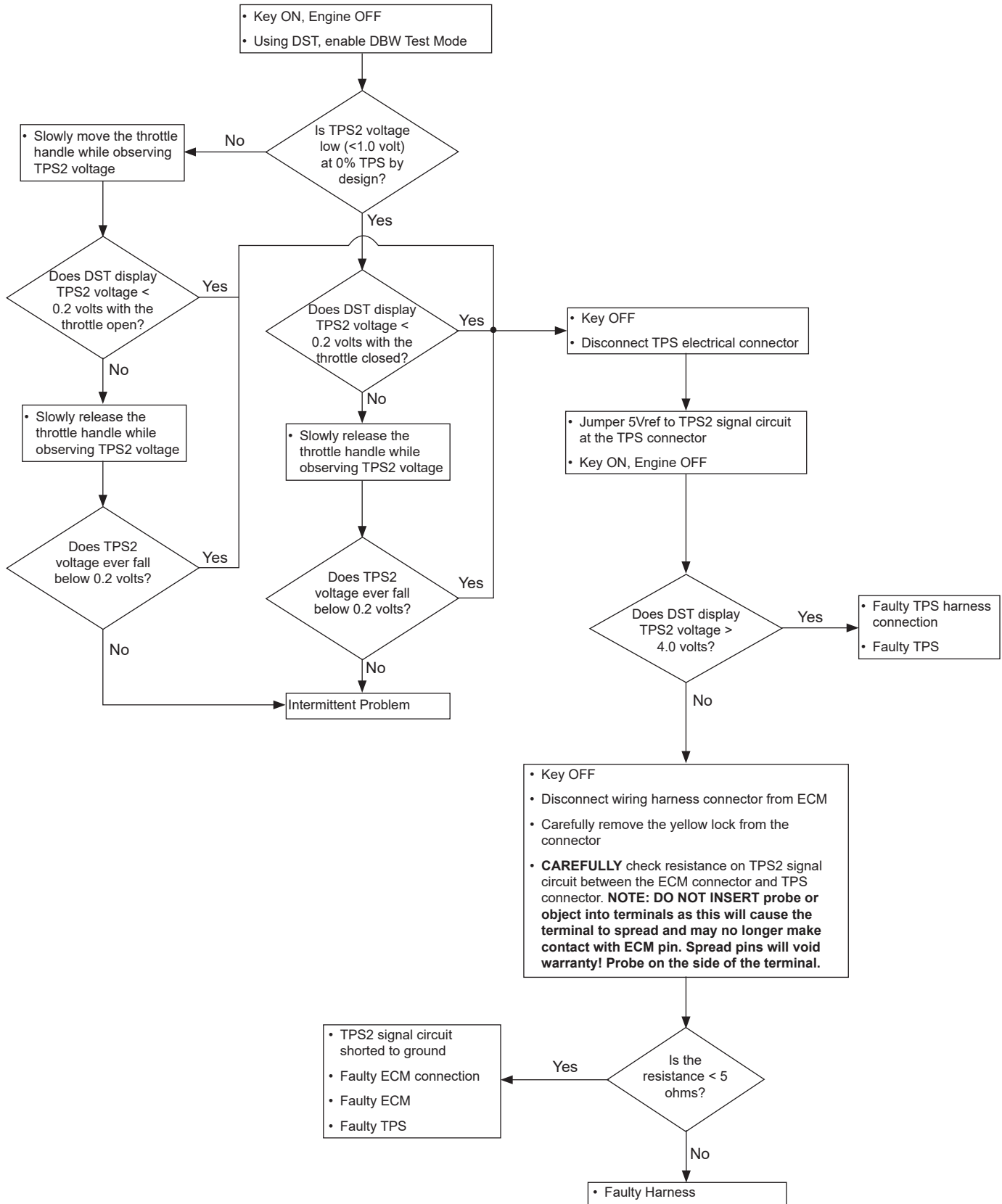
- Throttle Body - Throttle Position Sensor 2
- *Check Condition* - Key On, Engine Cranking or Running
- *Fault Condition* - TPS2 sensor voltage lower than 0.20 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions related fault

The throttle controls the airflow through the engine, directly affecting the power output of the engine. When the throttle is electronically controlled in an Electronic Throttle Body it can be used to control the idle stability and limit engine speed based on operating conditions.

The Throttle Position Sensor uses a variable resistor and voltage divider circuit to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In an Electronic Throttle Body multiple position feedback sensors (usually two counteracting potentiometers/hall-effects) are used to perform speed governing with improved safety and redundancy.

This fault will set if TPS2 voltage is lower than 0.20 volts at any operating condition while the engine is cranking or running. The limit is generally set to 4.90 VDC. In many cases, this condition is caused by the TPS sensor being disconnected from the engine harness, an open-circuit or short-to-ground of the TPS circuit in the wire harness, or a failure of the sensor. This fault should be configured to trigger an engine shutdown and the engine will not start with this fault active.

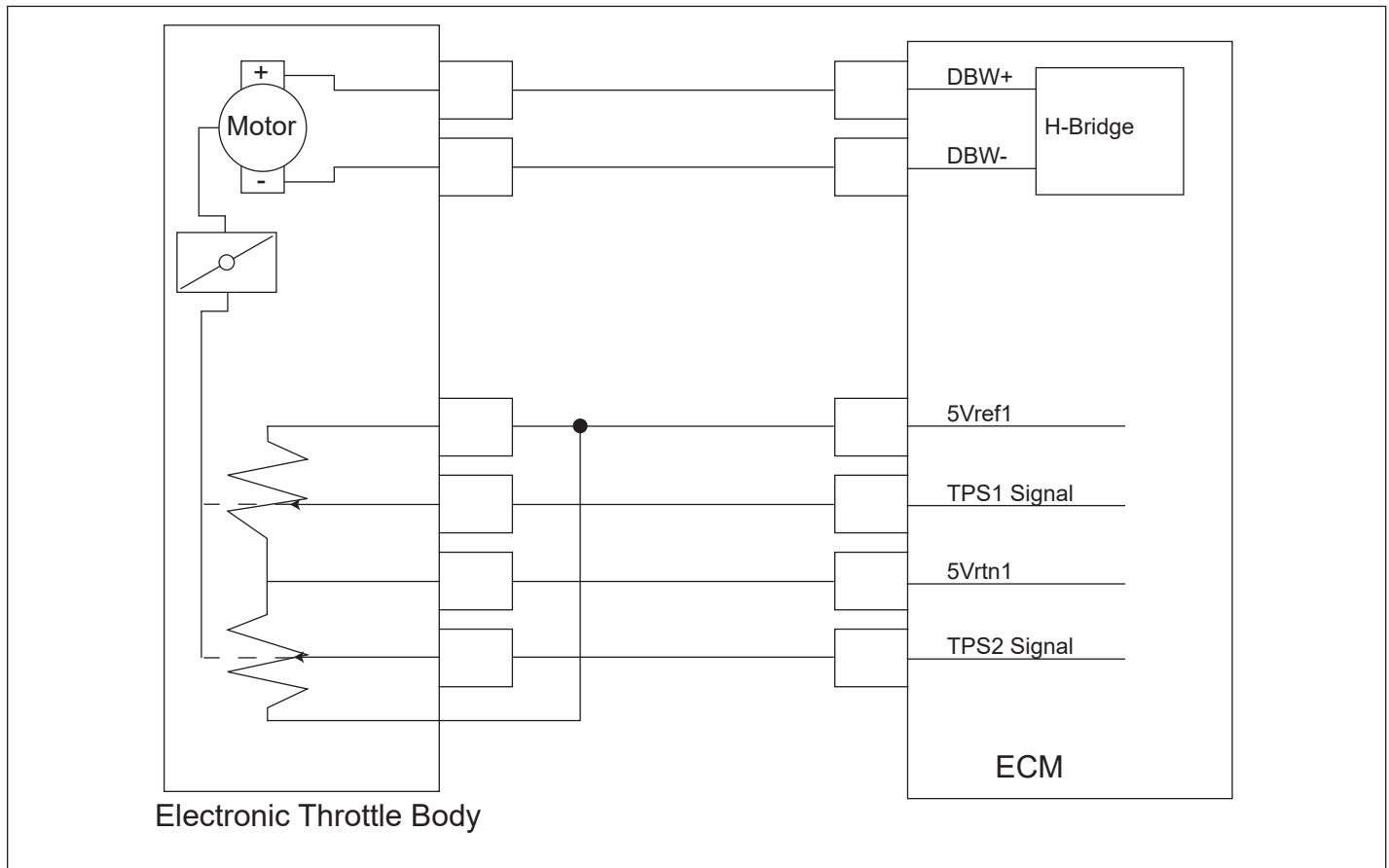
DTC 0222 - TPS2 Signal Circuit Voltage Low SPN - 3673; FMI - 4



Diagnostics

DTC 0223 - TPS2 Signal Circuit Voltage High

SPN - 3673; FMI - 3



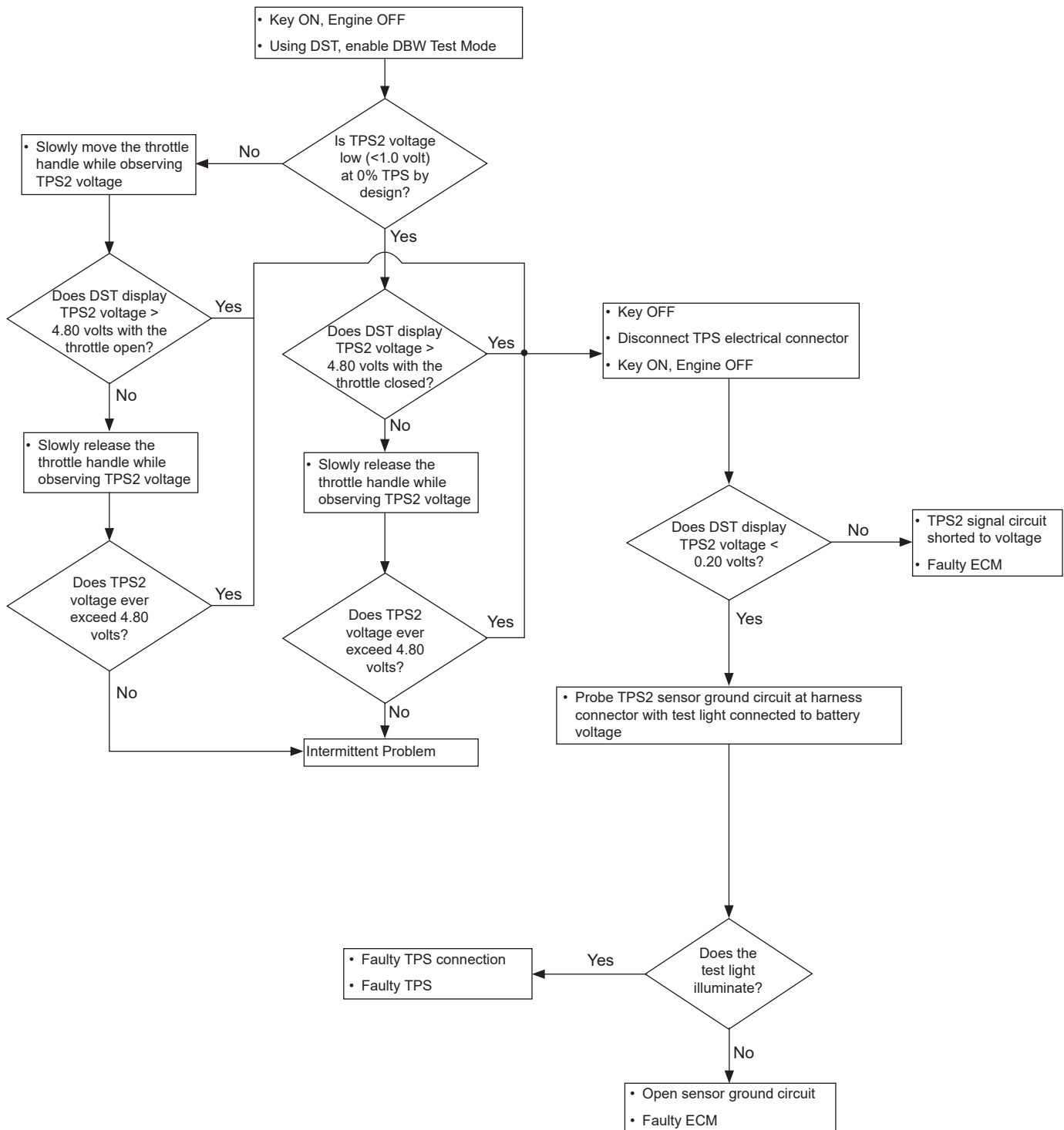
- Throttle Body - Throttle Position Sensor 2
- *Check Condition* - Key On, Engine Cranking or Running
- *Fault Condition* - TPS2 sensor voltage higher than 4.80 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions related fault

The throttle controls the airflow through the engine, directly affecting the power output of the engine. When the throttle is electronically controlled in an Electronic Throttle Body it can be used to control the idle stability and limit engine speed based on operating conditions.

The Throttle Position Sensor uses a variable resistor and voltage divider circuit to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In an Electronic Throttle Body multiple position feedback sensors (usually two counteracting potentiometers/hall-effects) are used to perform speed governing with improved safety and redundancy.

This fault will set if TPS2 voltage is higher than 4.80 volts at any operating condition while the engine is cranking or running. The limit is generally set to 4.90 VDC. In many cases, this condition is caused by a short-to-power of the TPS circuit in the wire harness or a failure of the sensor. This fault should be configured to trigger an engine shutdown and the engine will not start with this fault active.

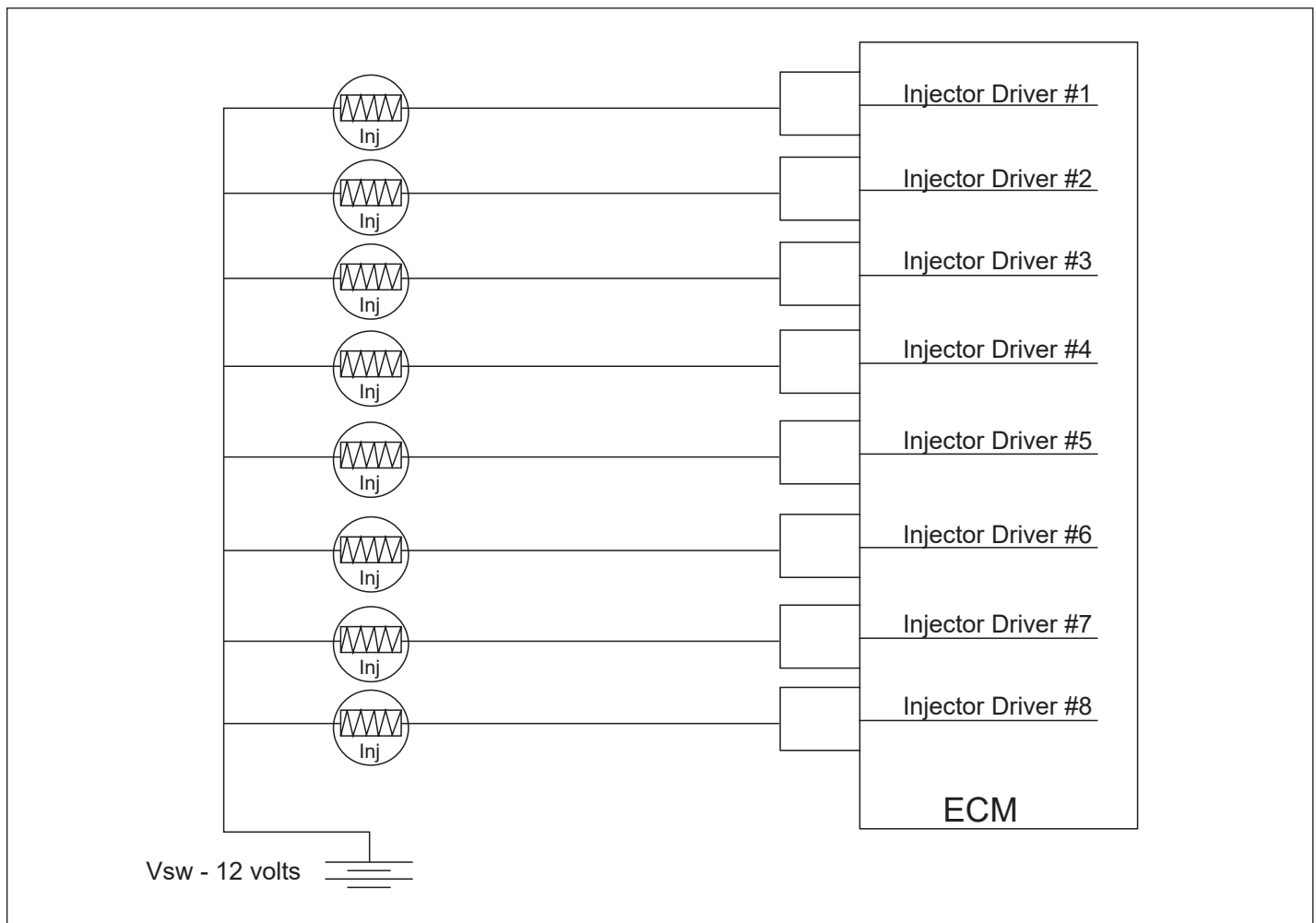
DTC 0223 - TPS2 Signal Circuit Voltage High SPN - 3673; FMI - 3



Diagnostics

DTC 0261 - Injector Driver #1 Open / Short to Ground

SPN - 651; FMI - 5

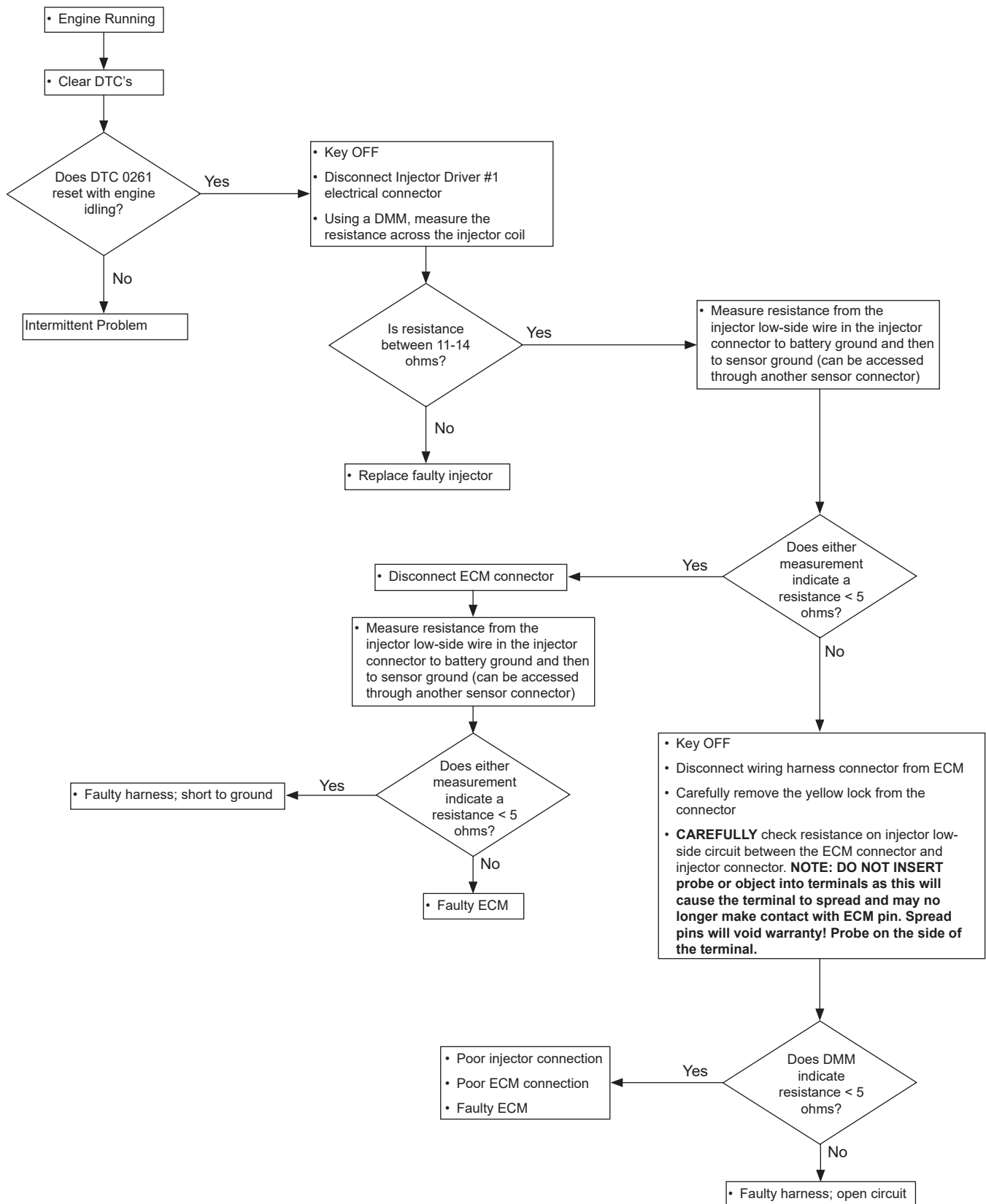


- Injector #1 Coil or Driver Open Circuit or Short-to-Ground
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM greater than 9.0 volts and injector low-side less than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable adaptive learn and closed-loop fueling correction for key-cycle.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #1.

This fault will set if the ECM detects low feedback voltage (4.0 VDC) on the injector coil while the injector drive circuit is in the off-state and battery voltage is greater than 9.0 volts for 10 injector firings as defined in the diagnostic calibration.

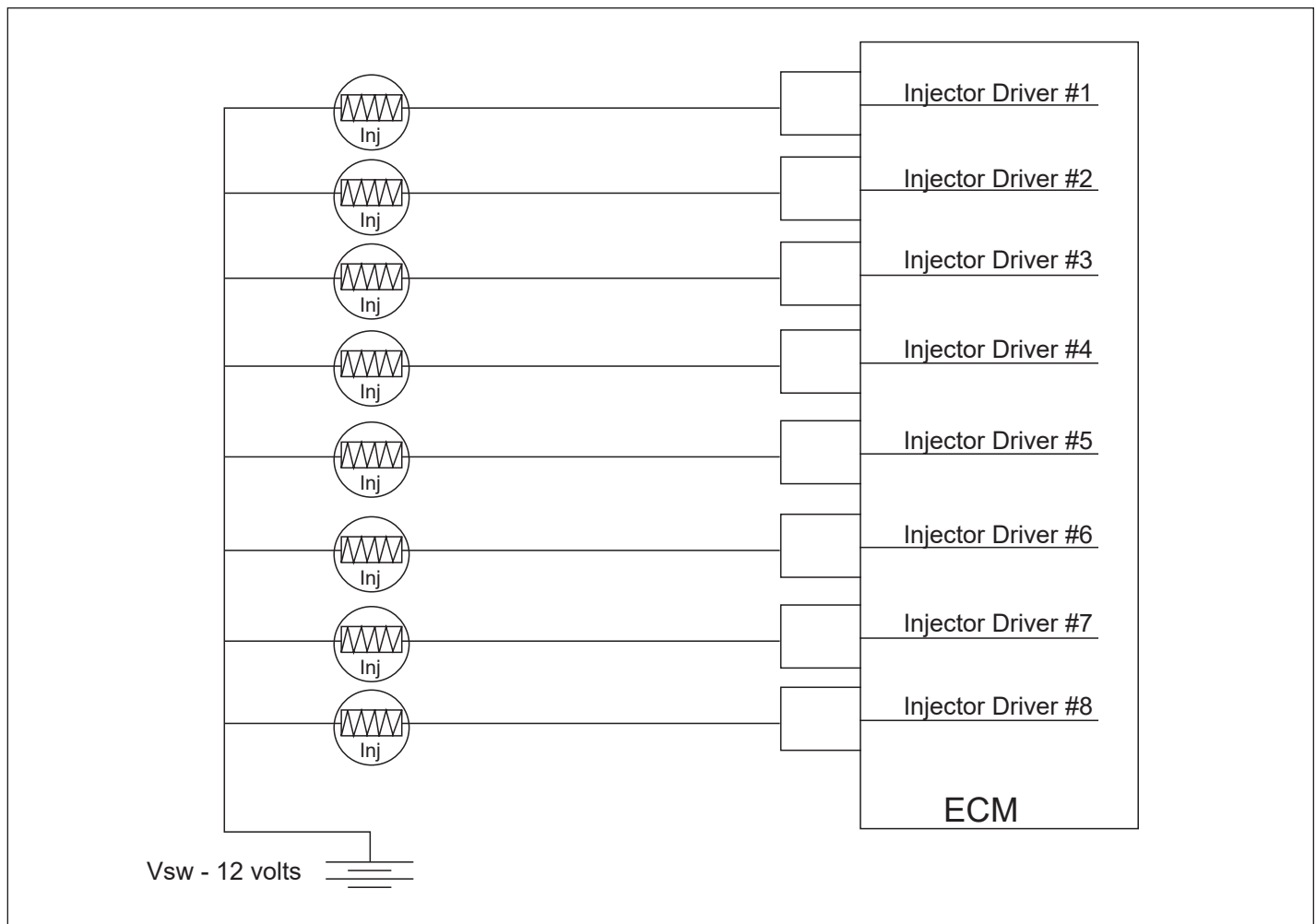
DTC 0261 - Injector Driver #1 Open / Short to Ground SPN - 651; FMI - 5



Diagnostics

DTC 0262 - Injector Driver #1 Short to Power

SPN - 651; FMI - 6

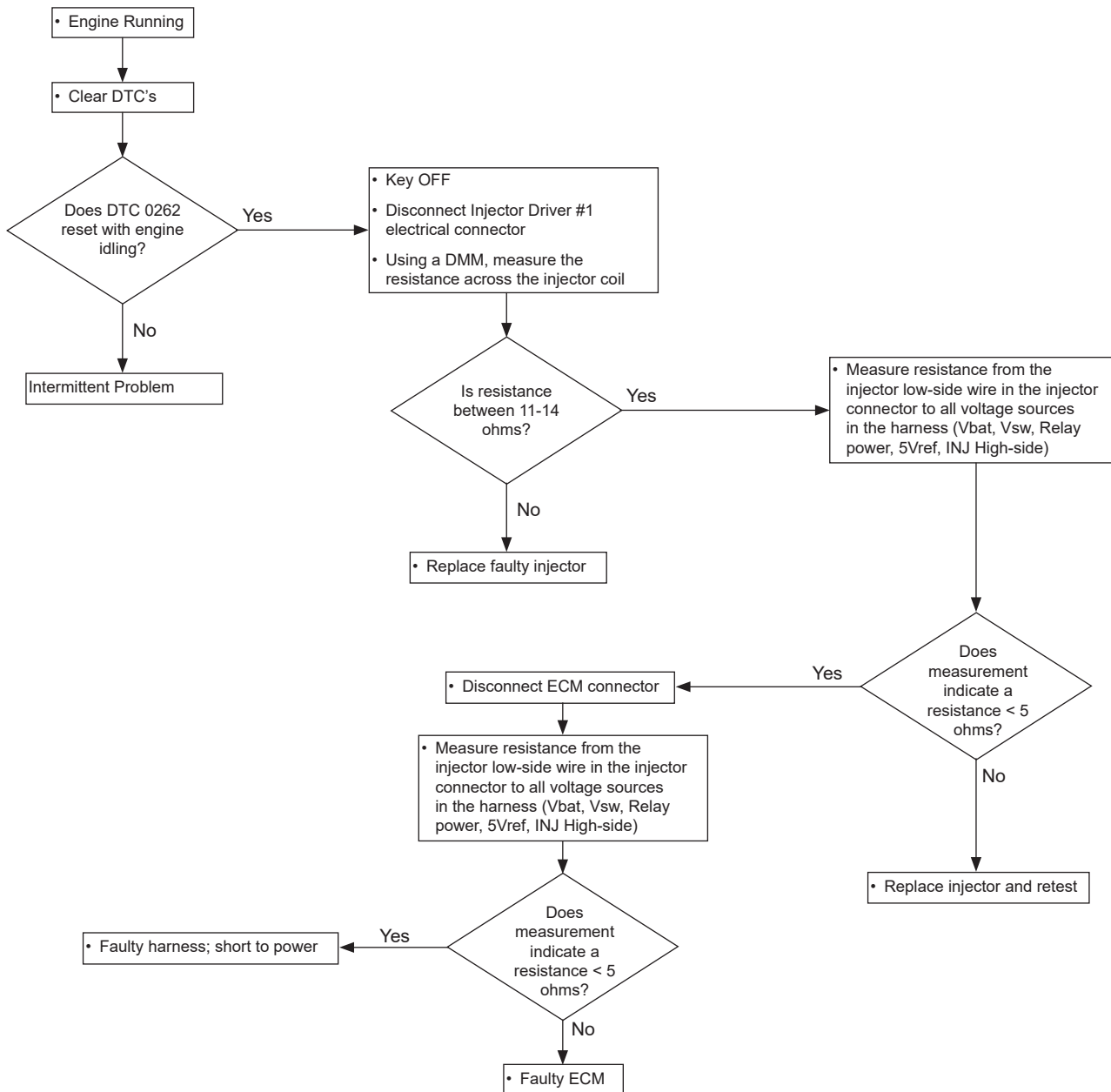


- Injector #1 Coil or Driver Short-to-Power
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM less than 16.0 volts and injector low-side greater than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable adaptive learn and closed-loop fueling correction for key-cycle.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #1.

This fault will set if the ECM detects higher than expected feedback voltage (4.0 VDC) on the injector coil while the injector drive circuit is in the on-state and battery voltage is less than 16.0 volts for 10 injector firings as defined in the diagnostic calibration.

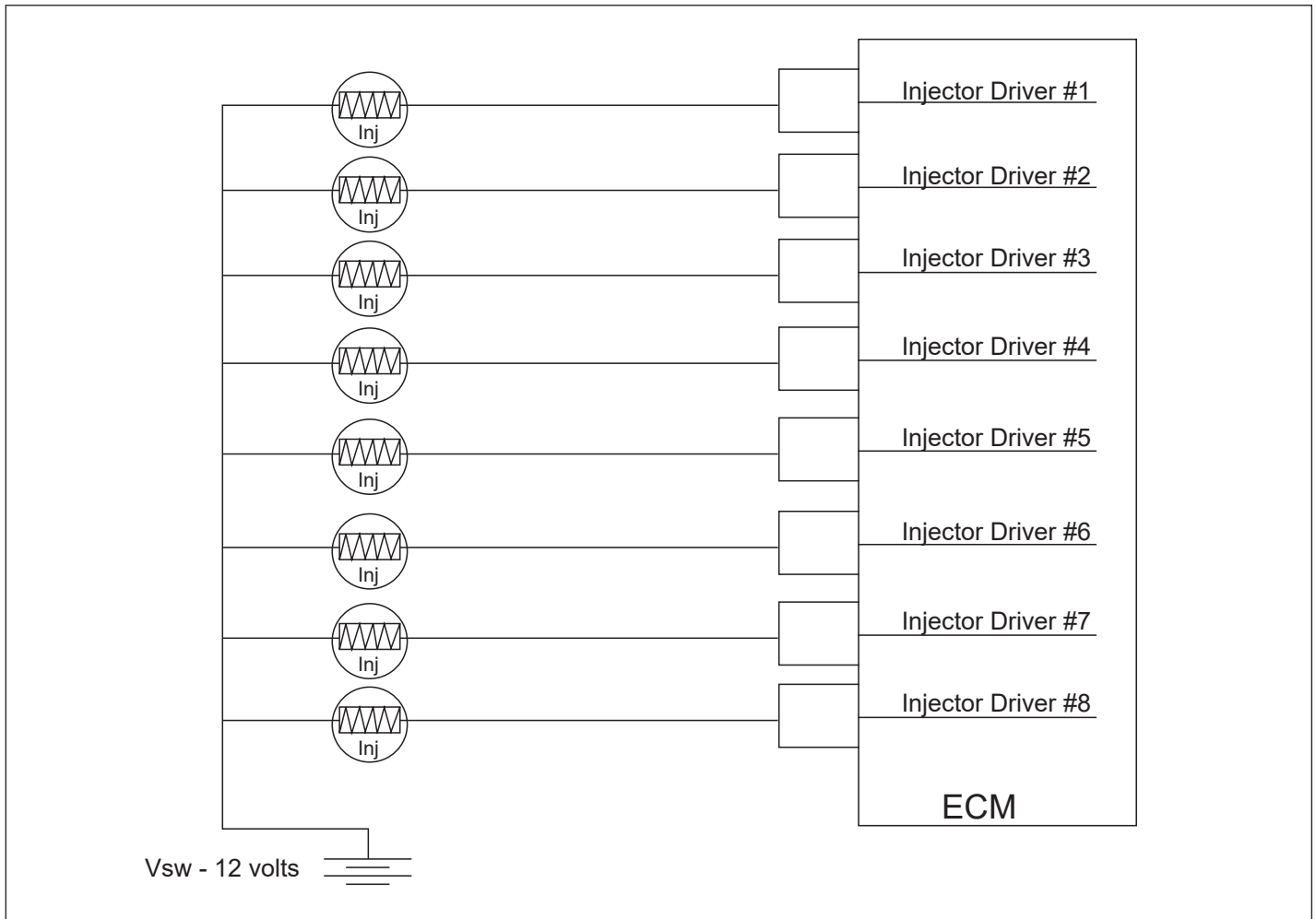
DTC 0262 - Injector Driver #1 Short to Power SPN - 651; FMI - 6



Diagnostics

DTC 0264 - Injector Driver #2 Open / Short to Ground

SPN - 652; FMI - 5

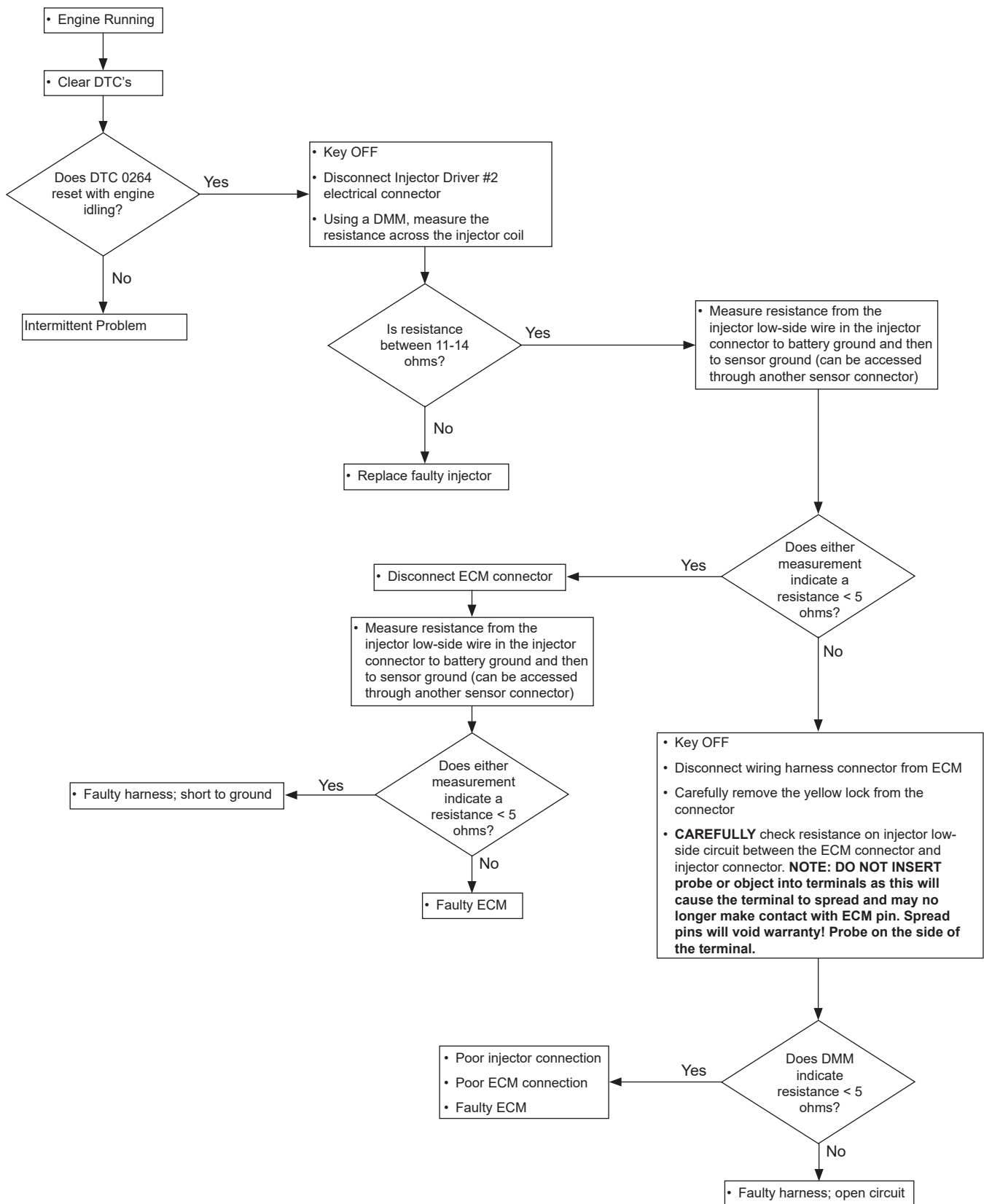


- Injector #2 Coil or Driver Open Circuit or Short-to-Ground
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM greater than 9.0 volts and injector low-side less than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable adaptive learn and closed-loop fueling correction for key-cycle.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #2.

This fault will set if the ECM detects low feedback voltage (4.0 VDC) on the injector coil while the injector drive circuit is in the off-state and battery voltage is greater than 9.0 volts for 10 injector firings as defined in the diagnostic calibration.

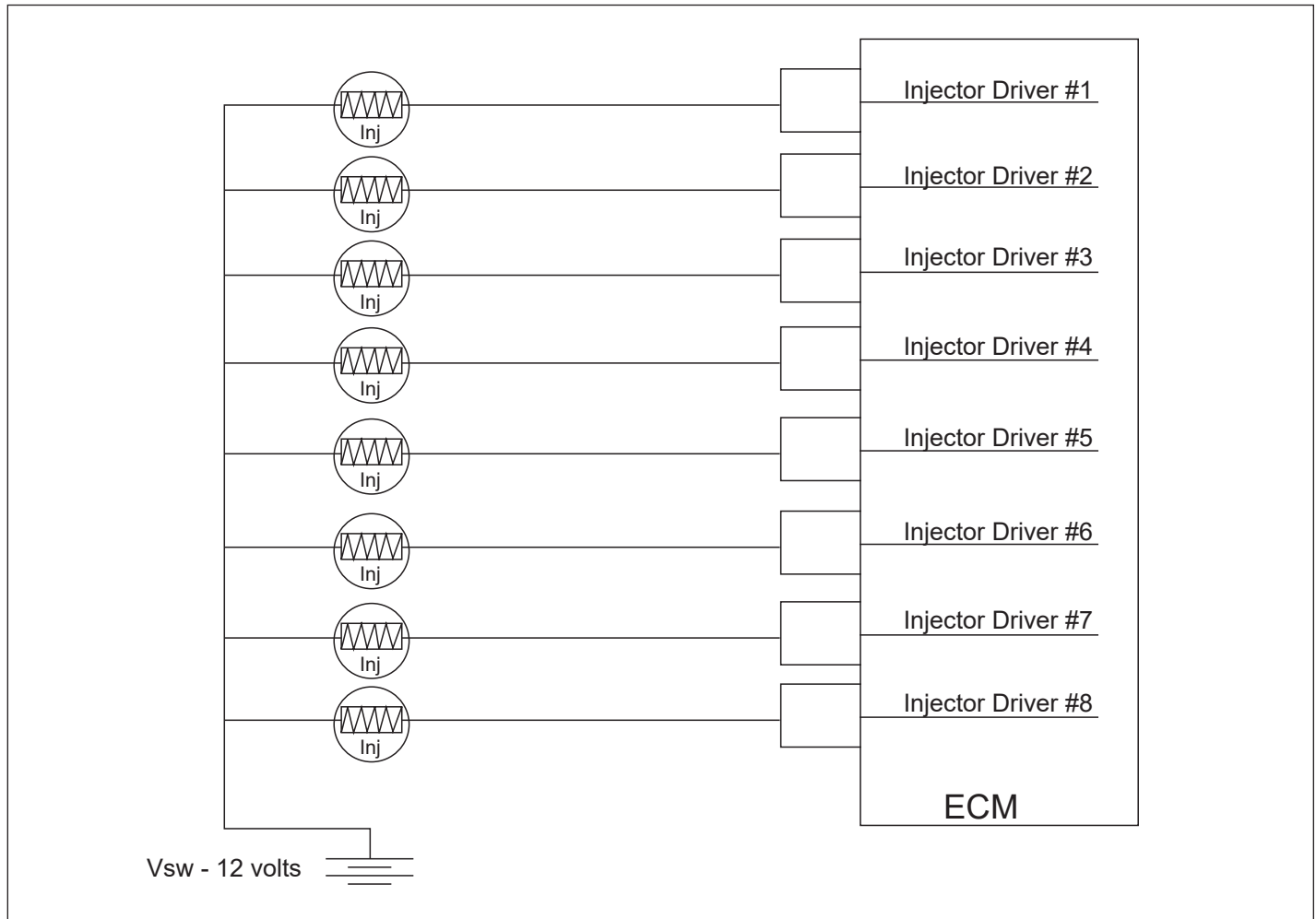
DTC 0264 - Injector Driver #2 Open / Short to Ground SPN - 652; FMI - 5



Diagnostics

DTC 0265 - Injector Driver #2 Short to Power

SPN - 652; FMI - 6

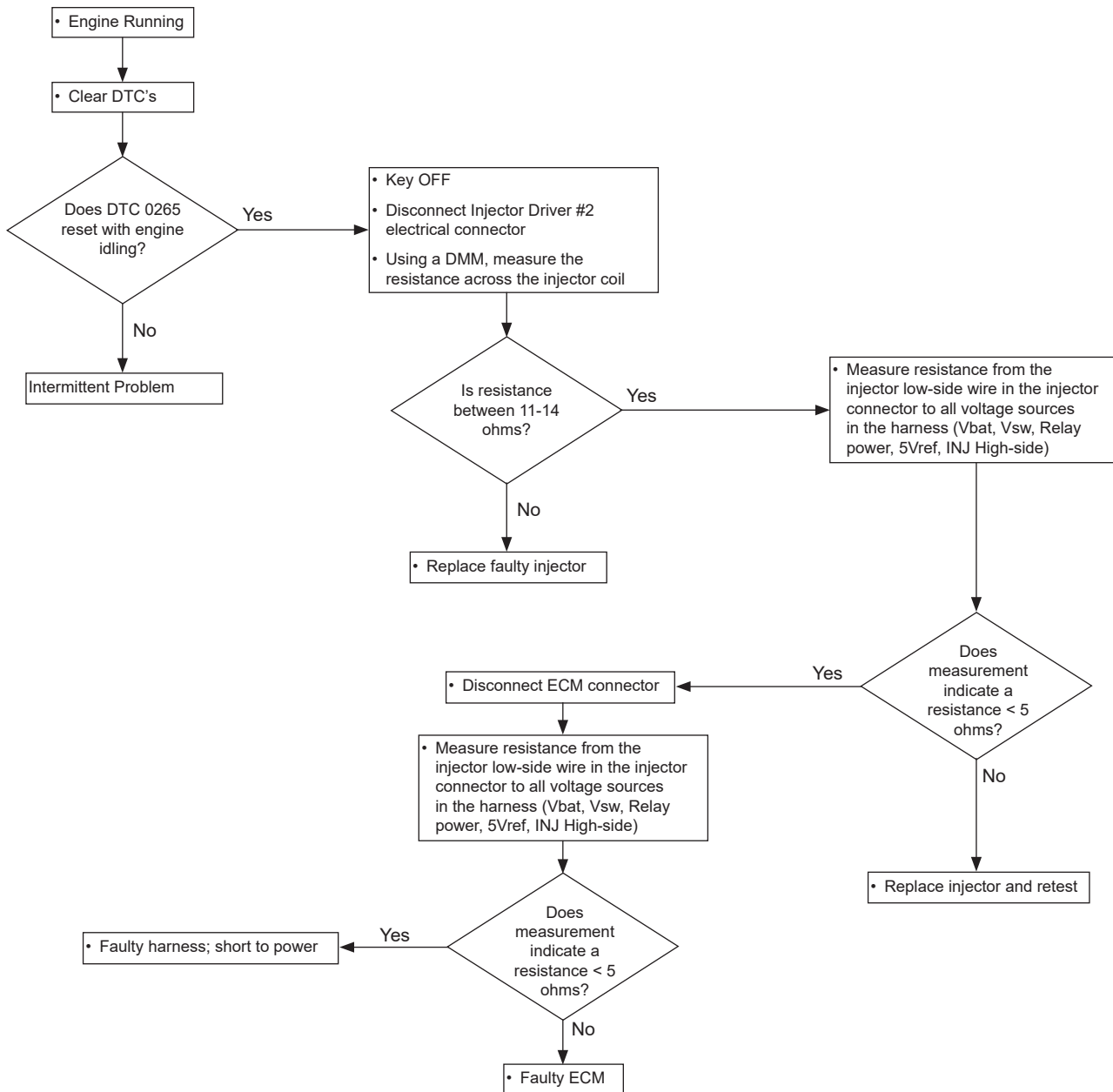


- Injector #2 Coil or Driver Short-to-Power
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM less than 16.0 volts and injector low-side greater than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable adaptive learn and closed-loop fueling correction for key-cycle.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #2.

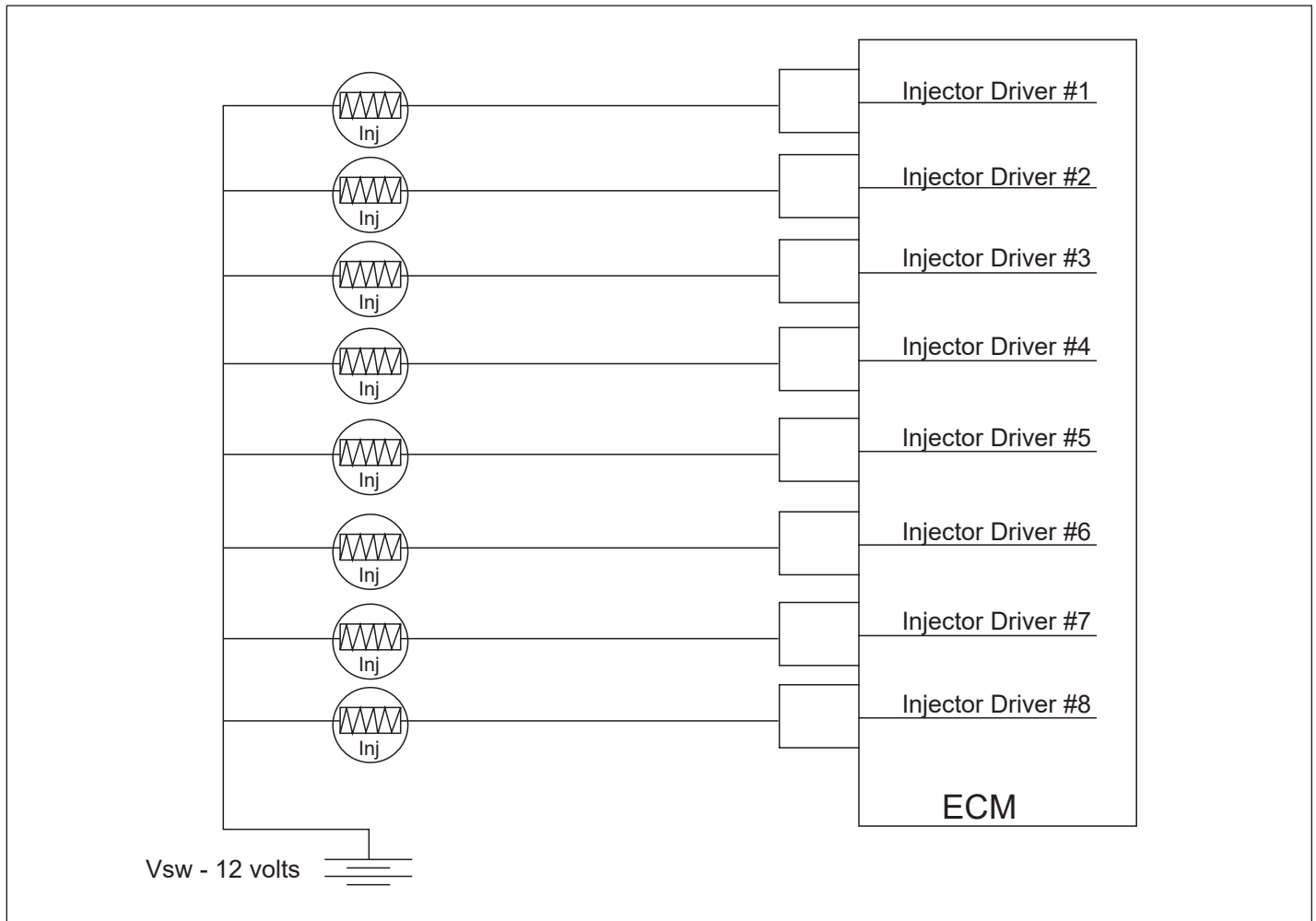
This fault will set if the ECM detects higher than expected feedback voltage (4.0 VDC) on the injector coil while the injector drive circuit is in the on-state and battery voltage is less than 16.0 volts for 10 injector firings as defined in the diagnostic calibration.

DTC 0265 - Injector Driver #2 Short to Power SPN - 652; FMI - 6



Diagnostics

DTC 0267 - Injector Driver #3 SPN - 653; FMI - 5

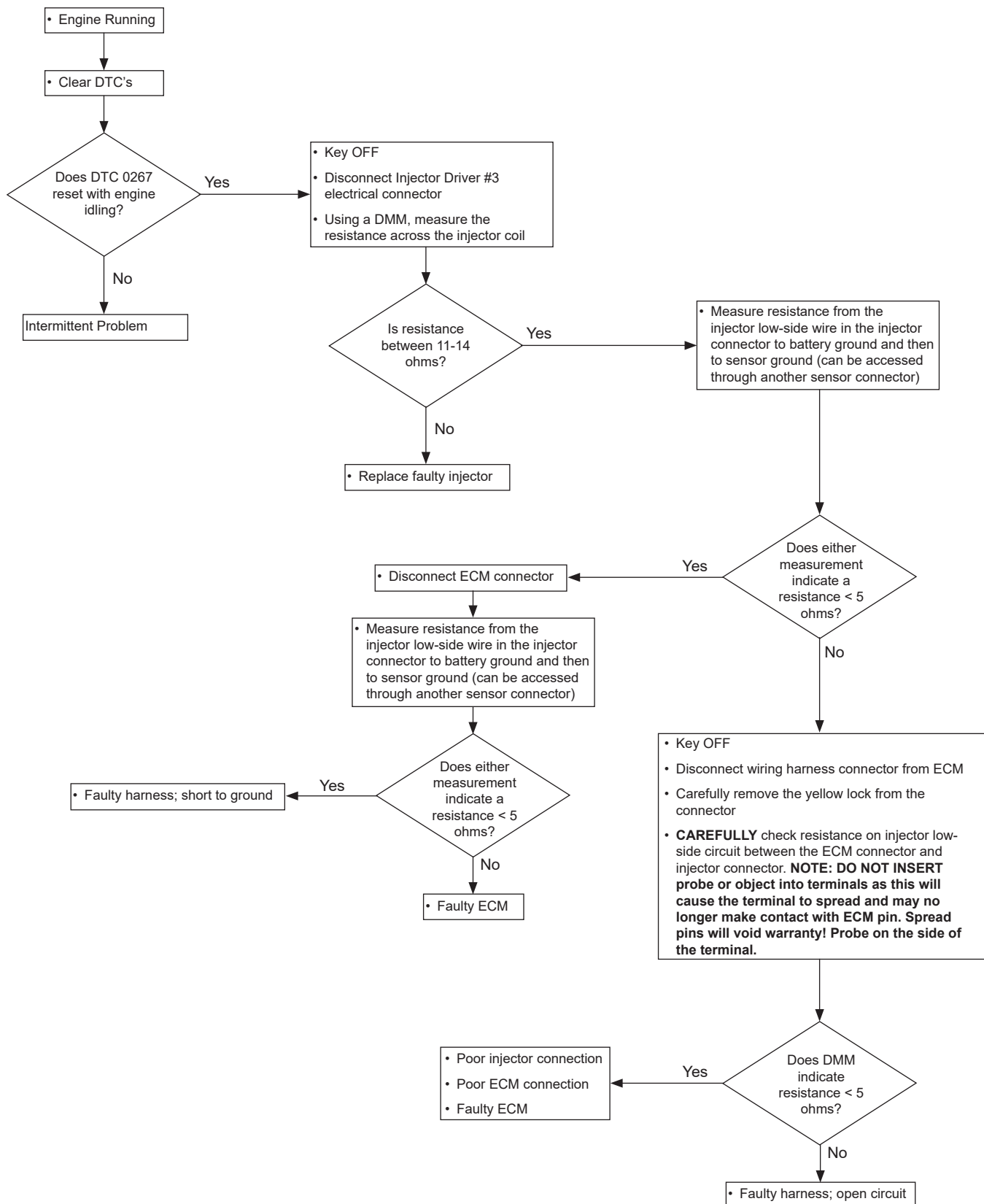


- Injector #3 Coil or Driver Open Circuit or Short-to-Ground
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM greater than 9.0 volts and injector low-side less than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable adaptive learn and closed-loop fueling correction for key-cycle.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #3.

This fault will set if the ECM detects low feedback voltage (4.0 VDC) on the injector coil while the injector drive circuit is in the off-state and battery voltage is greater than 9.0 volts for 10 injector firings as defined in the diagnostic calibration.

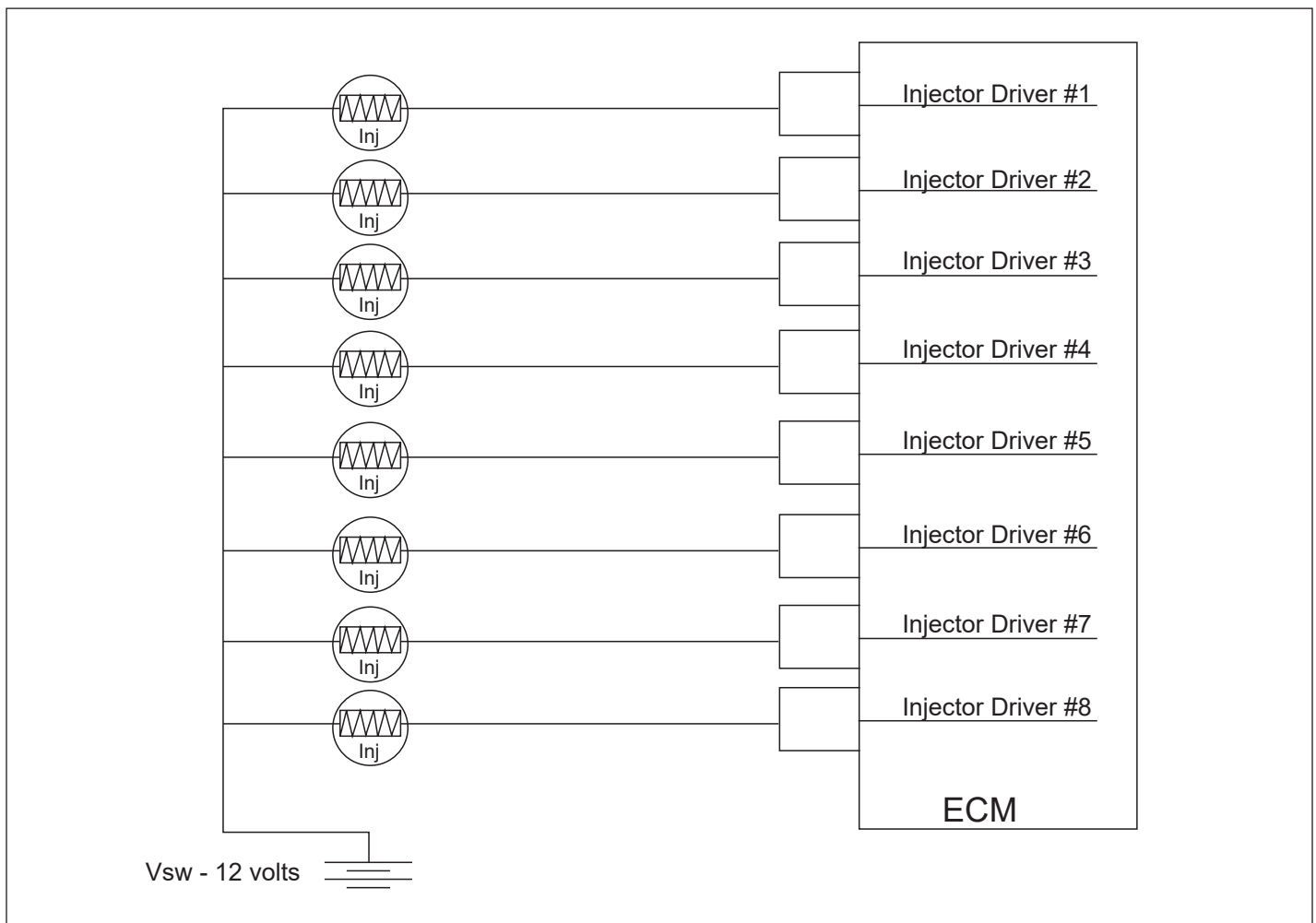
DTC 0267 - Injector Driver #3 SPN - 653; FMI - 5



Diagnostics

DTC 0268 - Injector Driver #3 Short to Power

SPN - 653; FMI - 6

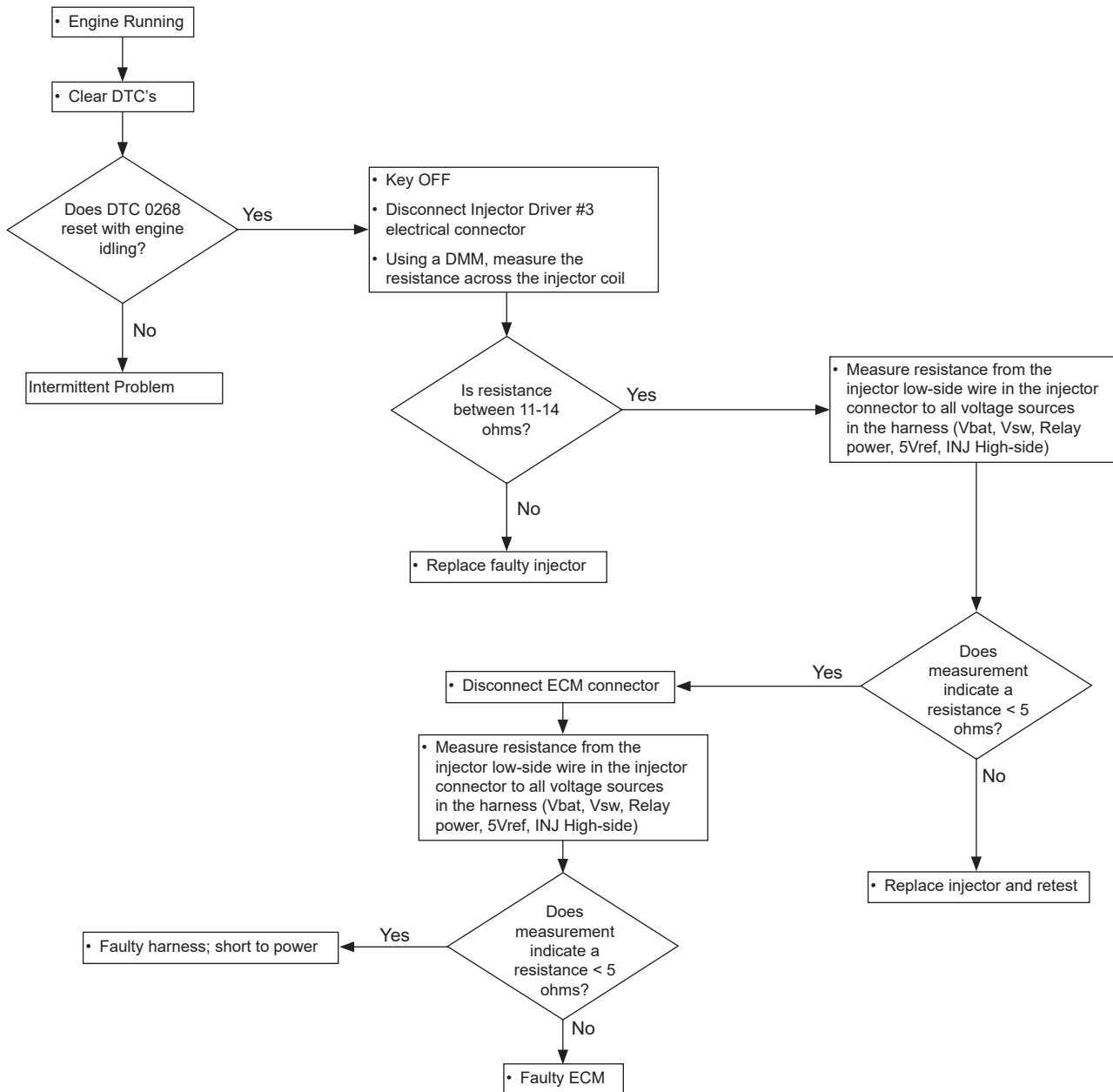


- Injector #3 Coil or Driver Short-to-Power
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM less than 16.0 volts and injector low-side greater than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable adaptive learn and closed-loop fueling correction for key-cycle.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #3.

This fault will set if the ECM detects higher than expected feedback voltage (4.0 VDC) on the injector coil while the injector drive circuit is in the on-state and battery voltage is less than 16.0 volts for 10 injector firings as defined in the diagnostic calibration.

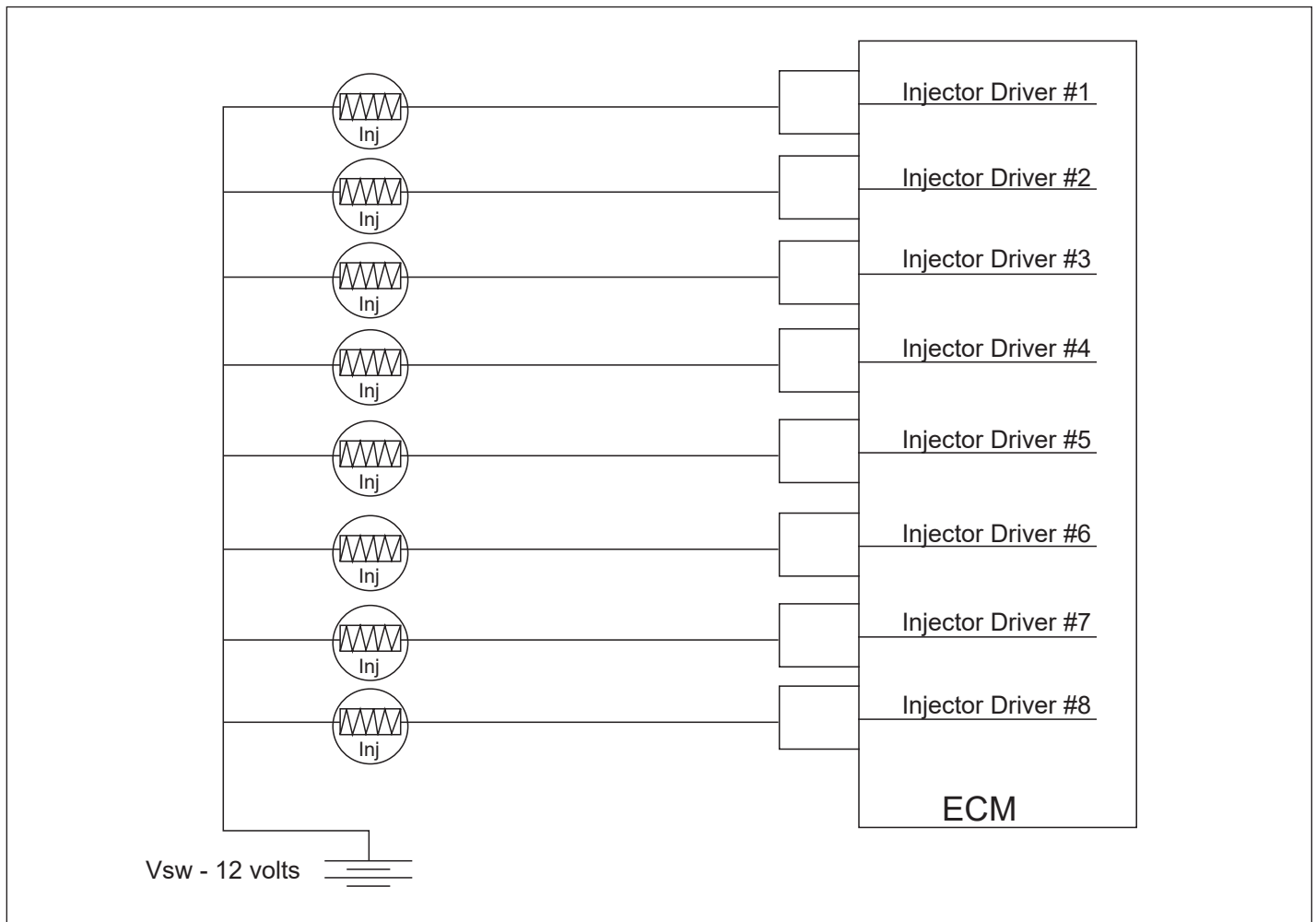
DTC 0268 - Injector Driver #3 Short to Power SPN - 653; FMI - 6



Diagnostics

DTC 0270 - Injector Driver #4 Open / Short to Ground

SPN - 654; FMI - 5

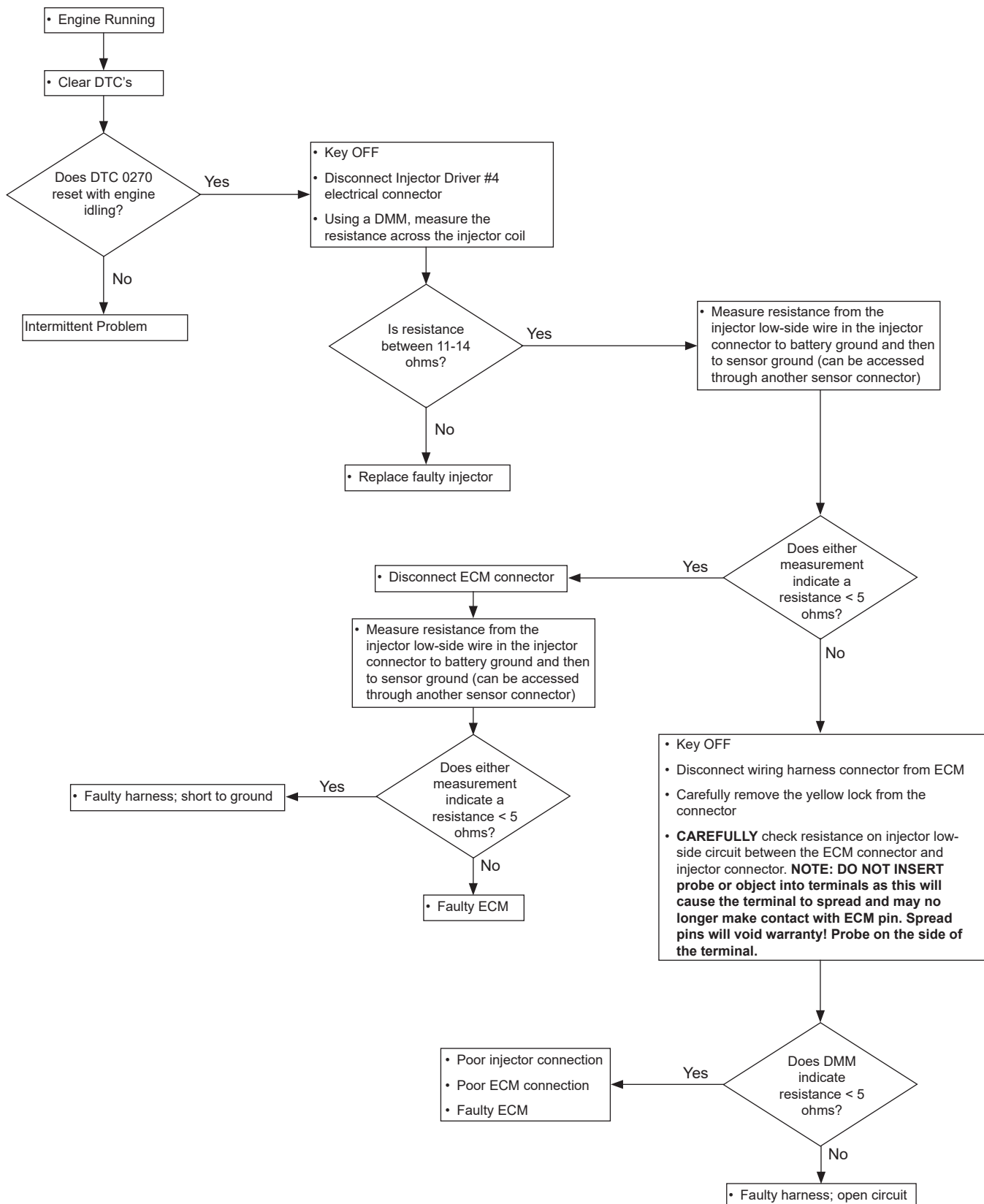


- Injector #4 Coil or Driver Open Circuit or Short-to-Ground
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM greater than 9.0 volts and injector low-side less than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable adaptive learn and closed-loop fueling correction for key-cycle.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #4.

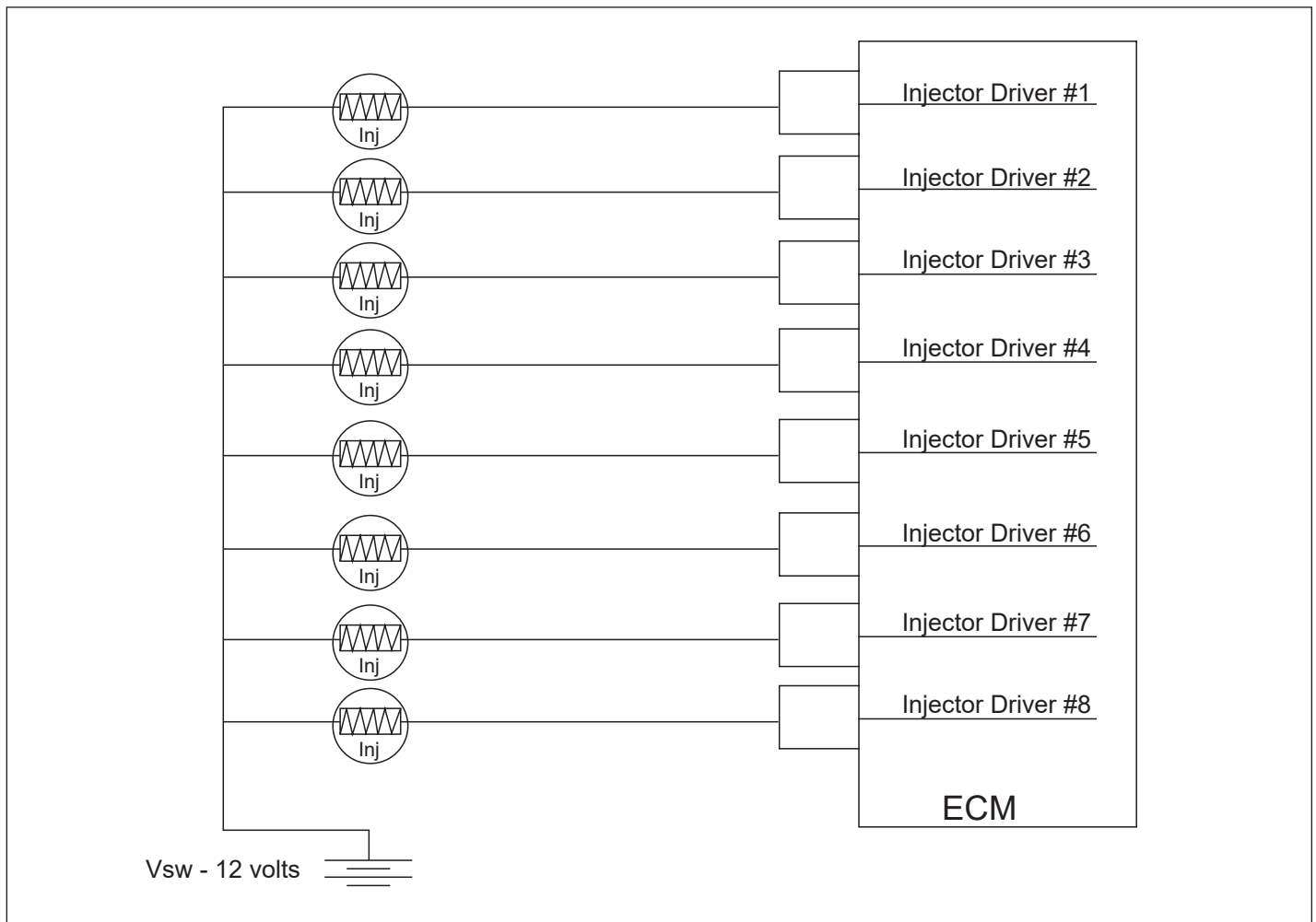
This fault will set if the ECM detects low feedback voltage (4.0 VDC) on the injector coil while the injector drive circuit is in the off-state and battery voltage is greater than 9.0 volts for 10 injector firings as defined in the diagnostic calibration.

DTC 0270 - Injector Driver #4 Open / Short to Ground SPN - 654; FMI - 5



Diagnostics

DTC 0271 - Injector Driver #4 Short to Power SPN - 654; FMI - 6

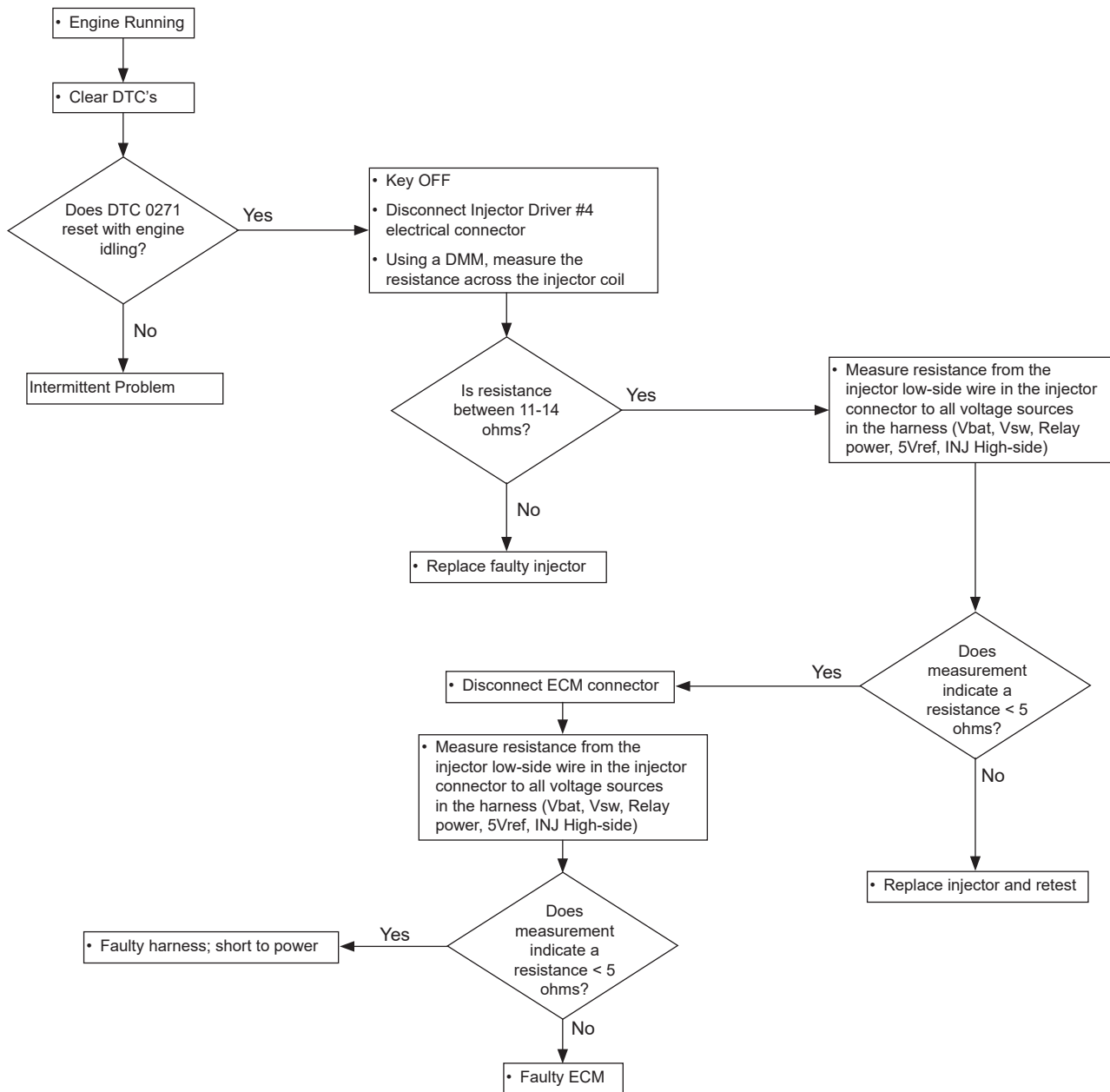


- Injector #4 Coil or Driver Short-to-Power
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM less than 16.0 volts and injector low-side greater than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable adaptive learn and closed-loop fueling correction for key-cycle.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #4.

This fault will set if the ECM detects higher than expected feedback voltage (4.0 VDC) on the injector coil while the injector drive circuit is in the on-state and battery voltage is less than 16.0 volts for 10 injector firings as defined in the diagnostic calibration.

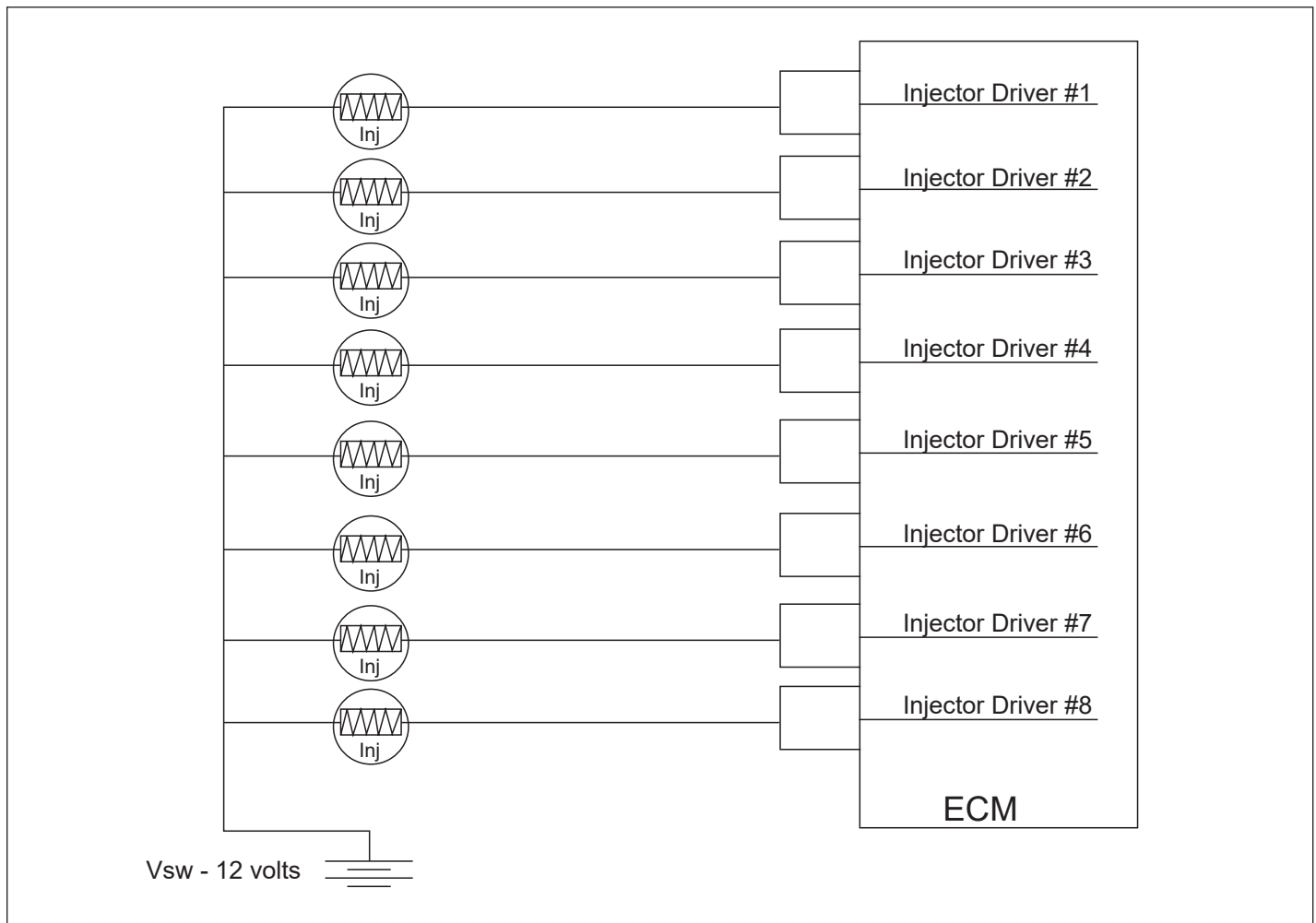
DTC 0271 - Injector Driver #4 Short to Power SPN - 654; FMI - 6



Diagnostics

DTC 0273 - Injector Driver #5 Open / Short to Ground

SPN - 655; FMI - 5

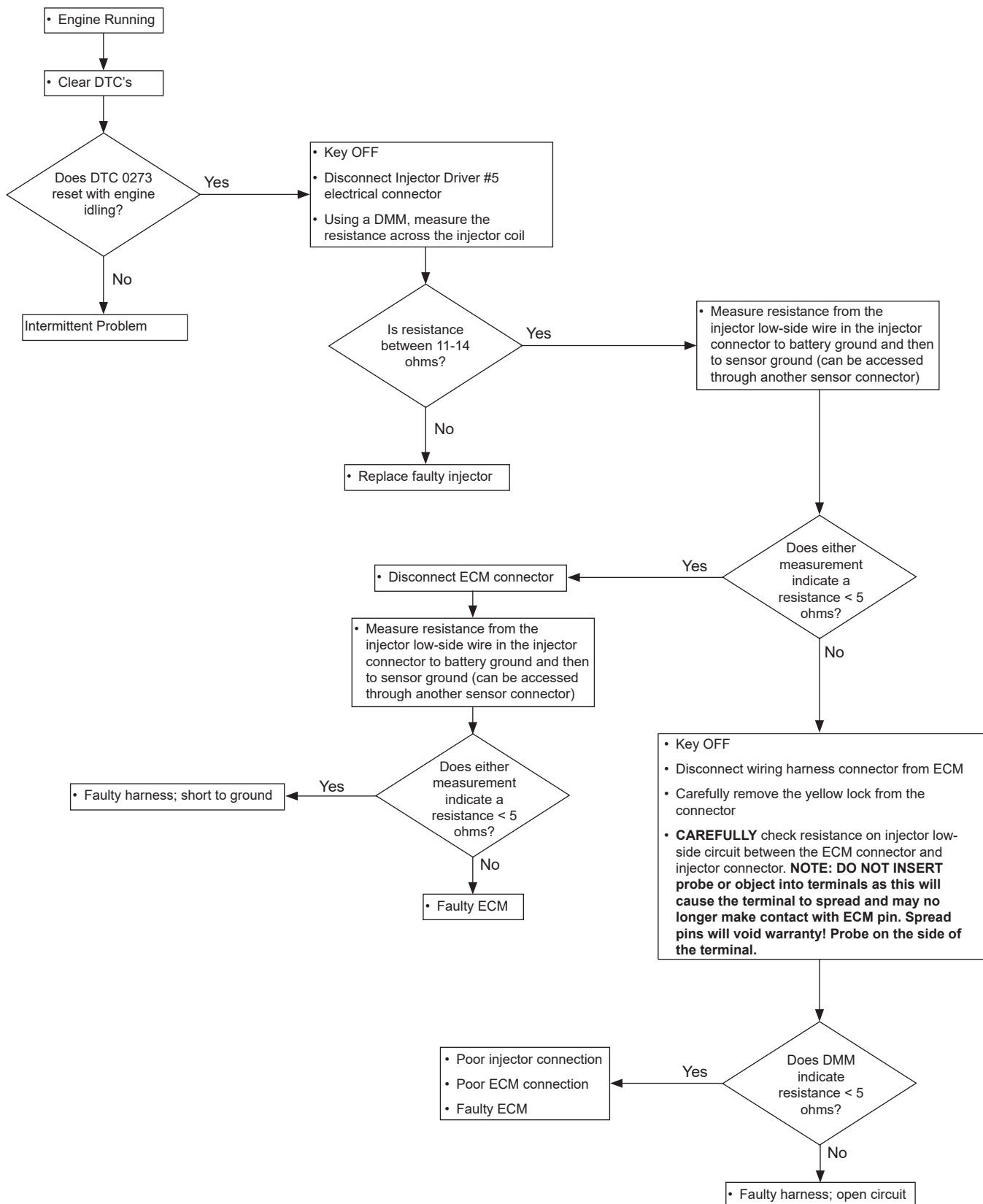


- Injector #5 Coil or Driver Open Circuit or Short-to-Ground
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM greater than 9.0 volts and injector low-side less than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable adaptive learn and closed-loop fueling correction for key-cycle.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #5.

This fault will set if the ECM detects low feedback voltage (4.0 VDC) on the injector coil while the injector drive circuit is in the off-state and battery voltage is greater than 9.0 volts for 10 injector firings as defined in the diagnostic calibration.

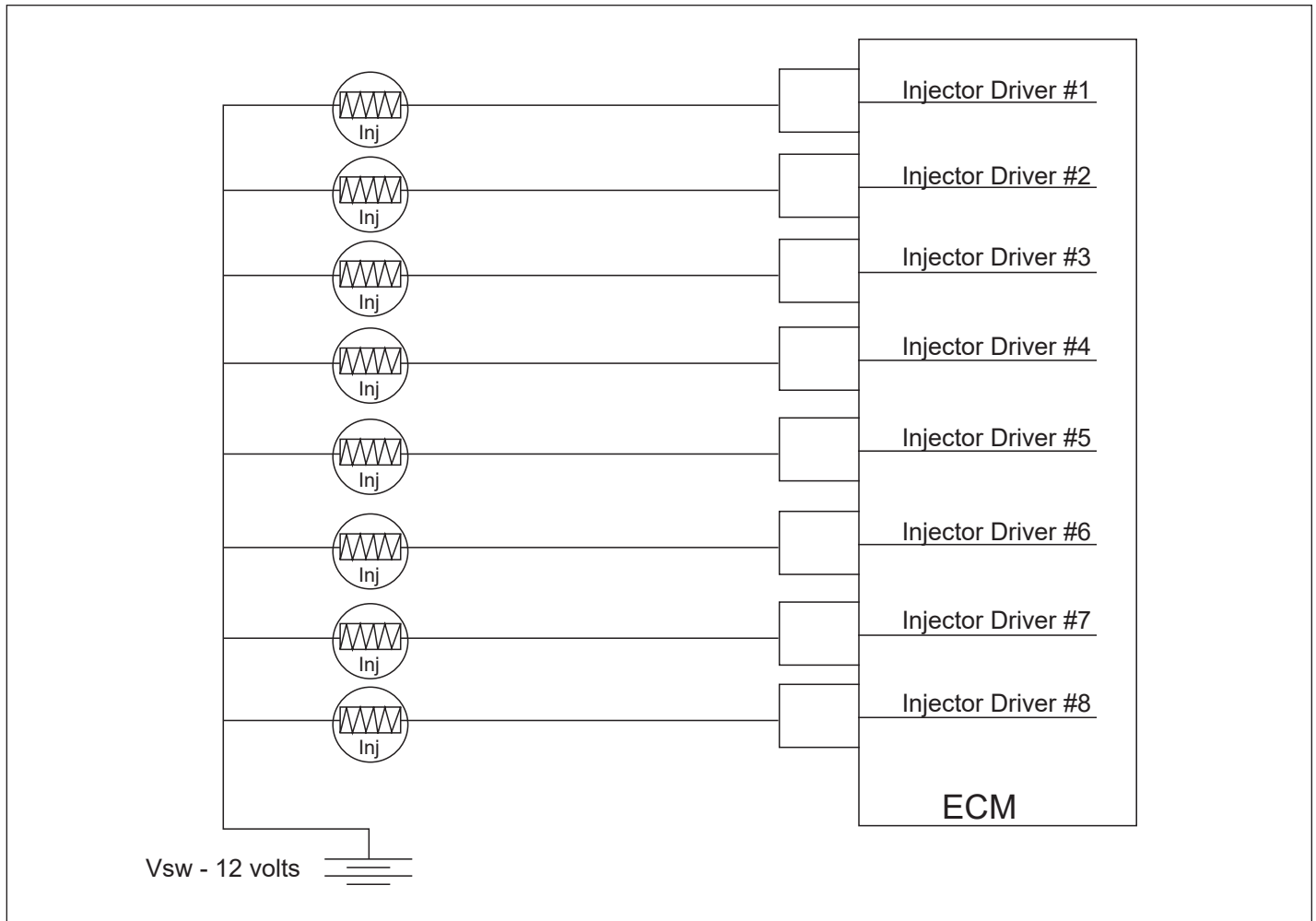
DTC 0273 - Injector Driver #5 Open / Short to Ground SPN - 655; FMI - 5



Diagnostics

DTC 0274 - Injector Driver #5 Short to Power

SPN - 655; FMI - 6

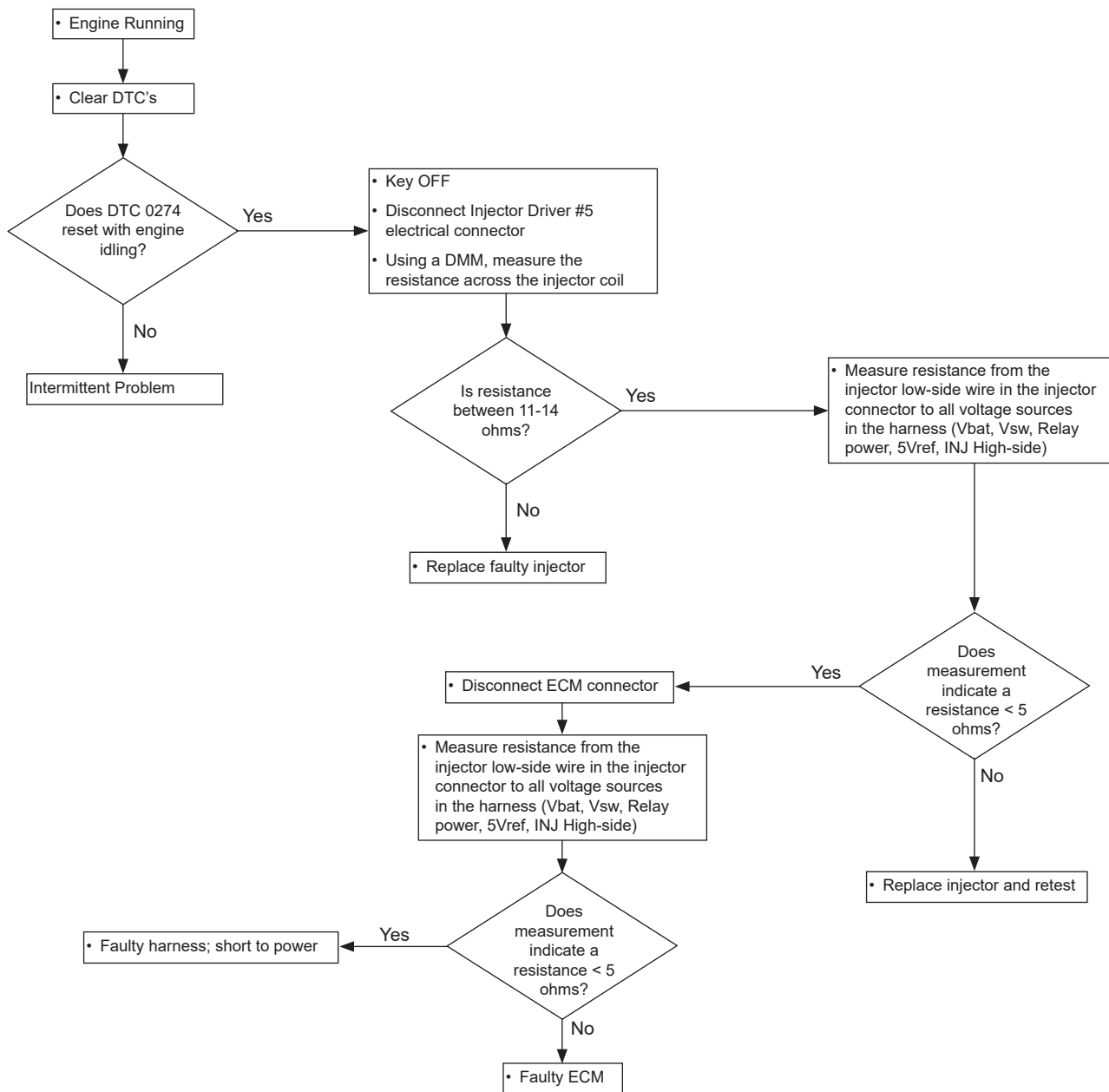


- Injector #5 Coil or Driver Short-to-Power
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM less than 16.0 volts and injector low-side greater than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable adaptive learn and closed-loop fueling correction for key-cycle.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #5.

This fault will set if the ECM detects higher than expected feedback voltage (4.0 VDC) on the injector coil while the injector drive circuit is in the on-state and battery voltage is less than 16.0 volts for 10 injector firings as defined in the diagnostic calibration.

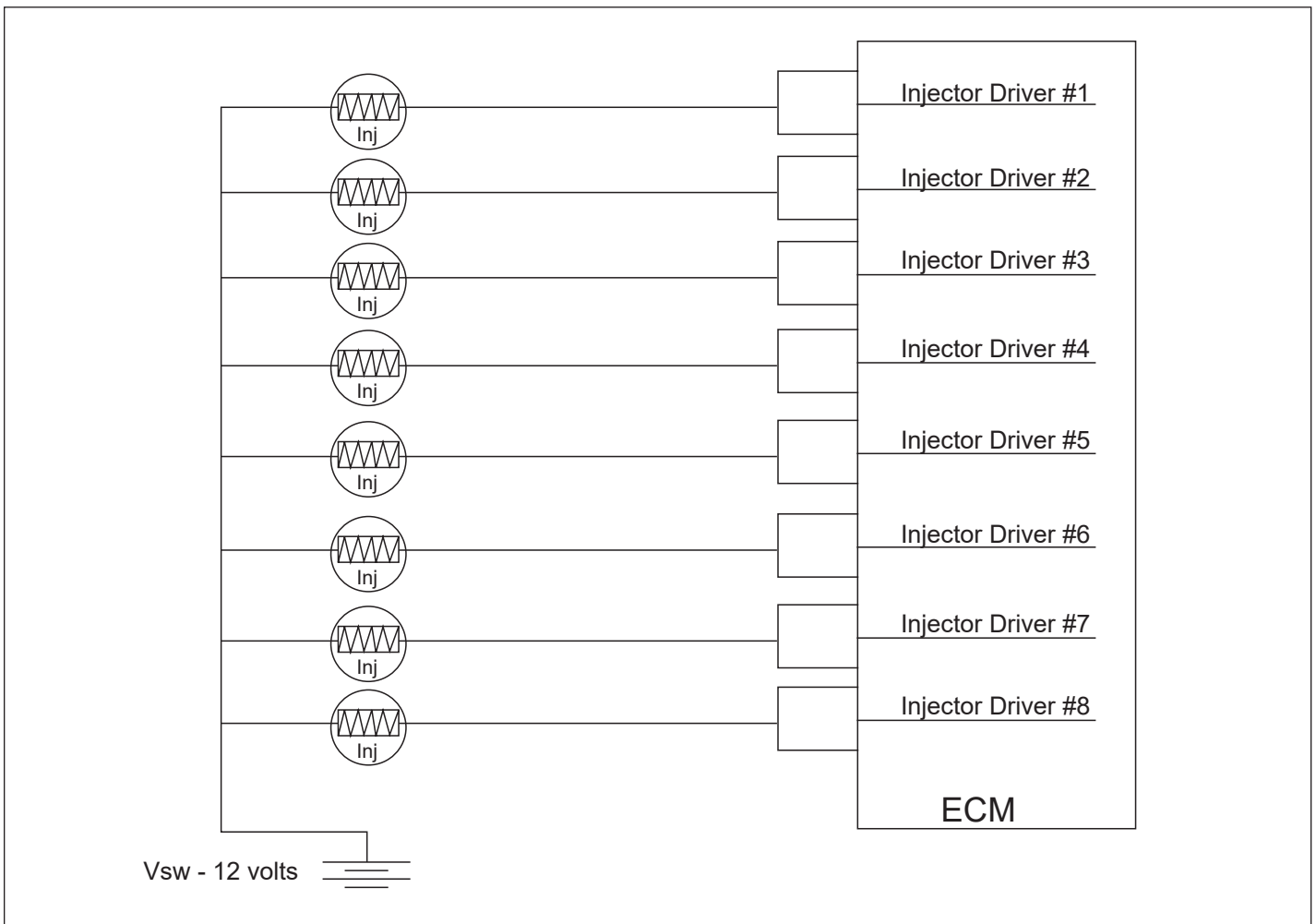
DTC 0274 - Injector Driver #5 Short to Power SPN - 655; FMI - 6



Diagnostics

DTC 0276 - Injector Driver #6 Open / Short to Ground

SPN - 656; FMI - 5

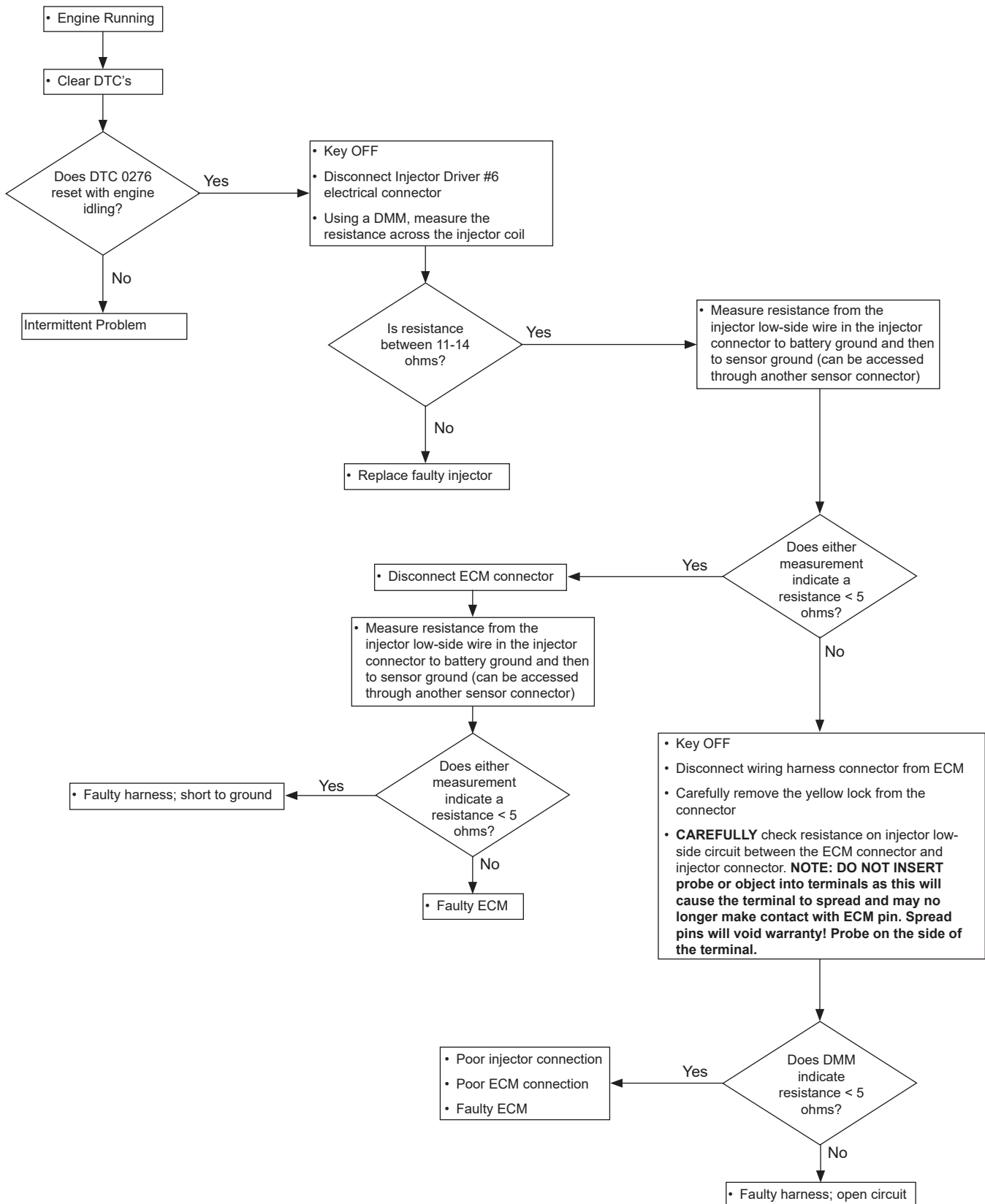


- Injector #6 Coil or Driver Open Circuit or Short-to-Ground
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM greater than 9.0 volts and injector low-side less than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable adaptive learn and closed-loop fueling correction for key-cycle.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #6.

This fault will set if the ECM detects low feedback voltage (4.0 VDC) on the injector coil while the injector drive circuit is in the off-state and battery voltage is greater than 9.0 volts for 10 injector firings as defined in the diagnostic calibration.

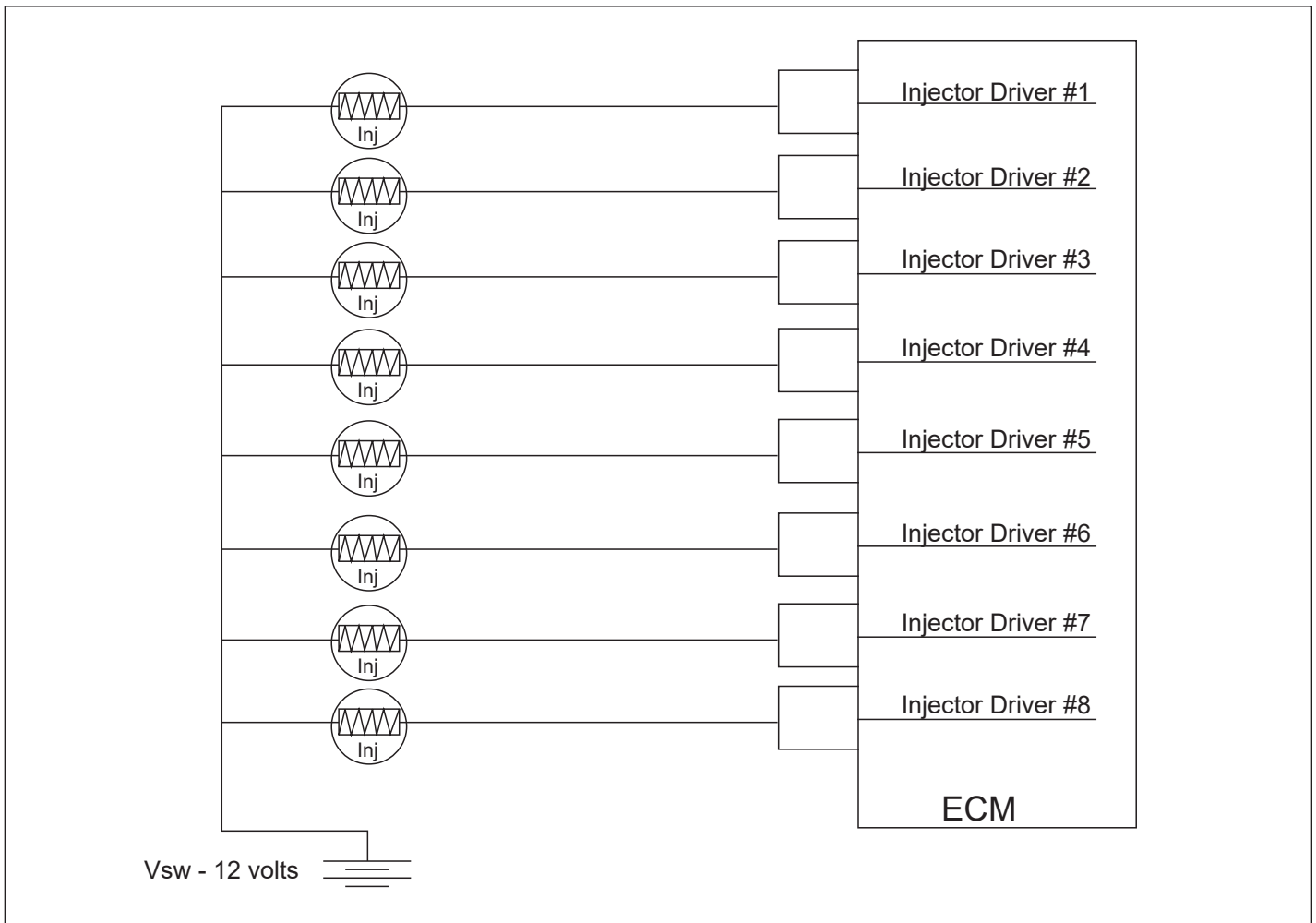
DTC 0276 - Injector Driver #6 Open / Short to Ground SPN - 656; FMI - 5



Diagnostics

DTC 0277 - Injector Driver #6 Short to Power

SPN - 656; FMI - 6

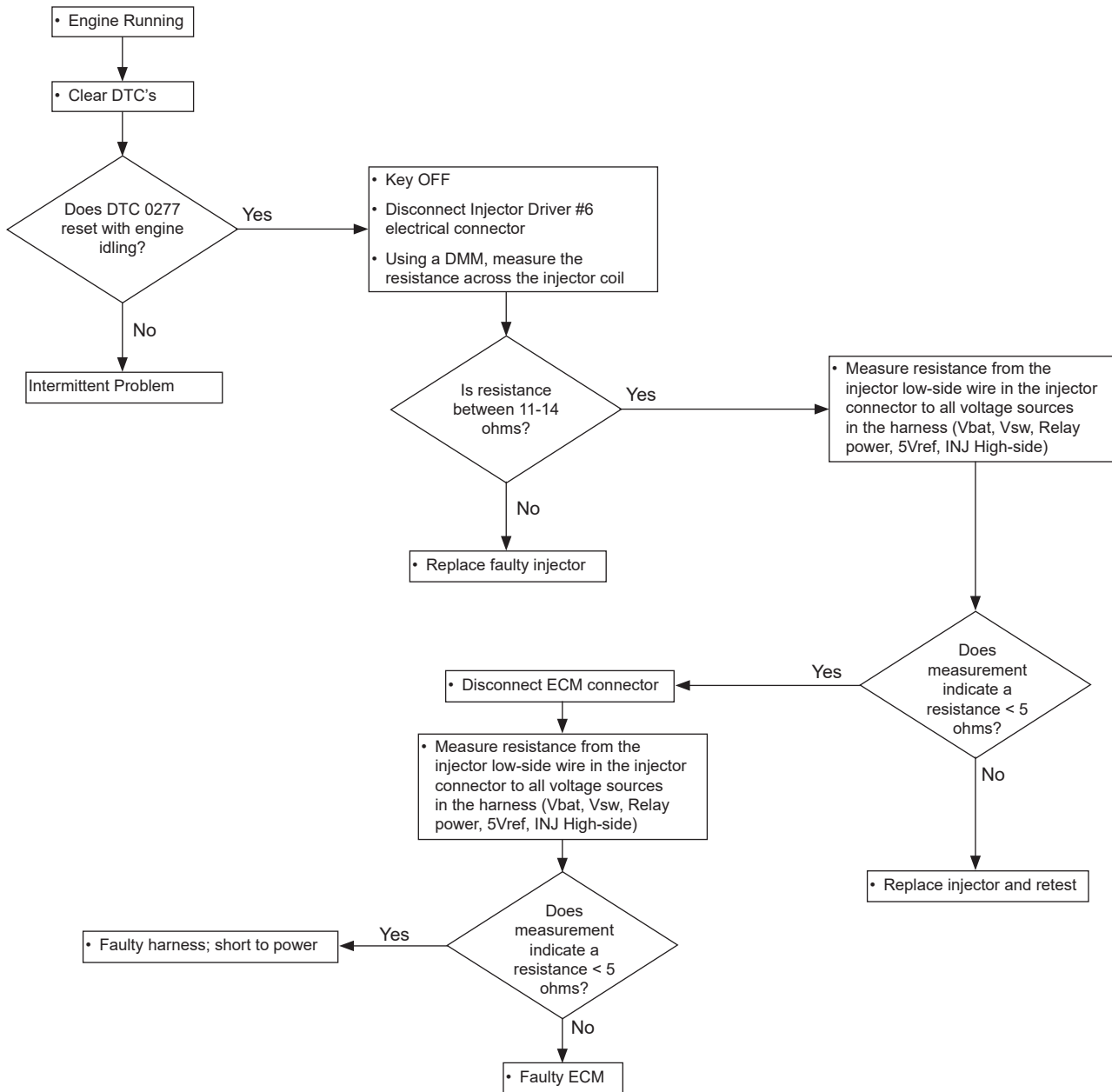


- Injector #6 Coil or Driver Short-to-Power
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM less than 16.0 volts and injector low-side greater than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable adaptive learn and closed-loop fueling correction for key-cycle.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #6.

This fault will set if the ECM detects higher than expected feedback voltage (4.0 VDC) on the injector coil while the injector drive circuit is in the on-state and battery voltage is less than 16.0 volts for 10 injector firings as defined in the diagnostic calibration.

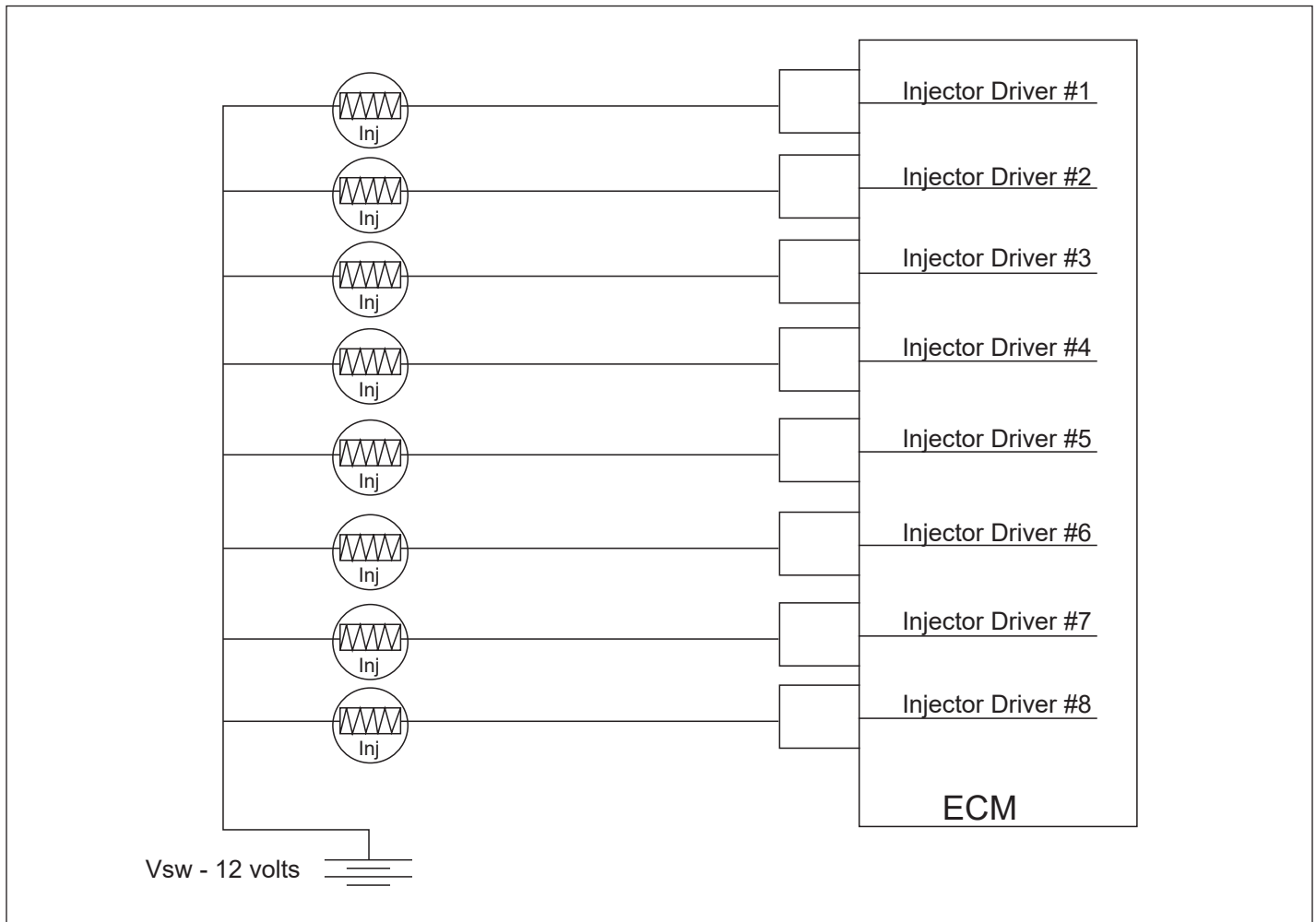
DTC 0277 - Injector Driver #6 Short to Power SPN - 656; FMI - 6



Diagnostics

DTC 0279 - Injector Driver #7 Open / Short to Ground

SPN - 657; FMI - 5

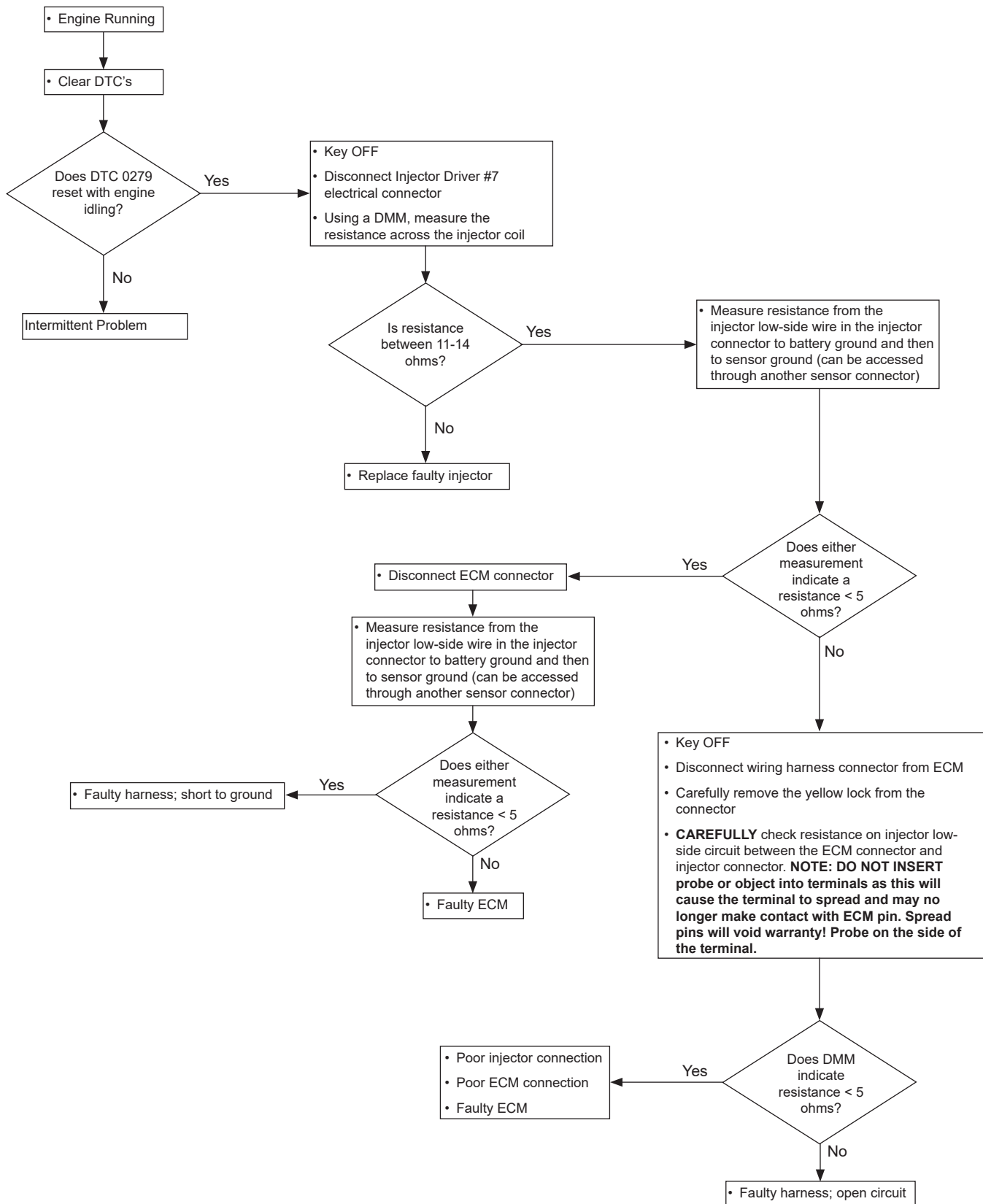


- Injector #7 Coil or Driver Open Circuit or Short-to-Ground
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM greater than 9.0 volts and injector low-side less than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable adaptive learn and closed-loop fueling correction for key-cycle.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #7.

This fault will set if the ECM detects low feedback voltage (4.0 VDC) on the injector coil while the injector drive circuit is in the off-state and battery voltage is greater than 9.0 volts for 10 injector firings as defined in the diagnostic calibration.

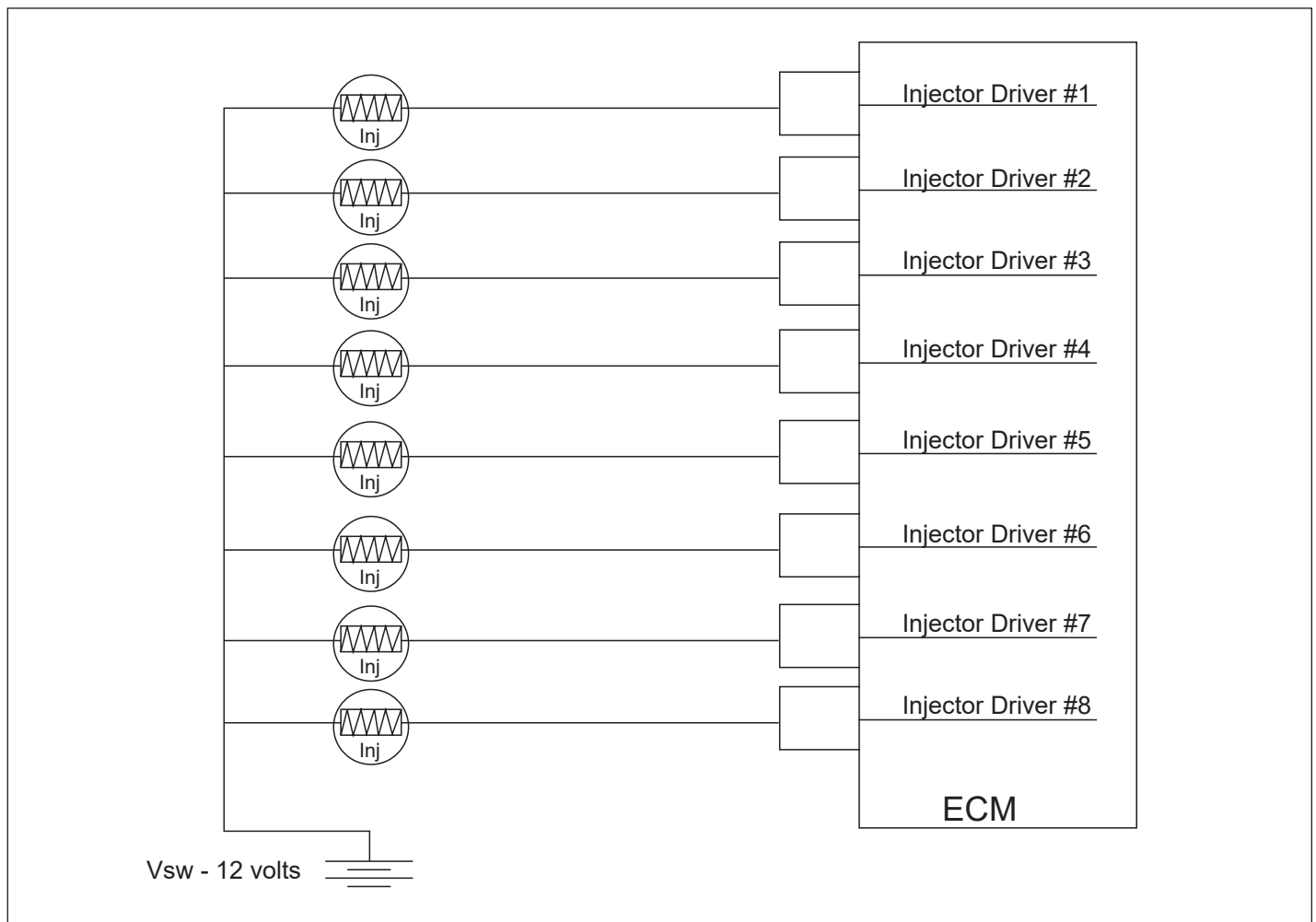
DTC 0279 - Injector Driver #7 Open / Short to Ground SPN - 657; FMI - 5



Diagnostics

DTC 0280 - Injector Driver #7 Short to Power

SPN - 657; FMI - 6

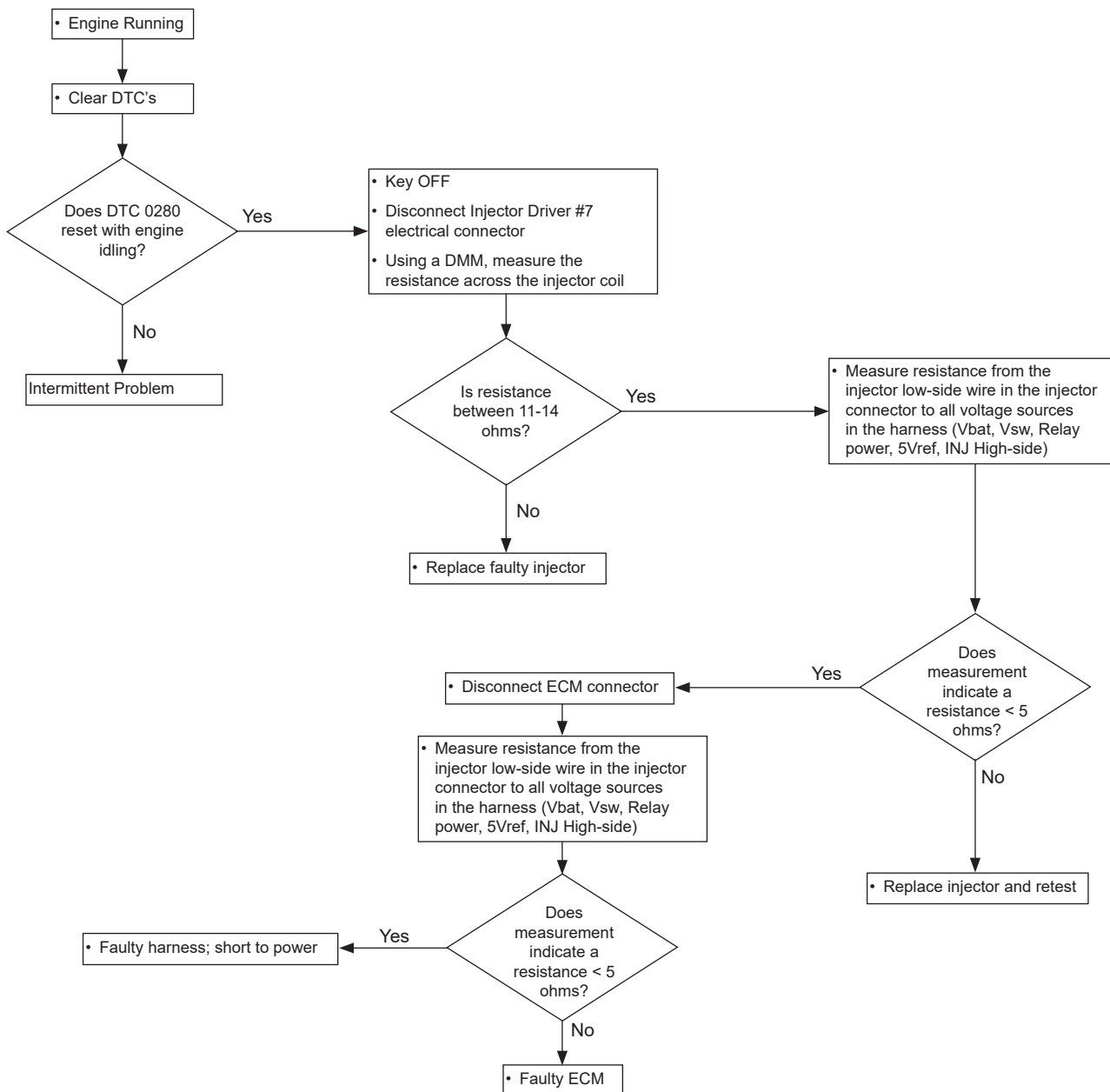


- Injector #7 Coil or Driver Short-to-Power
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM less than 16.0 volts and injector low-side greater than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable adaptive learn and closed-loop fueling correction for key-cycle.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #7.

This fault will set if the ECM detects higher than expected feedback voltage (4.0 VDC) on the injector coil while the injector drive circuit is in the on-state and battery voltage is less than 16.0 volts for 10 injector firings as defined in the diagnostic calibration.

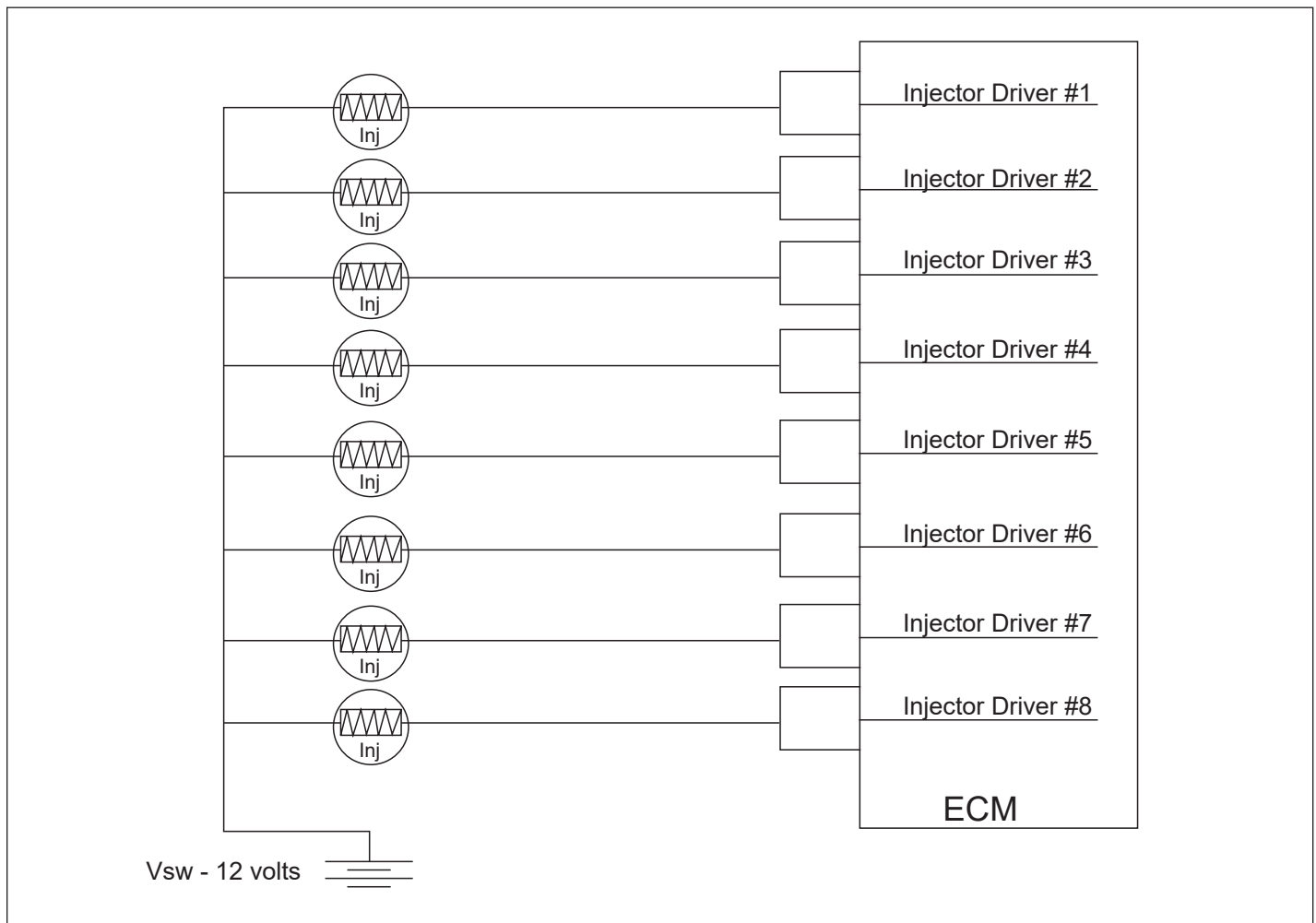
DTC 0280 - Injector Driver #7 Short to Power SPN - 657; FMI - 6



Diagnostics

DTC 0282 - Injector Driver #8 Open / Short to Ground

SPN - 658; FMI - 5

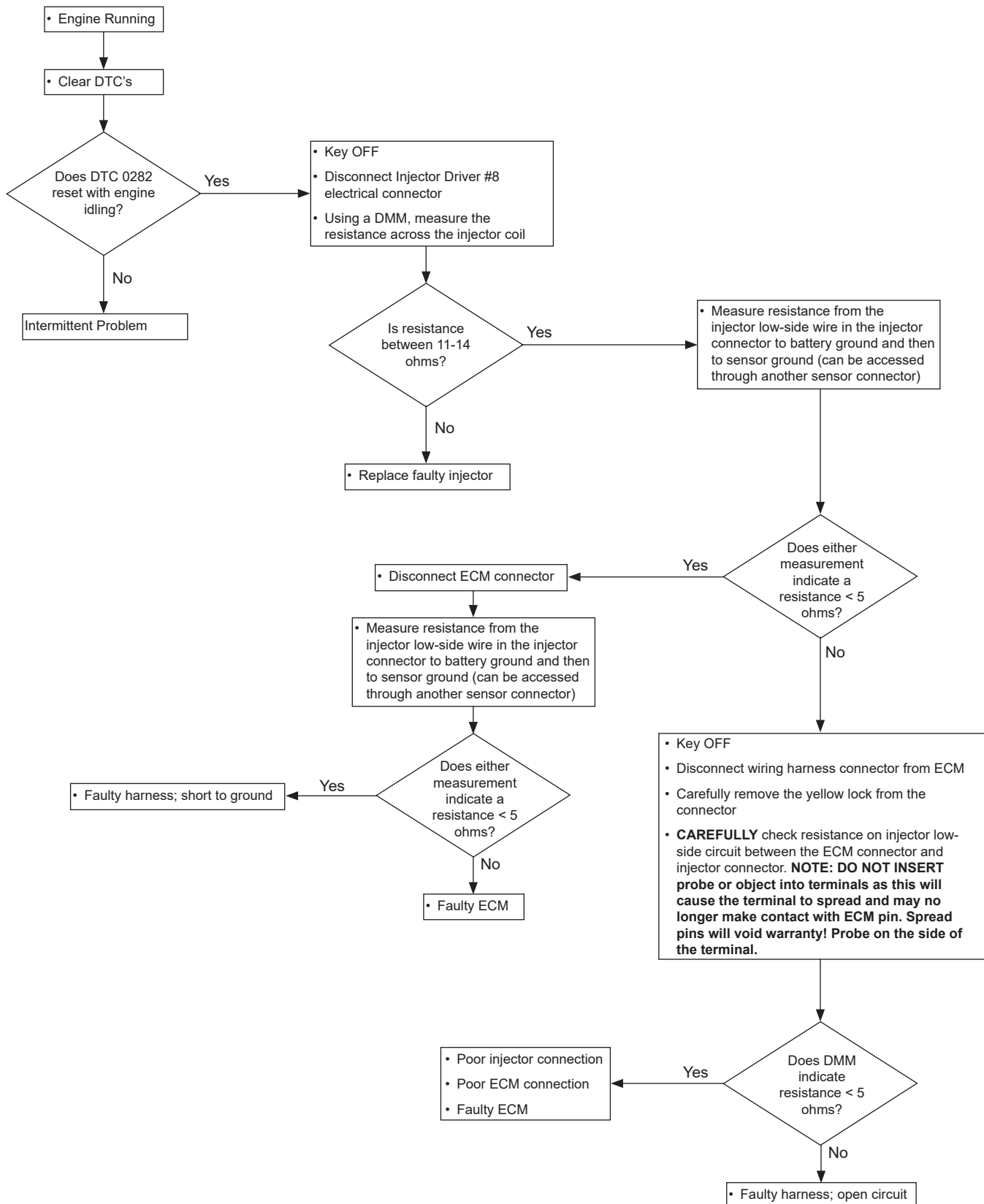


- Injector #8 Coil or Driver Open Circuit or Short-to-Ground
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM greater than 9.0 volts and injector low-side less than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable adaptive learn and closed-loop fueling correction for key-cycle.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #8.

This fault will set if the ECM detects low feedback voltage (4.0 VDC) on the injector coil while the injector drive circuit is in the off-state and battery voltage is greater than 9.0 volts for 10 injector firings as defined in the diagnostic calibration.

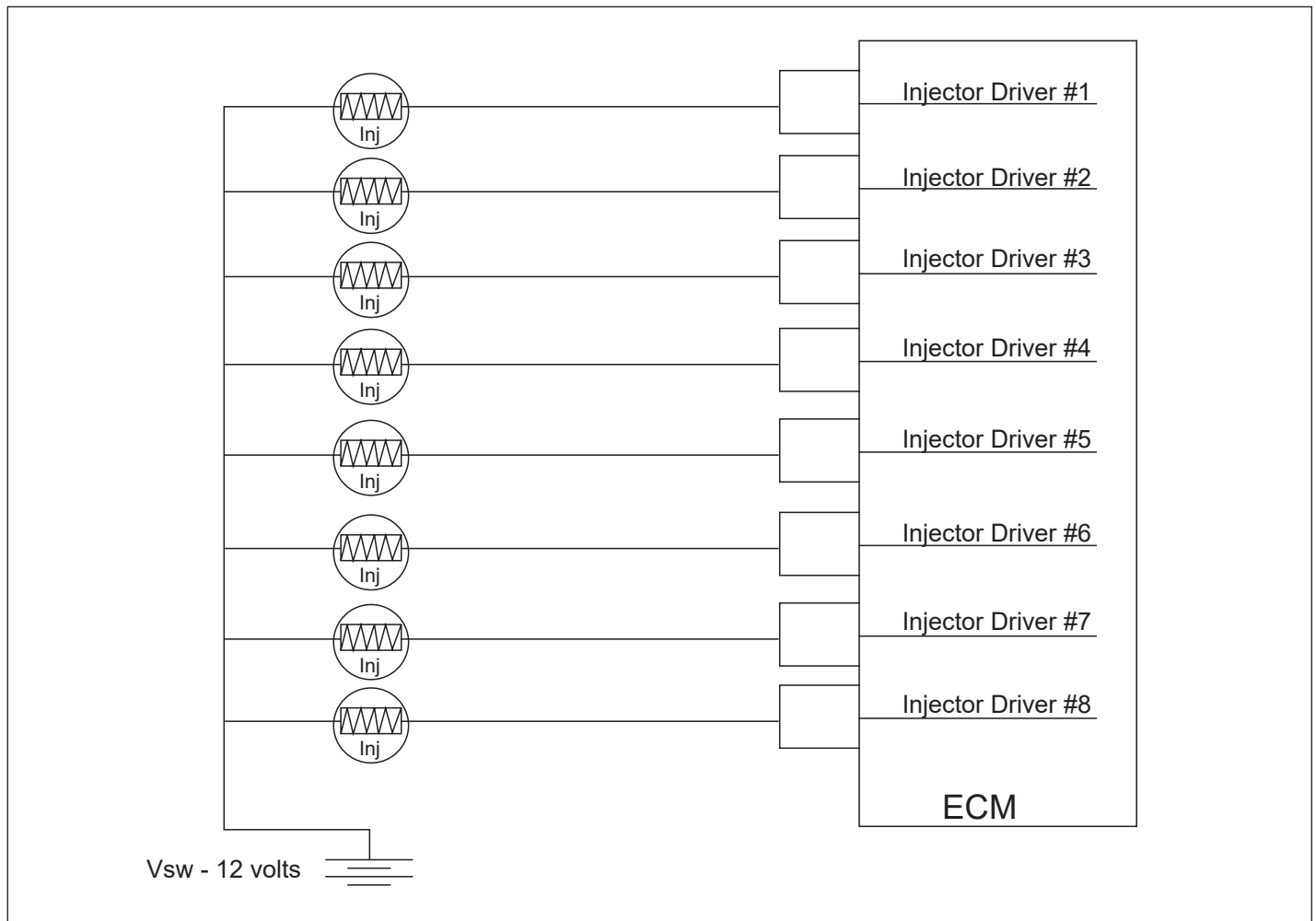
DTC 0282 - Injector Driver #8 Open / Short to Ground SPN - 658; FMI - 5



Diagnostics

DTC 0283 - Injector Driver #8 Short to Power

SPN - 658; FMI - 6

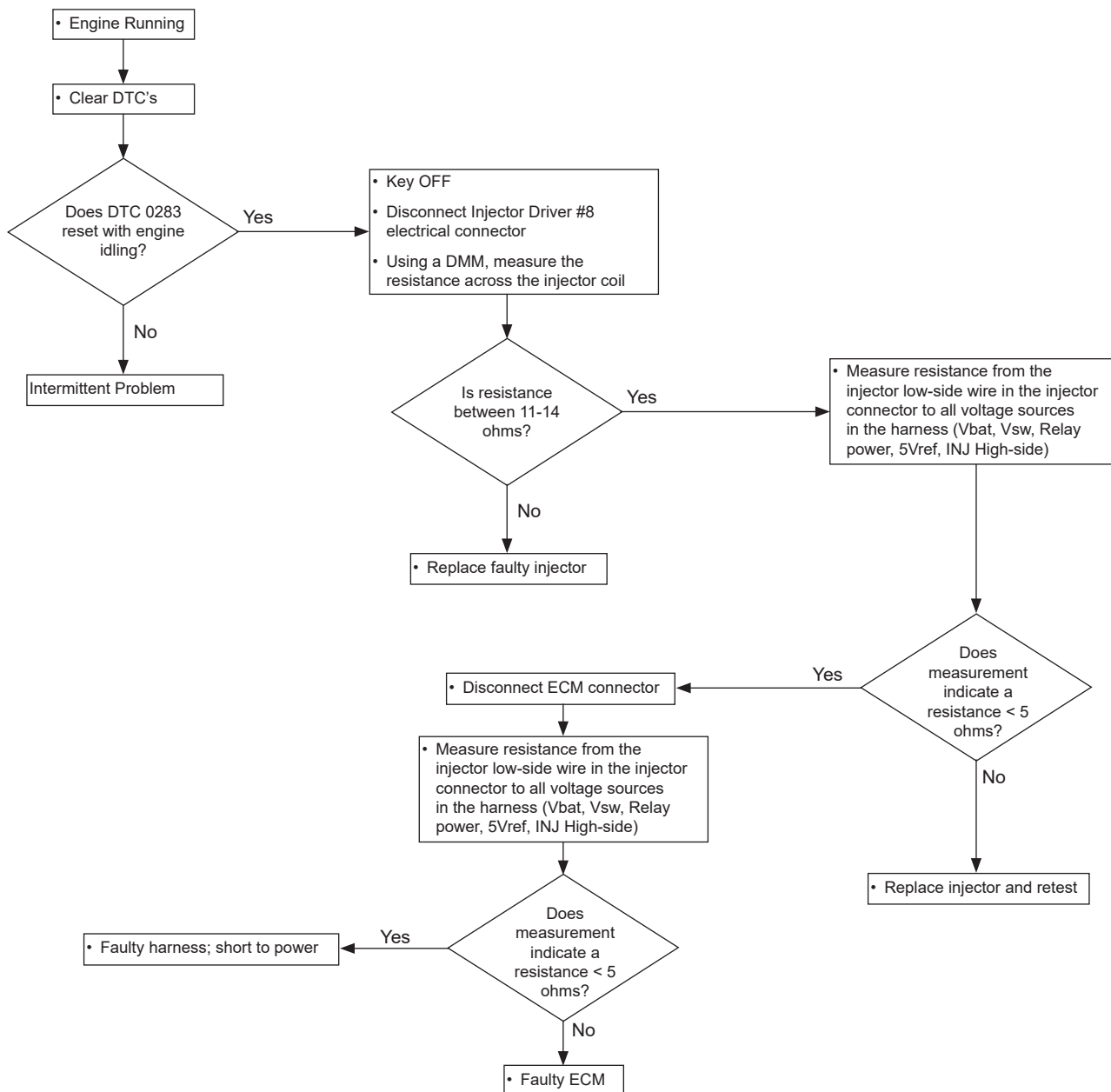


- Injector #8 Coil or Driver Short-to-Power
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM less than 16.0 volts and injector low-side greater than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable adaptive learn and closed-loop fueling correction for key-cycle.
- Emissions-related fault

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #8.

This fault will set if the ECM detects higher than expected feedback voltage (4.0 VDC) on the injector coil while the injector drive circuit is in the on-state and battery voltage is less than 16.0 volts for 10 injector firings as defined in the diagnostic calibration.

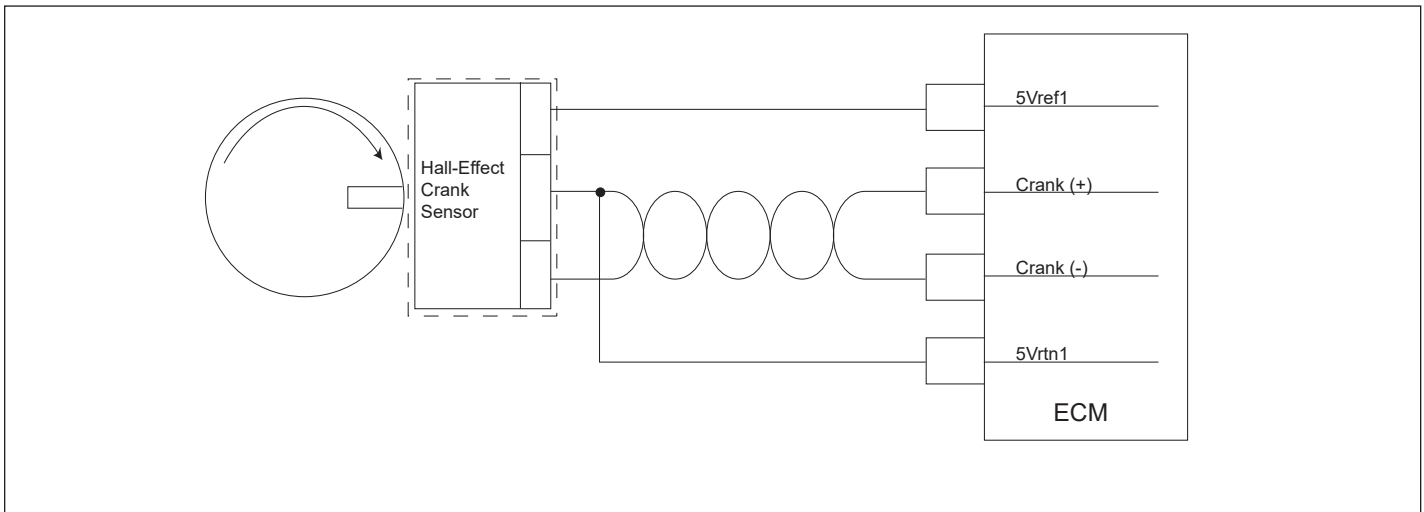
DTC 0283 - Injector Driver #8 Short to Power SPN - 658; FMI - 6



Diagnostics

DTC 0301 - Emissions / Catalyst Damage Misfire Detected Cylinder #1

SPN - 1323; FMI - 31



- Cylinder #1 Misfire Detected - Emissions/Catalyst Damaging
- *Check Condition* - Key On, Engine Running
- *Fault Condition* - Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in catalyst damage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECM is capable of detecting combustion misfire for certain crank-cam software modules. The ECM continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The ECM has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that bank's aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

- 1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
- 2) Emissions are higher than allowed by legislation due to the presence of misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

DTC 0301 - Emissions / Catalyst Damage Misfire Detected Cylinder #1

SPN - 1323; FMI - 31

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

Diagnostic Aids

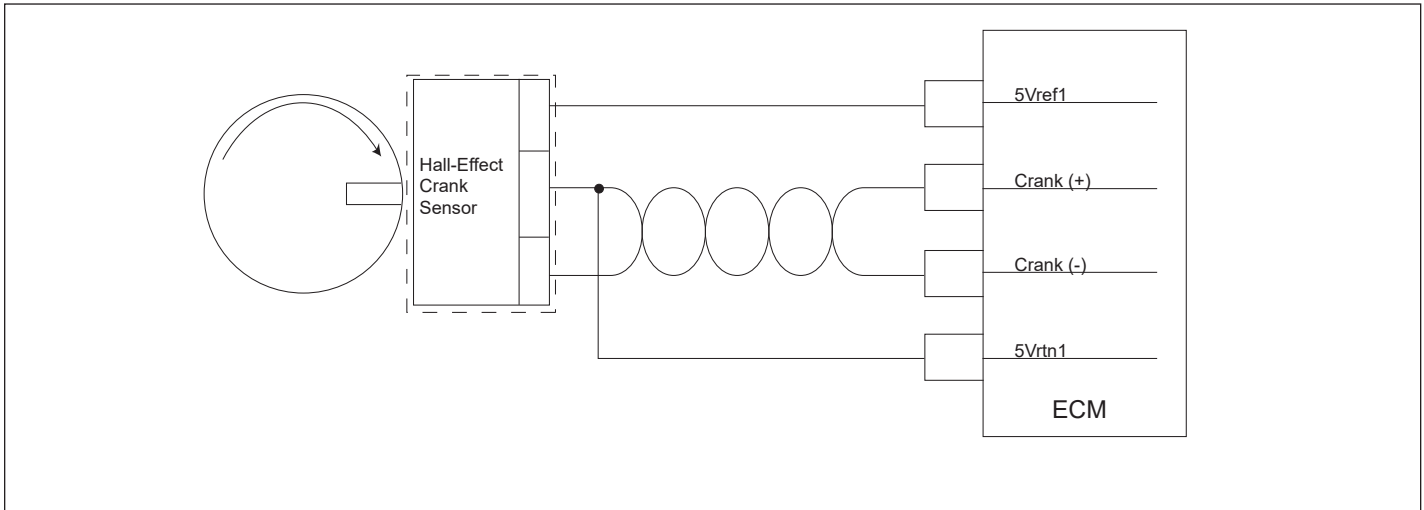
NOTE: If any other DTCs are present, diagnose those first.

- Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
- Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
- Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

Diagnostics

DTC 0302 - Emissions / Catalyst Damage Misfire Detected Cylinder #2

SPN - 1324; FMI - 31



- Cylinder #2 Misfire Detected - Emissions/Catalyst Damaging
- *Check Condition* - Key On, Engine Running
- *Fault Condition* - Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in catalyst damage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECM is capable of detecting combustion misfire for certain crank-cam software modules. The ECM continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The ECM has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that bank's aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

- 1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
- 2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

DTC 0302 - Emissions / Catalyst Damage Misfire Detected Cylinder #2

SPN - 1324; FMI - 31

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

Diagnostic Aids

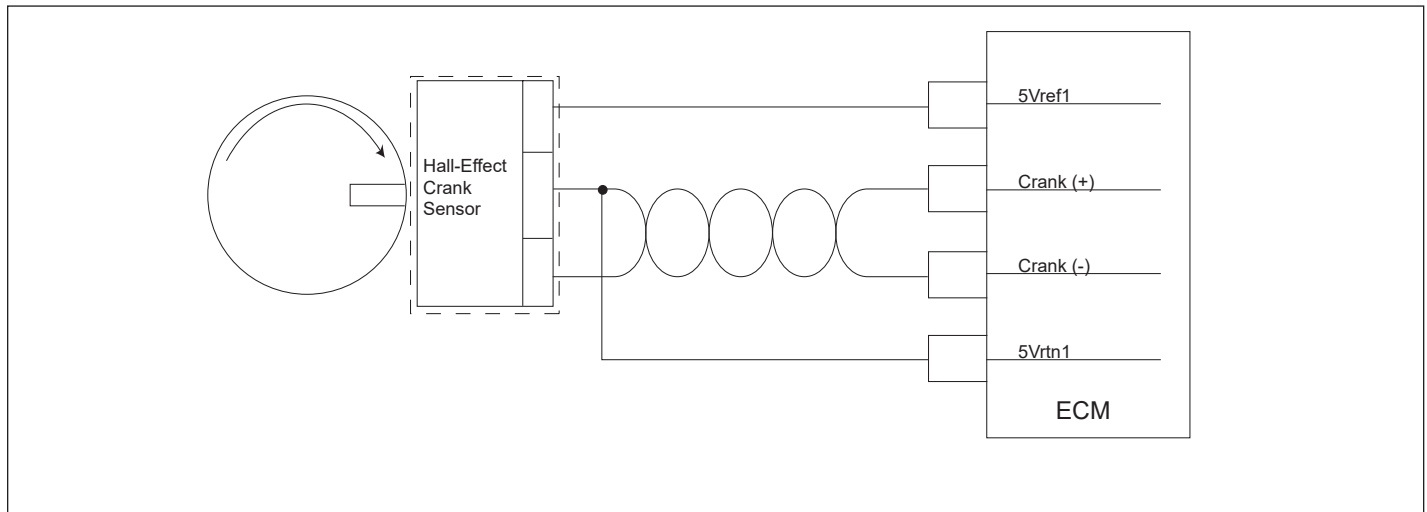
NOTE: If any other DTCs are present, diagnose those first.

- Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
- Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
- Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

Diagnostics

DTC 0303 - Emissions / Catalyst Damage Misfire Detected Cylinder #3

SPN - 1325; FMI - 31



- Cylinder #3 Misfire Detected - Emissions/Catalyst Damaging
- *Check Condition* - Key On, Engine Running
- *Fault Condition* - Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in catalyst damage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECM is capable of detecting combustion misfire for certain crank-cam software modules. The ECM continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The ECM has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that bank's aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

- 1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
- 2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

DTC 0303 - Emissions / Catalyst Damage Misfire Detected Cylinder #3

SPN - 1325; FMI - 31

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

Diagnostic Aids

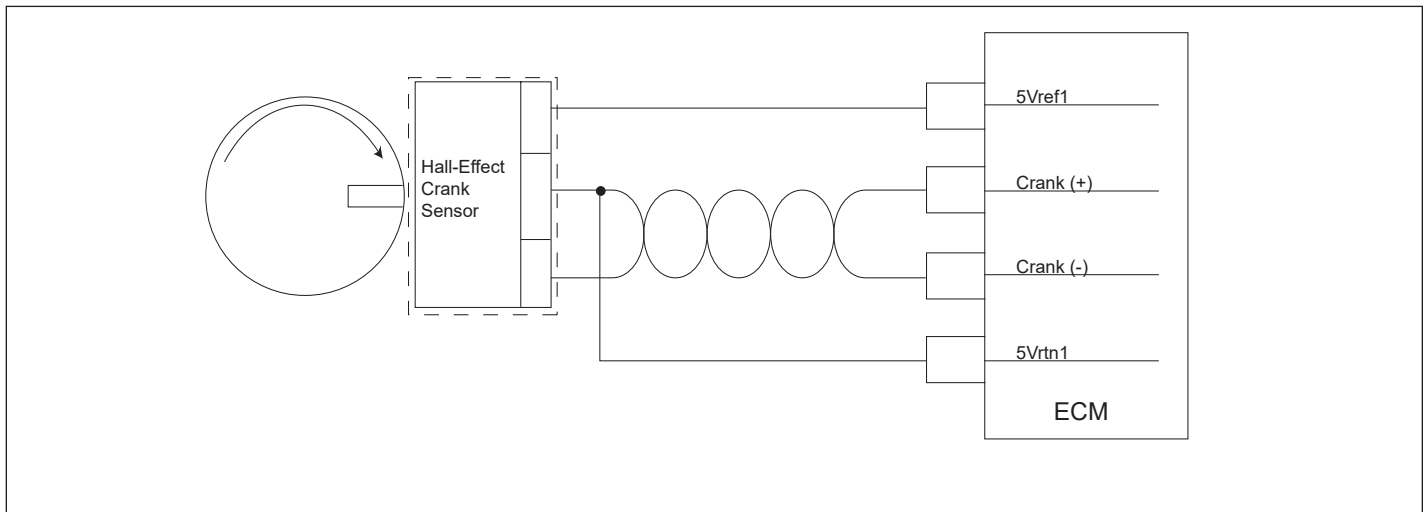
NOTE: If any other DTCs are present, diagnose those first.

- Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
- Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
- Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

Diagnostics

DTC 0304 - Emissions / Catalyst Damage Misfire Detected Cylinder #4

SPN - 1326; FMI - 31



- Cylinder #4 Misfire Detected - Emissions/Catalyst Damaging
- *Check Condition* - Key On, Engine Running
- *Fault Condition* - Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in catalyst damage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECM is capable of detecting combustion misfire for certain crank-cam software modules. The ECM continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The ECM has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that bank's aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

- 1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
- 2) Emissions are higher than allowed by legislation due to the presence of misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

DTC 0304 - Emissions / Catalyst Damage Misfire Detected Cylinder #4

SPN - 1326; FMI - 31

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

Diagnostic Aids

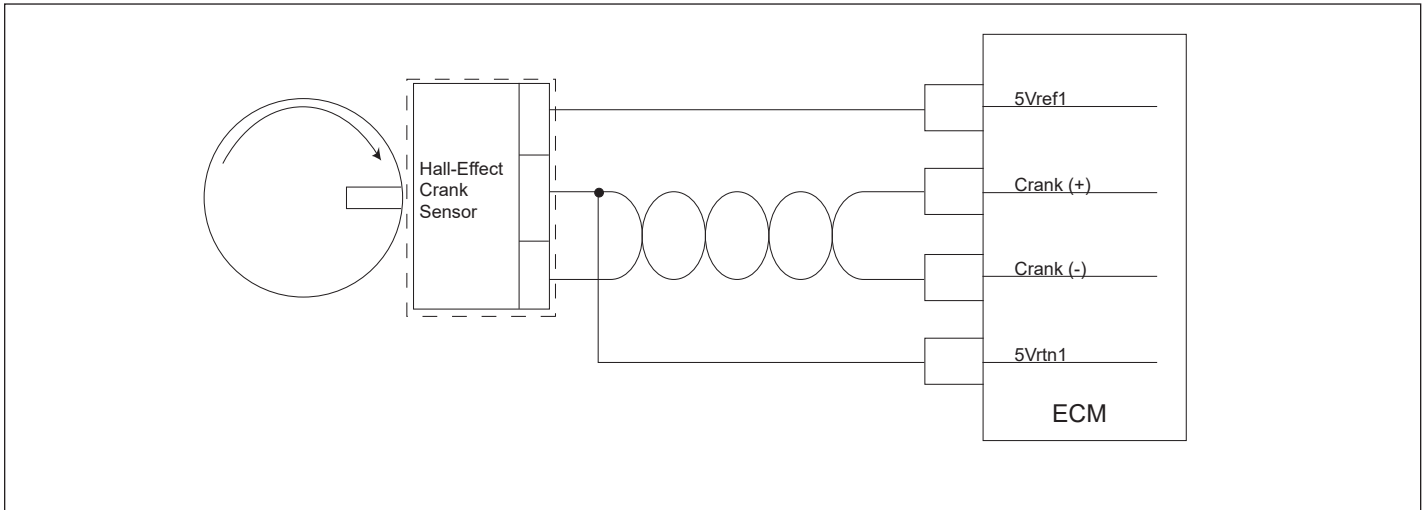
NOTE: If any other DTCs are present, diagnose those first.

- Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
- Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
- Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

Diagnostics

DTC 0305 - Emissions / Catalyst Damage Misfire Detected Cylinder #5

SPN - 1327; FMI - 31



- Cylinder #5 Misfire Detected - Emissions/Catalyst Damaging
- *Check Condition* - Key On, Engine Running
- *Fault Condition* - Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in catalyst damage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECM is capable of detecting combustion misfire for certain crank-cam software modules. The ECM continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The ECM has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that bank's aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

- 1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
- 2) Emissions are higher than allowed by legislation due to the presence of misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

DTC 0305 - Emissions / Catalyst Damage Misfire Detected Cylinder #5

SPN - 1327; FMI - 31

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

Diagnostic Aids

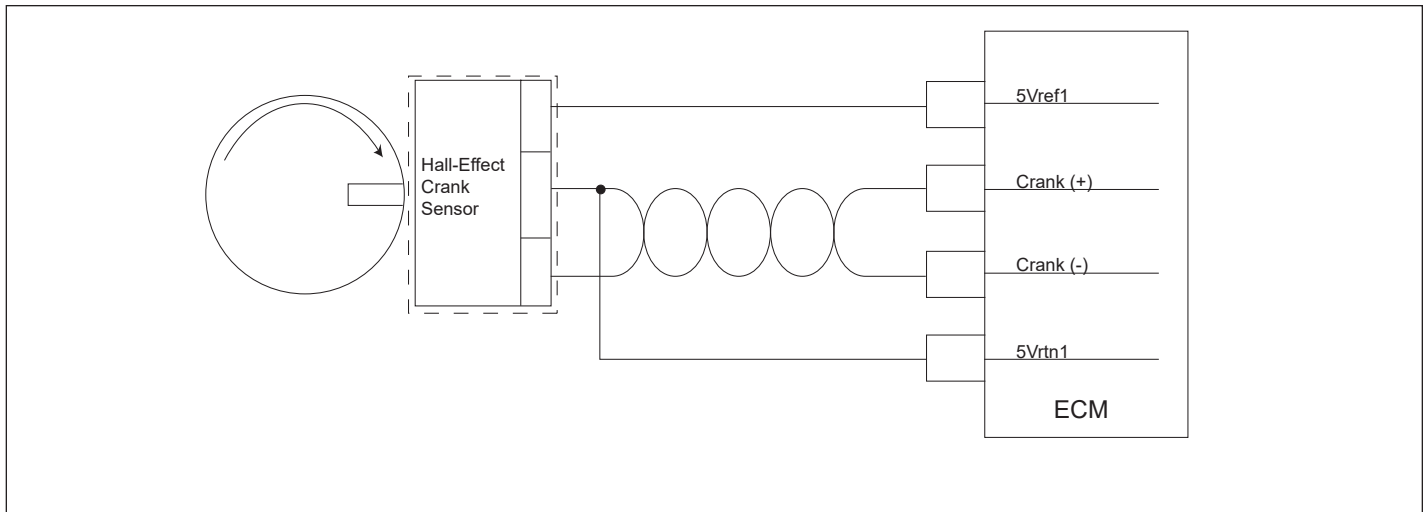
NOTE: If any other DTCs are present, diagnose those first.

- Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
- Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
- Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

Diagnostics

DTC 0306 - Emissions / Catalyst Damage Misfire Detected Cylinder #6

SPN - 1328; FMI - 31



- Cylinder #6 Misfire Detected - Emissions/Catalyst Damaging
- *Check Condition* - Key On, Engine Running
- *Fault Condition* - Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in catalyst damage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECM is capable of detecting combustion misfire for certain crank-cam software modules. The ECM continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The ECM has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that bank's aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

- 1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
- 2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

DTC 0306 - Emissions / Catalyst Damage Misfire Detected Cylinder #6

SPN - 1328; FMI - 31

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

Diagnostic Aids

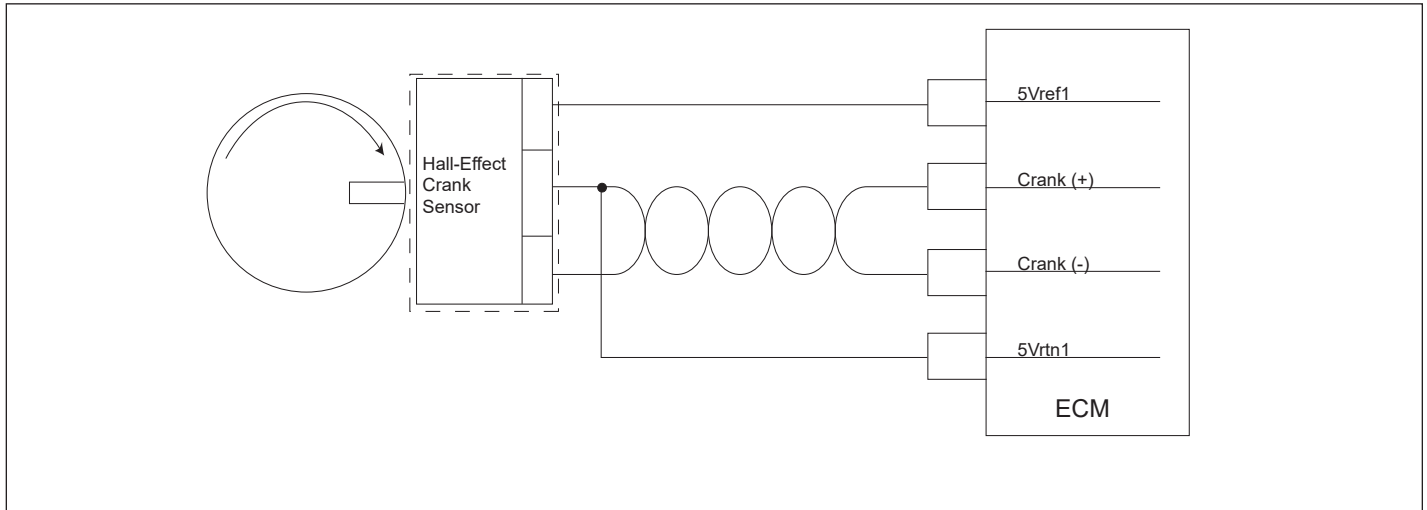
NOTE: If any other DTCs are present, diagnose those first.

- Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
- Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
- Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

Diagnostics

DTC 0307 - Emissions / Catalyst Damage Misfire Detected Cylinder #7

SPN - 1329; FMI - 31



- Cylinder #7 Misfire Detected - Emissions/Catalyst Damaging
- *Check Condition* - Key On, Engine Running
- *Fault Condition* - Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in catalyst damage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECM is capable of detecting combustion misfire for certain crank-cam software modules. The ECM continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The ECM has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that bank's aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

- 1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
- 2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

DTC 0307 - Emissions / Catalyst Damage Misfire Detected Cylinder #7

SPN - 1329; FMI - 31

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

Diagnostic Aids

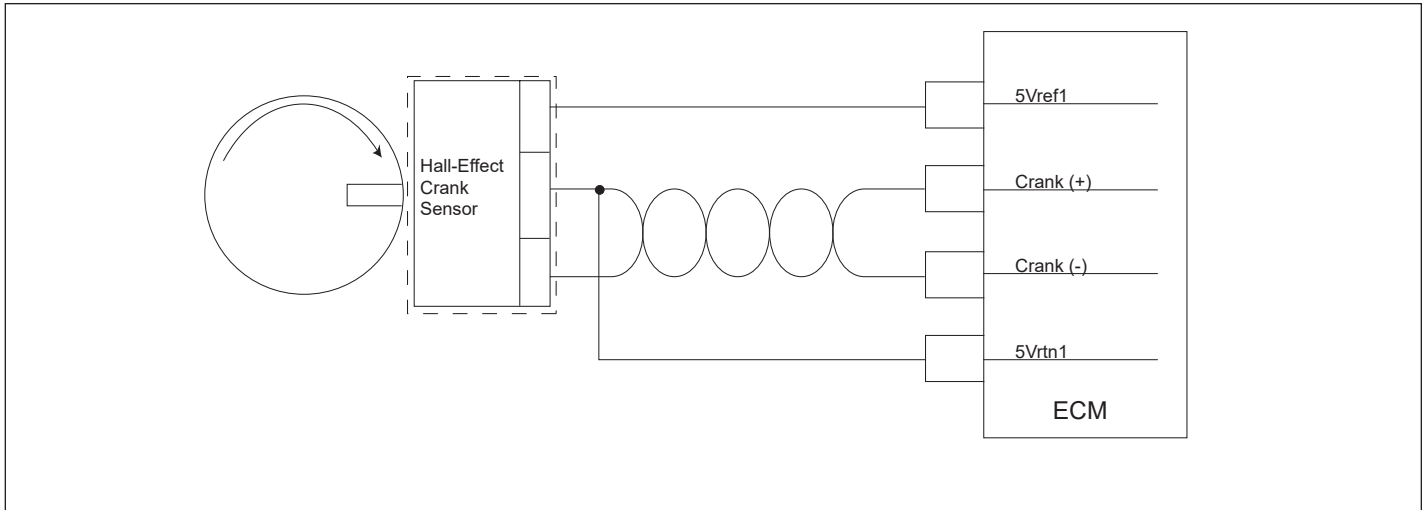
NOTE: If any other DTCs are present, diagnose those first.

- Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
- Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
- Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

Diagnostics

DTC 0308 - Emissions / Catalyst Damage Misfire Detected Cylinder #8

SPN - 1330; FMI - 31



- Cylinder #8 Misfire Detected - Emissions/Catalyst Damaging
- *Check Condition* - Key On, Engine Running
- *Fault Condition* - Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in catalyst damage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECM is capable of detecting combustion misfire for certain crank-cam software modules. The ECM continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The ECM has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that bank's aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

- 1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
- 2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

DTC 0308 - Emissions / Catalyst Damage Misfire Detected Cylinder #8

SPN - 1330; FMI - 31

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

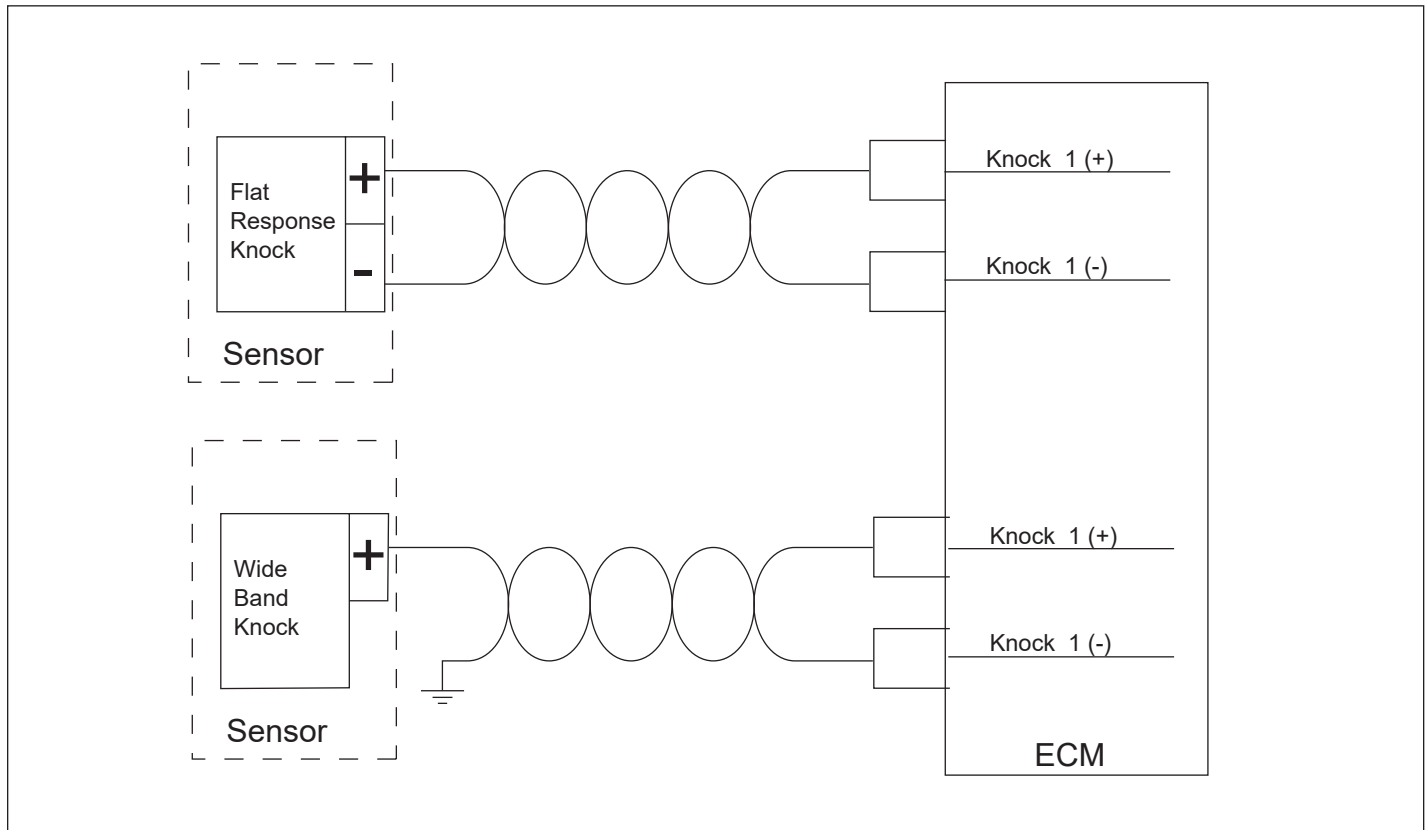
Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
- Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
- Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

Diagnostics

DTC 0326 - Knock 1 Excessive or Erratic Signal SPN - 731; FMI - 2

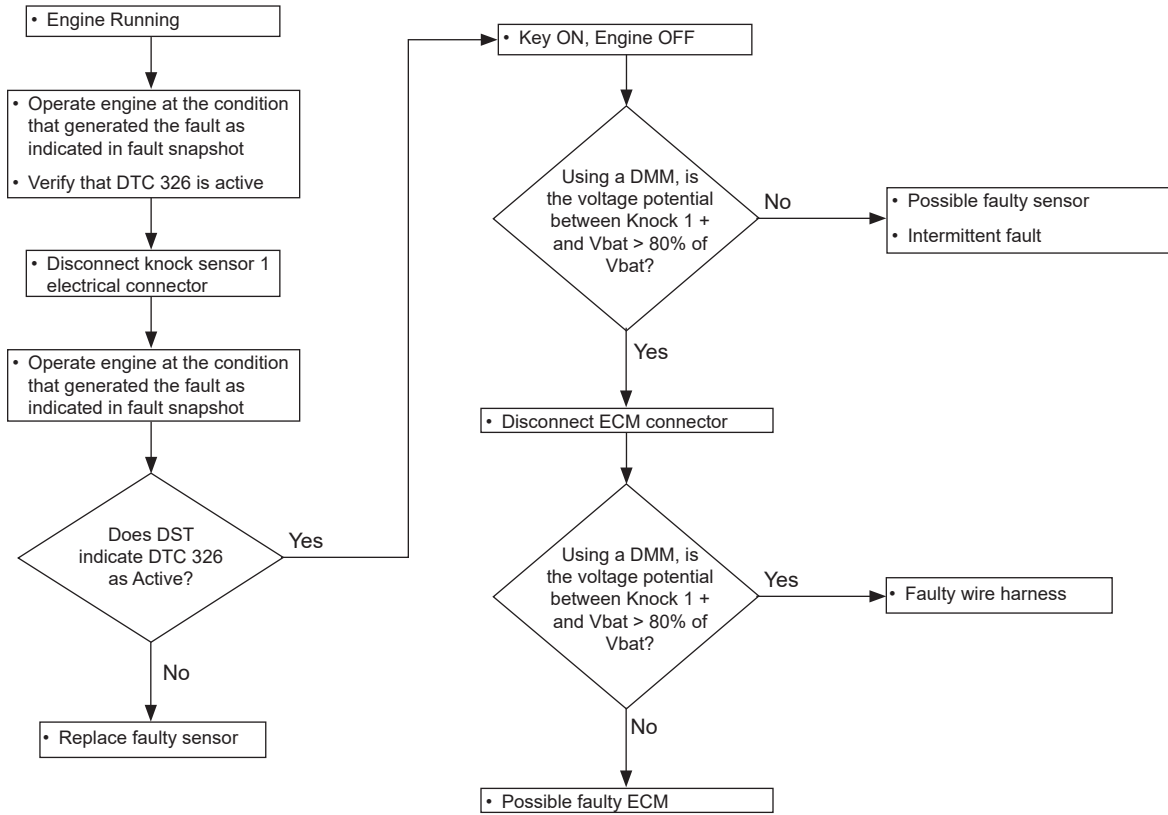


- Knock sensor #1
- *Check Condition* - Key On, Engine On
- *Fault Condition* - Knock sensor 1 indicates an excessive signal level
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, possibly power derate the engine, and retard spark to Faulted KNK Retard level to protect engine from possible damage due to unsensed detonation
- Emissions related fault

The knock sensor is used to detect detonation through mechanical vibration in the engine block and/or cylinder heads and provide feedback for the ignition system to retard spark to reduce knock intensity. In most applications the knock sensor is used to protect the engine from damage that can be caused from detonation or knock based on fixed spark advance. In other applications, the knock sensor is used to optimize spark advance and “learn” between spark tables based on fuel quality.

This fault sets if the signal from knock sensor 1 is higher than 4.50 volts and MAP less than 8.00 psia. If this fault sets, spark is lowered by the amount defined in calibration for Faulted KNK Retard.

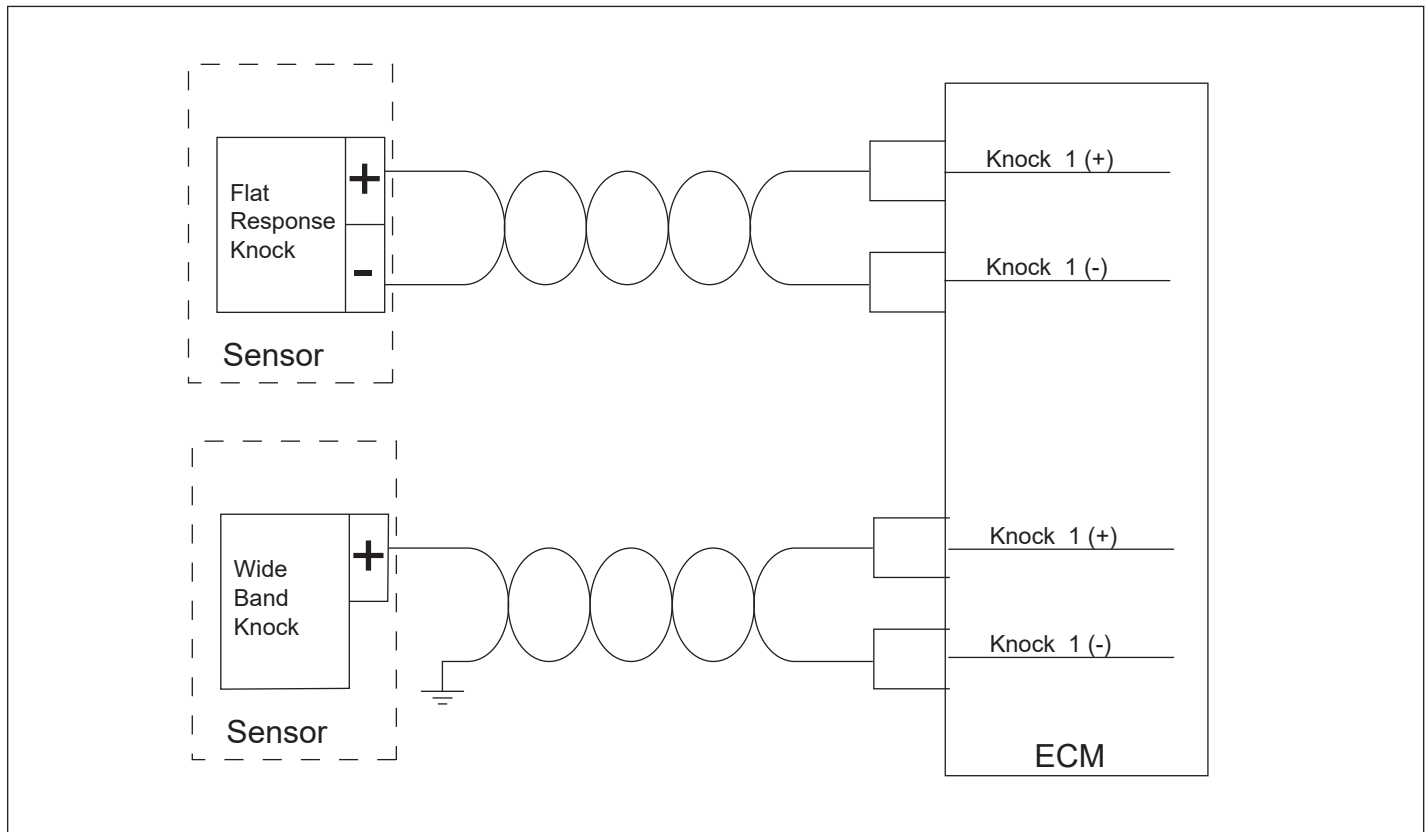
DTC 0326 - Knock 1 Excessive or Erratic Signal SPN - 731; FMI - 2



Diagnostics

DTC 0327 - Knock 1 Sensor Circuit Open

SPN - 731; FMI - 4

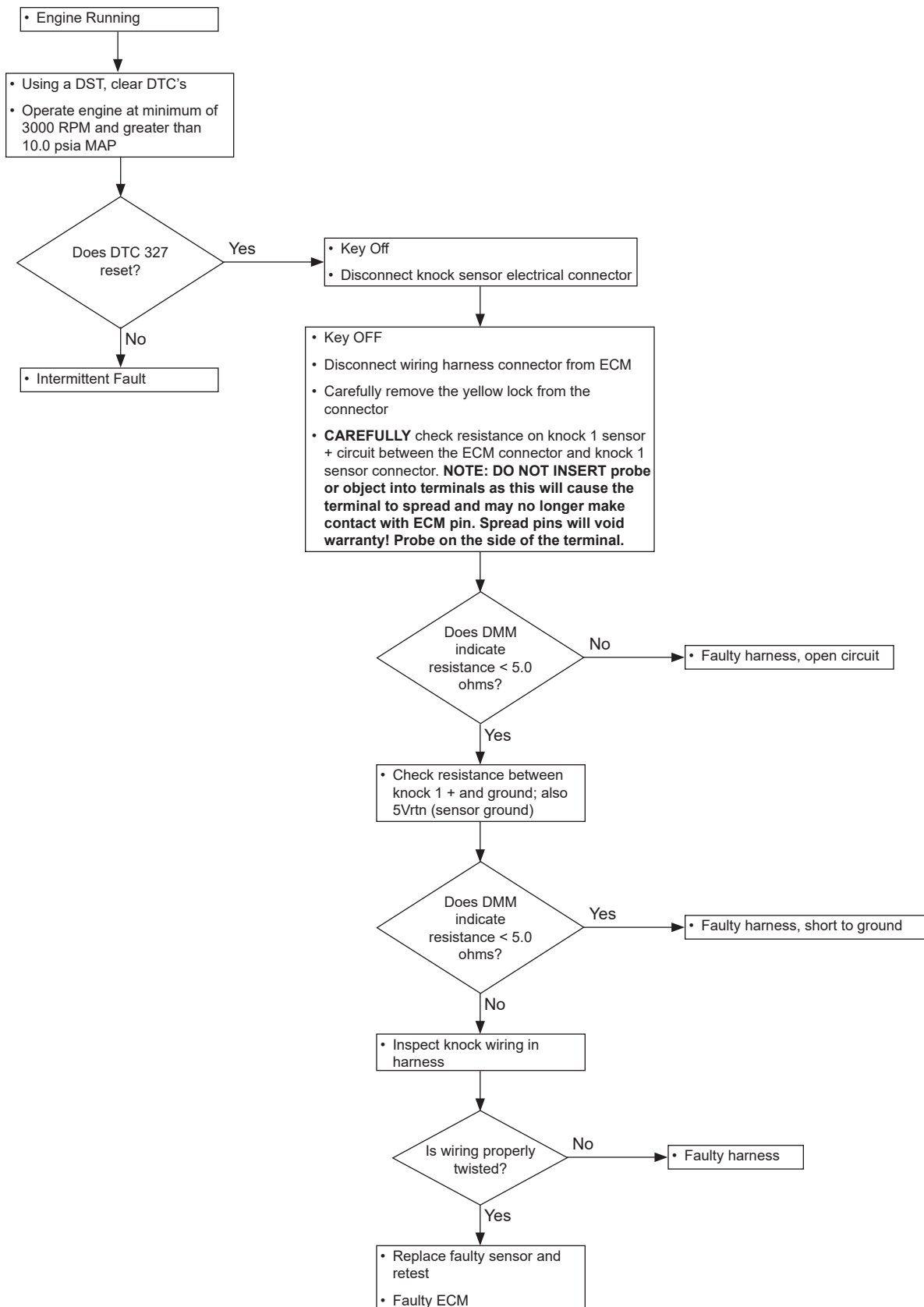


- Knock sensor #1
- *Check Condition* - Key On, Engine On
- *Fault Condition* - Knock sensor 1 signal low while engine speed is greater than 3000 RPM and MAP is greater than 10.00 psia as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, possibly power derate the engine, and retard spark to Faulted KNK Retard level to protect engine from possible damage due to inability to sense detonation
- Emissions related fault

The knock sensor is used to detect detonation through mechanical vibration in the engine block and/or cylinder heads and provide feedback for the ignition system to retard spark to reduce knock intensity. In most applications the knock sensor is used to protect the engine from damage that can be caused from detonation or knock based on fixed spark advance. In other applications, the knock sensor is used to optimize spark advance and “learn” between spark tables based on fuel quality.

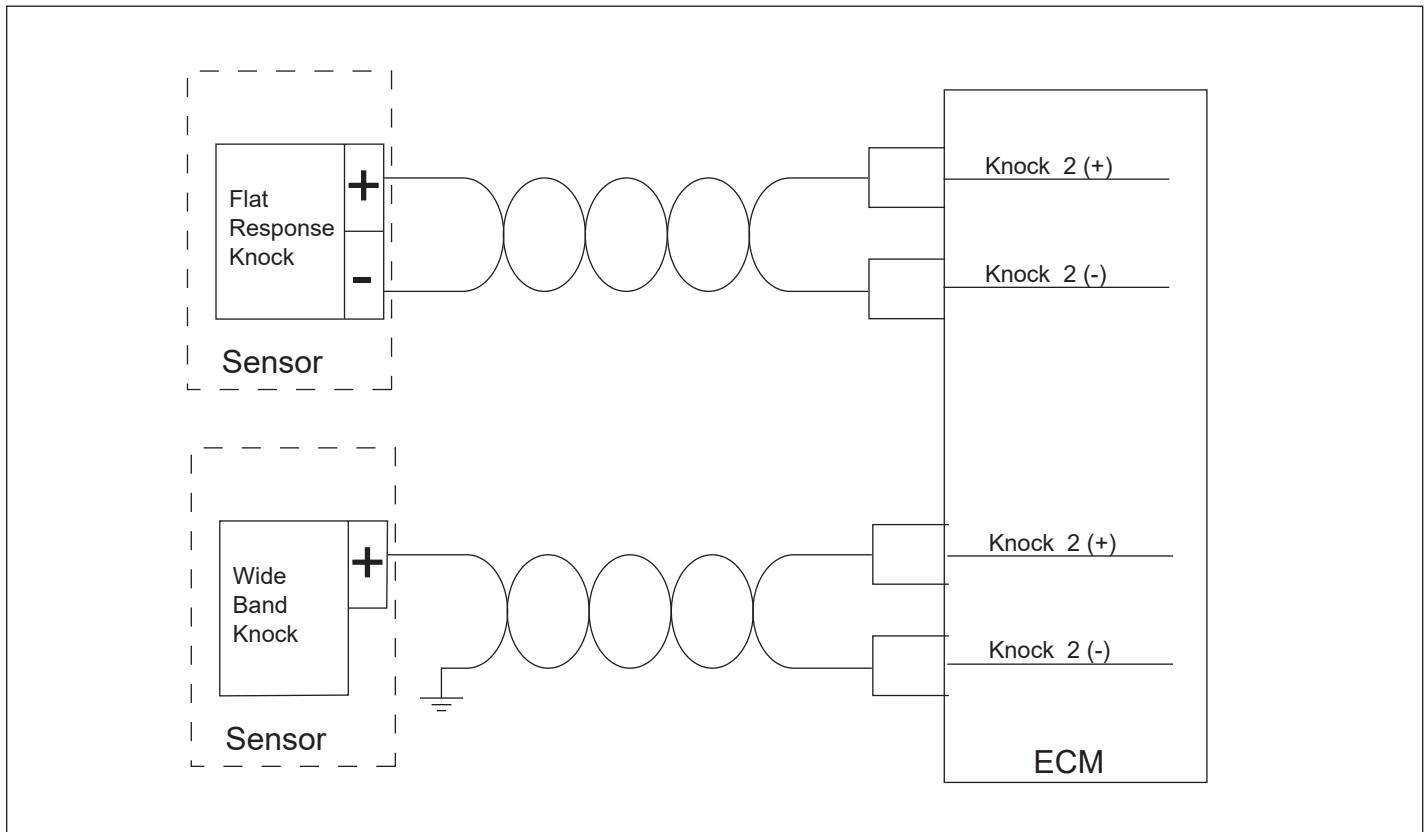
This fault sets if the signal from knock sensor 1 is lower than expected for higher speed and load operation as defined in calibration. If this fault sets, spark is lowered by the amount defined in calibration for Faulted KNK Retard.

DTC 0327 - Knock 1 Sensor Circuit Open SPN - 731; FMI - 4



Diagnostics

DTC 0331 - Knock 2 Excessive or Erratic Signal SPN - 520197; FMI - 2

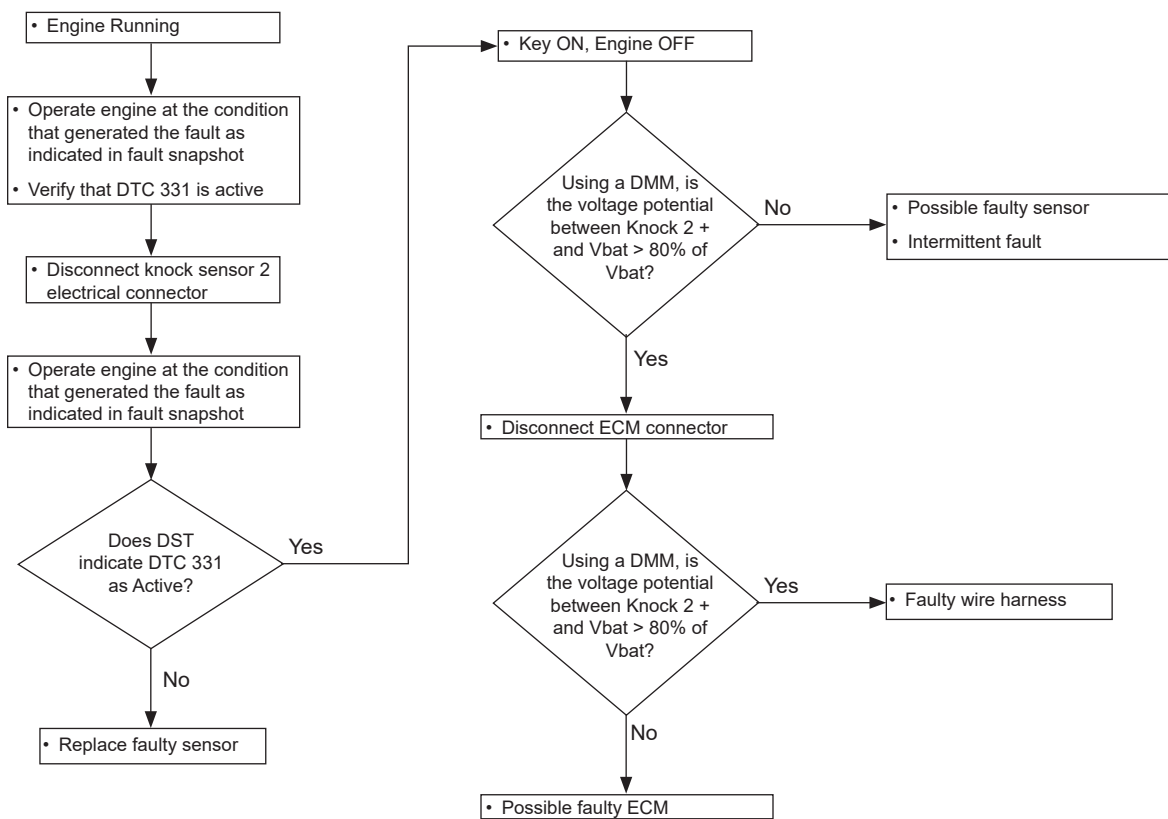


- Knock sensor #2
- *Check Condition* - Key On, Engine On
- *Fault Condition* - Knock sensor 2 indicates an excessive signal level
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, possibly power derate the engine, and retard spark to Faulted KNK Retard level to protect engine from possible damage due to unsensed detonation
- Emissions related fault

The knock sensor is used to detect detonation through mechanical vibration in the engine block and/or cylinder heads and provide feedback for the ignition system to retard spark to reduce knock intensity. In most applications the knock sensor is used to protect the engine from damage that can be caused from detonation or knock based on fixed spark advance. In other applications, the knock sensor is used to optimize spark advance and “learn” between spark tables based on fuel quality.

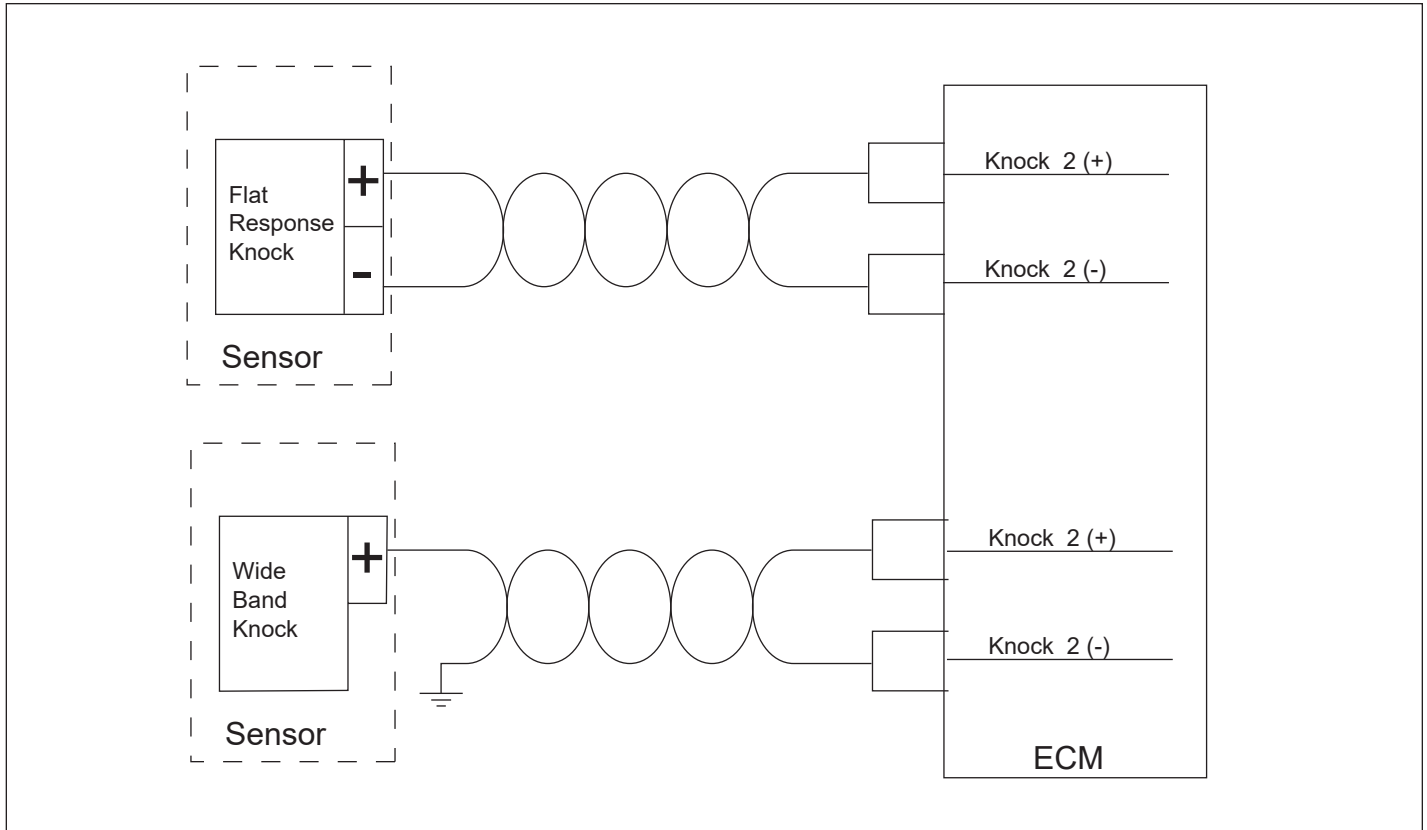
This fault sets if the signal from knock sensor 2 is higher than 4.50 volts and MAP less than 8.00 psia. If this fault sets, spark is lowered by the amount defined in calibration for Faulted KNK Retard.

DTC 0331 - Knock 2 Excessive or Erratic Signal SPN - 520197; FMI - 2



Diagnostics

DTC 0332 - Knock 2 Sensor Circuit Open SPN - 520197; FMI - 4

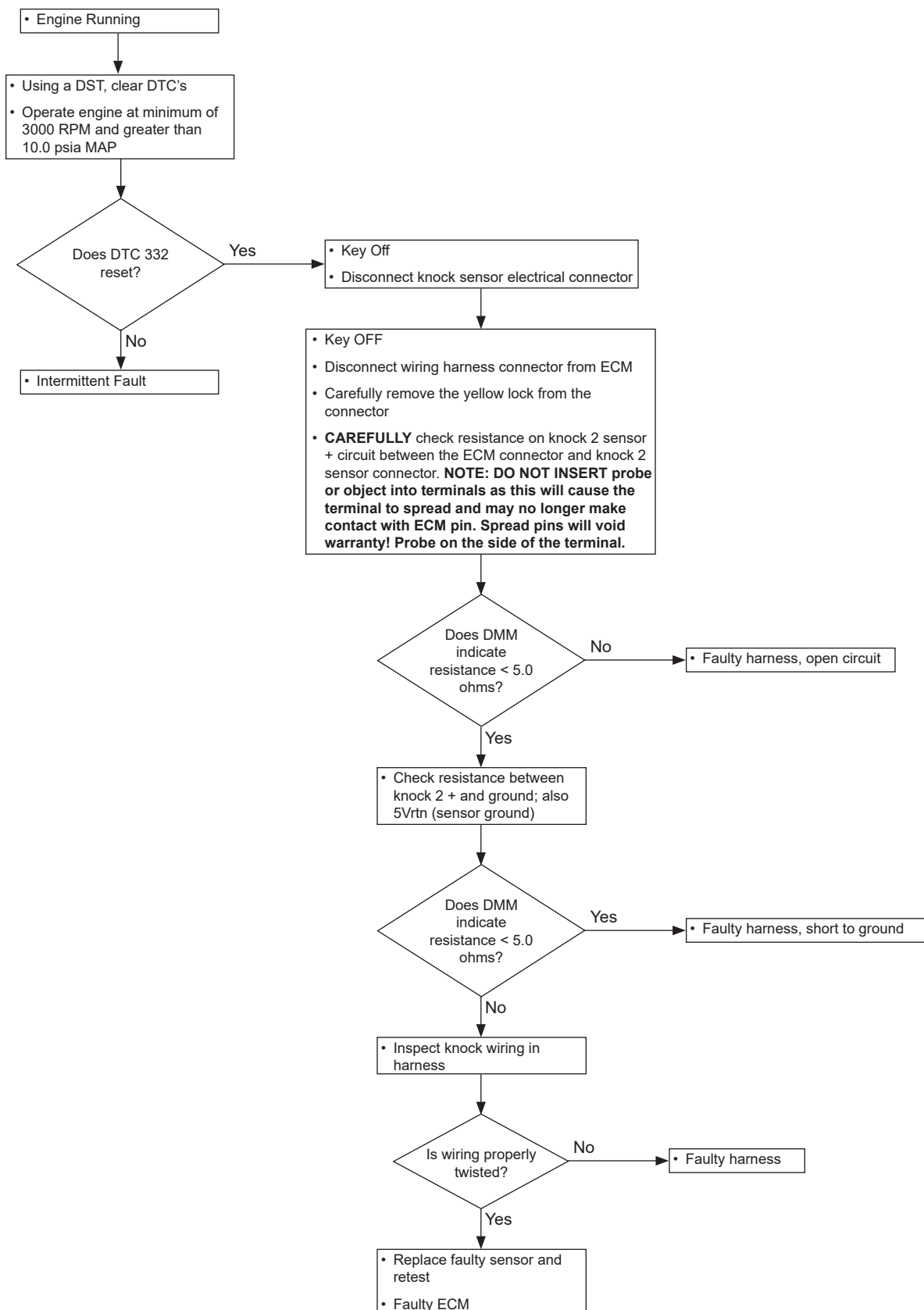


- Knock sensor #2
- *Check Condition* - Key On, Engine On
- *Fault Condition* - Knock sensor 2 signal low while engine speed is greater than 3000 RPM and MAP is greater than 10.00 psia as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, possibly power derate the engine, and retard spark to Faulted KNK Retard level to protect engine from possible damage due to inability to sense detonation
- Emissions related fault

The knock sensor is used to detect detonation through mechanical vibration in the engine block and/or cylinder heads and provide feedback for the ignition system to retard spark to reduce knock intensity. In most applications the knock sensor is used to protect the engine from damage that can be caused from detonation or knock based on fixed spark advance. In other applications, the knock sensor is used to optimize spark advance and “learn” between spark tables based on fuel quality.

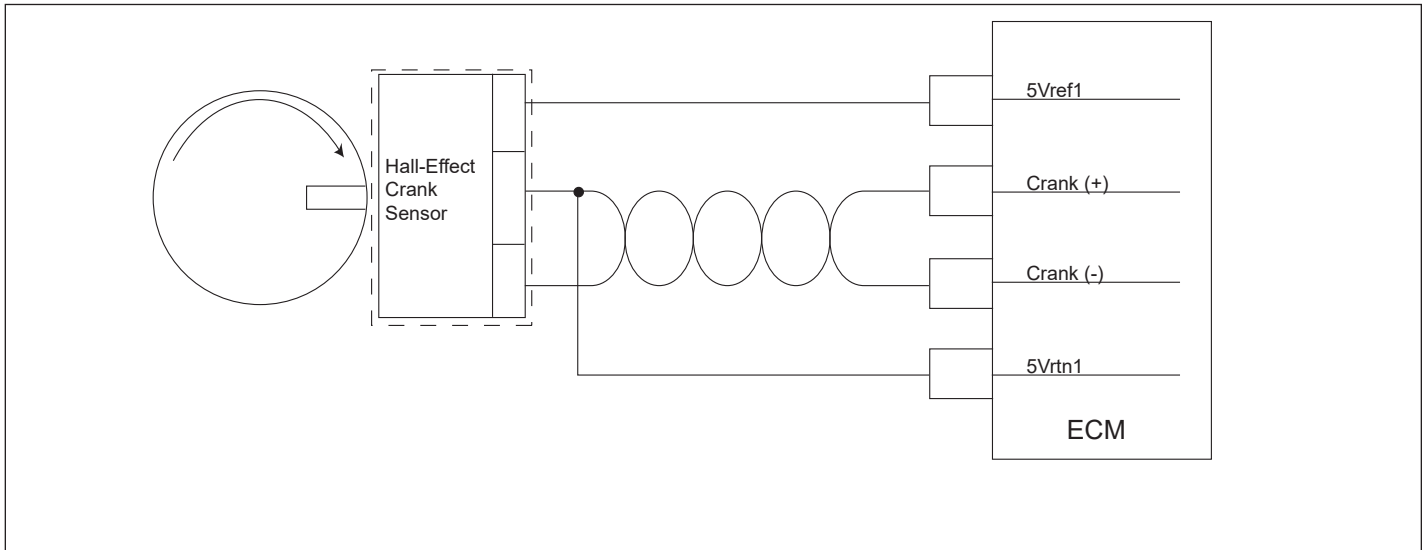
This fault sets if the signal from knock sensor 2 is lower than expected for higher speed and load operation as defined in calibration. If this fault sets, spark is lowered by the amount defined in calibration for Faulted KNK Retard.

DTC 0332 - Knock 2 Sensor Circuit Open SPN - 520197; FMI - 4



Diagnostics

DTC 0336 - Crank Sensor Input Signal Noise SPN - 636; FMI - 2

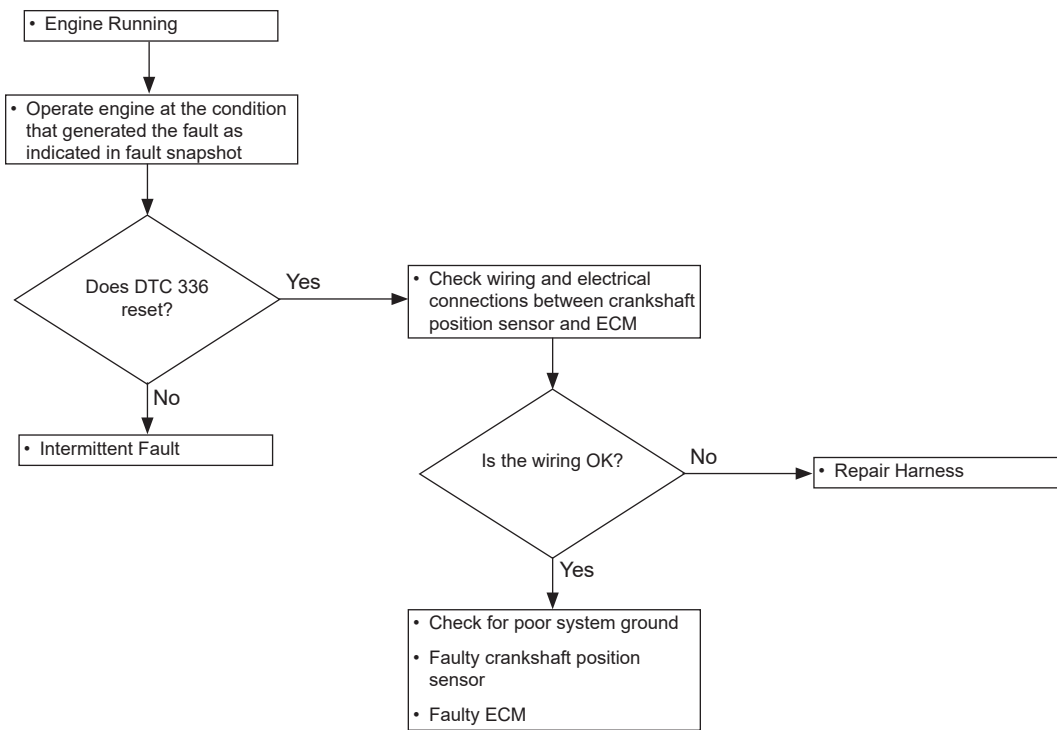


- Crankshaft Position sensor
- *Check Condition* - Key On, Engine On
- *Fault Condition* - Electrical noise or irregular crank pattern detected causing 1 number of crank re-synchronization events as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp and disable adaptive fueling correction for remainder of key-cycle.
- Emissions related fault

The crankshaft position sensor is a magnetic sensor installed in the engine block adjacent to a “coded” trigger wheel located on the crankshaft. The sensor-trigger wheel combination is used to determine crankshaft position (with respect to TDC cylinder #1 compression) and the rotational engine speed. Determination of the crankshaft position and speed is necessary to properly activate the ignition, fuel injection, and throttle governing systems for precise engine control.

The ECM must see a valid crankshaft position signal while running. If no signal is present, the signal amplitude is too high (due to improper air gap with respect to trigger wheel), or an irregular crank pattern is detected causing the ECM to resynchronize x times for y ms or longer as defined in the diagnostic calibration, this fault will set. Irregular crank patterns can be detected by the ECM due to electrical noise, poor machining of trigger wheel, or trigger wheel runout and/or gear lash.

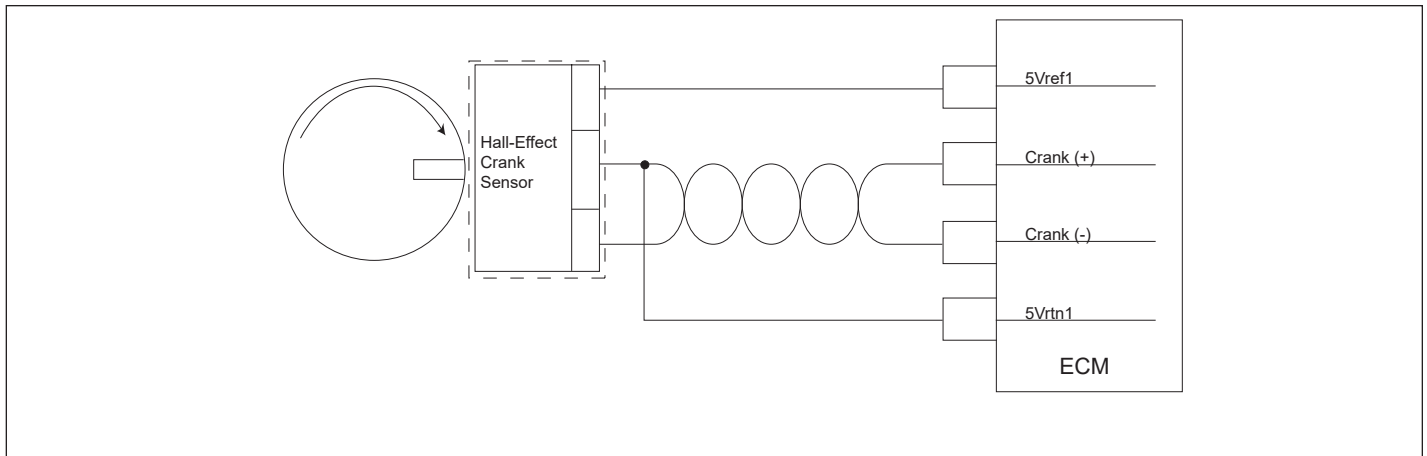
DTC 0336 - Crank Sensor Input Signal Noise SPN - 636; FMI - 2



Diagnostics

DTC 0337 - Loss of Crankshaft Input Signal

SPN - 636; FMI - 4



- Crankshaft Position sensor
- *Check Condition* - Key On, Engine On, Engine Cranking
- *Fault Condition* - Loss of crankshaft position signal while valid camshaft position signals continue for 3 number of cam pulses as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Emissions related fault

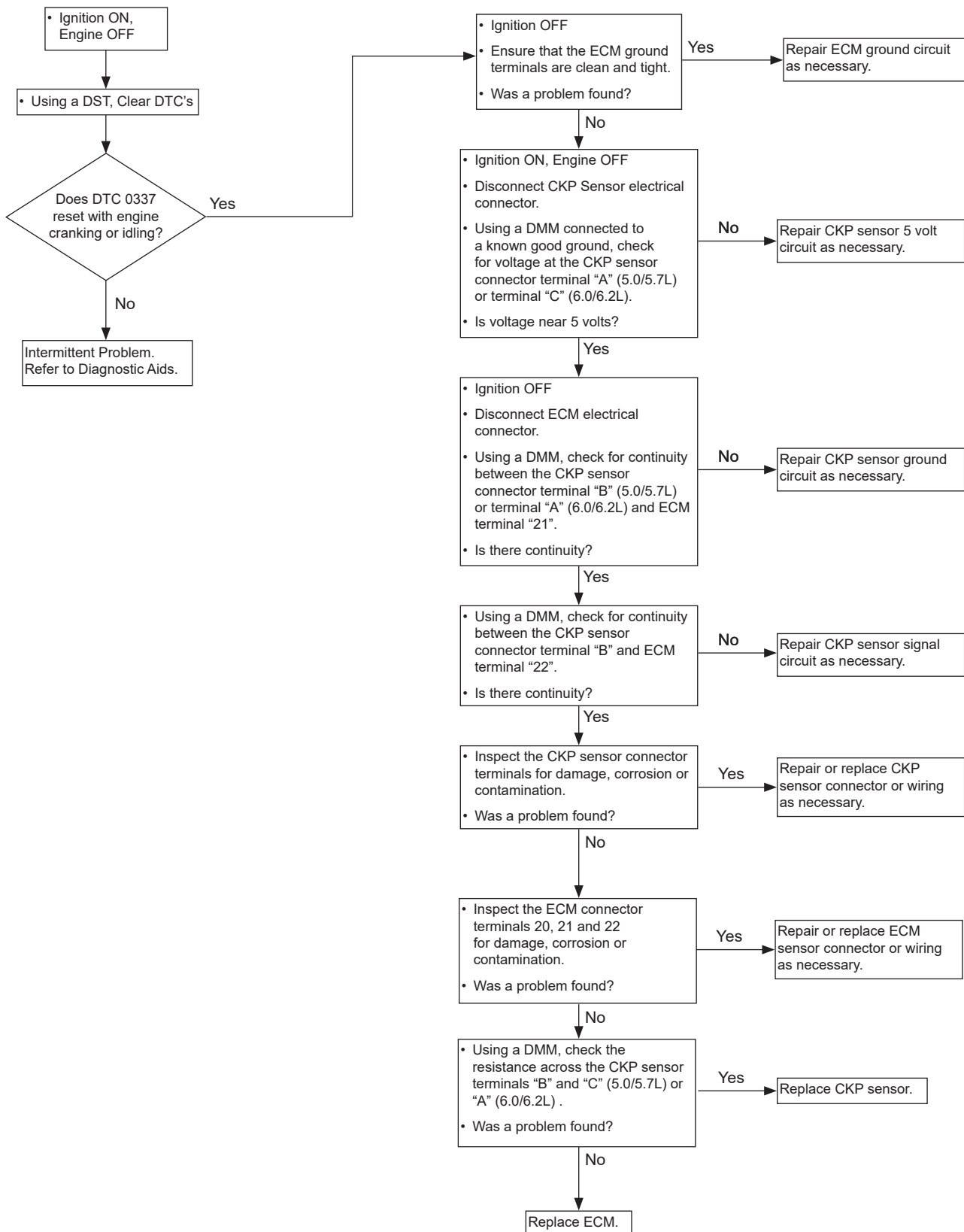
The crankshaft position sensor is a magnetic sensor installed in the engine block adjacent to a “coded” trigger wheel located on the crankshaft. The sensor-trigger wheel combination is used to determine crankshaft position (with respect to TDC cylinder #1 compression) and the rotational engine speed. Determination of the crankshaft position and speed is necessary to properly activate the ignition, fuel injection, and throttle governing systems for precise engine control.

The ECM must see a valid crankshaft position signal while running. If no signal is present while 3 cam pulses continue the fault will set. The engine typically stalls or dies as a result of this fault condition due to the lack of crankshaft speed input resulting in the inability to control ignition timing.

Diagnostic Aids

- Check for poor connection in harness. Inspect the harness connectors for backed out terminals, improper mating, broken locks, improperly formed or damaged terminals and poor terminal to wire connection.
- Crankshaft reluctor wheel damaged or improper installation.
- Excessive air gap between the CKP sensor and the reluctor.
- Excessive crankshaft end play.

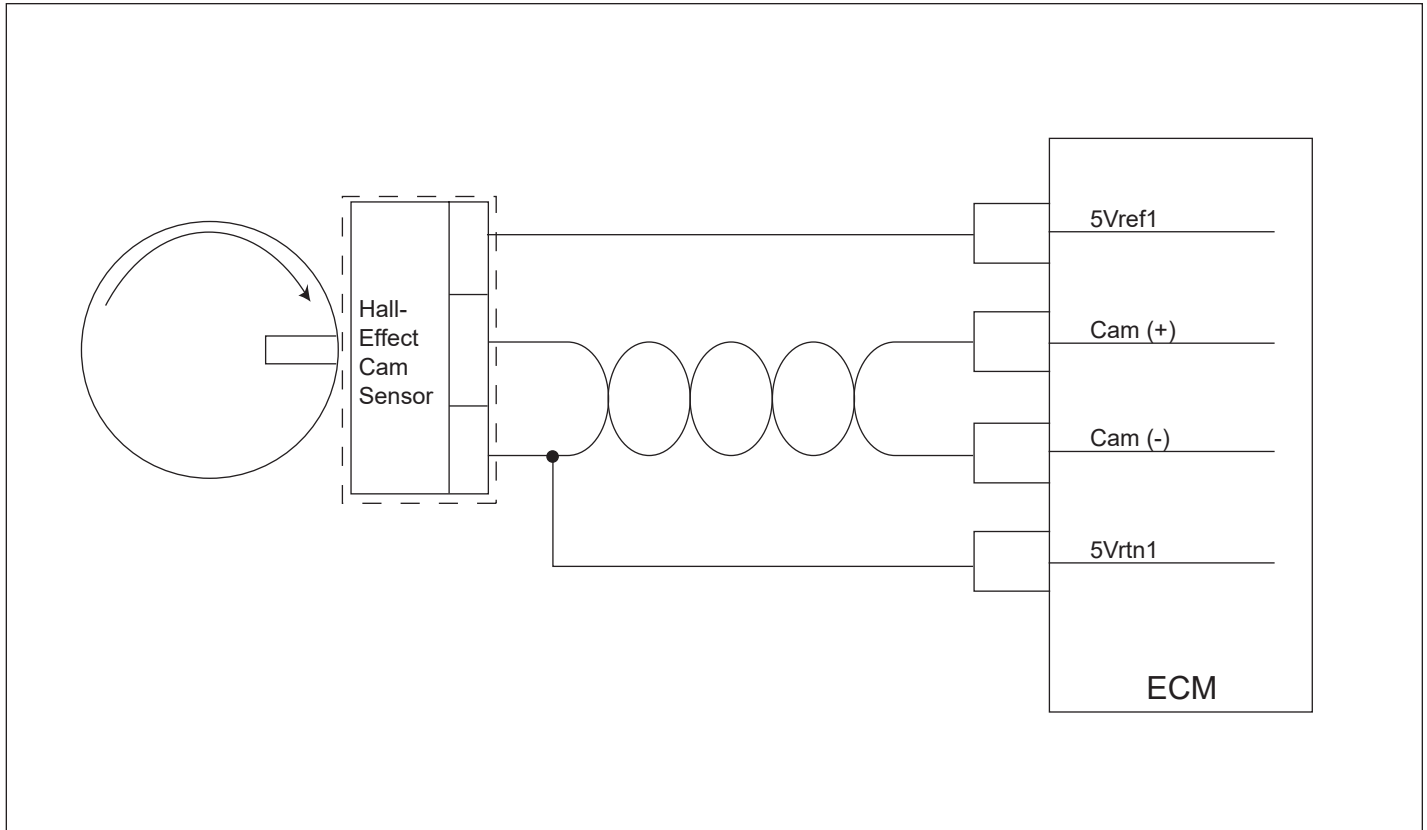
DTC 0337 - Loss of Crankshaft Input Signal SPN - 636; FMI - 4



Diagnostics

DTC 0341 - Camshaft Sensor Input Signal Noise

SPN - 723; FMI - 2

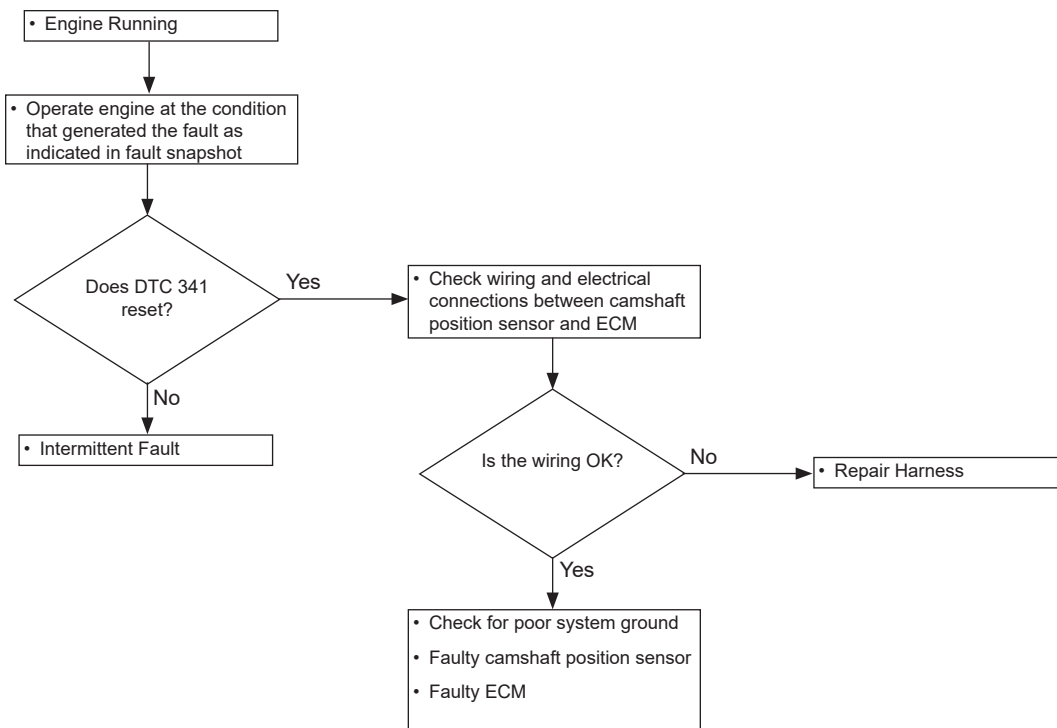


- Camshaft Position sensor
- *Check Condition* - Key On, Engine On
- *Fault Condition* - Electrical noise or irregular cam pattern detected causing 1 number of cam re-synchronization events as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp and disable adaptive fueling correction for remainder of key-cycle.
- Emissions related fault

The camshaft position sensor is a magnetic sensor installed in the engine block or valve train adjacent to a “coded” trigger wheel located on or off of the camshaft. The sensor-trigger wheel combination is used to determine cam position (with respect to TDC cylinder #1 compression). Determination of the camshaft position is necessary to identify the stroke (or cycle) of the engine to properly activate the fuel injection system and ignition (for coil-on-plug engines) for precise engine control.

For a cam synchronized engine, the ECM must see a valid camshaft position signal while running. If no signal is present, the signal amplitude is too high (due to improper air gap with respect to trigger wheel), or an irregular cam pattern is detected causing the ECM to resynchronize x times for y ms or longer as defined in the diagnostic calibration, this fault will set. Irregular cam patterns can be detected by the ECM due to electrical noise, poor machining of trigger wheel, or trigger wheel runout and/or gear lash. Normally the engine will continue to run if equipped with a waste-spark or distributor ignition system. In some instances this fault can cause rough engine operation and can cause the engine to stall or die if equipped with coil-on-plug ignition engines.

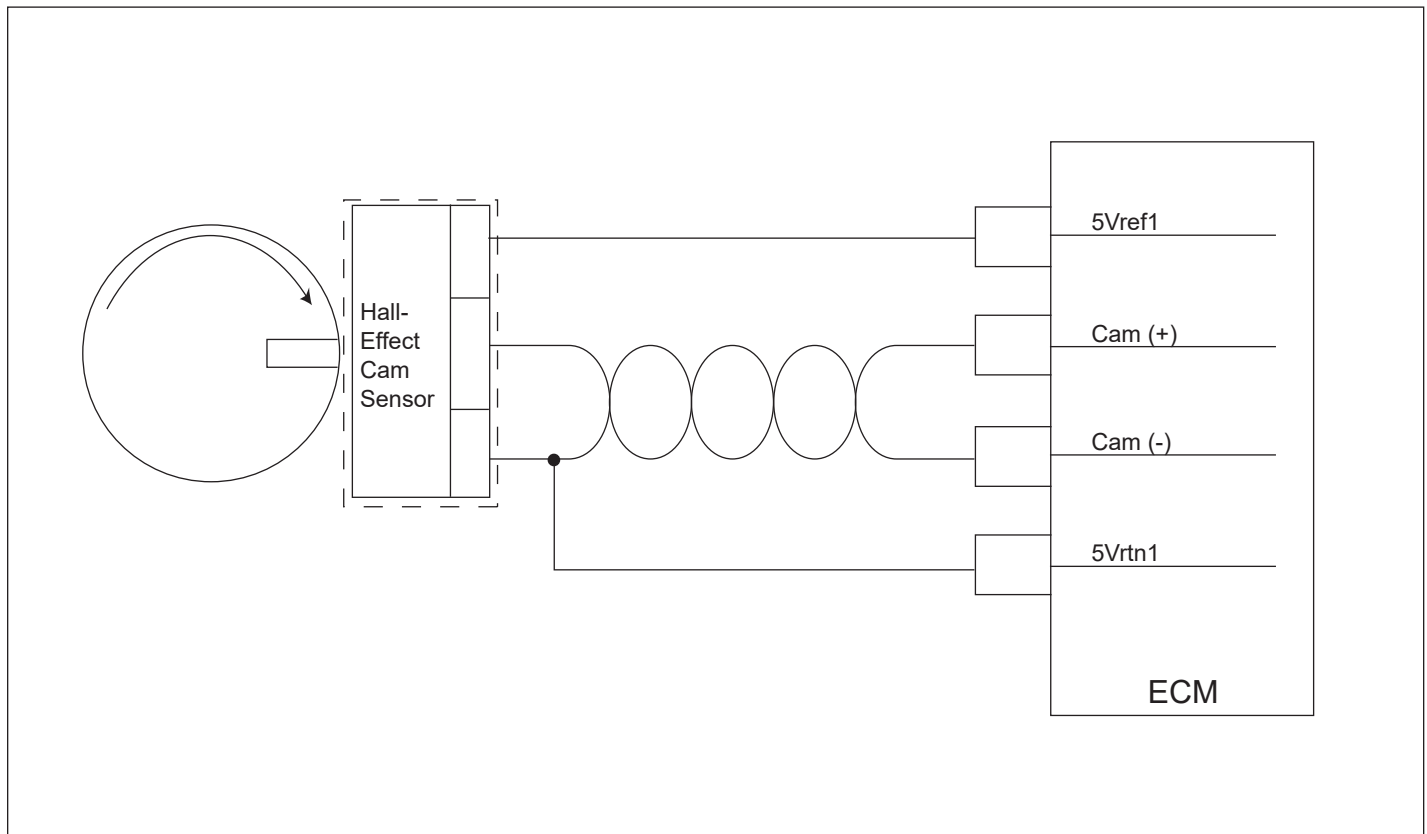
DTC 0341 - Camshaft Sensor Input Signal Noise SPN - 723; FMI - 2



Diagnostics

DTC 0342 - Loss of Camshaft Input Signal

SPN - 723; FMI - 4



- Camshaft Position sensor
- *Check Condition* - Key On, Engine On
- *Fault Condition* - Loss of camshaft position signal while valid crankshaft position signals continue for 2.0 number of engine cycles while operating at an engine speed > than 100 RPM as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for the remainder of the key-cycle
- Emissions related fault

The camshaft position sensor is a magnetic sensor (variable reluctance/magnetic pick-up or hall-effect) installed in the engine block or valve train adjacent to a “coded” trigger wheel located on or off of the camshaft. The sensor-trigger wheel combination is used to determine cam position (with respect to TDC cylinder #1 compression). Determination of the camshaft position is necessary to identify the stroke (or cycle) of the engine to properly activate the fuel injection system and ignition (for coil-on-plug engines) for precise engine control.

For a cam synchronized engine, the ECM must see a valid camshaft position signal while running. This fault will set if valid crankshaft position data is received for 2.0 number of engine cycles while engine speed is greater than 100 RPM and no camshaft signal is received. Normally the engine will continue to run if equipped with a waste-spark or distributor ignition system. In some instances this fault can cause rough engine operation and can cause the engine to stall or die if equipped with coil-on-plug ignition engines.

DTC 0342 - Loss of Camshaft Input Signal SPN - 723; FMI - 4

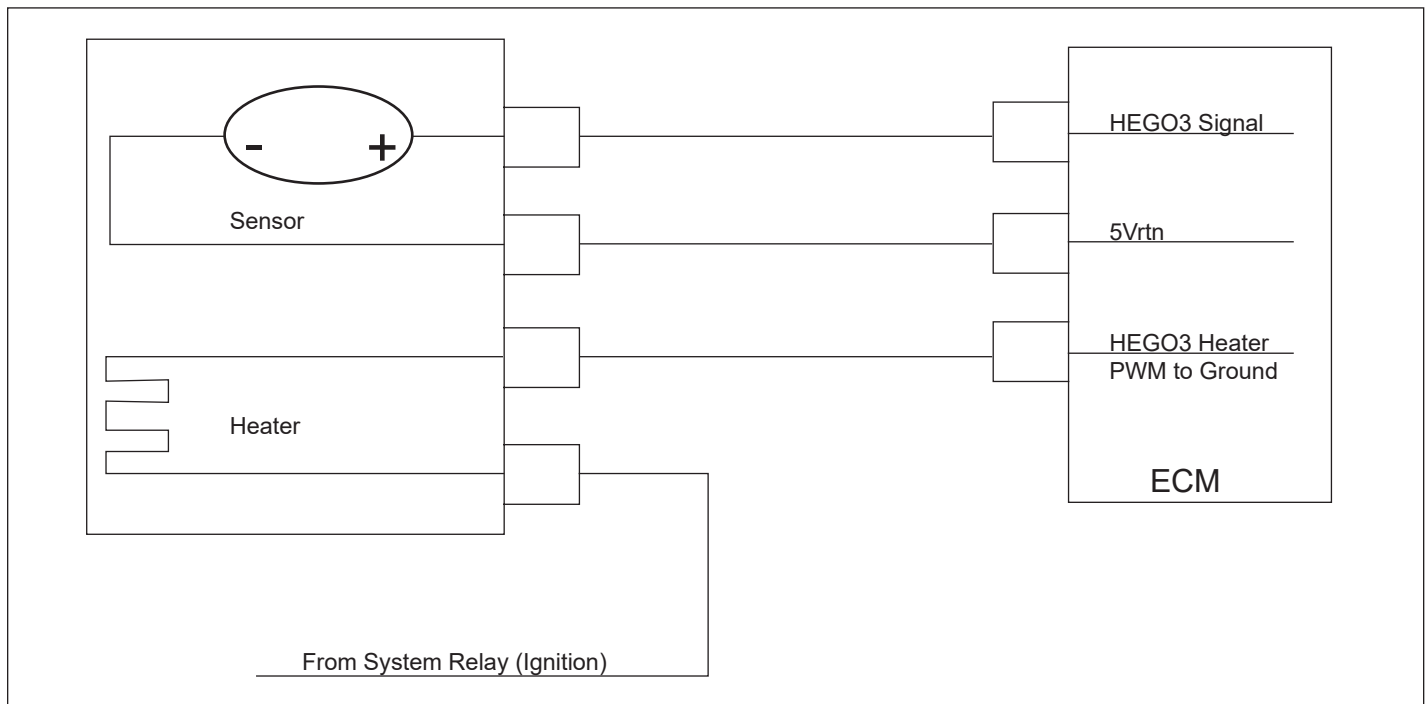
Diagnostic Aids

- Check that camshaft position sensor is securely connected to harness
- Check that camshaft position sensor is securely installed into engine block
- Check camshaft position sensor circuit wiring for open circuit

Diagnostics

DTC 0420 - Catalyst Inactive on Bank 1

SPN - 3050; FMI - 11



- Bank 1 Catalyst, Heated Exhaust Gas Oxygen Sensor (Bank 1-Sensor 3-After Catalyst)
- Check Condition- Engine Running
- Fault Condition- Bank 1 catalyst inactive on gasoline
- Corrective Action(s)- Illuminate MIL and/or sound audible warning.
- Emissions related fault

A catalyst or catalytic converter is a component in the exhaust subsystem used to accelerate/generate chemical reactions within the engine exhaust to convert undesirable gases/pollutants into less harmful gases. In many spark-ignited applications, a three-way catalyst is used to convert hydrocarbons, oxides of nitrogen, and carbon monoxide into nitrogen, water, and carbon dioxide. In addition, many low-emission applications require the use of OBDM, which typically require a catalyst monitor to identify whether or not the catalyst is functioning properly. The catalyst monitor diagnostic is configured such that exhaust emissions are near compliance-failing levels based on the engines specific regulatory requirement(s). Catalyst monitor techniques typically utilize a HEGO sensor to monitor the amount of oxygen present downstream of the catalyst. This is generally a good indicator of how efficiently the catalyst is using the oxygen entering the catalyst.

The ECM uses a HEGO sensor for catalyst monitor. The HEGO is a switching-type sensor around stoichiometry that measures the oxygen content downstream of the catalyst for two main functions: 1) to compare it to the oxygen content upstream of the catalyst to determine how efficiently the catalyst is using oxygen to determine its effectiveness and 2) trim the commanded equivalence ratio target to maximize the catalyst conversion efficiency. The post-catalyst strategy and diagnostic is only active when the system is in either "CL Active" or "CL + Adapt" control modes.

DTC 0420 - Catalyst Inactive on Bank 1 SPN - 3050; FMI - 11

Diagnostic Aids

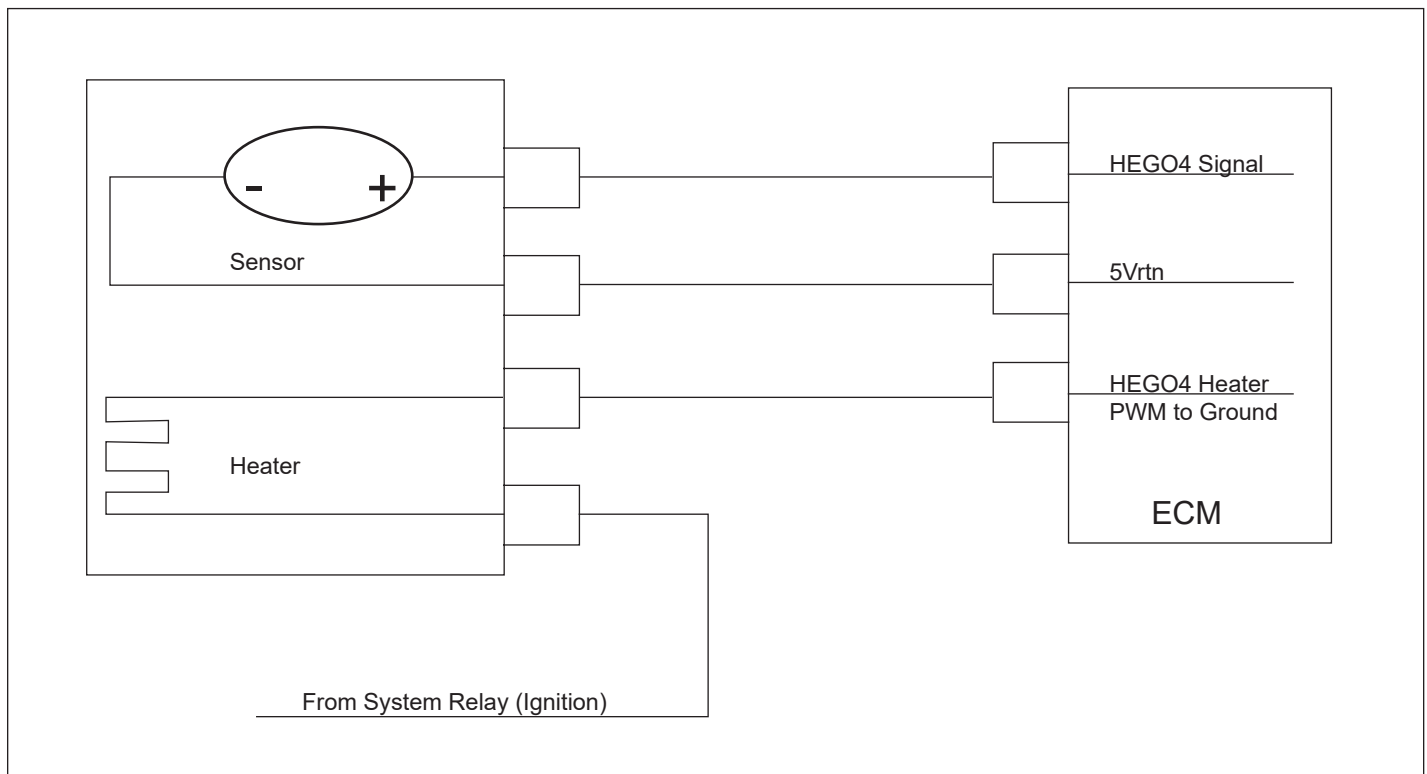
NOTE: If any other DTC's are present, diagnose those first.

- Exhaust Leak - Pressurize the exhaust system with 1-2 psi of air and check for pressure leaks upstream and around the catalyst and post-catalyst HEGO sensor. Replace gaskets and tighten fasteners if leaks are present.
- Perform Lake Test, allowing engine to warm-up to operating temperature and maintain average cruise speed to ensure DTC does not return.

Diagnostics

DTC 0430 - Catalyst Inactive on Bank 2

SPN - 3051; FMI - 11



- Bank 2 Catalyst, Heated Exhaust Gas Oxygen Sensor (Bank 2-Sensor 4-After Catalyst)
- Check Condition- Engine Running
- Fault Condition- Bank 1 catalyst inactive on gasoline
- Corrective Action(s)- Illuminate MIL and/or sound audible warning.
- Emissions related fault

A catalyst or catalytic converter is a component in the exhaust subsystem used to accelerate/generate chemical reactions within the engine exhaust to convert undesirable gases/pollutants into less harmful gases. In many spark-ignited applications, a three-way catalyst is used to convert hydrocarbons, oxides of nitrogen, and carbon monoxide into nitrogen, water, and carbon dioxide. In addition, many low-emission applications require the use of OBDM, which typically require a catalyst monitor to identify whether or not the catalyst is functioning properly. The catalyst monitor diagnostic is configured such that exhaust emissions are near compliance-failing levels based on the engines specific regulatory requirement(s). Catalyst monitor techniques typically utilize a HEGO sensor to monitor the amount of oxygen present downstream of the catalyst. This is generally a good indicator of how efficiently the catalyst is using the oxygen entering the catalyst.

The ECM uses a HEGO sensor for catalyst monitor. The HEGO is a switching-type sensor around stoichiometry that measures the oxygen content downstream of the catalyst for two main functions: 1) to compare it to the oxygen content upstream of the catalyst to determine how efficiently the catalyst is using oxygen to determine its effectiveness and 2) trim the commanded equivalence ratio target to maximize the catalyst conversion efficiency. The post-catalyst strategy and diagnostic is only active when the system is in either "CL Active" or "CL + Adapt" control modes.

DTC 0430 - Catalyst Inactive on Bank 2 SPN - 3051; FMI - 11

Diagnostic Aids

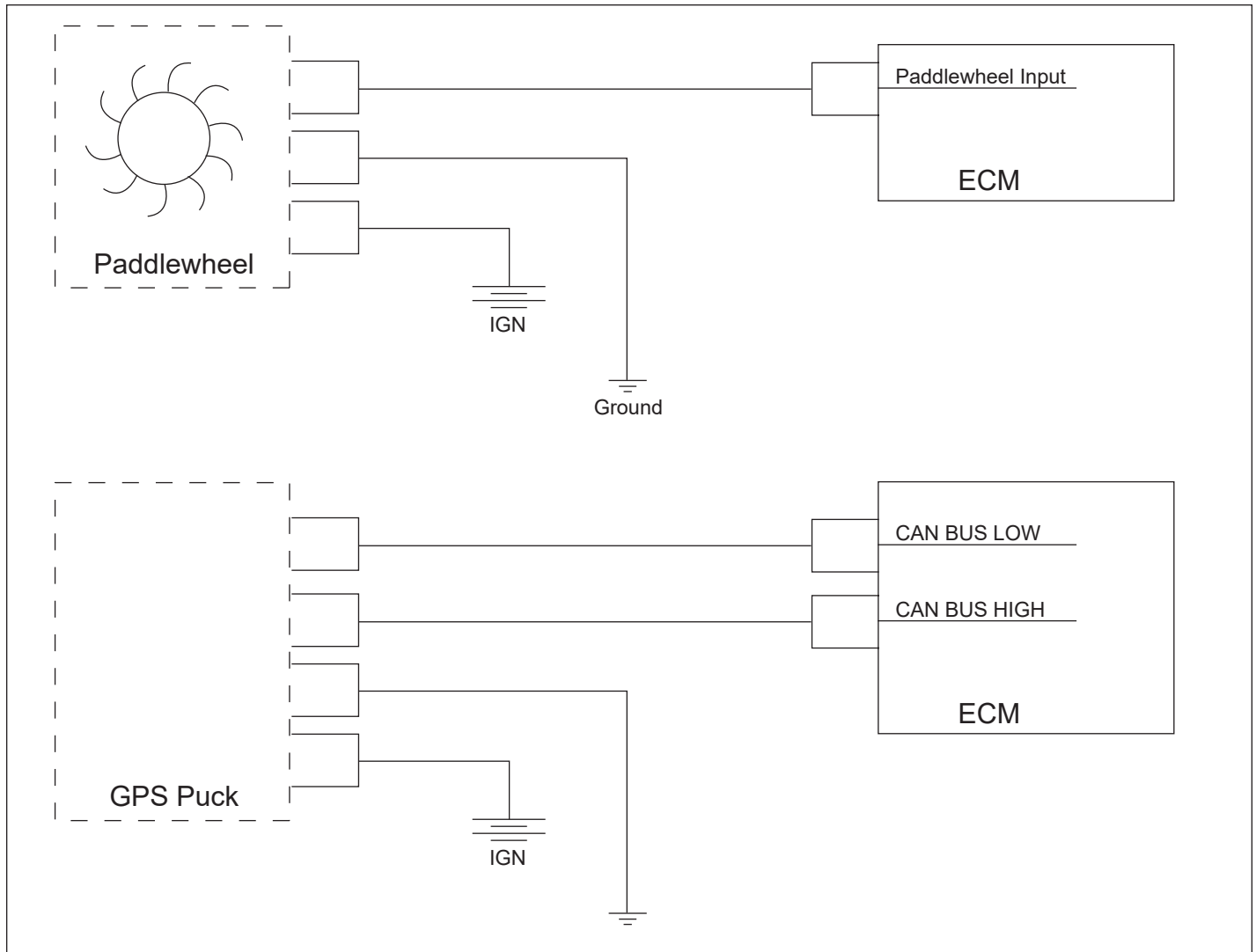
NOTE: If any other DTC's are present, diagnose those first.

- Exhaust Leak - Pressurize the exhaust system with 1-2 psi of air and check for pressure leaks upstream and around the catalyst and post-catalyst HEGO sensor. Replace gaskets and tighten fasteners if leaks are present.
- Perform Lake Test, allowing engine to warm-up to operating temperature and maintain average cruise speed to ensure DTC does not return.

Diagnostics

DTC 0502 - Boatspeed Input Loss of Signal

SPN - 84; FMI - 8



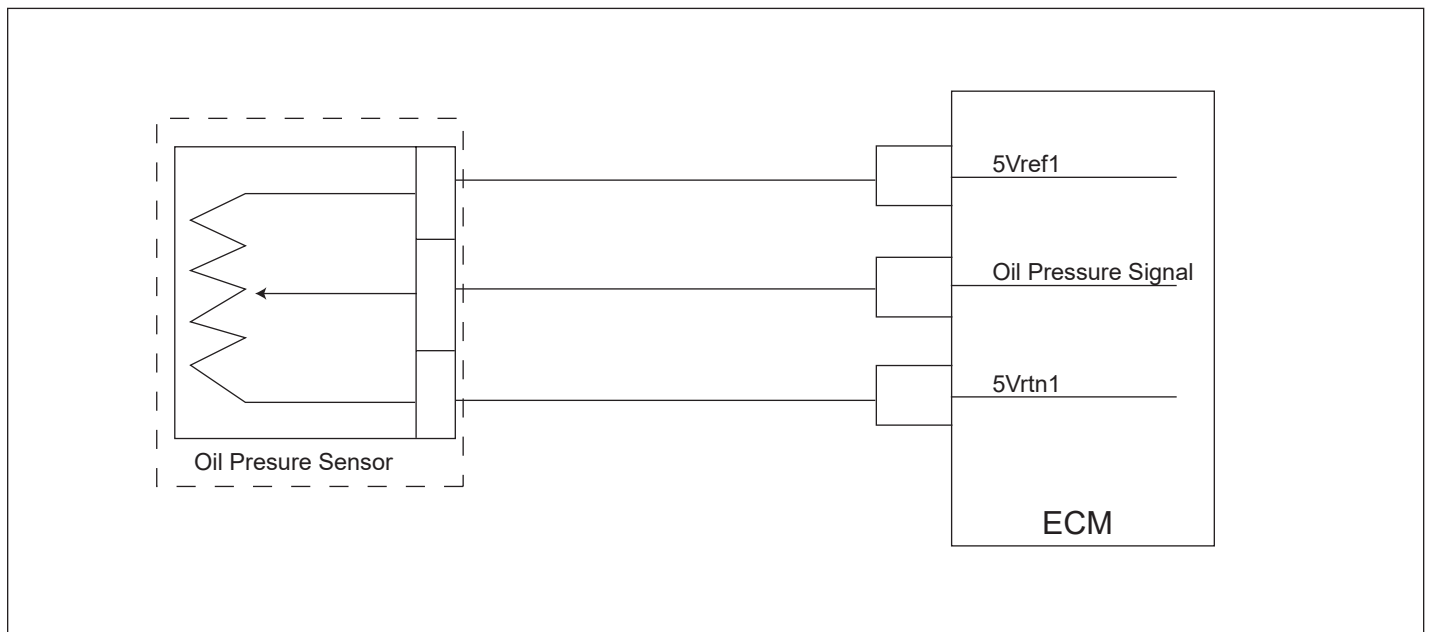
- Boat Speed (Paddlewheel OR GPS Input)
- *Check Condition* - Key on, Engine on
- *Fault Condition* - Boat speed less than 1.0 km/hr and engine speed greater than 2000 RPM with MAP greater than 10.00 psia; OR Instantaneous Dropout Detection: Engine speed greater than 1200 RPM with initial boat speed greater than 10.0 km/hr for at least 1000 ms followed by boat speed less than or equal to 2.0 km/hr for at least 200 ms after dropping boat speed faster than 200 ms
- *Corrective Action(s)* - Illuminate secondary warning lamp
- Non-emissions related fault

DTC 0502 - Boatspeed Input Loss of Signal
SPN - 84; FMI - 8

Diagnostics

DTC 0521 - Oil Pressure Sensor - High Pressure

SPN - 100; FMI - 0

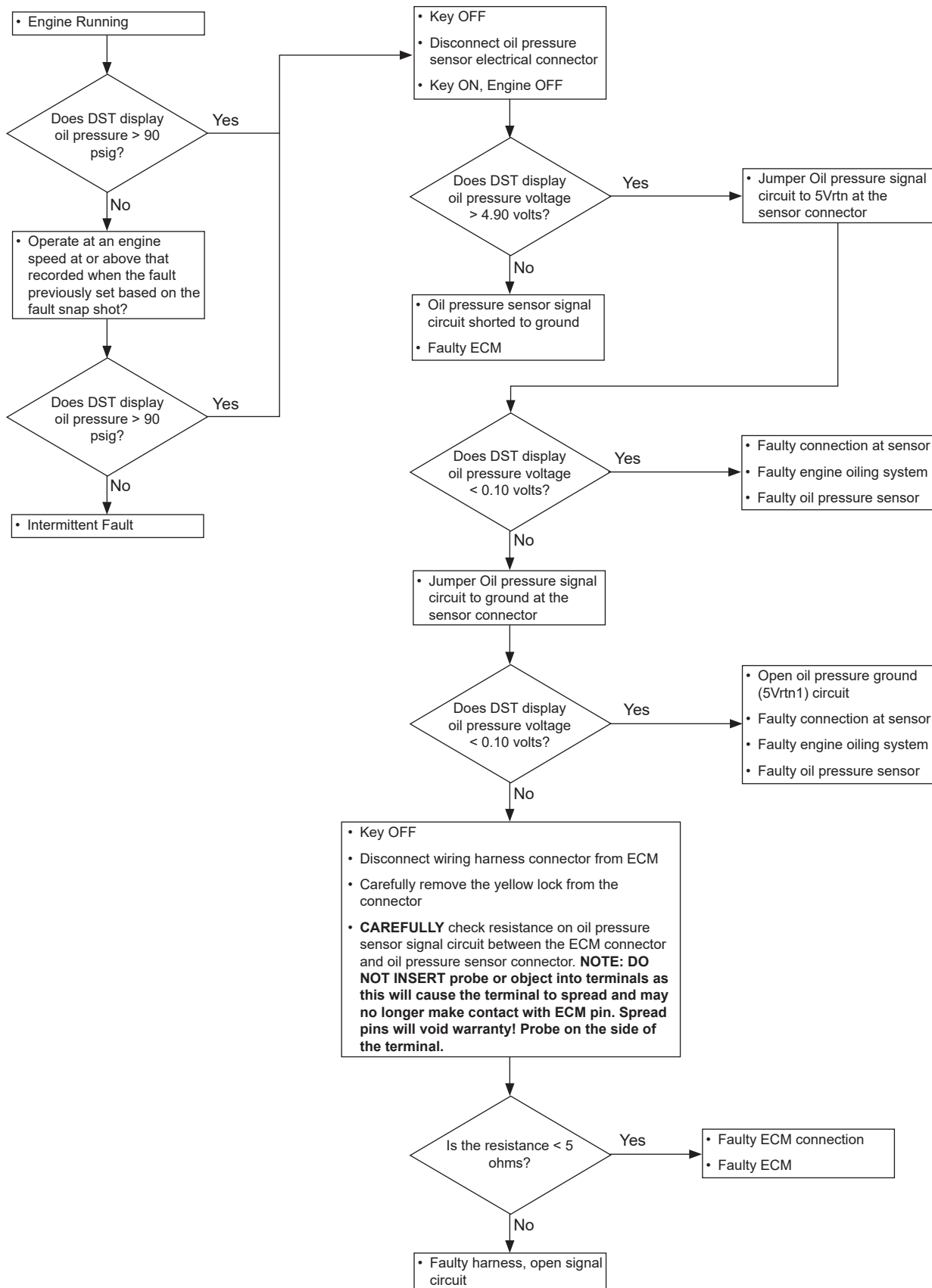


- Engine Oil Pressure
- *Check Condition* - Key on, Engine on
- *Fault Condition* - Oil pressure higher than 90.0 psia while engine speed is less than 3000 RPM.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

The ECM monitors oil pressure through a proportional transducer. Oil pressure monitoring is important to prevent engine damage due to low oil pressure resulting in higher friction and lack of lubrication. In addition, high oil pressure can be undesirable because it can cause oil to leak past seals and rings, can be a result of a restriction in the oil flow path, or can be a sign of a malfunctioning oiling system.

This fault sets if the engine oil pressure is higher than 90.0 psia and engine speed less than 3000 RPM as defined in the diagnostic calibration.

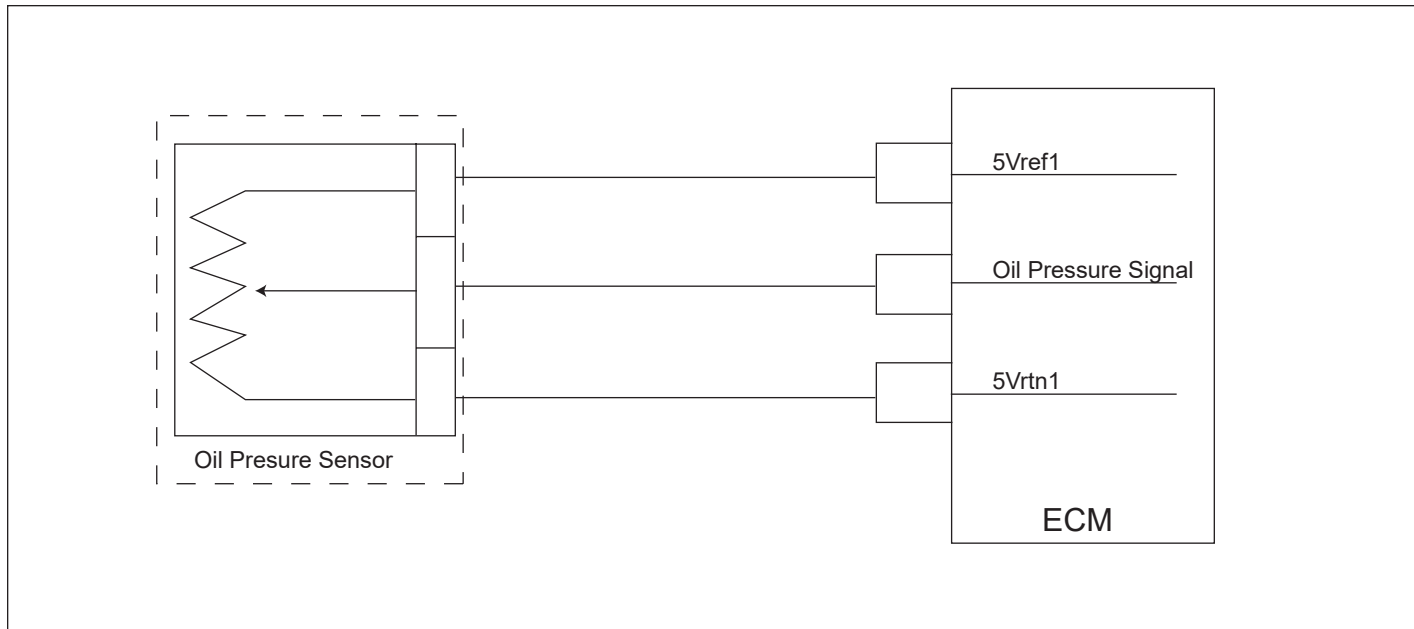
DTC 0521 - Oil Pressure Sensor - High Pressure SPN - 100; FMI - 0



Diagnostics

DTC 0522 - Oil Pressure Sensor - Low Voltage

SPN - 100; FMI - 4

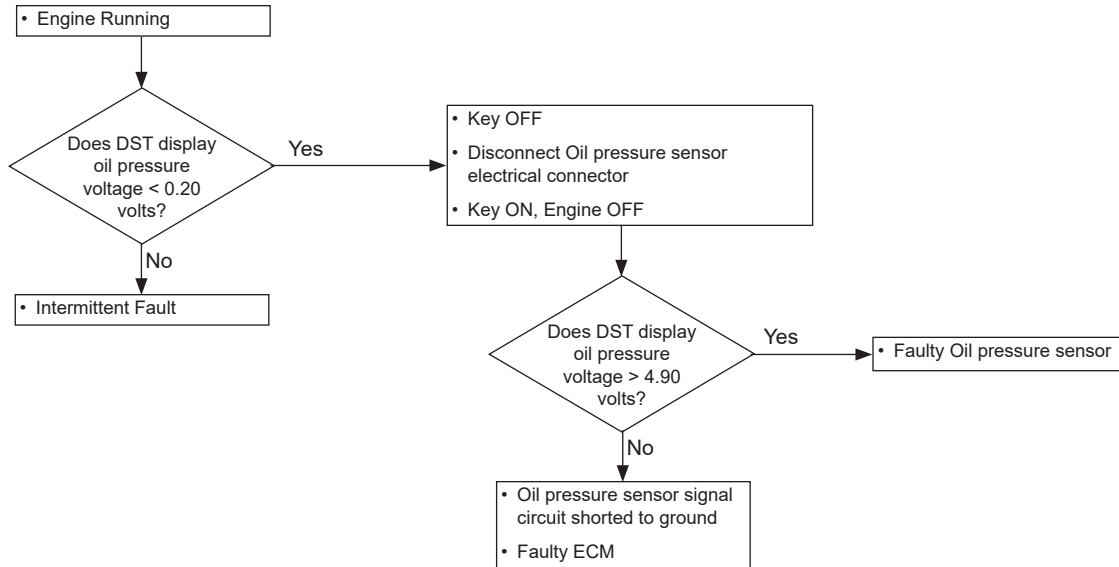


- Engine Oil Pressure
- *Check Condition* - Key on, Engine on
- *Fault Condition* - Oil pressure sensor voltage lower than 0.20 volts
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

The ECM monitors oil pressure through a proportional transducer. Oil pressure monitoring is important to prevent engine damage due to low oil pressure resulting in higher friction and lack of lubrication. In addition, high oil pressure can be undesirable because it can cause oil to leak past seals and rings, can be a result of a restriction in the oil flow path, or can be a sign of a malfunctioning oiling system.

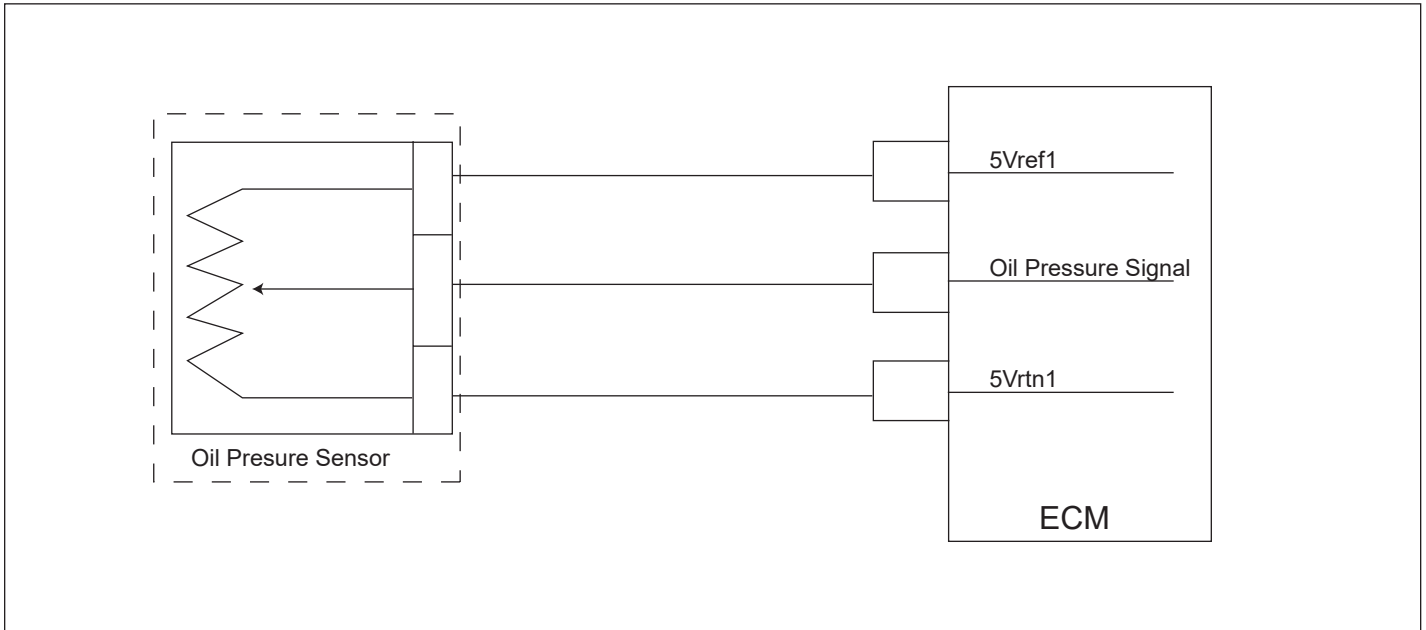
This fault sets if the engine oil pressure voltage is less than 0.20 volts as defined in the diagnostic calibration.

DTC 0522 - Oil Pressure Sensor - Low Voltage SPN - 100; FMI - 4



Diagnostics

DTC 0523 - Oil Pressure Sensor - High Voltage SPN - 100; FMI - 3

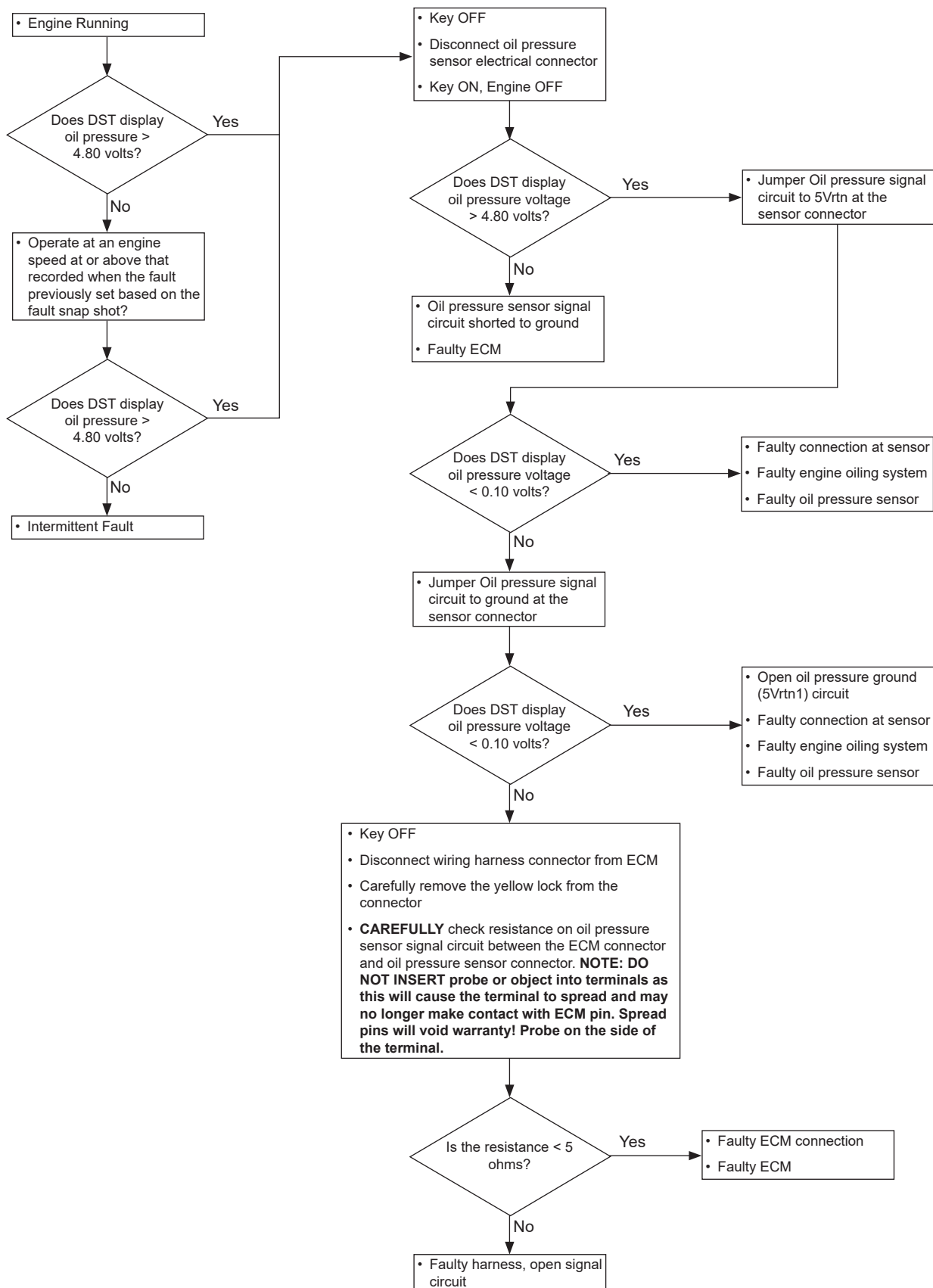


- Engine Oil Pressure
- *Check Condition* - Key on, Engine on
- *Fault Condition* - Oil pressure sensor voltage higher than 4.80 volts
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

The ECM monitors oil pressure through a proportional transducer. Oil pressure monitoring is important to prevent engine damage due to low oil pressure resulting in higher friction and lack of lubrication. In addition, high oil pressure can be undesirable because it can cause oil to leak past seals and rings, can be a result of a restriction in the oil flow path, or can be a sign of a malfunctioning oiling system.

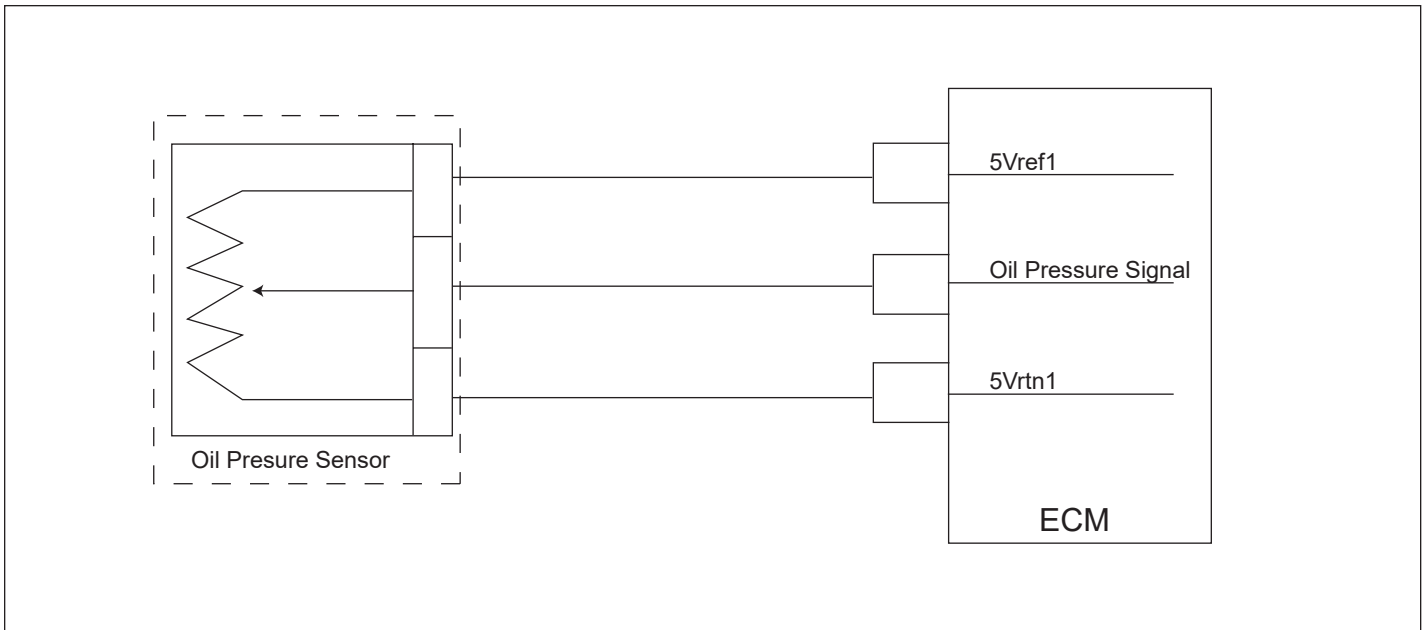
This fault sets if the engine oil pressure is higher than 4.80 volts as defined in the diagnostic calibration.

DTC 0523 - Oil Pressure Sensor - High Voltage SPN - 100; FMI - 3



Diagnostics

DTC 0524 - Oil Pressure Sensor - Low Pressure SPN - 100; FMI - 1

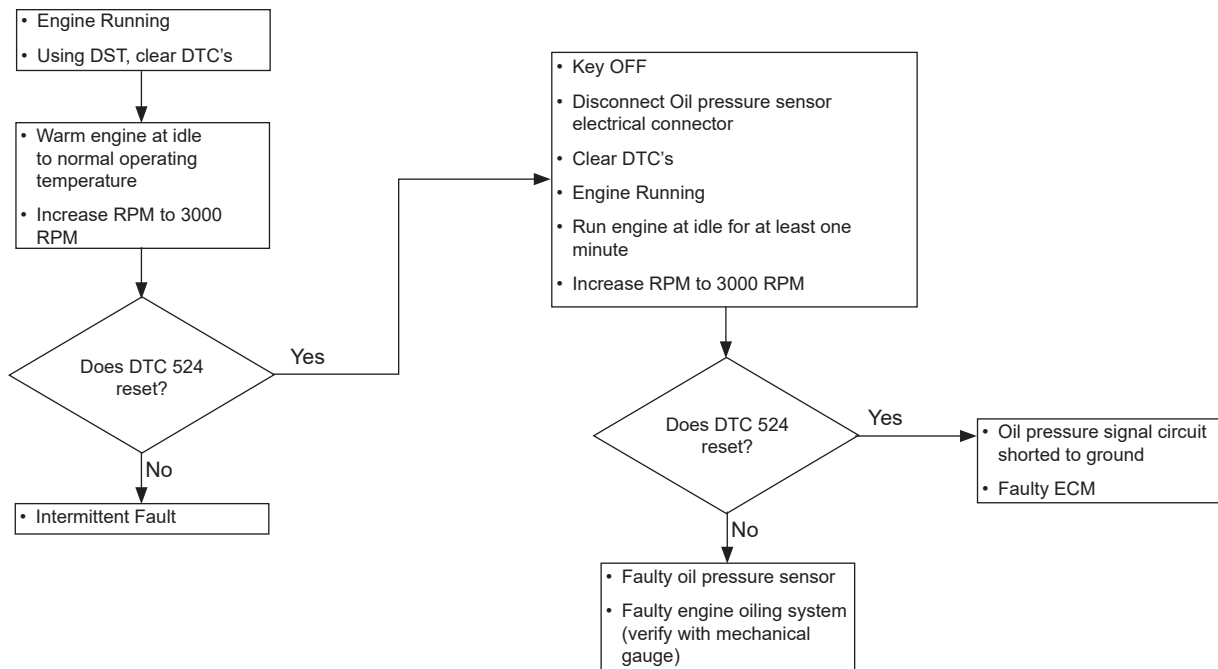


- Engine Oil Pressure
- *Check Condition* - Key on, Engine on
- *Fault Condition* - Engine oil pressure lower than expected while engine has been running for a minimum amount of time while engine speed is above some limit as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, generally configured to derate the engine and trigger an engine shutdown
- Non-emissions related fault

The ECM monitors oil pressure through a proportional transducer. Oil pressure monitoring is important to prevent engine damage due to low oil pressure resulting in higher friction and lack of lubrication. In addition, high oil pressure can be undesirable because it can cause oil to leak past seals and rings, can be a result of a restriction in the oil flow path, or can be a sign of a malfunctioning oiling system.

This fault sets if the engine has been running for at least 10.0 seconds and oil pressure is less than 5.0 psia at idle and linear up to oil pressure less than 24.0 psia at 4000 RPM as defined in the diagnostic calibration.

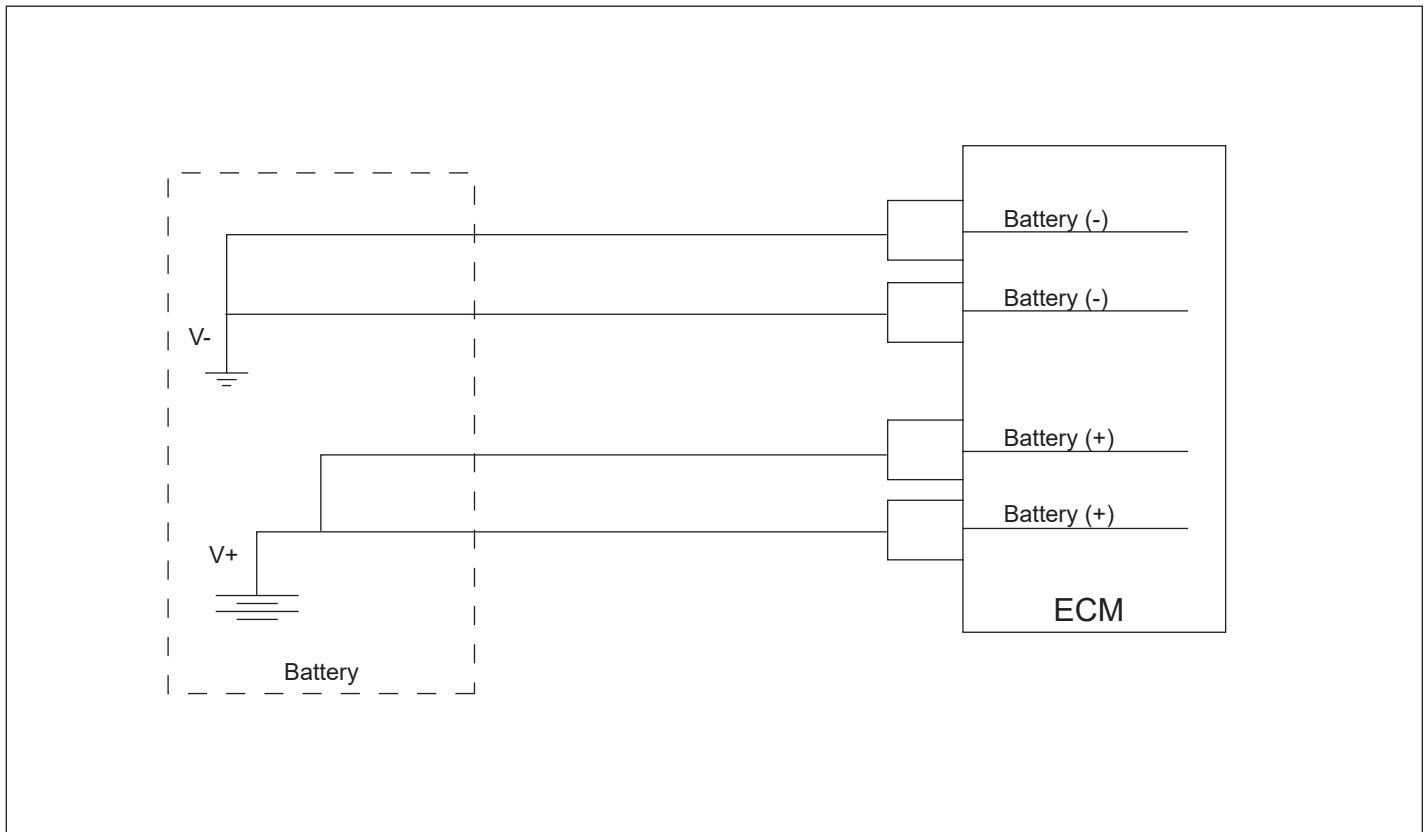
DTC 0524 - Oil Pressure Sensor - Low Pressure SPN - 100; FMI - 1



Diagnostics

DTC 0562 - Battery Voltage (Vbat) Low

SPN - 168; FMI - 17

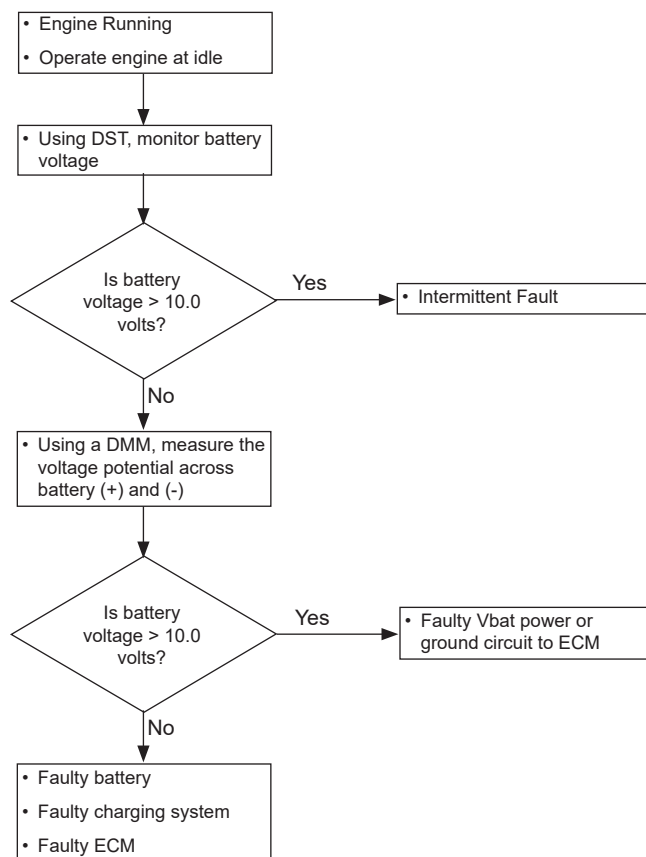


- System voltage to ECM
- *Check Condition* - Key on, Engine on
- *Fault Condition* - Battery voltage to ECM less than 10.0 volts while the engine is operating at 1500 RPM or greater as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle
- Non-emissions related fault

The battery voltage powers the ECM and must be within limits to correctly operate injector drivers, ignition coils, throttle, power supplies, and other powered devices that the ECM controls.

This fault will set if the ECM detects system voltage less than 10.0 volts while the engine is operating at 1500 RPM as defined in the diagnostic calibration as the alternator should be charging the system. The adaptive learn is disabled to avoid improper adaptive learning due to the inability to correctly time injector firings.

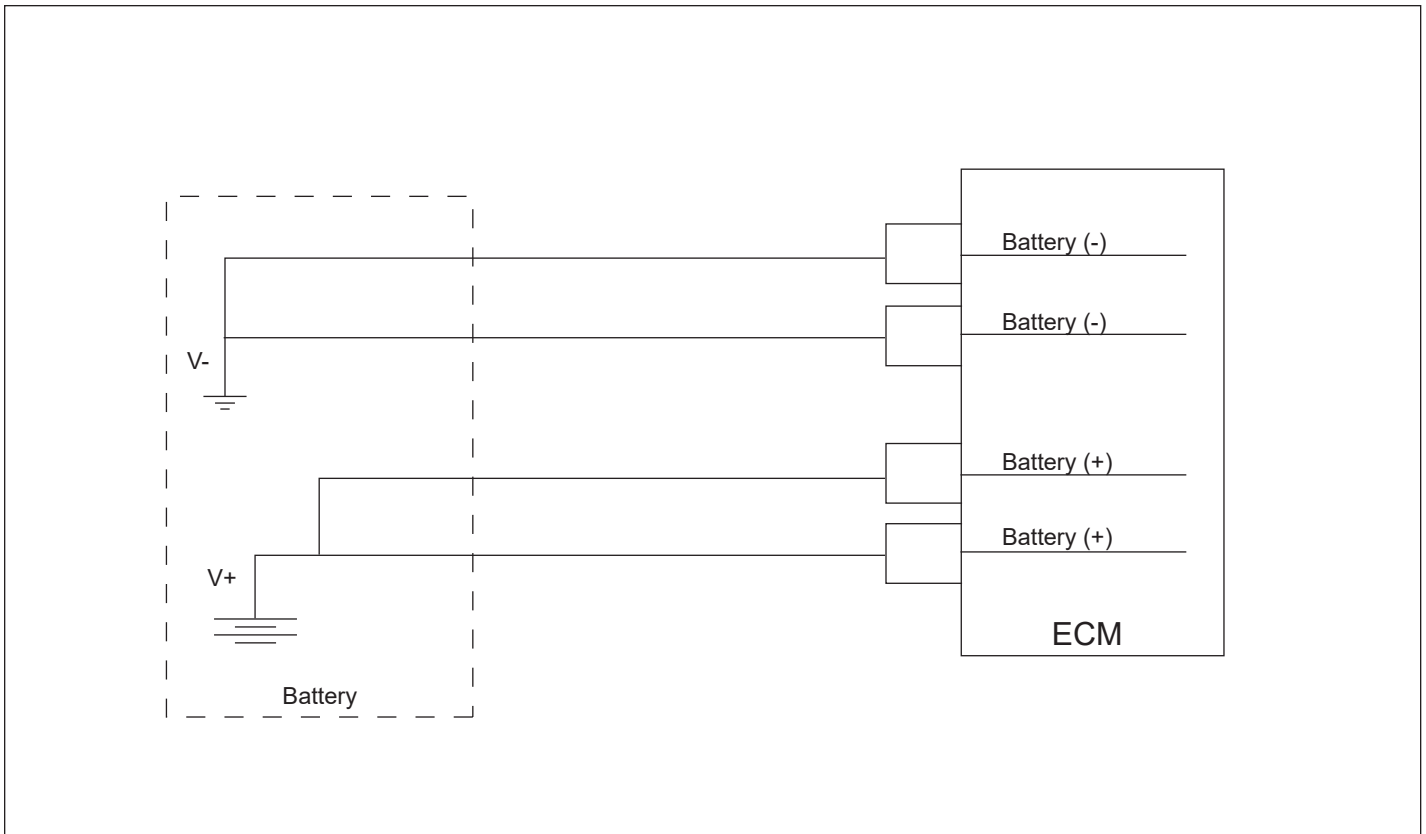
DTC 0562 - Battery Voltage (Vbat) Low SPN - 168; FMI - 17



Diagnostics

DTC 0563 - Battery Voltage (Vbat) High

SPN - 168; FMI - 15

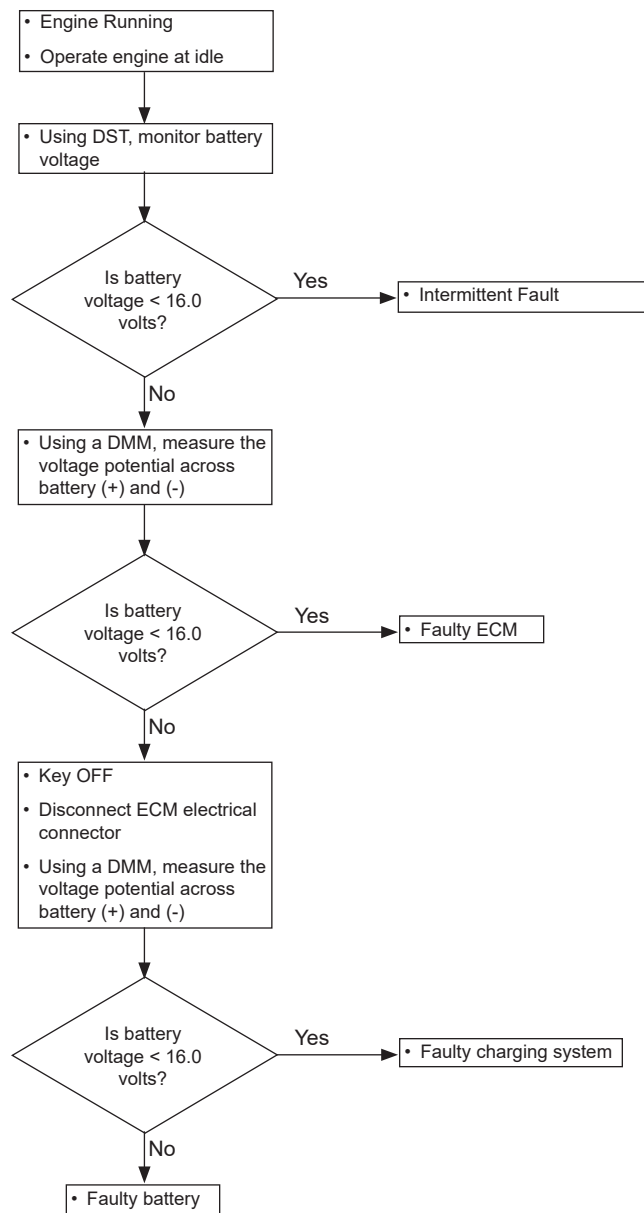


- System voltage to ECM
- *Check Condition* - Key on, Engine Cranking or Running
- *Fault Condition* - Battery voltage to ECM greater than 16.0 volts while the engine is running as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle
- Non-emissions related fault

The battery voltage powers the ECM and must be within limits to correctly operate injector drivers, ignition coils, throttle, power supplies, and other powered devices that the ECM controls.

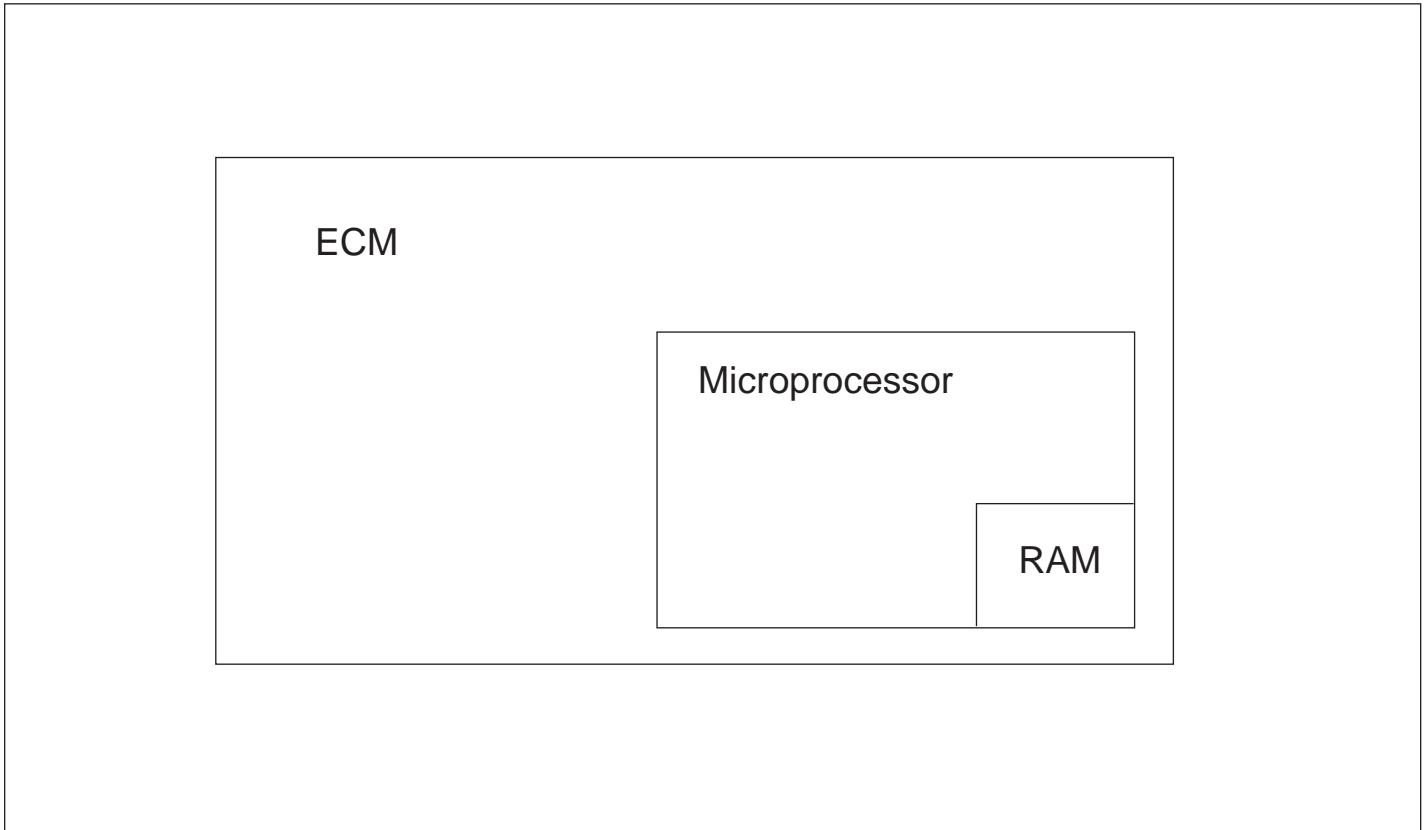
This fault will set if the ECM detects system voltage greater than 16.0 volts while the engine is running or cranking as defined in the diagnostic calibration. The adaptive learn is disabled to avoid improper adaptive learning.

DTC 0563 - Battery Voltage (Vbat) High SPN - 168; FMI - 15



Diagnostics

DTC 0601 - Microprocessor Failure - FLASH SPN - 628; FMI - 13

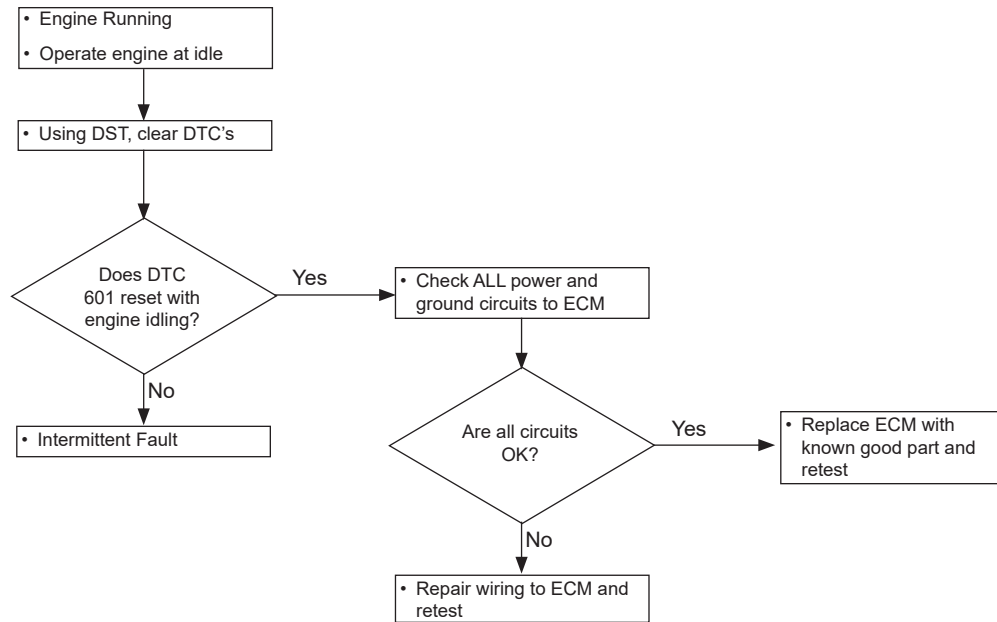


- Engine Control Module- Flash Memory
- *Check Condition* - Key on
- *Fault Condition* - Internal microprocessor error
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle, recommend power derate 2 and low rev limit to reduce possible engine damage and/or overspeed condition
- Non-emissions related fault

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault.

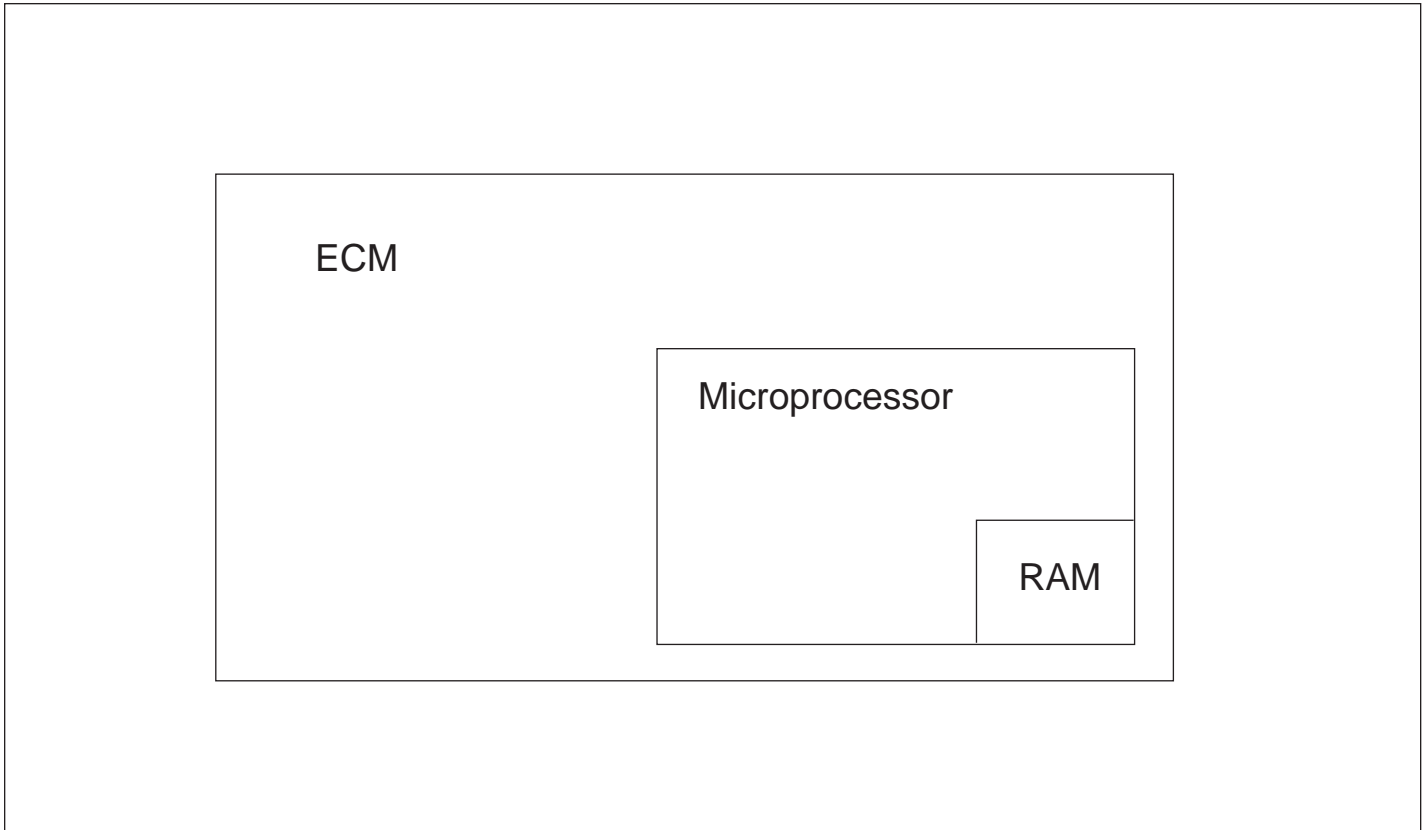
If this fault sets, the ECM will reset itself and log the code. The fault should be configured to never forget and will not self-erase and will not clear until a technician performs diagnostics and manually clears the code. This fault should be configured to set a power derate 2 and low rev limit to reduce possible engine damage and reduce possibility of an overspeed condition. A fault of flash memory can occur for any calibration variable set and thus could cause undesirable operation.

DTC 0601 - Microprocessor Failure - FLASH SPN - 628; FMI - 13



Diagnostics

DTC 0604 - Microprocessor Failure - RAM SPN - 630; FMI - 12

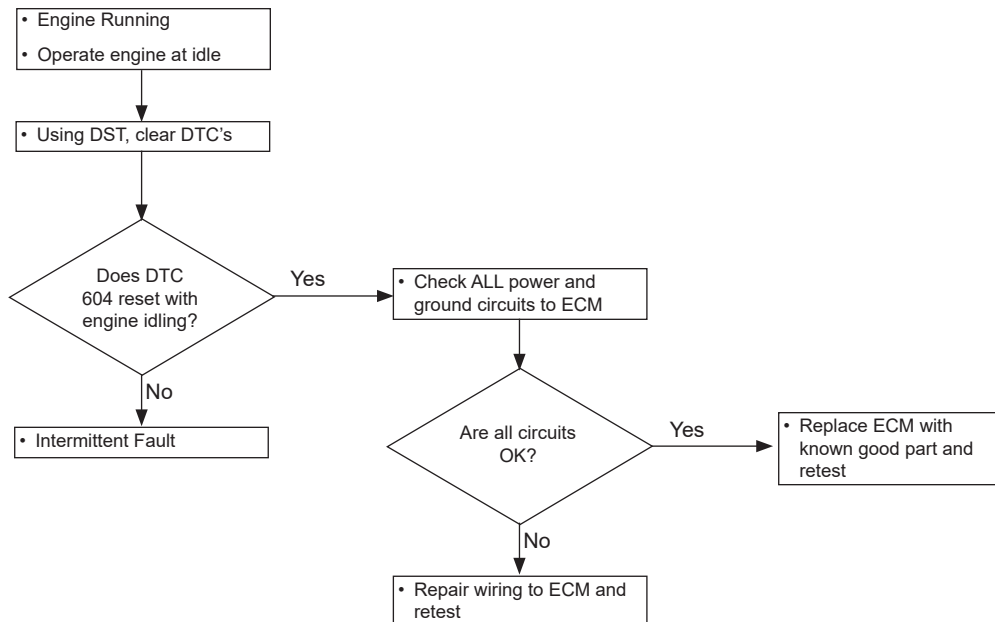


- Engine Control Module- Random Access Memory
- *Check Condition* - Key on
- *Fault Condition* - Internal ECM microprocessor memory access failure
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle, recommend power derate 2 and low rev limit to reduce possible engine damage and/or overspeed condition
- Non-emissions related fault

Random Access Memory is located within the microprocessor and can be read from or written to at any time. Data stored in RAM include DTCs (when fault configuration is set to “Battery Power Retained”), adaptive fuel learn tables, octane adaptation table, misfire adaption tables, and closed loop fuel multipliers. The ECM has checks that must be satisfied each time an instruction is executed.

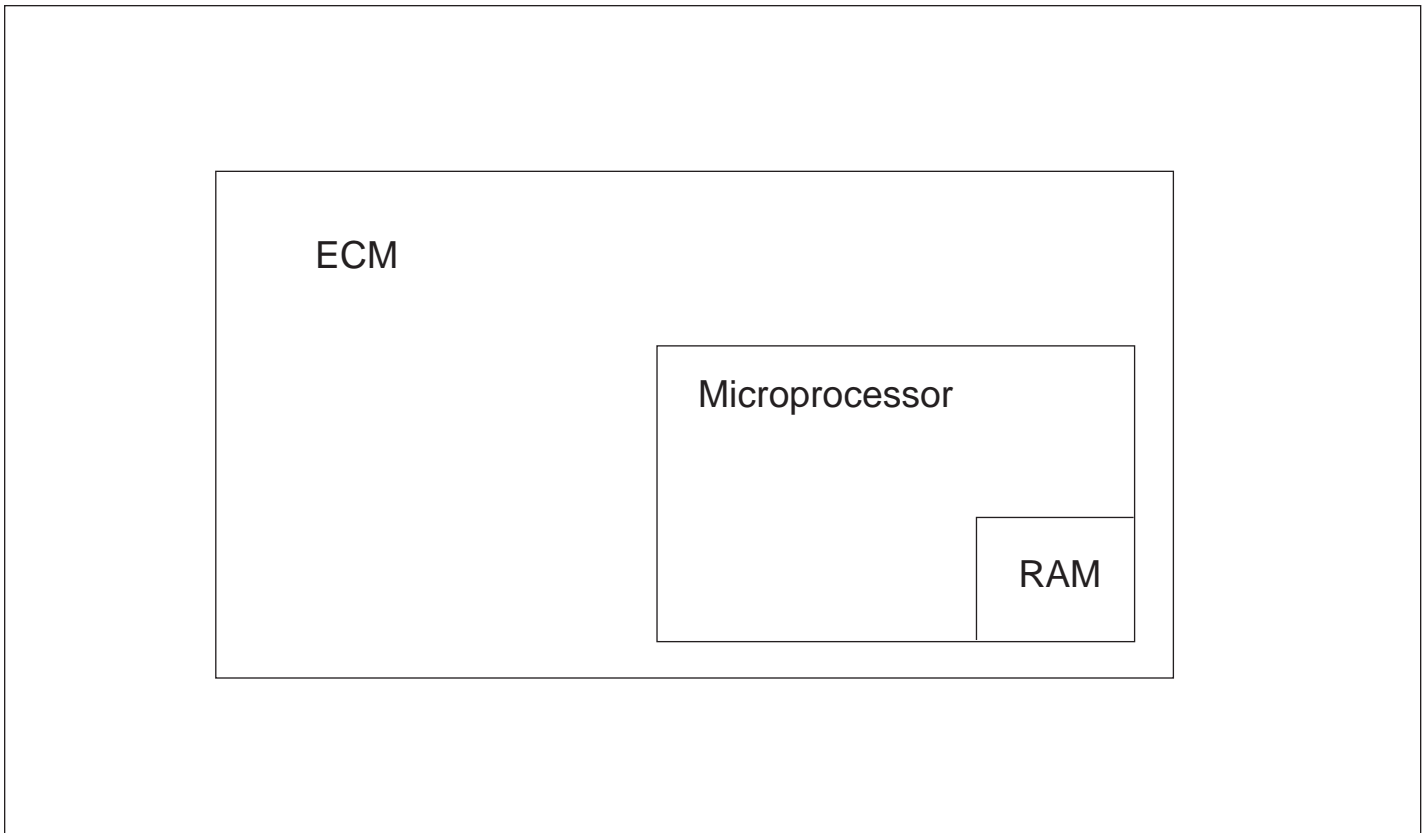
This fault will set if the ECM detects a problem accessing or writing information to RAM and should be configured to set a power derate 2 and low rev limit to reduce possible engine damage and reduce possibility of an overspeed condition. If this fault sets, the ECM will reset itself and log the code. This fault should be erased by a technician after diagnostics are performed. The fault should be configured to never forget and will not self-erase.

DTC 0604 - Microprocessor Failure - RAM SPN - 630; FMI - 12



Diagnostics

DTC 0606 - Microprocessor Failure - COP SPN - 629; FMI - 31

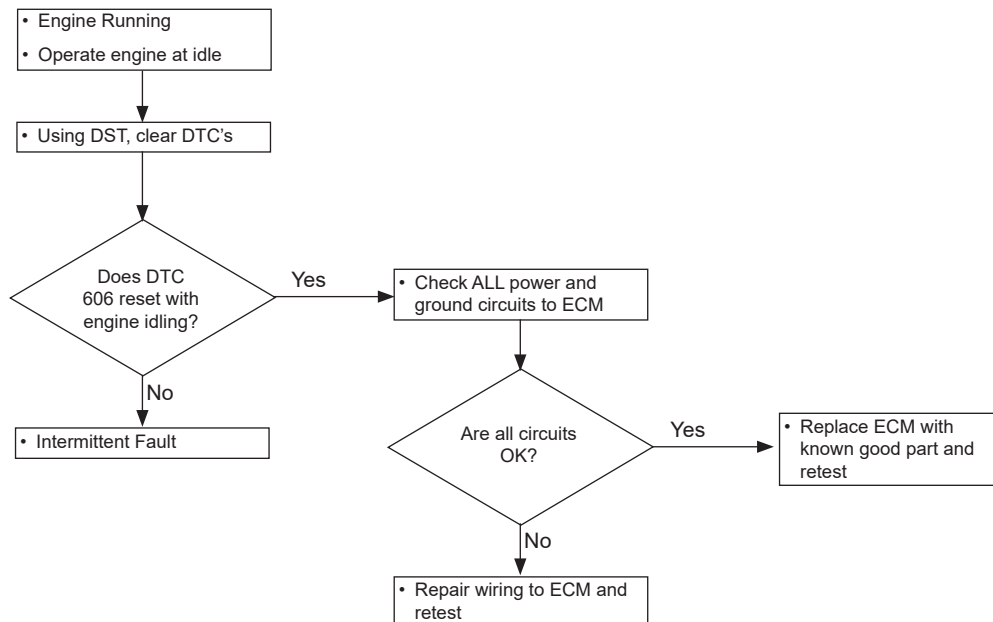


- Engine Control Module
- *Check Condition* - Key on
- *Fault Condition* - Internal microprocessor error
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle, recommend power derate 2 and low rev limit to reduce possible engine damage and/or overspeed condition
- Non-emissions related fault

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault.

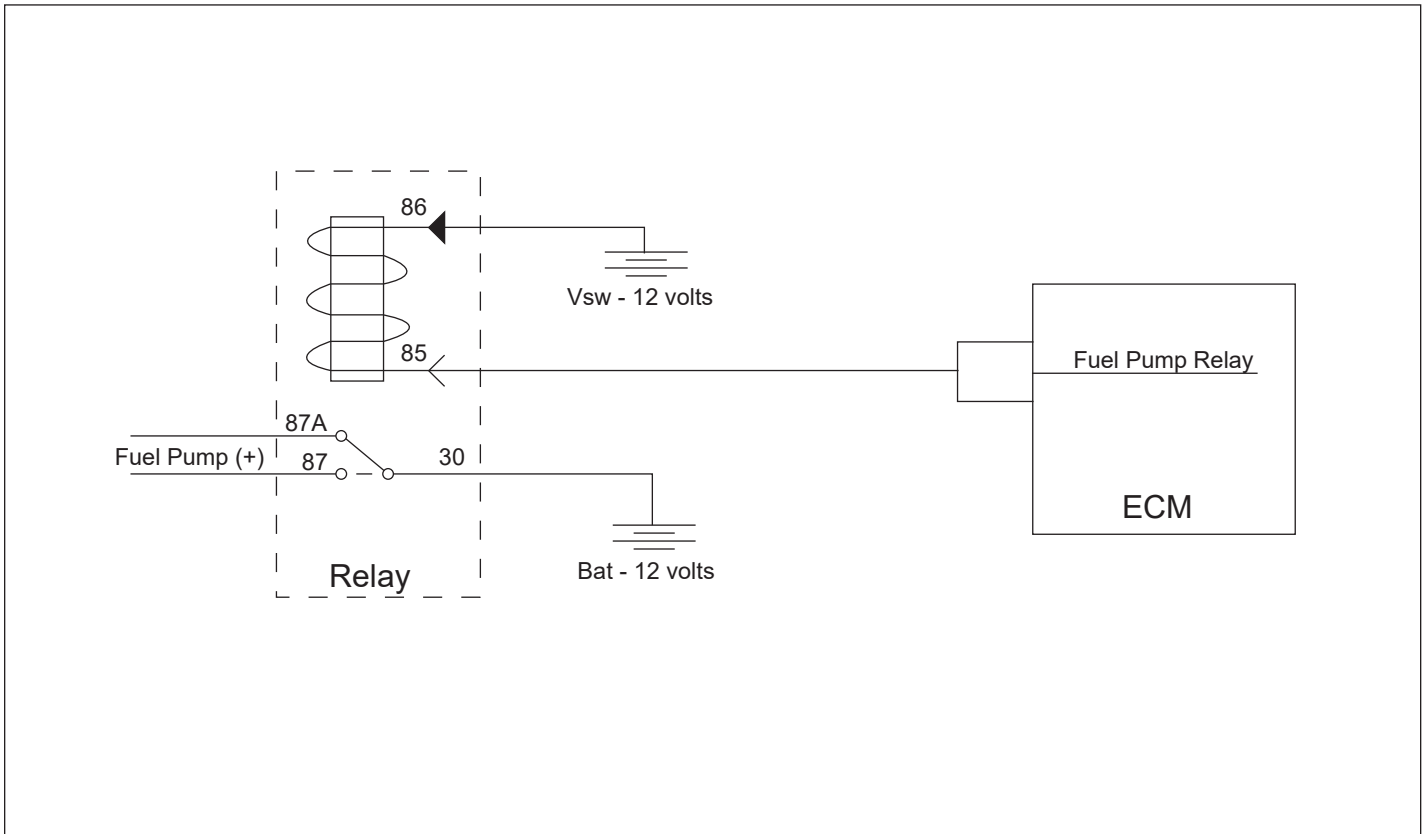
If this fault sets, the ECM will reset itself and log the code. The fault should be configured to never forget and will not self-erase and will not clear until a technician performs diagnostics and manually clears the code. This fault should be configured to set a power derate 2 and low rev limit to reduce possible engine damage and reduce possibility of an overspeed condition.

DTC 0606 - Microprocessor Failure - COP SPN - 629; FMI - 31



Diagnostics

DTC 0627 - Fuel Pump Relay Coil Open SPN - 1348; FMI - 5

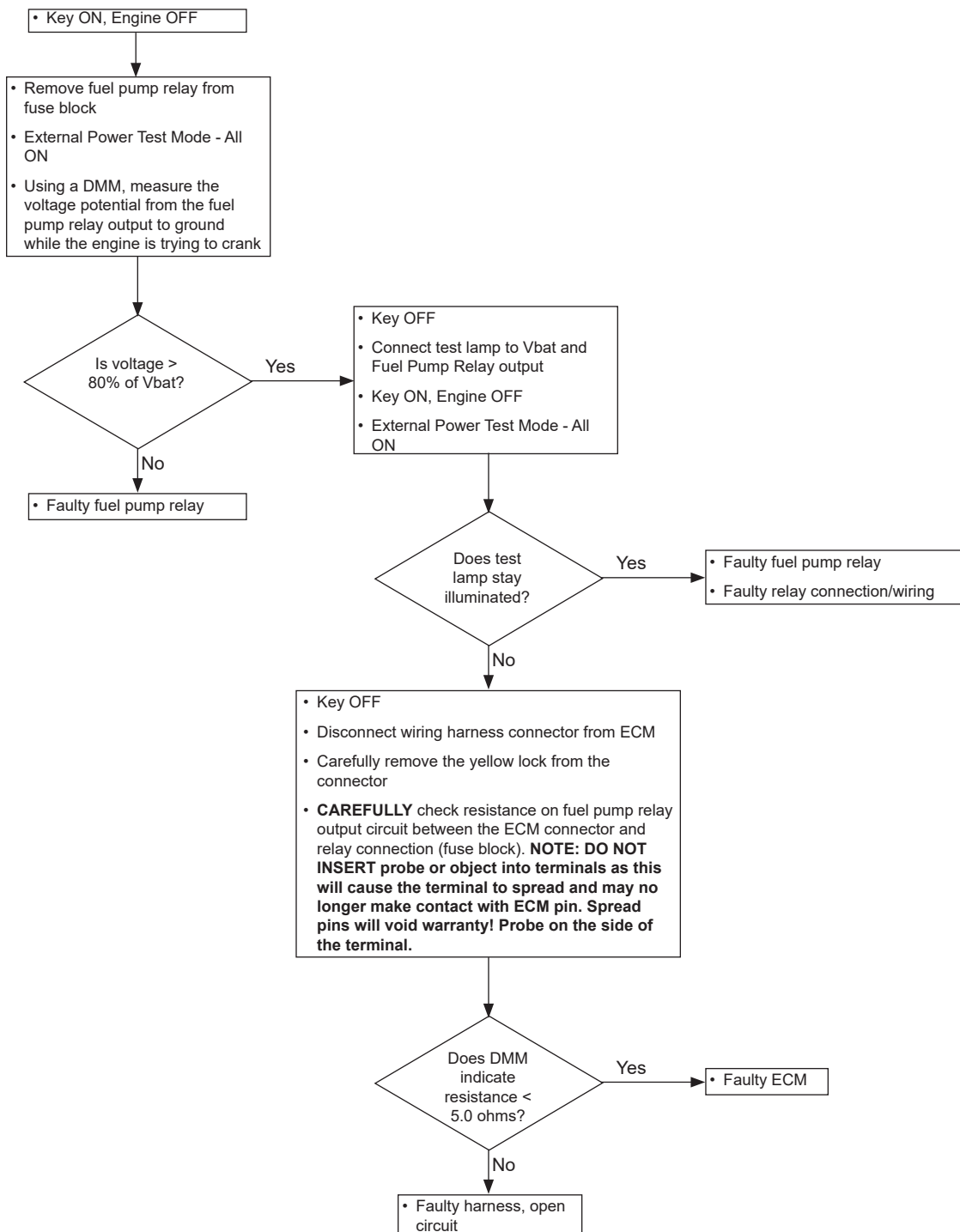


- Fuel Pump Relay
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - Fuel Pump relay coil output open circuit
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

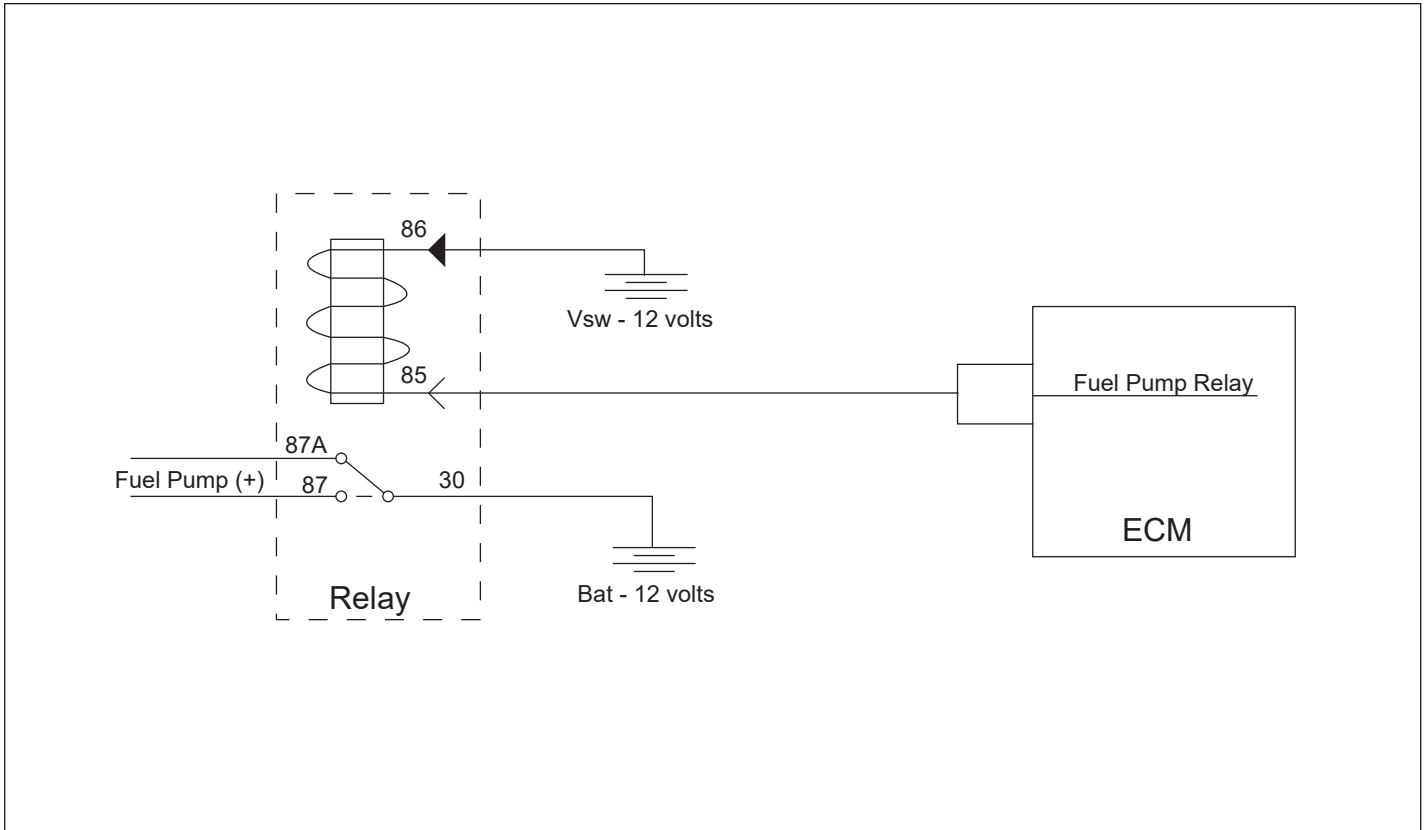
This fault sets if the output for the fuel pump relay is detected as an open circuit. If this fault is active the fuel pump will not receive power and the engine will not run on gasoline.

DTC 0627 - Fuel Pump Relay Coil Open SPN - 1348; FMI - 5



Diagnostics

DTC 0628 - Fuel Pump Relay Control Ground Short SPN - 1348; FMI - 4

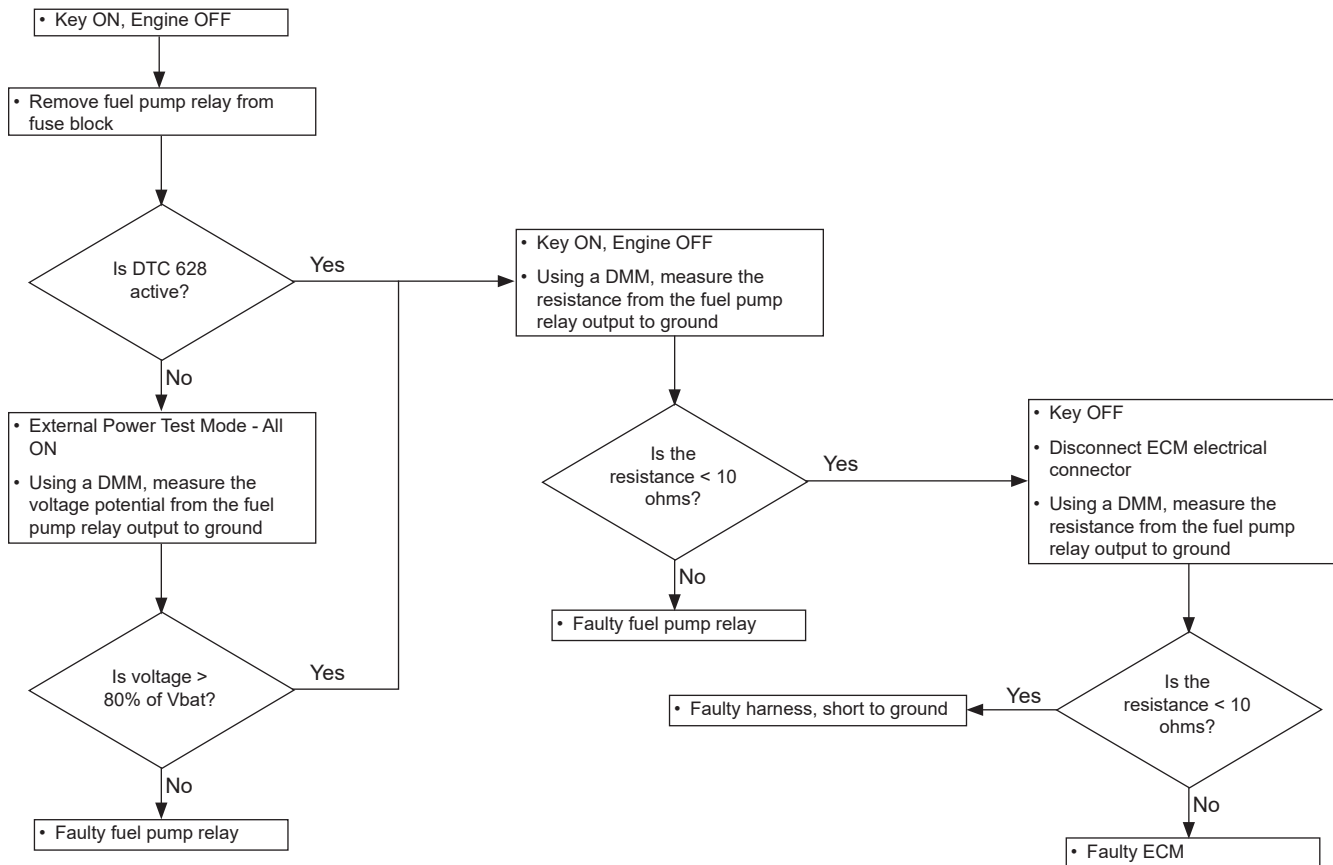


- Fuel Pump Relay
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - Fuel Pump relay coil output shorted to ground
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

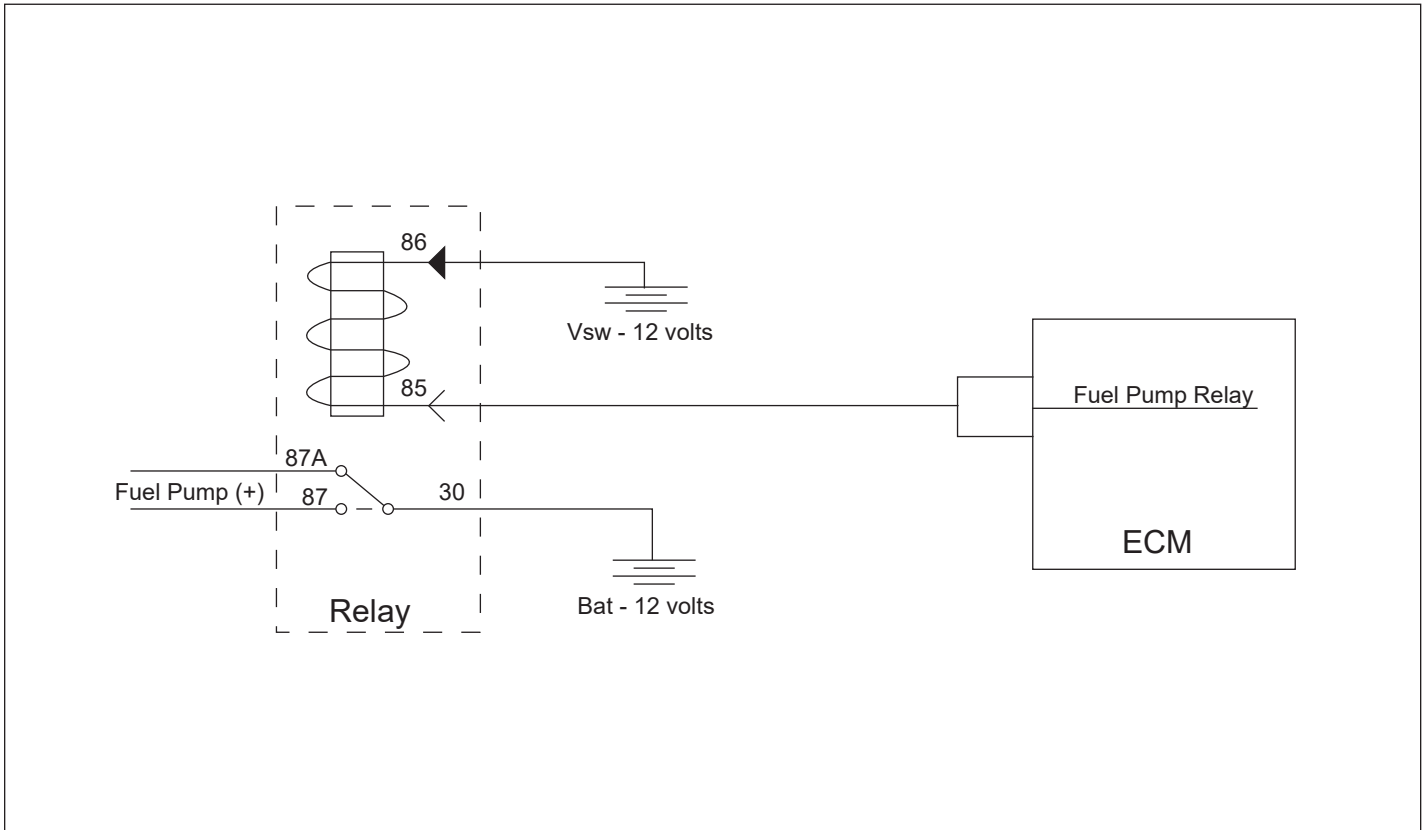
This fault sets if the output for the fuel pump relay is detected as being shorted to ground. If this fault is active and the high-side of the fuel pump relay is supplied, the fuel pump will run until the relay or high-side power is removed.

DTC 0628 - Fuel Pump Relay Control Ground Short SPN - 1348; FMI - 4



Diagnostics

DTC 0629 - Fuel Pump Relay Coil Short to Power SPN - 1348; FMI - 3

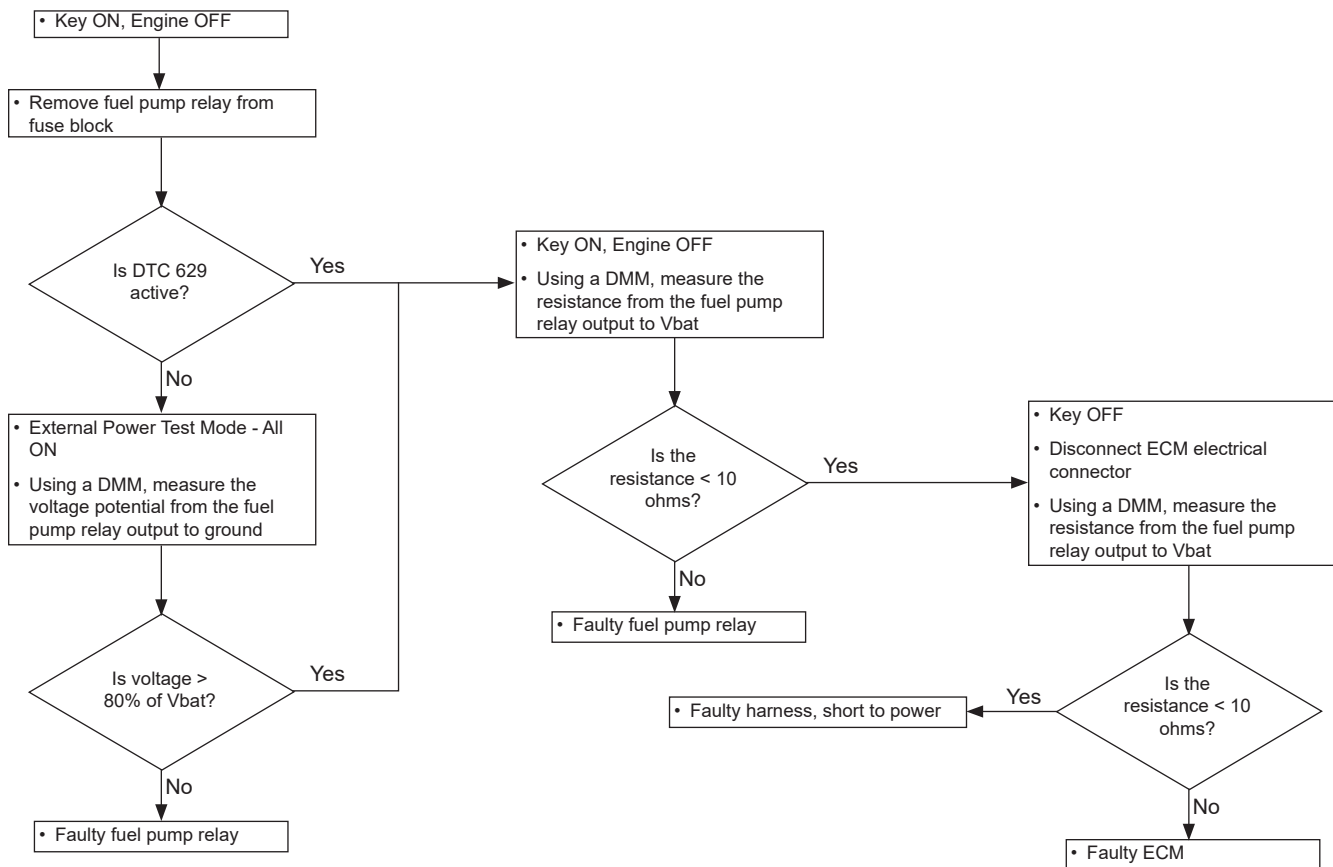


- Fuel Pump Relay
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - Fuel Pump relay coil output short to power/voltage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

This fault sets if the output for the fuel pump relay is detected as shorted to power. If this fault is active the fuel pump will not receive power and will not run.

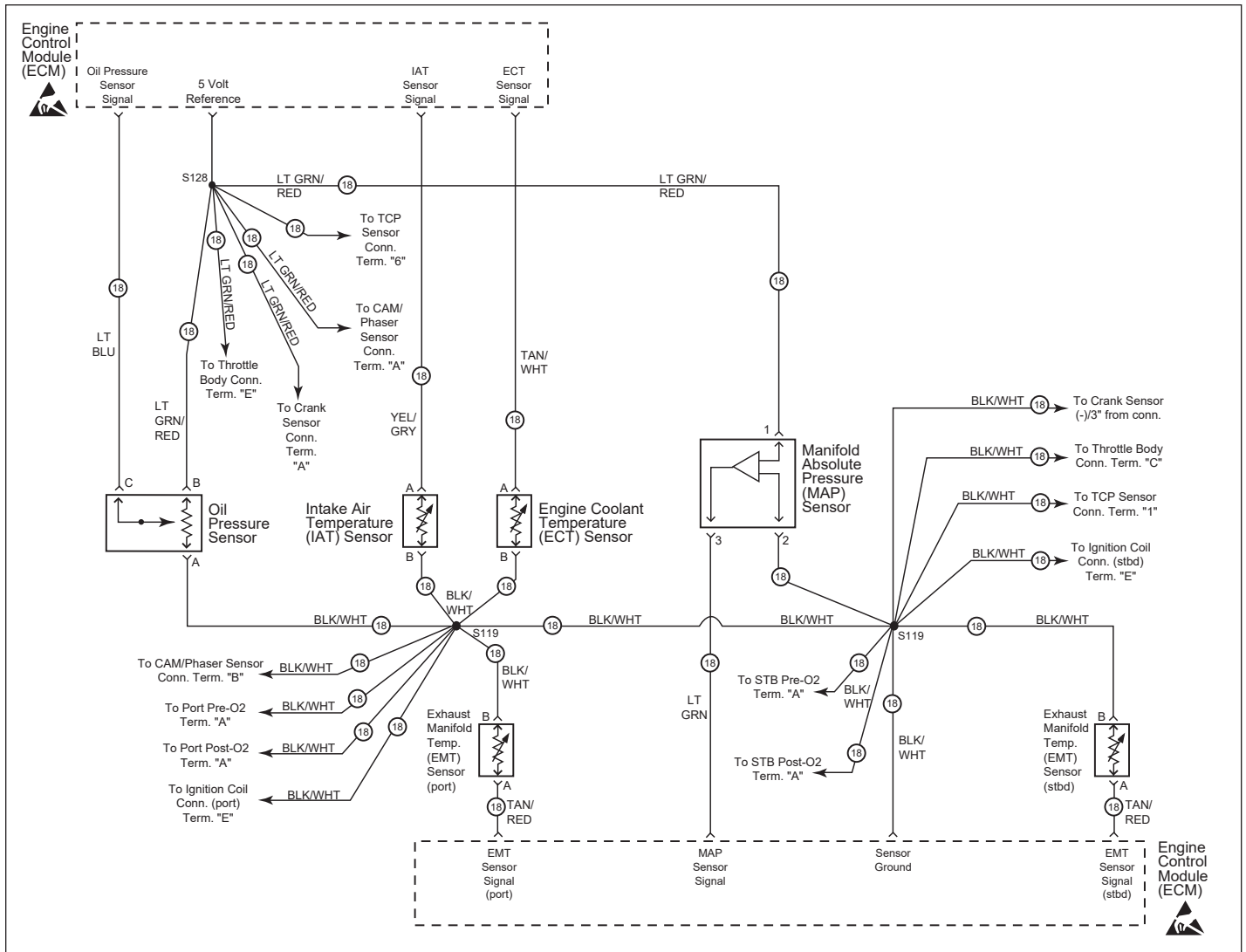
DTC 0629 - Fuel Pump Relay Coil Short to Power SPN - 1348; FMI - 3



Diagnostics

DTC 0642 - Sensor Supply Voltage 1 Low (5Vref1)

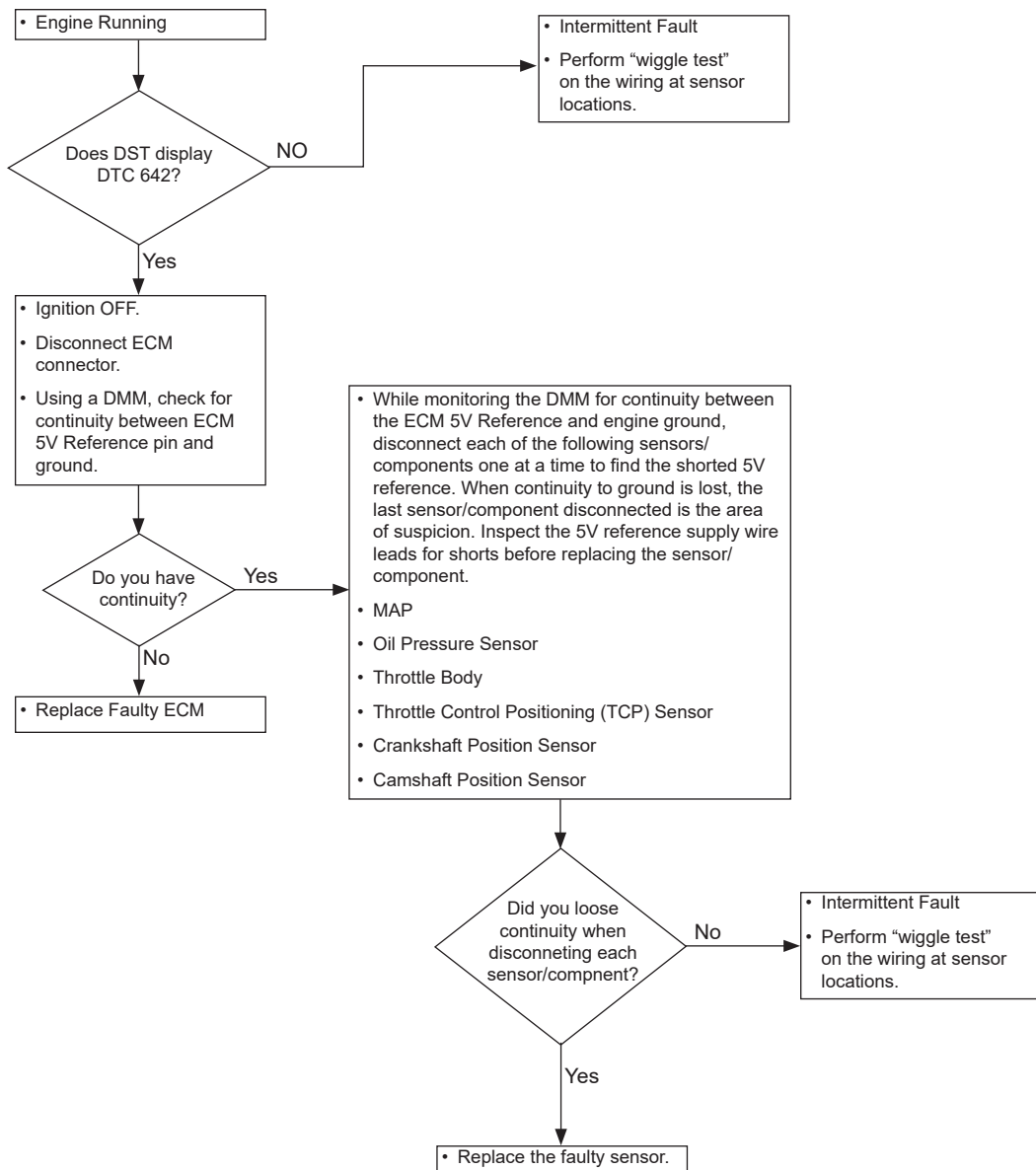
SPN - 1079; FMI - 4



- External 5V Reference
- *Check Condition* - Cranking with battery voltage greater than 8 volts or engine running.
- *Fault Condition* - 5V Reference voltage lower than 4.6 volts.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning
- Non-emissions related fault

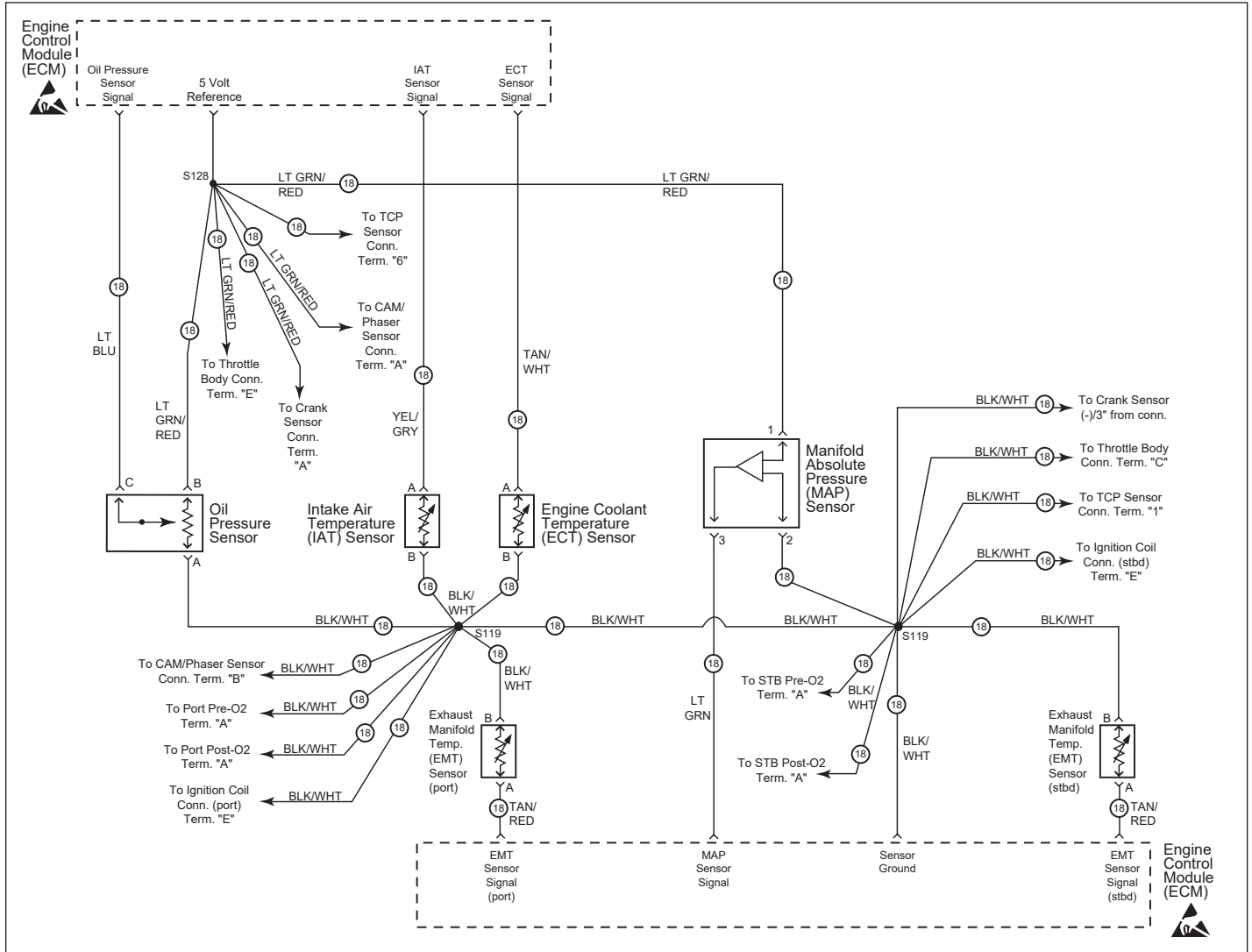
The external 5-volt supply powers some of the sensors and other components in the system. The accuracy of the 5-volt supply is very important to the accuracy of the sensors and therefore controlled by the ECM. The ECM monitors the 5-volt supply to determine if it is over-loaded, shorted, or otherwise out of specification.

DTC 0642 - Sensor Supply Voltage 1 Low (5Vref1) SPN - 1079; FMI - 4



Diagnostics

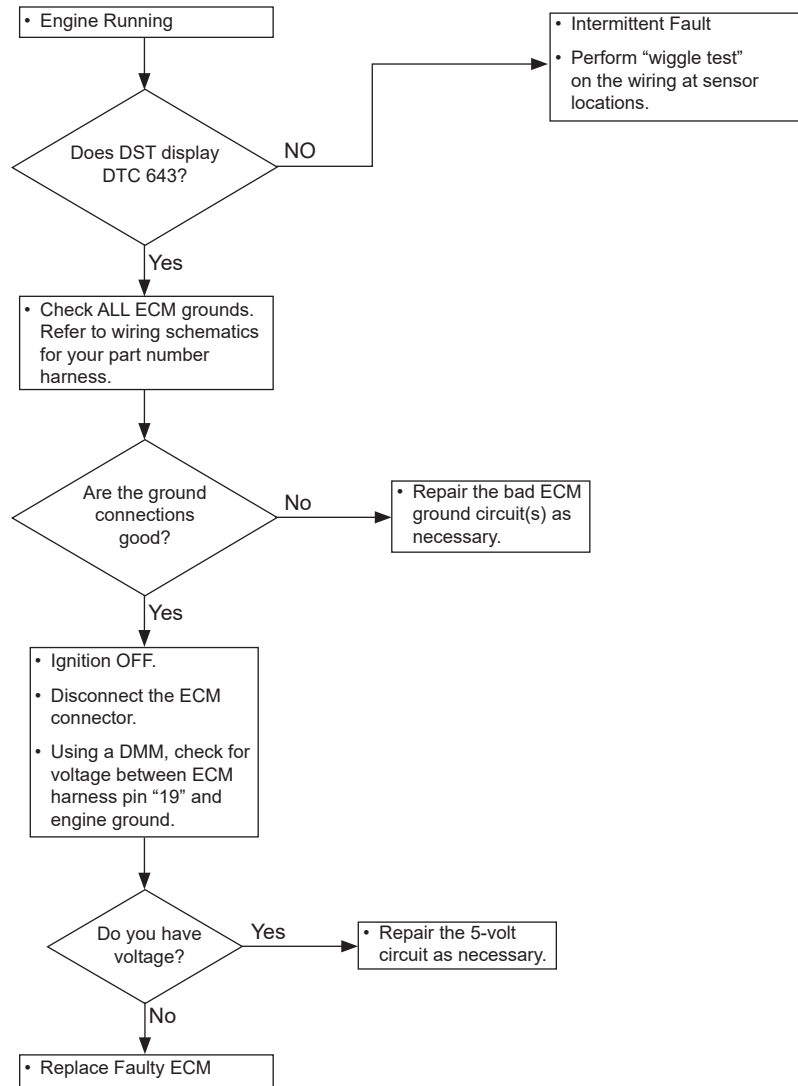
DTC 0643 - Sensor Supply Voltage 1 High (5Vref1) SPN - 1079; FMI - 3



- External 5V Reference
- *Check Condition* - Cranking with battery voltage greater than 8 volts or engine running.
- *Fault Condition* - 5V Reference voltage higher than 5.4 volts.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning
- Non-emissions related fault

The external 5-volt supply powers some of the sensors and other components in the system. The accuracy of the 5-volt supply is very important to the accuracy of the sensors and therefore controlled by the ECM. The ECM monitors the 5-volt supply to determine if it is over-loaded, shorted, or otherwise out of specification.

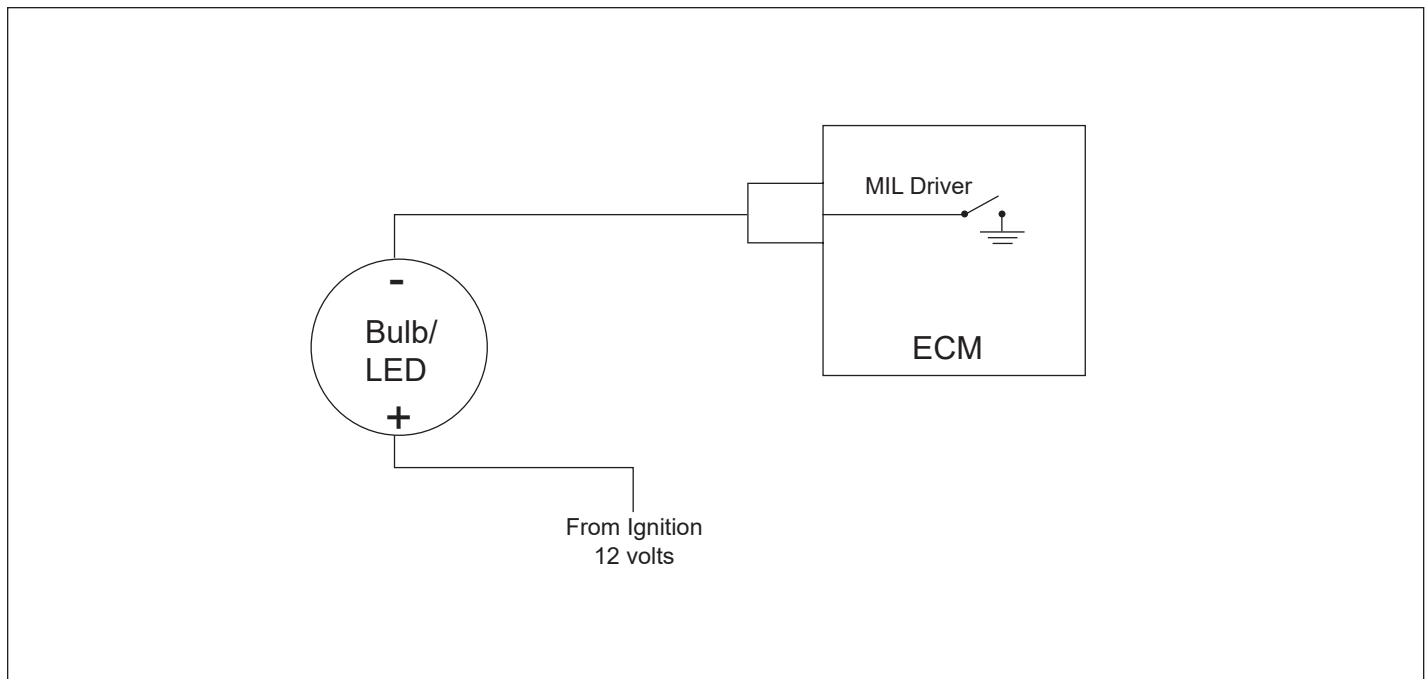
DTC 0643 - Sensor Supply Voltage 1 High (5Vref1) SPN - 1079; FMI - 3



Diagnostics

DTC 0650 - Malfunction Indicator Lamp (MIL) Open

SPN - 1213; FMI - 5

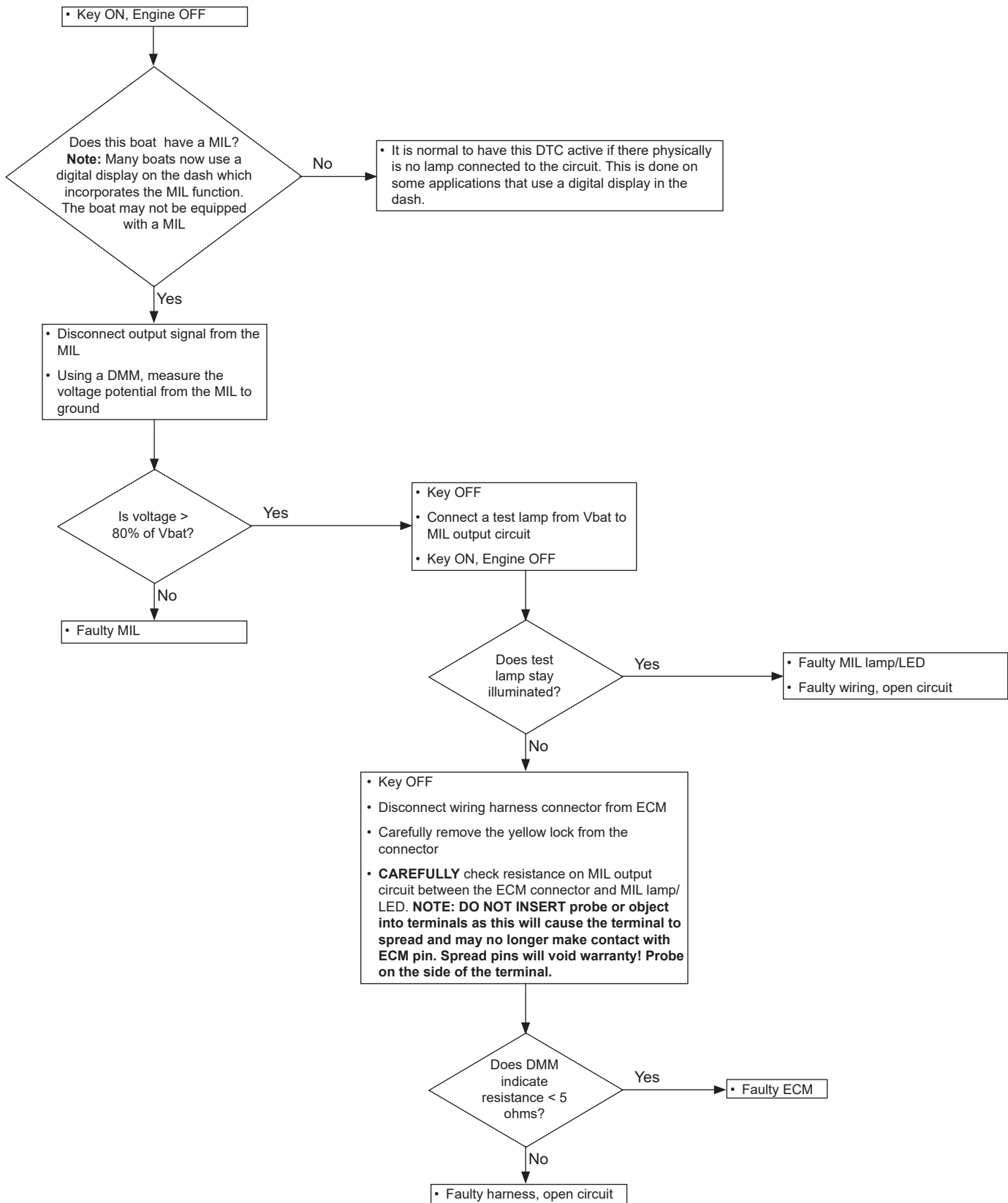


- MIL
- *Check Condition* - Key On, Engine Off or Running
- *Fault Condition* - ECM MIL output open circuit.
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

This ECM output is used to provide a low-side switch to a MIL that is used to indicate that an emission related fault has been set.

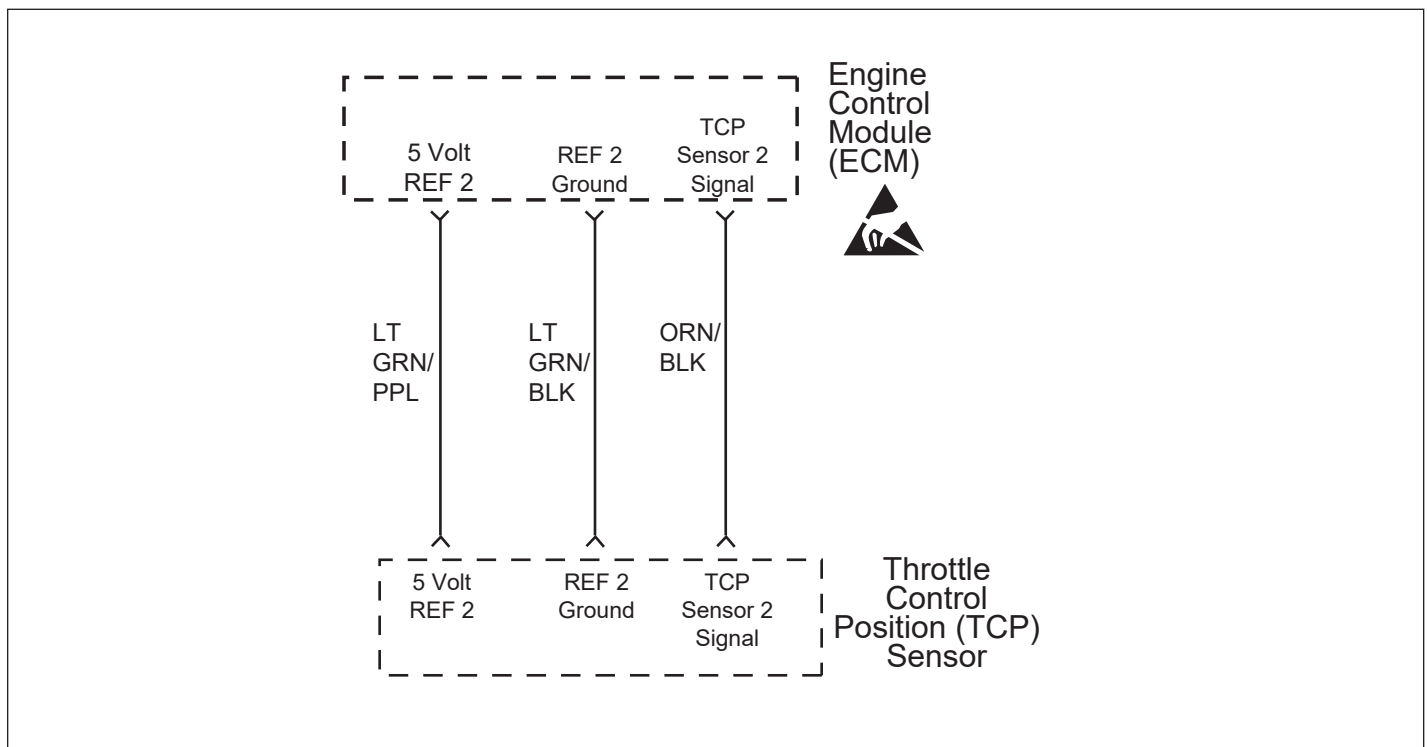
This fault will set if the ECM detects that there is no load connected to the MIL output. There are many applications that utilize Digital Dash Displays that act as the MIL. In these cases, the MIL is activated over the CAN BUS system to alert the operator. These applications may not have a separate MIL connected to the ECM output and will exhibit this as an Active DTC all the time. That is normal, ignore this code in those applications.

DTC 0650 - Malfunction Indicator Lamp (MIL) Open SPN - 1213; FMI - 5



Diagnostics

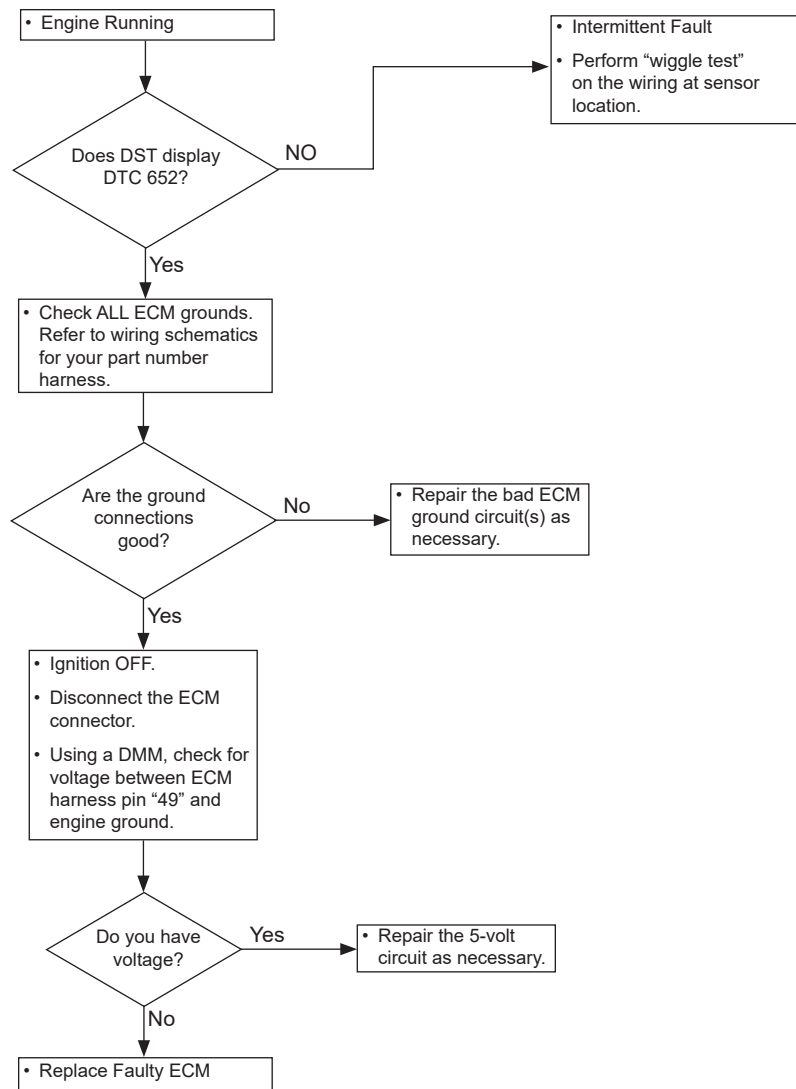
DTC 0652 - Sensor Supply Voltage 2 Low (5Vref2) SPN - 1080; FMI - 4



- External 5V Reference
- *Check Condition* - Cranking with battery voltage greater than 8 volts or engine running.
- *Fault Condition* - 5V Reference 2 voltage lower than 3.0 volts.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning
- Non-emissions related fault

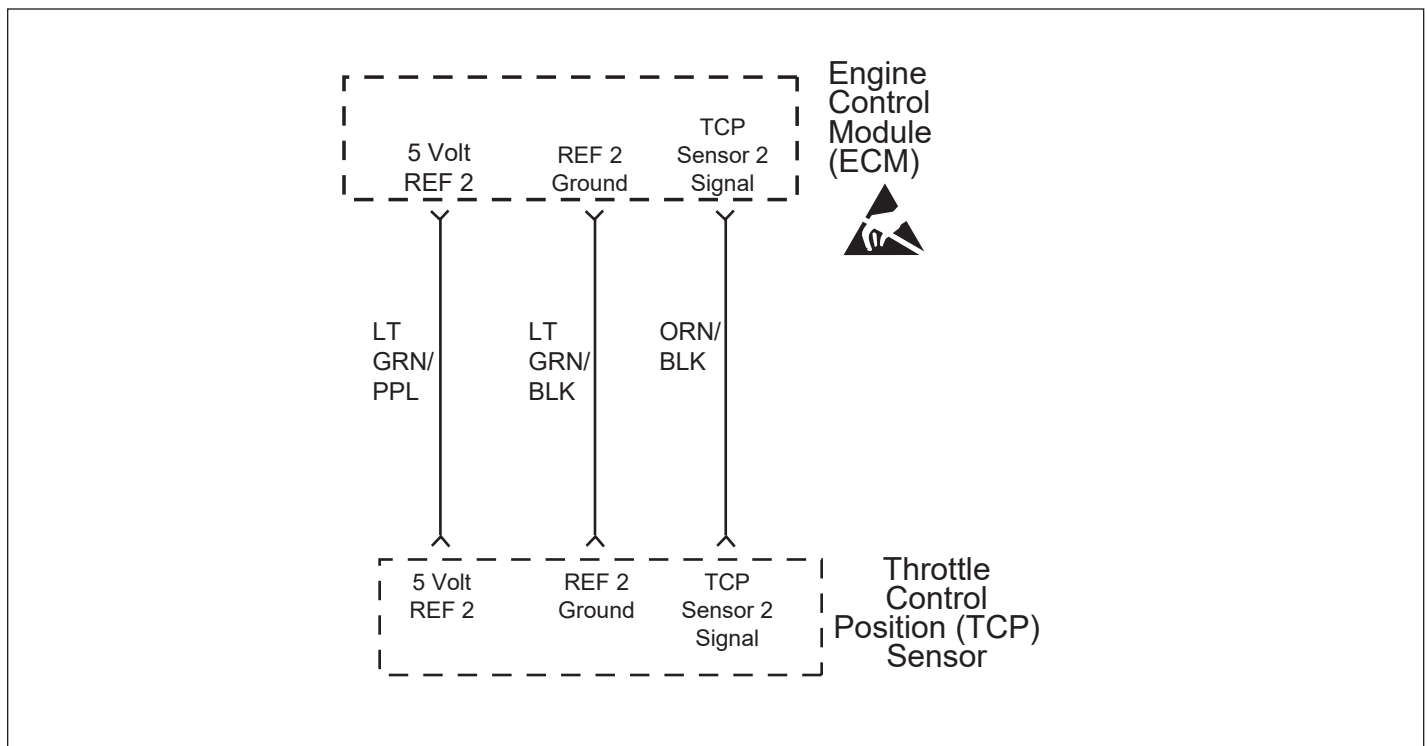
The external 5-volt supply 2 is a dedicated supply voltage to power the TCP Sensor 2 for redundancy. The accuracy of the 5-volt supply is very important to the accuracy of the sensor and therefore controlled by the ECM. The ECM monitors the 5-volt supply to determine if it is over-loaded, shorted, or otherwise out of specification.

DTC 0652 - Sensor Supply Voltage 2 Low (5Vref2) SPN - 1080; FMI - 4



Diagnostics

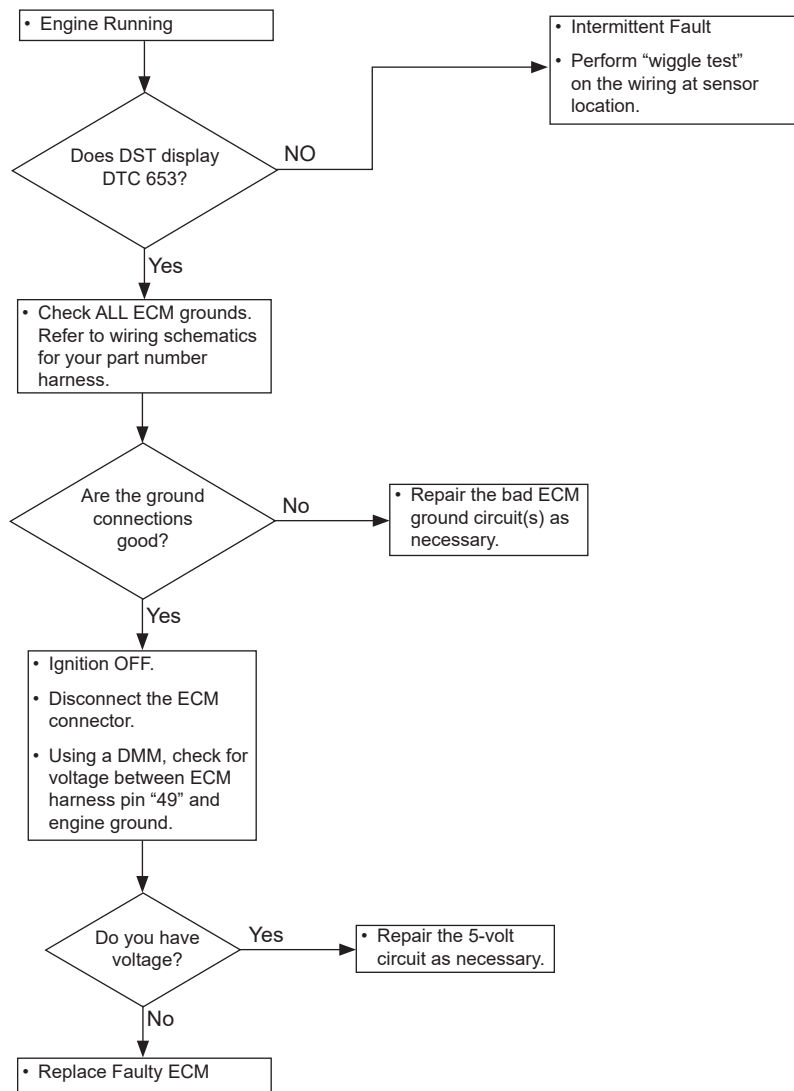
DTC 0653 - Sensor Supply Voltage 2 High (5Vref2) SPN - 1080; FMI - 3



- External 5V Reference
- *Check Condition* - Cranking with battery voltage greater than 8 volts or engine running.
- *Fault Condition* - 5V Reference 2 voltage higher than 5.4 volts.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning
- Non-emissions related fault

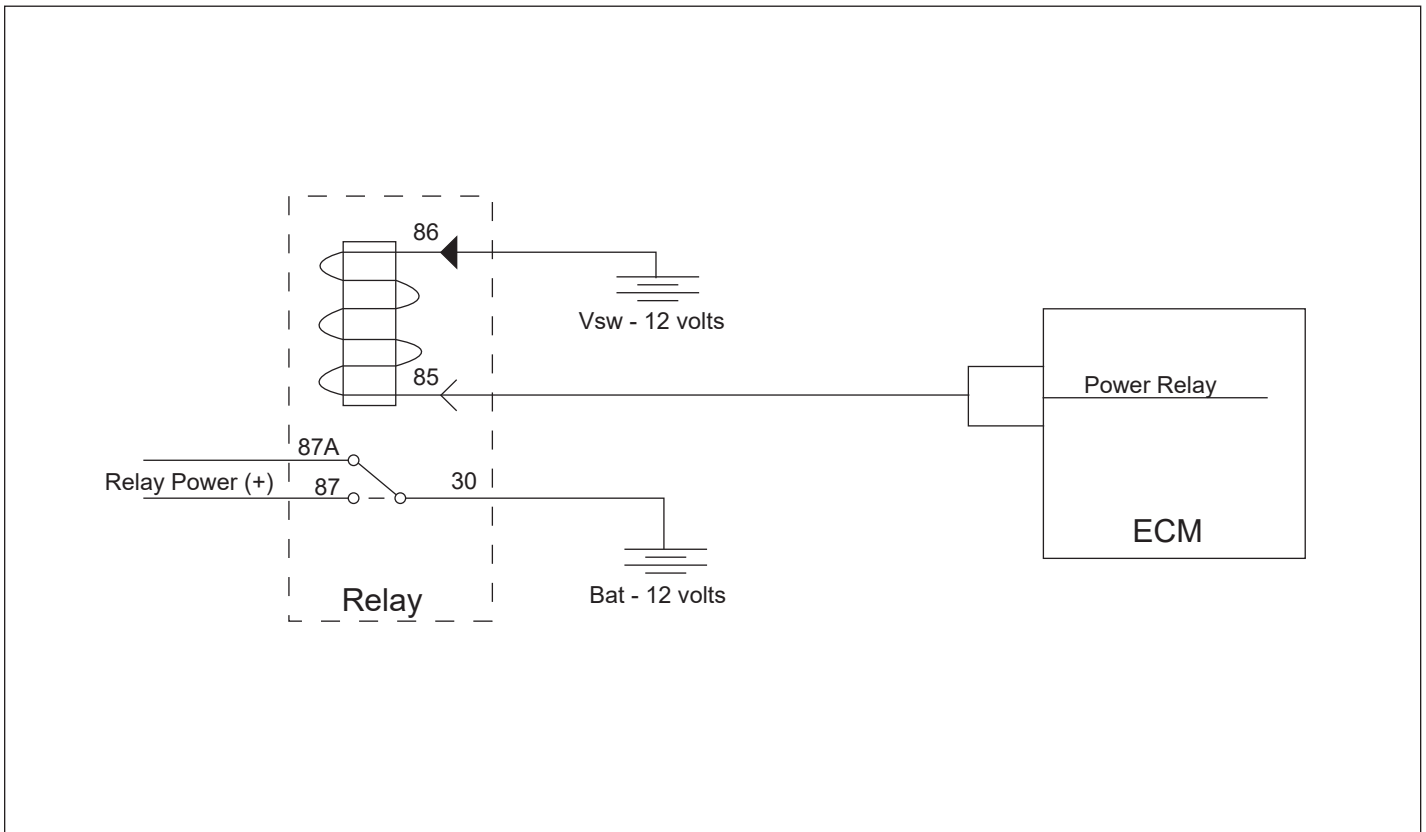
The external 5-volt supply 2 is a dedicated supply voltage to power the TCP Sensor 2 for redundancy. The accuracy of the 5-volt supply is very important to the accuracy of the sensor and therefore controlled by the ECM. The ECM monitors the 5-volt supply to determine if it is over-loaded, shorted, or otherwise out of specification.

DTC 0653 - Sensor Supply Voltage 2 High (5Vref2) SPN - 1080; FMI - 3



Diagnostics

DTC 0685 - Power Relay Coil Open SPN - 1485; FMI - 5

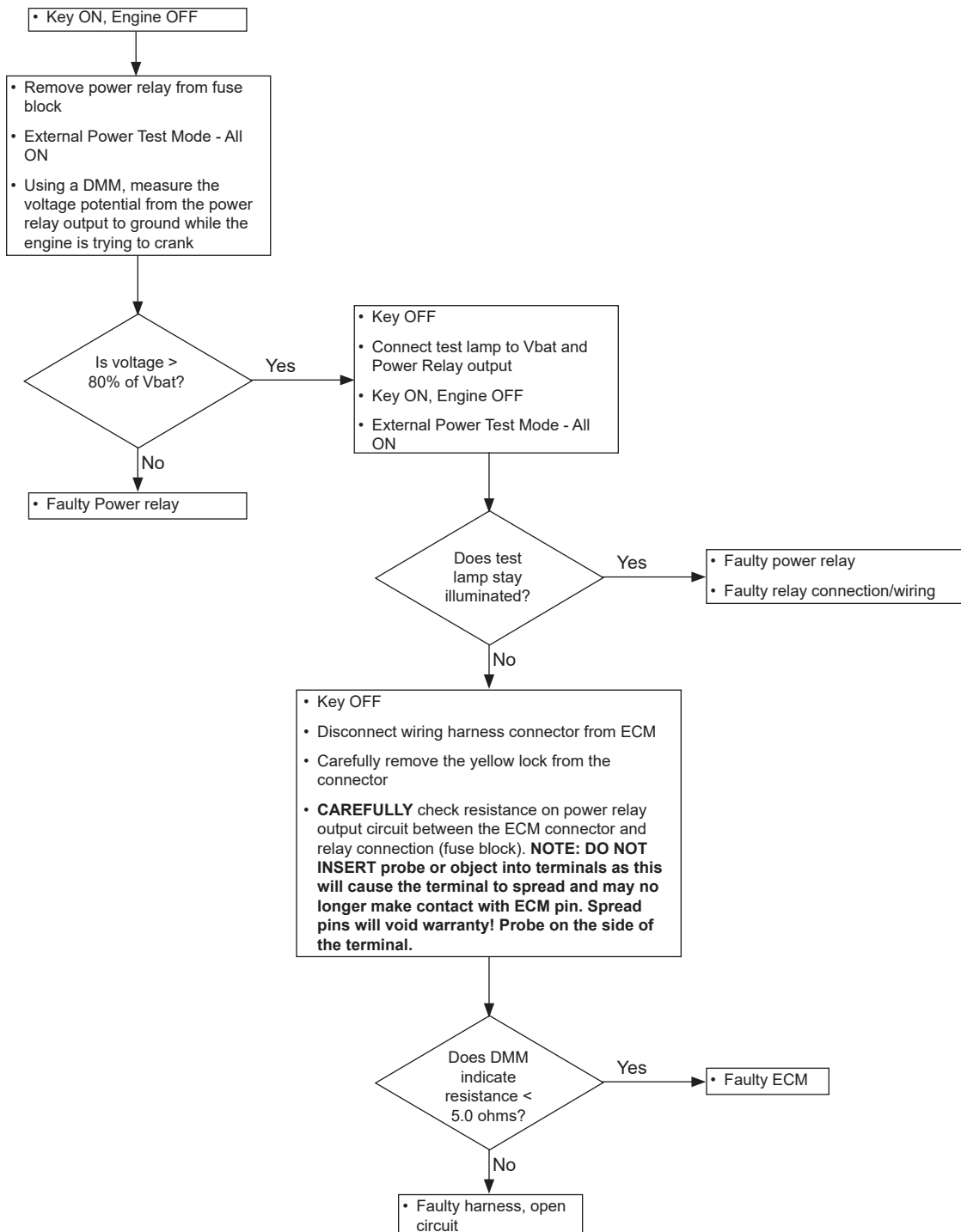


- Power Relay
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - Power relay coil output open circuit
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

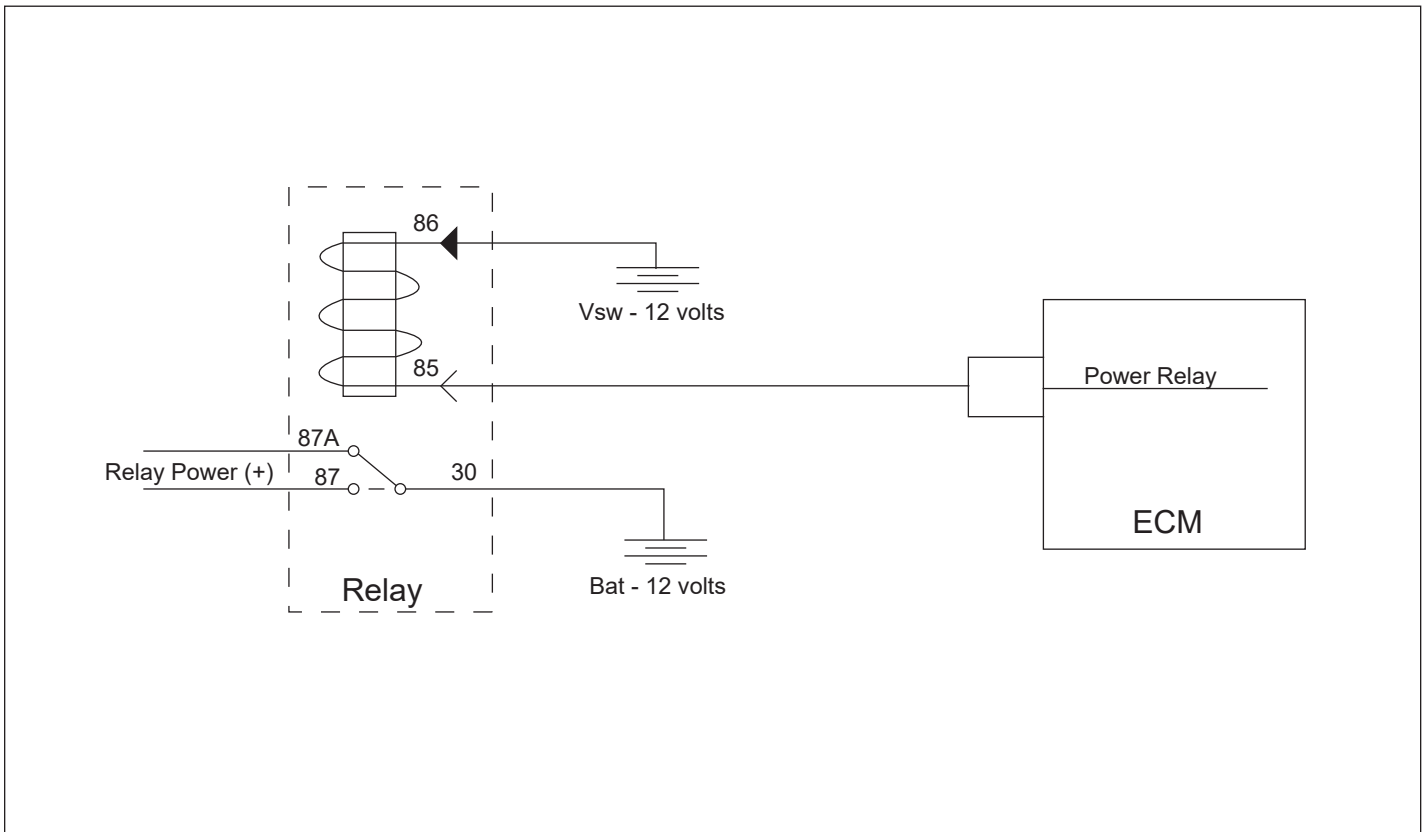
This fault sets if the output for the power relay is detected as an open circuit. If this fault is active the injector and ignition coil high-side will not receive power and the engine will not run.

DTC 0685 - Power Relay Coil Open SPN - 1485; FMI - 5



Diagnostics

DTC 0686 - Power Relay Control Ground Short SPN - 1485; FMI - 4

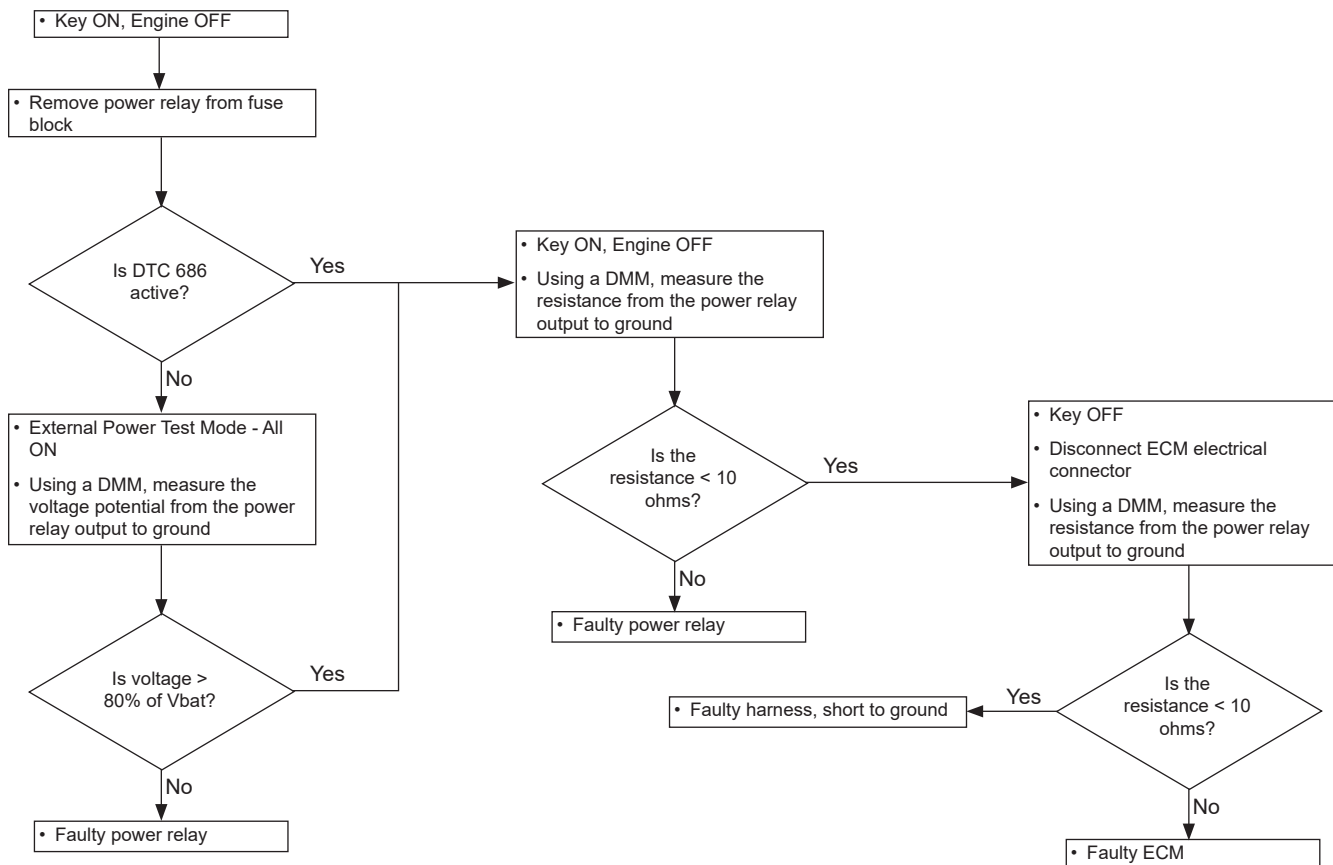


- Power Relay
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - Power relay coil output shorted to ground
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

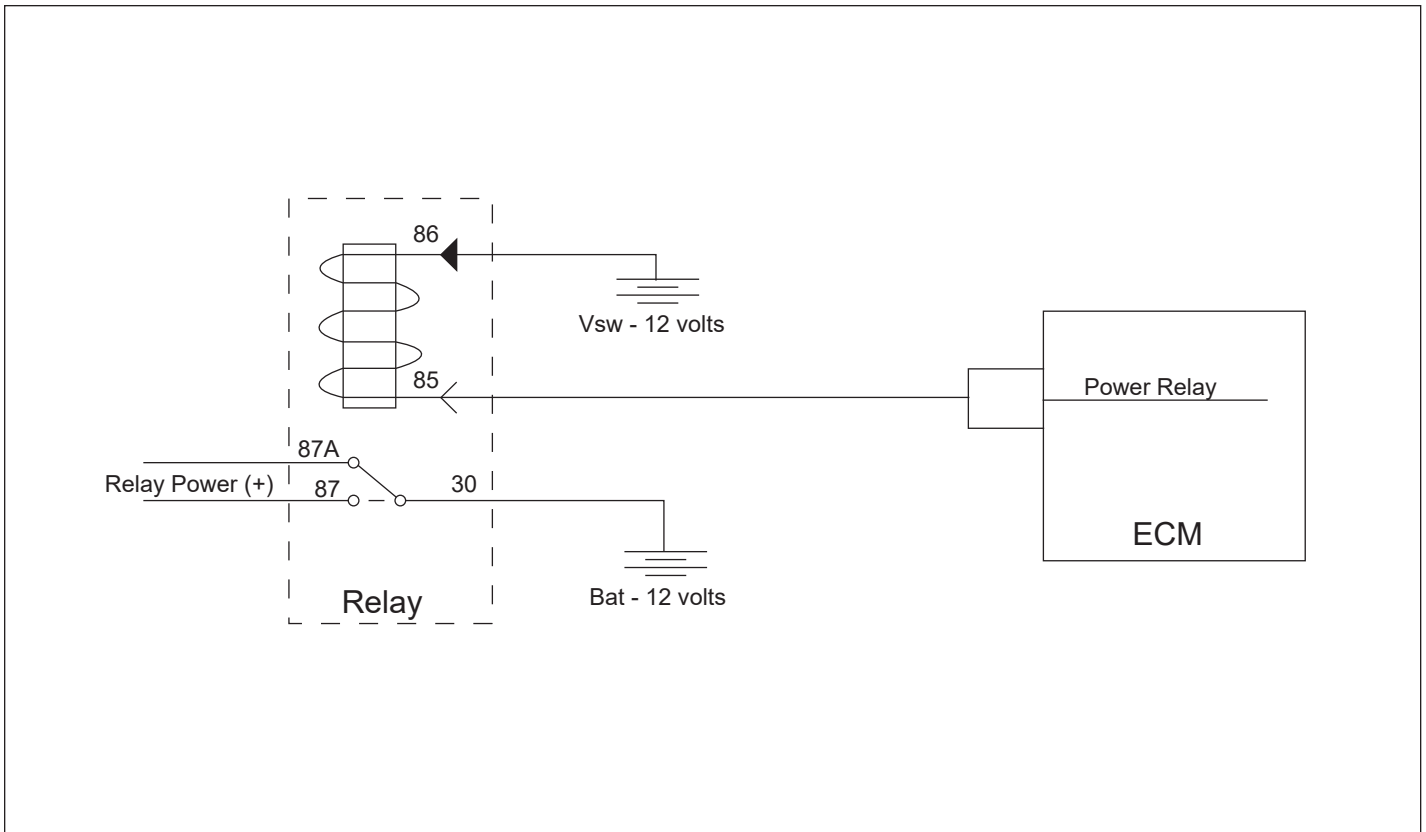
This fault sets if the output for the power relay is detected as being shorted to ground.

DTC 0686 - Power Relay Control Ground Short SPN - 1485; FMI - 4



Diagnostics

DTC 0687 - Power Relay Coil Short to Power SPN - 1485; FMI - 3

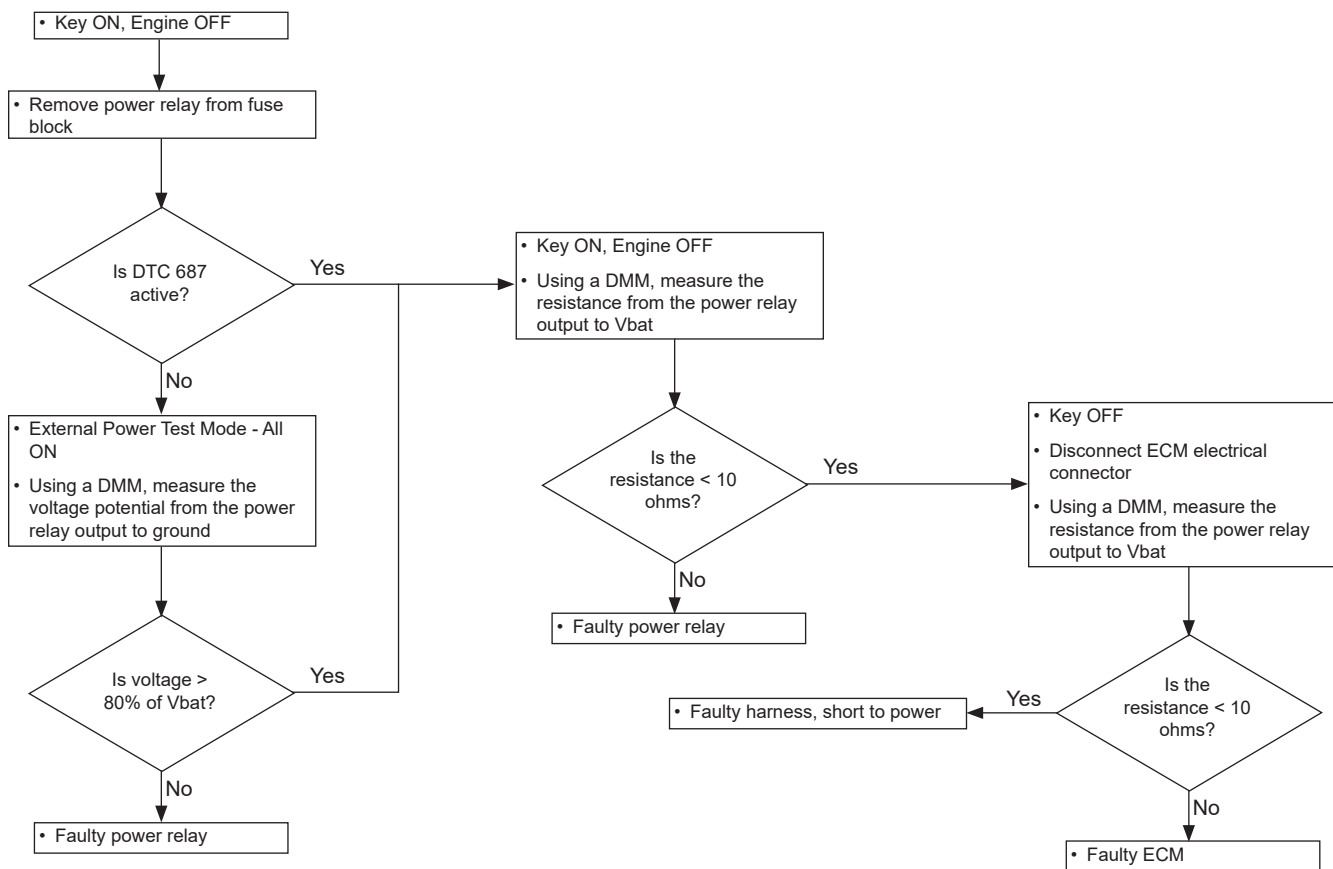


- Power Relay
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - Power relay coil output short to power/voltage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

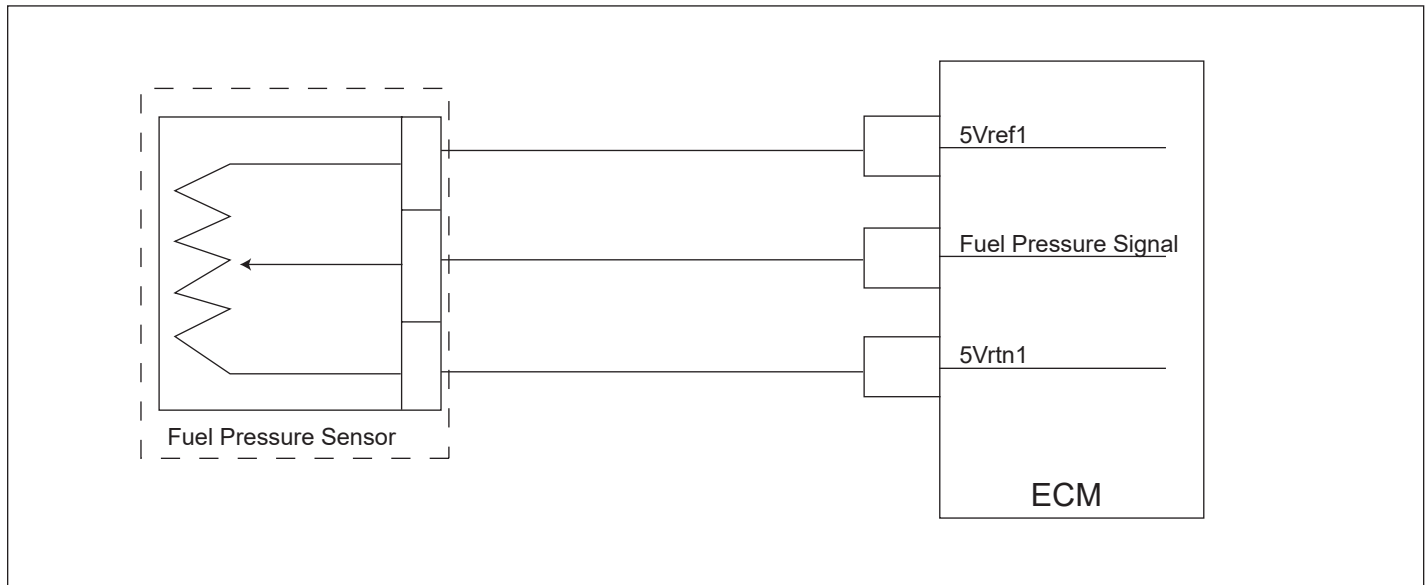
This fault sets if the output for the power relay is detected as shorted to power.

DTC 0687 - Power Relay Coil Short to Power SPN - 1485; FMI - 3



Diagnostics

DTC 1087 - Secondary Fuel Pressure Low Pressure (Direct Injection) SPN - 94; FMI - 1



- Secondary Fuel Pressure Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Engine run time greater than 10 seconds and Fuel Pressure is less than 55 psi.
- *Corrective Action(s)* - Illuminate MIL, disable adaptive learn and closed loop fueling correction.
- Emissions related fault

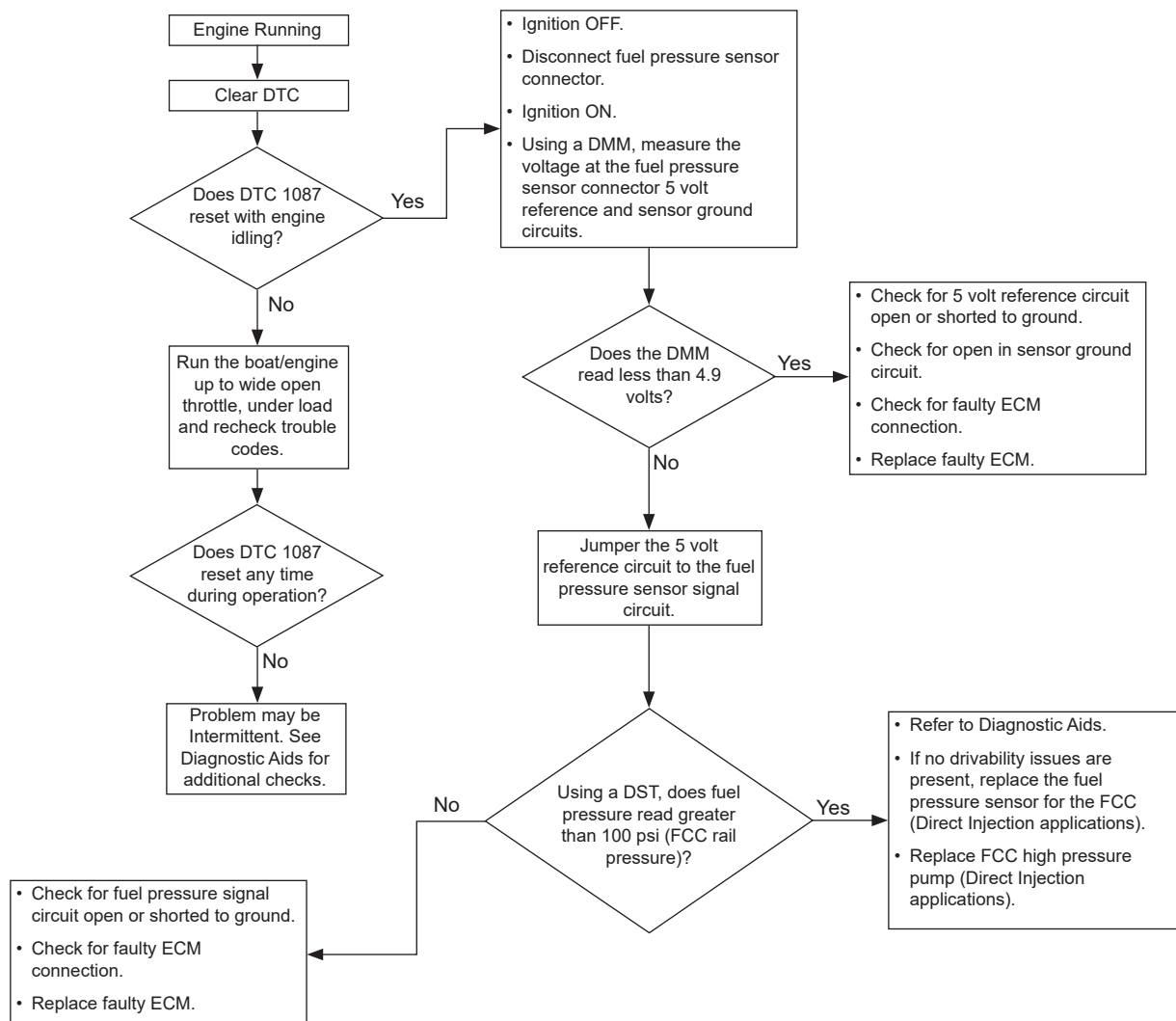
The Secondary Fuel Pressure sensor is the Fuel Control Cell fuel pressure on direct injection engines. This value is steady between 59-62 psi. This value does not vary with RPM.

This fault will set when the fuel pressure sensor is indicating a fuel pressure lower than expected.

Diagnostic Aids

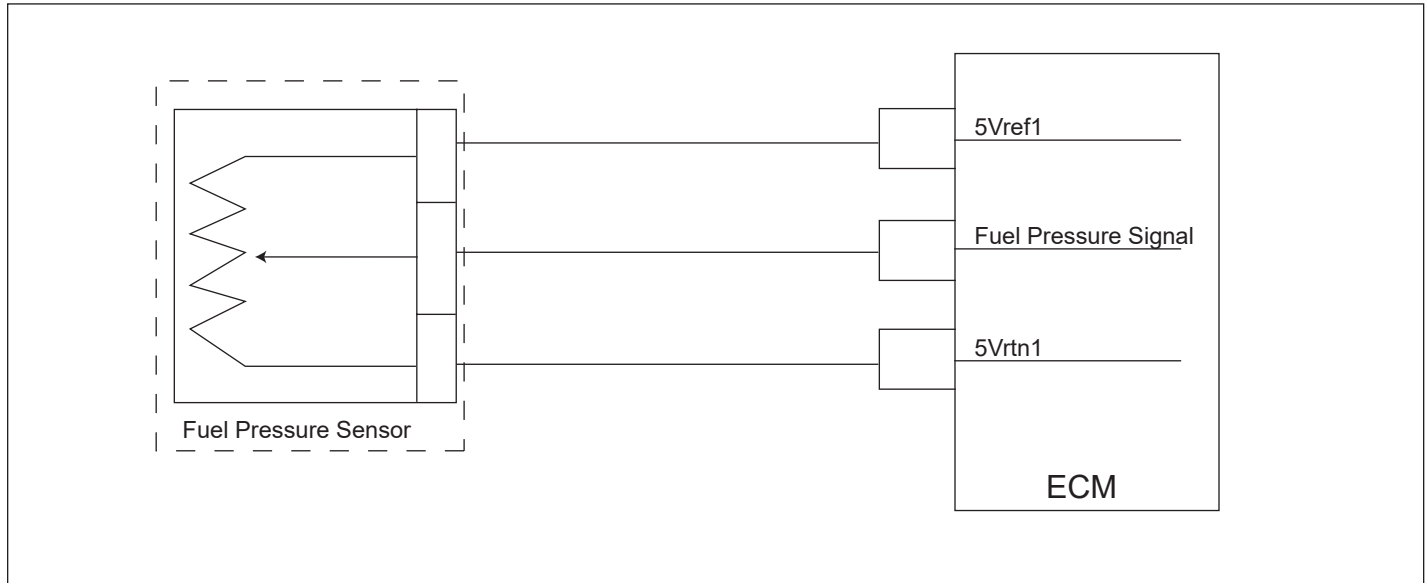
- Check the fuel filters for restrictions. Replace fuel filters as necessary.
- Check for fuel line restrictions, loose fittings or deteriorated fuel lines. Correct any problems found.
- Check fuel pressure sensor circuit wiring for a bad connection causing an intermittent problem. Correct any problems found.

DTC 1087 - Secondary Fuel Pressure Low Pressure (Direct Injection) SPN - 94; FMI - 1



Diagnostics

DTC 1088 - Secondary Fuel Pressure High Pressure SPN - 94; FMI - 0



- Secondary Fuel Pressure Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Engine run time greater than 10 seconds and Fuel Pressure is more than 70 psi.
- *Corrective Action(s)* - Illuminate MIL, disable adaptive learn and closed loop fueling correction.
- Emissions related fault

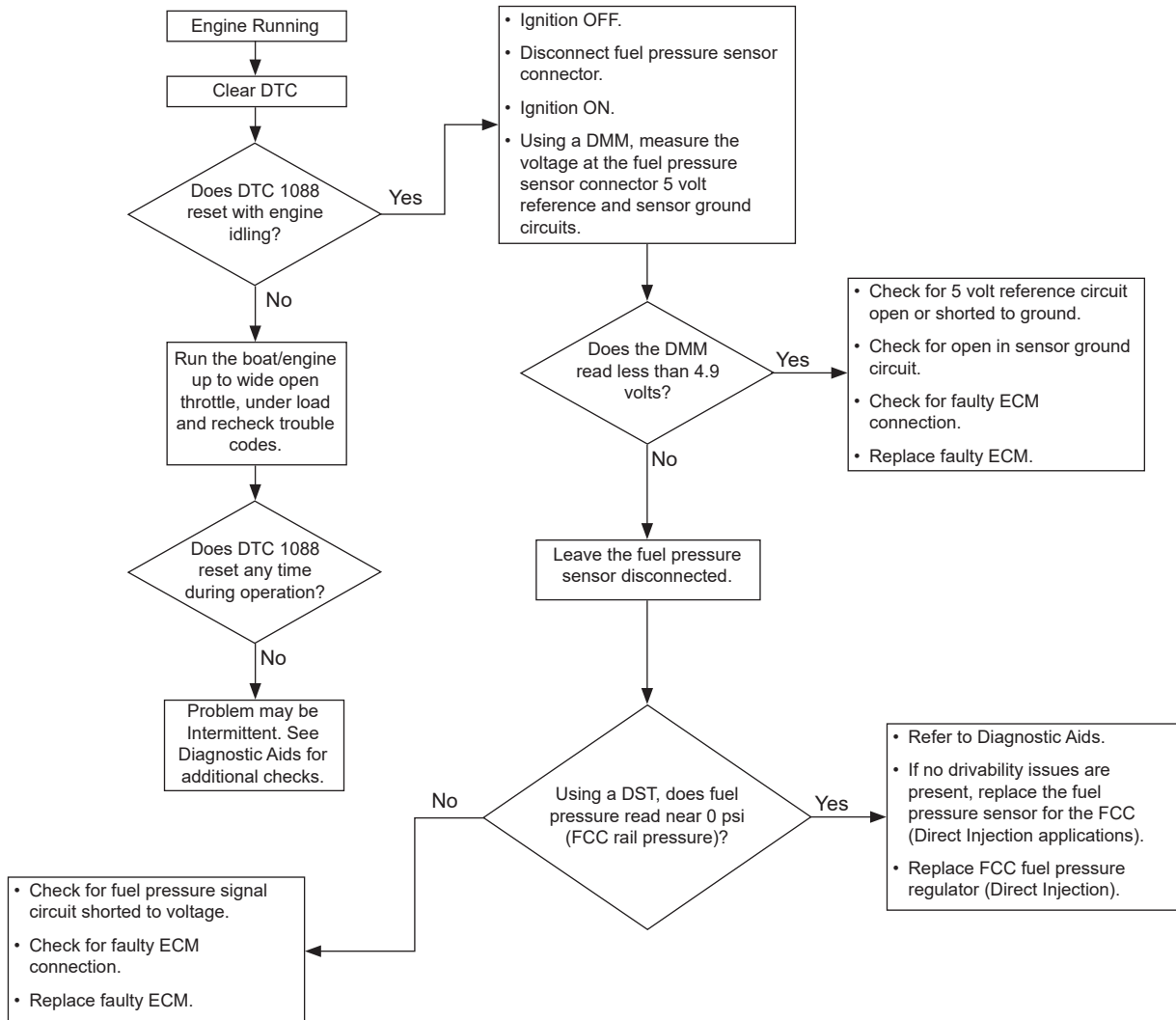
The Secondary Fuel Pressure sensor is the Fuel Control Cell fuel pressure on direct injection engines. This value is steady between 59-62 psi. This value does not vary with RPM.

This fault will set when the fuel pressure sensor is indicating a fuel pressure higher than expected.

Diagnostic Aids

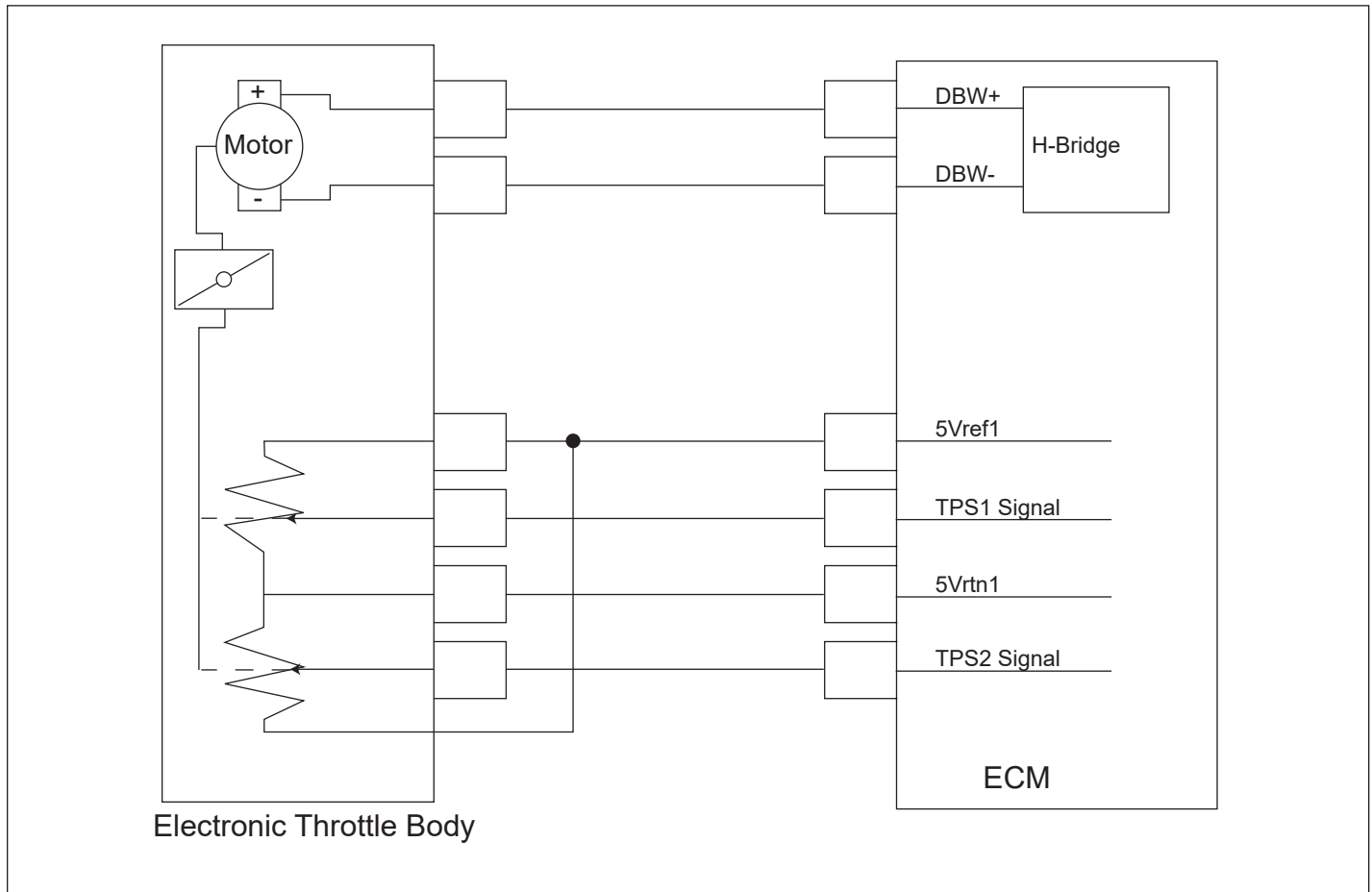
- Check the fuel filters for restrictions. Replace fuel filters as necessary.
- Check for fuel return line restrictions, loose fittings or deteriorated fuel lines. Correct any problems found.
- Check fuel pressure sensor circuit wiring for a bad connection causing an intermittent problem. Correct any problems found.

DTC 1088 - Secondary Fuel Pressure High Pressure SPN - 94; FMI - 0



Diagnostics

DTC 1111 - RPM Above Fuel Rev Limit Level SPN - 515; FMI - 16



- Fuel Rev Limit - Crankshaft Position Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Engine speed greater than the Fuel Rev Limit speed as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable fuel injectors or gaseous fuel control actuator to limit speed. Recommend disabling closed loop and adaptive learn fueling corrections while fault is active
- Non-emissions related fault

This fault will set anytime the engine RPM exceeds the limit set in the diagnostic calibration for the latch time or more. This speed overrides any higher max governor speeds programmed by the user. This fault is designed to help prevent engine or equipment damage and will disable fuel injectors or gaseous fuel actuator to reduce engine speed. The throttle will also be lowered in order to govern the engine to the speed set in the diagnostic calibration for Max Gov Override.

DTC 1111 - RPM Above Fuel Rev Limit Level SPN - 515; FMI - 16

Diagnostic Aids

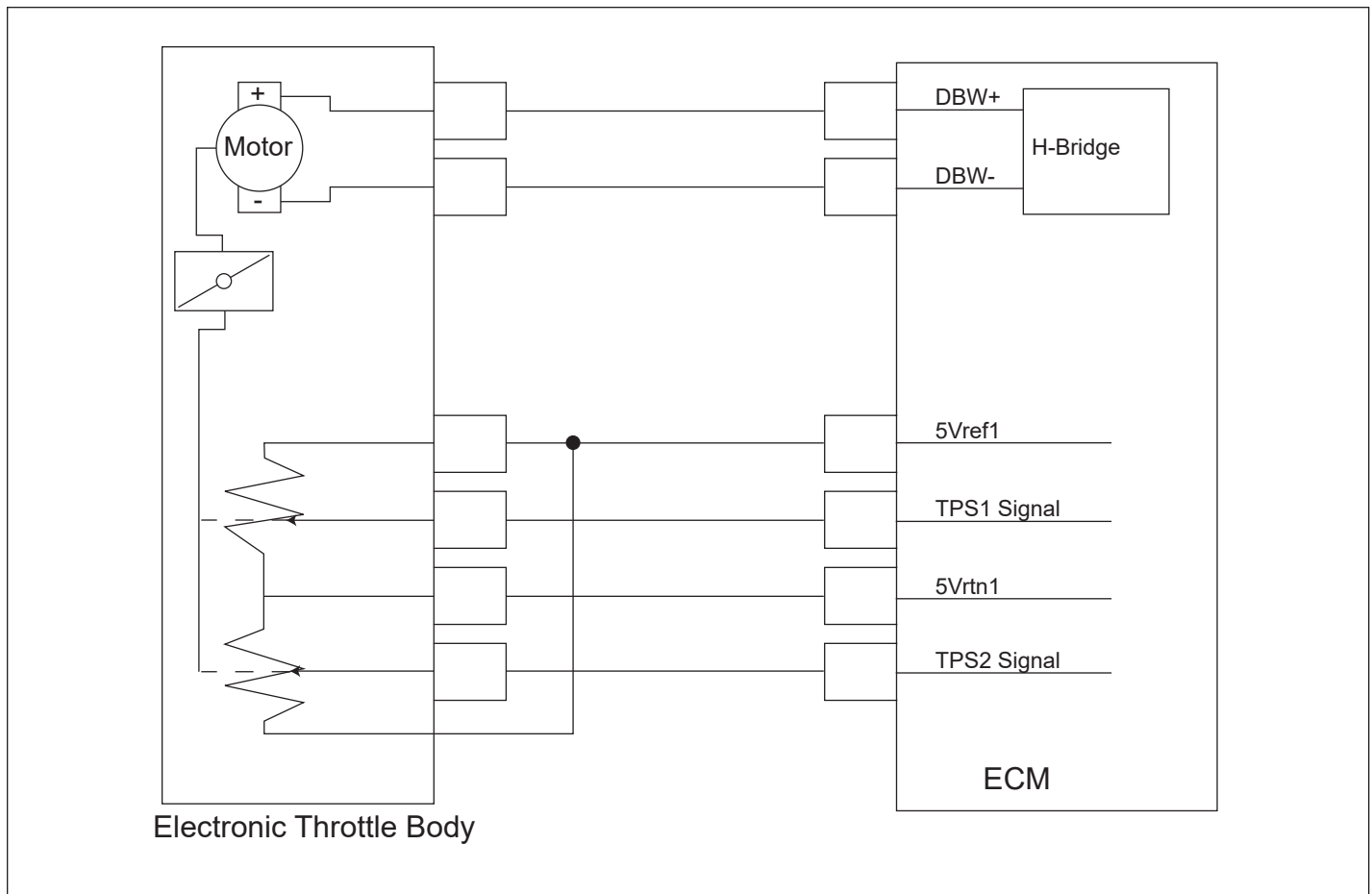
NOTE: If any other DTCs are present, diagnose those first.

- Check mechanical operation of the throttle
- Check the engine intake for large air leaks downstream of the throttle body

Diagnostics

DTC 1112 - RPM Above Spark Rev Limit Level

SPN - 515; FMI - 0



- Spark Rev Limit - Crankshaft Position Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Engine speed greater than the Spark Rev Limit speed as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable ignition coils. Recommend disabling closed loop and adaptive learn fueling corrections while fault is active
- Non-emissions related fault

This fault will set anytime the engine RPM exceeds the limit set in the diagnostic calibration for the latch time or more. This speed overrides any higher max governor speeds programmed by the user. This fault is designed to help prevent engine or equipment damage and will disable the ignition coils to reduce engine speed. In addition, the throttle will be lowered in order to govern the engine to the speed set in the diagnostic calibration for Max Gov Override and the fuel injectors or gaseous fuel control actuator will be disabled to reduce the engine speed below the speed set in the diagnostic calibration for Fuel Rev Limit.

DTC 1112 - RPM Above Spark Rev Limit Level SPN - 515; FMI - 0

Diagnostic Aids

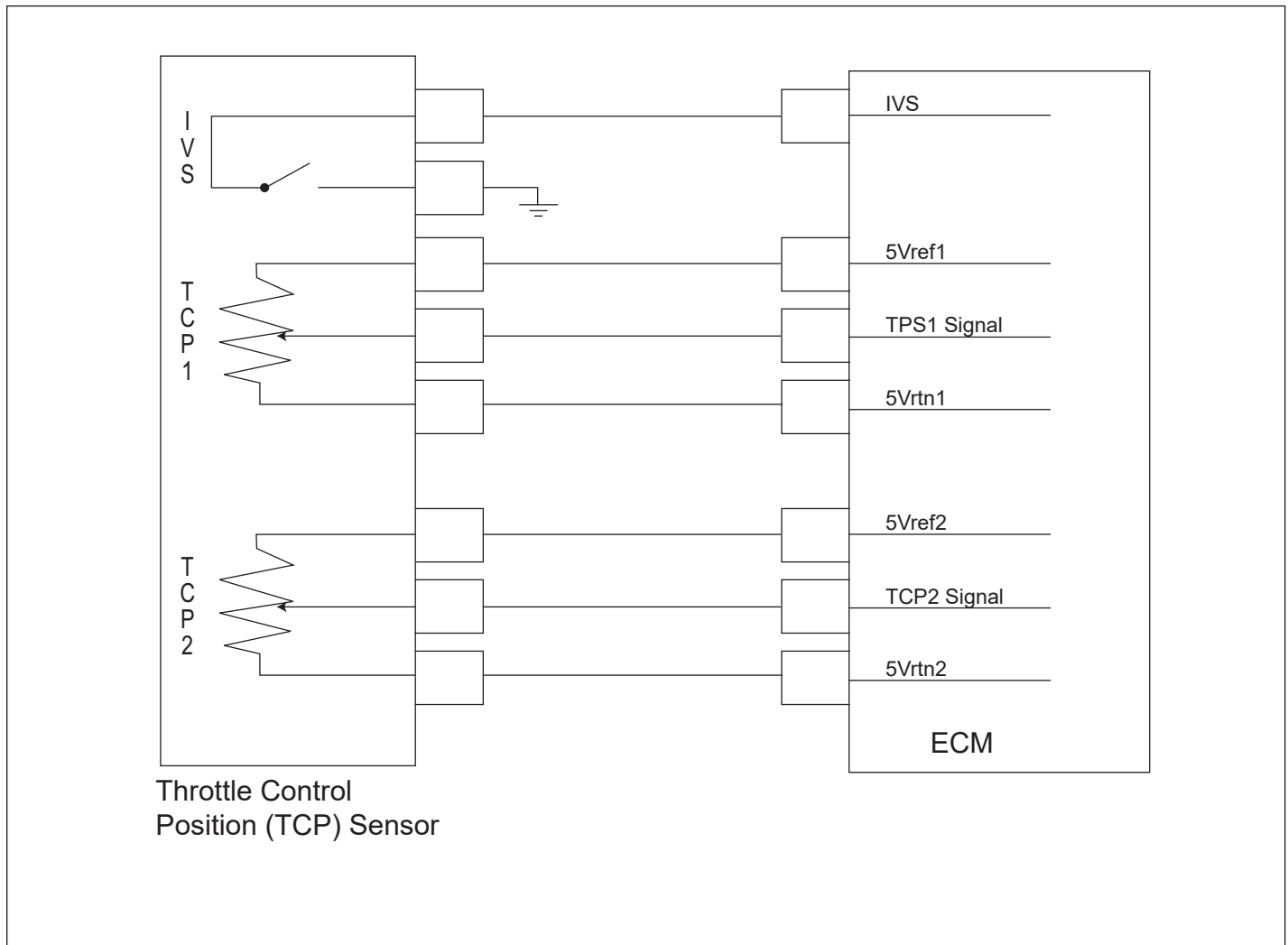
NOTE: If any other DTCs are present, diagnose those first.

- Check mechanical operation of the throttle
- Check the engine intake for large air leaks downstream of the throttle body

Diagnostics

DTC 1121 - TCP1 & TCP2 Simultaneous Voltages Out-of-Range (Redundancy Lost)

SPN - 91; FMI - 31



- Electronic Throttle Control Position (TCP) Sensor
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - TCP1 and TCP2 %'s do not correlate and neither correlate with IVS state
- *Corrective Action(s)* - Illuminate MIL, sound audible warning or illuminate secondary warning lamp, and forced idle
- Non-emissions related fault

The TCP sensor is an electronic device that is coupled to a mechanically driven input as commanded by the vehicle/engine operator. A TCP sensor may be, but is not limited to a foot pedal assembly, a cable-lever-sensor assembly, or a rotary potentiometer. General sensor configurations consist of two potentiometers with IVS. The TCP sensor outputs are proportional to the commanded input. The ECM uses the TCP sensor inputs to control the throttle and adjust the engine's load in order to achieve the requested power. Since the TCP sensor inputs directly affect the engine's power output, redundant sensors are generally used to ensure safe, reliable operation.

This fault is only applicable for dual potentiometer/single IVS sensors and indicates that TCP1 and TCP2 percentages correlate and register an off-idle condition but the IVS state reads at idle throughout the entire operating range.

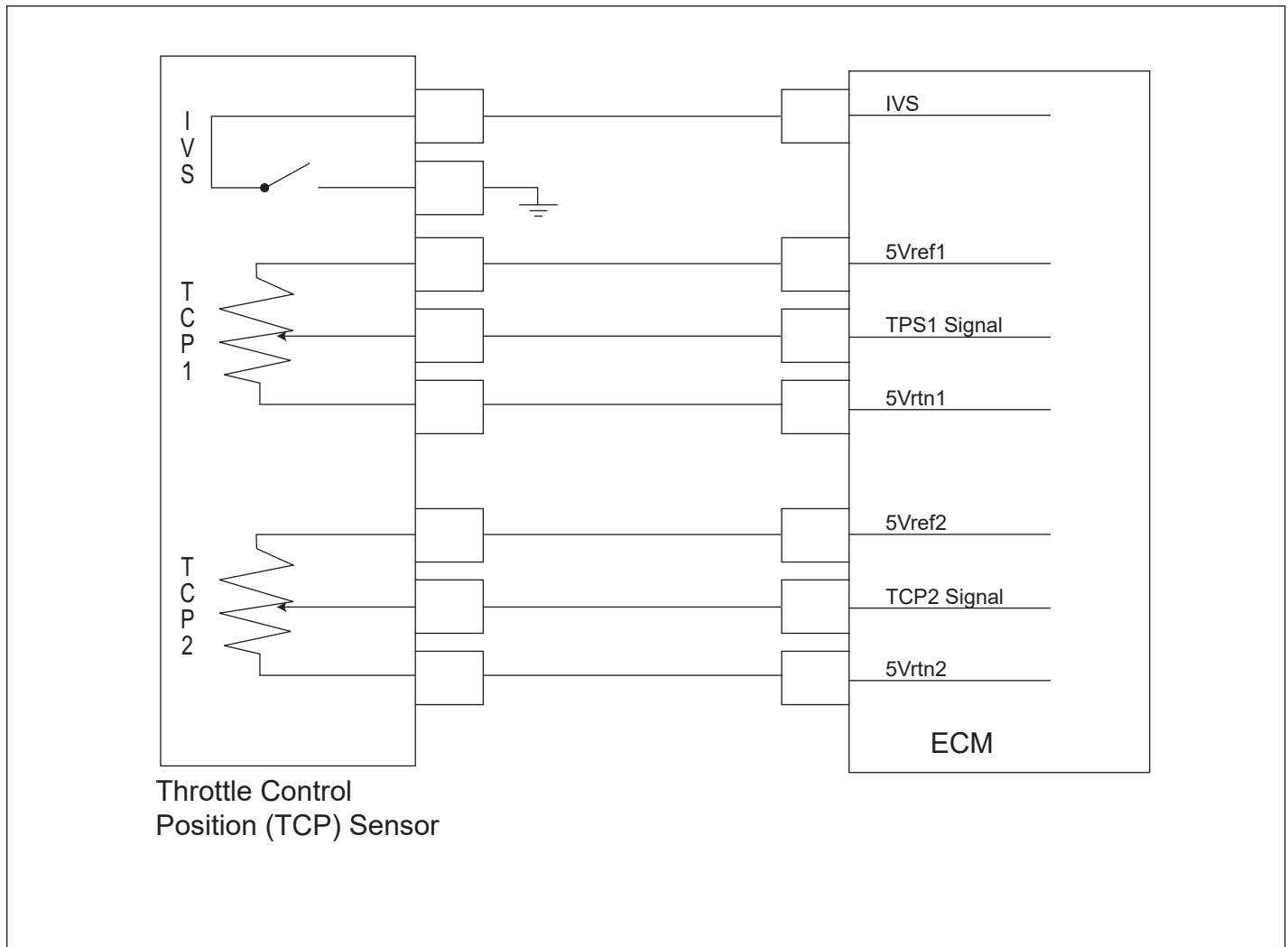
DTC 1121 - TCP1 & TCP2 Simultaneous Voltages Out-of-Range (Redundancy Lost) SPN - 91; FMI - 31

Diagnostic Aids

- **For TCP1 Out-of-Range** - Troubleshoot according to *DTC 2122 TCP1 High Voltage* and *DTC 2123 TCP1 Low Voltage* procedures.
- **For TCP2 Out-of-Range** - Troubleshoot according to *DTC 2127 TCP2 Low Voltage* and *DTC 2128 TCP2 High Voltage* procedures.

Diagnostics

DTC 1122 - TCP1 & TCP2 Do Not Match Each Other or IVS SPN - 520199; FMI - 11



- Electronic foot pedal/throttle control sensor
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - TCP1 and TCP2 %'s do not correlate and neither correlate with IVS state
- *Corrective Action(s)* - Illuminate MIL, sound audible warning or illuminate secondary warning lamp, and forced idle
- Non-emissions related fault

The TCP sensor is an electronic device that is coupled to a mechanically driven input as commanded by the vehicle/engine operator. A TCP sensor may be, but is not limited to a foot pedal assembly, a cable-lever-sensor assembly, or a rotary potentiometer. General sensor configurations consist of single potentiometer with IVS, two potentiometers, or two potentiometers with IVS. The TCP sensor outputs are proportional to the commanded input. The ECM uses the TCP sensor inputs to control the throttle and adjust the engine's load in order to achieve the requested power. Since the TCP sensor inputs directly affect the engine's power output, redundant sensors are generally used to ensure safe, reliable operation.

This fault is only applicable for dual potentiometer/single IVS sensors and indicates that TCP1 and TCP2 percentages do not correlate with each other and neither of the two potentiometers correlate with the IVS.

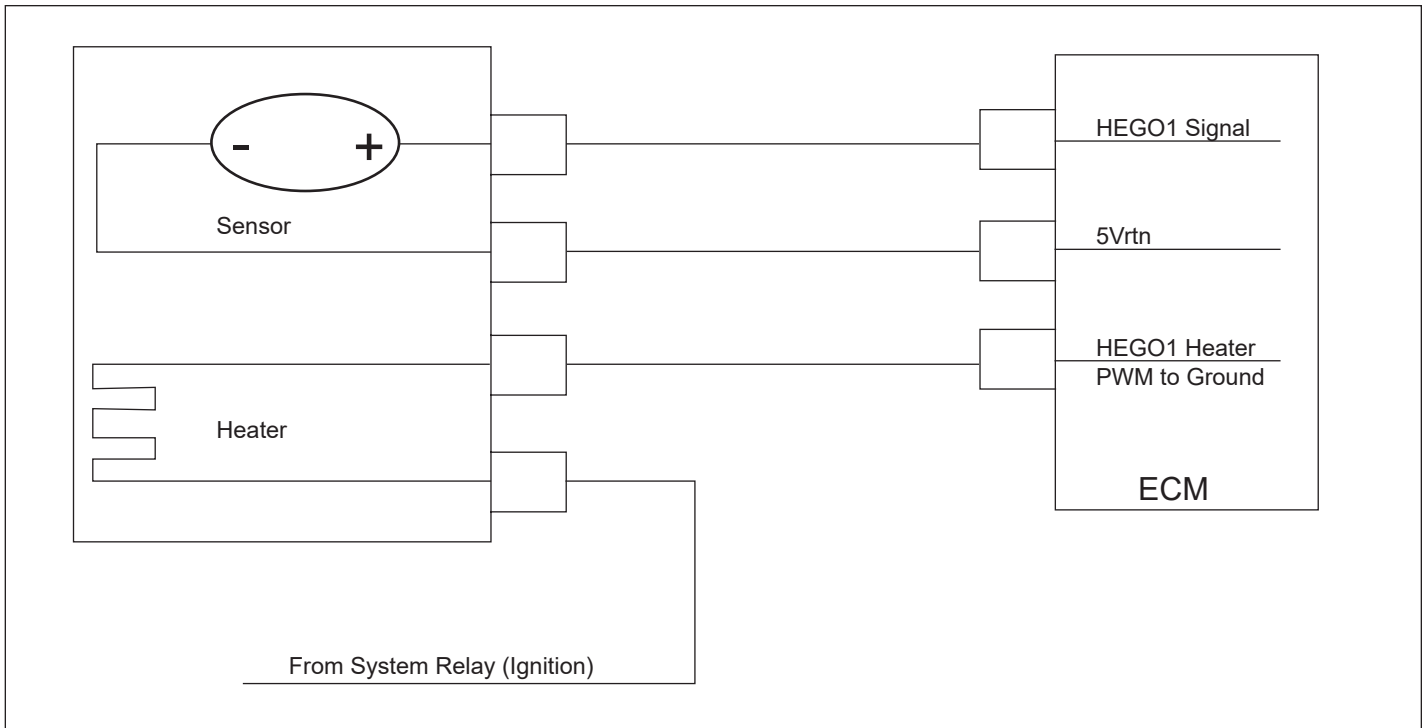
DTC 1122 - FPP1 & FPP2 Do Not Match Each Other or IVS SPN - 520199; FMI - 11

Diagnostic Aids

- **For TCP1 and TCP2 Do Not Match** - Troubleshoot according to *DTC 2121 TCP1 Lower Than TCP2* and *DTC 2126 TCP1 Higher Than TCP2* procedures.
- **For TCP1 and TCP2 Do Not Match IVS** - Troubleshoot according to *DTC 2115 TCP1 Higher Than IVS Limit* and *DTC 2116 TCP2 Higher Than IVS Limits* procedures.

Diagnostics

DTC 1155 - Closed Loop Bank 1 High SPN - 4236; FMI - 0



- Heated Exhaust Gas Oxygen Sensor (Bank 1-Sensor 1/Bank 1-Before Catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Bank 1 closed loop fuel multiplier higher than defined in diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and possibly disable closed-loop fueling correction during active fault.
- Emissions related fault

The HEGO sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either “CL Active” or “CL + Adapt” control modes. The purpose of the closed loop fuel multiplier is to quickly adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation prior to adaptive learn fueling correction “learning” the fueling deviation.

This fault sets if the closed loop multiplier exceeds the high limit of normal operation indicating that the engine is operating lean (excess oxygen) and requires more fuel than allowed by corrections. Often high positive fueling corrections are a function of one or more of the following conditions: 1) exhaust leaks upstream or near the HEGO sensor, 2) reduced fuel supply pressure to the fuel injection system, 3) a non-responsive HEGO sensor, and/or 3) an injector that is stuck closed.

DTC 1155 - Closed Loop Bank 1 High

SPN - 4236; FMI - 0

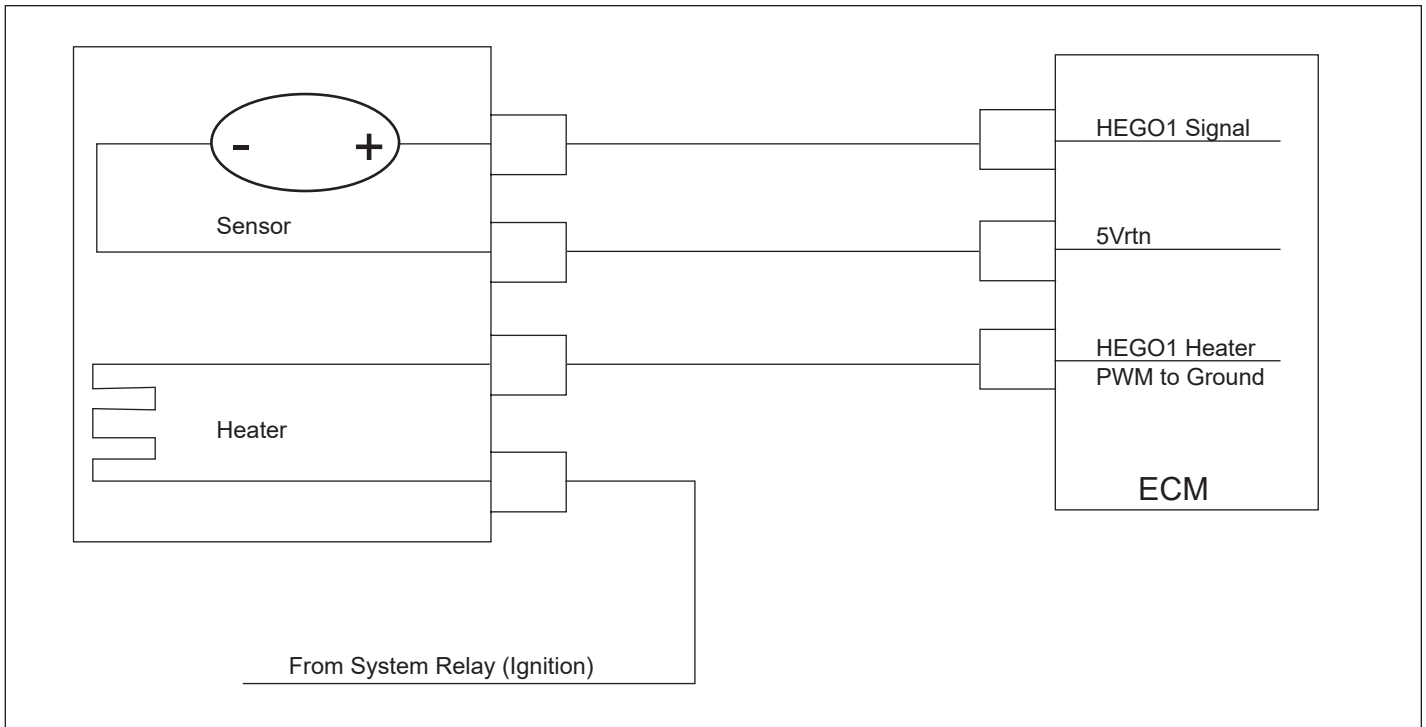
Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- Vacuum Leaks - Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at light load.
- Injectors - System will be lean if an injector driver or driver circuit fails. The system will also be lean if an injector fails in a closed manner or is dirty.
- Fuel Pressure - System will be lean if fuel pressure is too low. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- Air in Fuel - If the fuel return hose/line is too close to the fuel supply pickup in the fuel tank, air may become entrapped in the pump or supply line causing a lean condition and driveability problems.
- Exhaust Leaks - If there is an exhaust leak, outside air can be pulled into the exhaust and past the O2 sensor causing a false lean condition.
- Fuel Quality - A drastic variation in fuel quality may cause the system to be lean including oxygenated fuels.
- System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- If all tests are OK, replace the HO2S sensor with a known good part and retest.

Diagnostics

DTC 1156 - Closed Loop Bank 1 Low SPN - 4236; FMI - 1



- Heated Exhaust Gas Oxygen Sensor (Bank 1-Sensor 1/Bank 1-Before Catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Bank 1 closed loop fuel multiplier lower than defined in diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and possibly disable closed-loop fueling correction during active fault .
- Emissions related fault

The HEGO sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either “CL Active” or “CL + Adapt” control modes. The purpose of the closed loop fuel multiplier is to quickly adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation prior to adaptive learn fueling correction “learning” the fueling deviation.

This fault sets if the closed loop multiplier exceeds the low limit of normal operation indicating that the engine is operating rich (excess fuel) and requires less fuel than allowed by corrections. Often high negative fueling corrections are a function of one or more of the following conditions: 1) high fuel supply pressure to the fuel injection system, 2) a non-responsive HEGO sensor, and/or 3) an injector that is stuck open.

DTC 1156 - Closed Loop Bank 1 Low SPN - 4236; FMI - 1

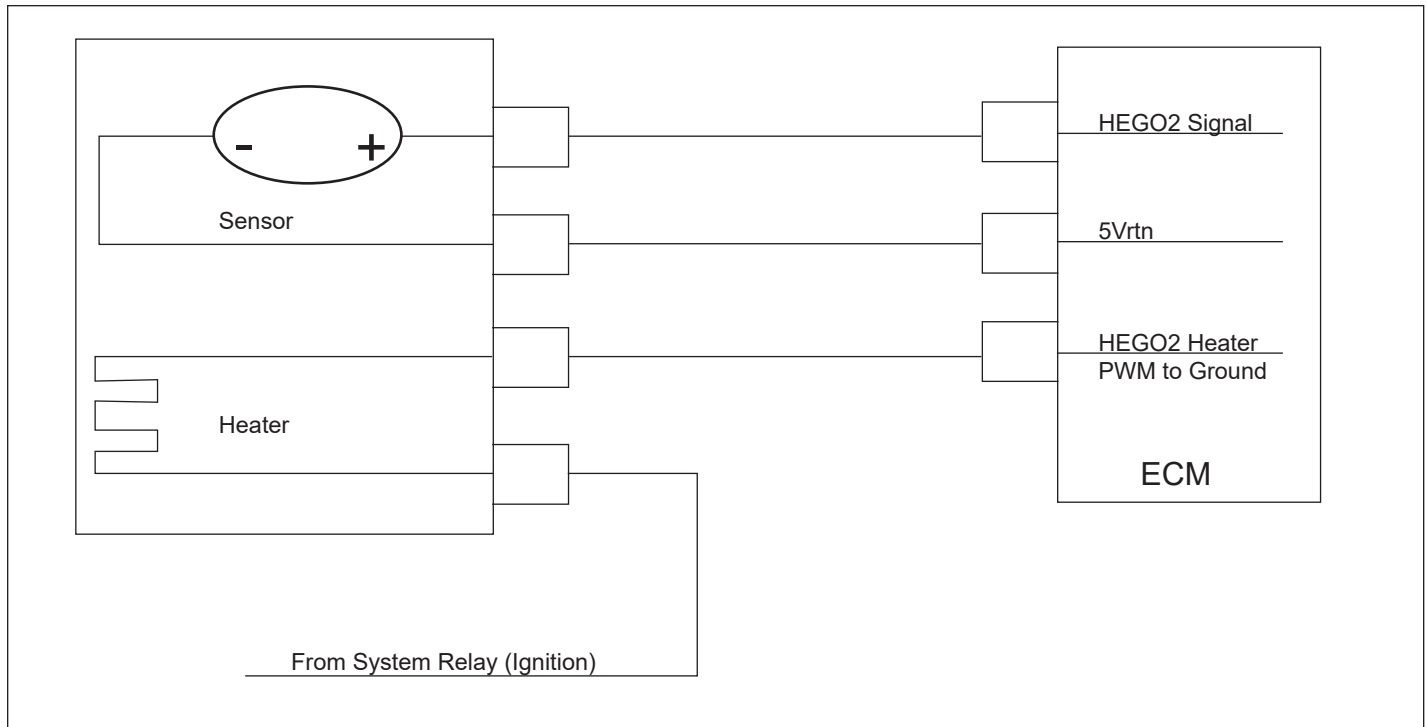
Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- Injectors - System will be rich if an injector driver or driver circuit fails shorted-to-ground. The system will also be rich if an injector fails in an open.
- Fuel Pressure - System will be rich if fuel pressure is too high. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- If all tests are OK, replace the HO2S sensor with a known good part and retest.

Diagnostics

DTC 1157 - Closed Loop Bank 2 High SPN - 4238; FMI - 0



- Heated Exhaust Gas Oxygen Sensor (Bank 2-Sensor 1/Bank 2-Before Catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Bank 2 closed loop fuel multiplier higher than defined in diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and possibly disable closed-loop fueling correction during active fault.
- Emissions related fault

The HEGO sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either “CL Active” or “CL + Adapt” control modes. The purpose of the closed loop fuel multiplier is to quickly adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation prior to adaptive learn fueling correction “learning” the fueling deviation.

This fault sets if the closed loop multiplier exceeds the high limit of normal operation indicating that the engine is operating lean (excess oxygen) and requires more fuel than allowed by corrections. Often high positive fueling corrections are a function of one or more of the following conditions: 1) exhaust leaks upstream or near the HEGO sensor, 2) reduced fuel supply pressure to the fuel injection system, 3) a non-responsive HEGO sensor, and/or 3) an injector that is stuck closed.

DTC 1157 - Closed Loop Bank 2 High

SPN - 4238; FMI - 0

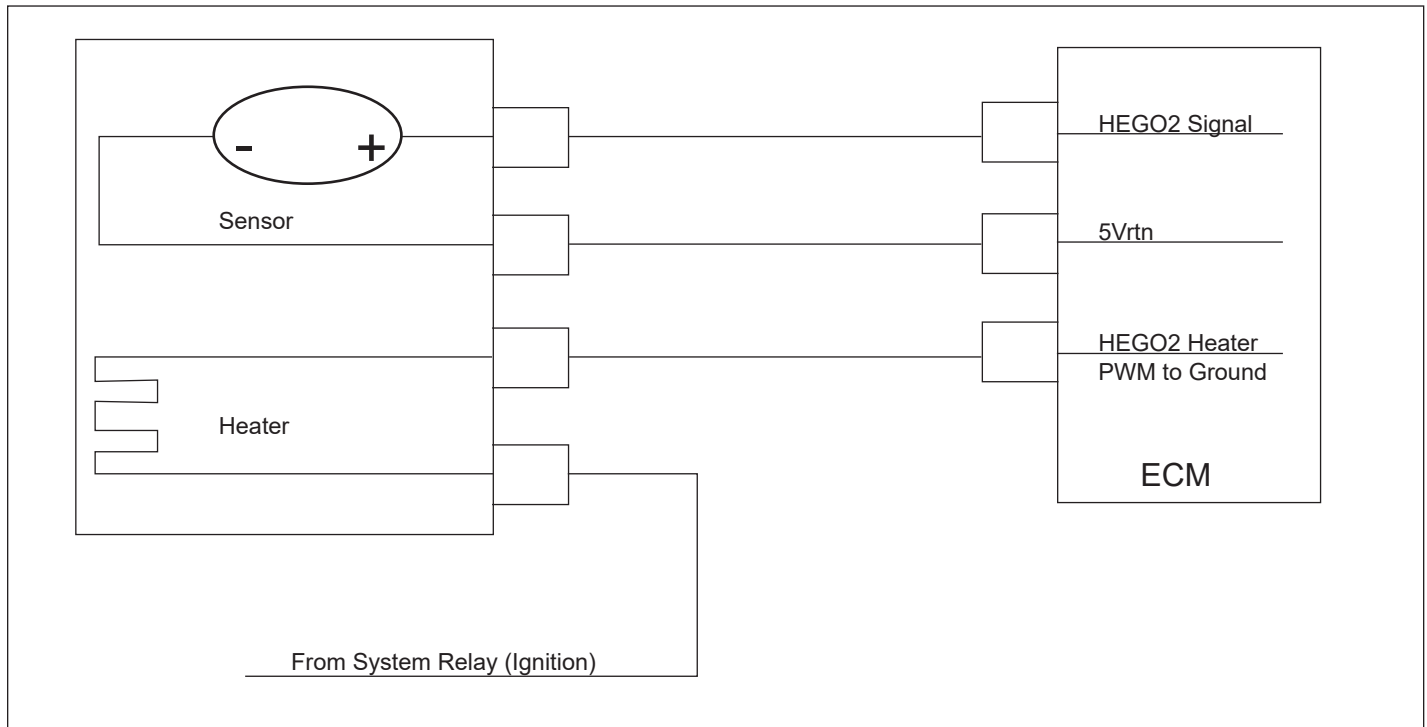
Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- Vacuum Leaks - Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at light load.
- Injectors - System will be lean if an injector driver or driver circuit fails. The system will also be lean if an injector fails in a closed manner or is dirty.
- Fuel Pressure - System will be lean if fuel pressure is too low. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- Air in Fuel - If the fuel return hose/line is too close to the fuel supply pickup in the fuel tank, air may become entrapped in the pump or supply line causing a lean condition and driveability problems.
- Exhaust Leaks - If there is an exhaust leak, outside air can be pulled into the exhaust and past the O2 sensor causing a false lean condition.
- Fuel Quality - A drastic variation in fuel quality may cause the system to be lean including oxygenated fuels.
- System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- If all tests are OK, replace the HO2S sensor with a known good part and retest.

Diagnostics

DTC 1158 - Closed Loop Bank 2 Low SPN - 4238; FMI - 1



- Heated Exhaust Gas Oxygen Sensor (Bank 2-Sensor 1/Bank 2-Before Catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Bank 2 closed loop fuel multiplier lower than defined in diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and possibly disable closed-loop fueling correction during active fault .
- Emissions related fault

The HEGO sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then “learned” with the Adaptive multiplier. The multipliers only update when the system is in either “CL Active” or “CL + Adapt” control modes. The purpose of the closed loop fuel multiplier is to quickly adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation prior to adaptive learn fueling correction “learning” the fueling deviation.

This fault sets if the closed loop multiplier exceeds the low limit of normal operation indicating that the engine is operating rich (excess fuel) and requires less fuel than allowed by corrections. Often high negative fueling corrections are a function of one or more of the following conditions: 1) high fuel supply pressure to the fuel injection system, 2) a non-responsive HEGO sensor, and/or 3) an injector that is stuck open.

DTC 1158 - Closed Loop Bank 2 Low SPN - 4238; FMI - 1

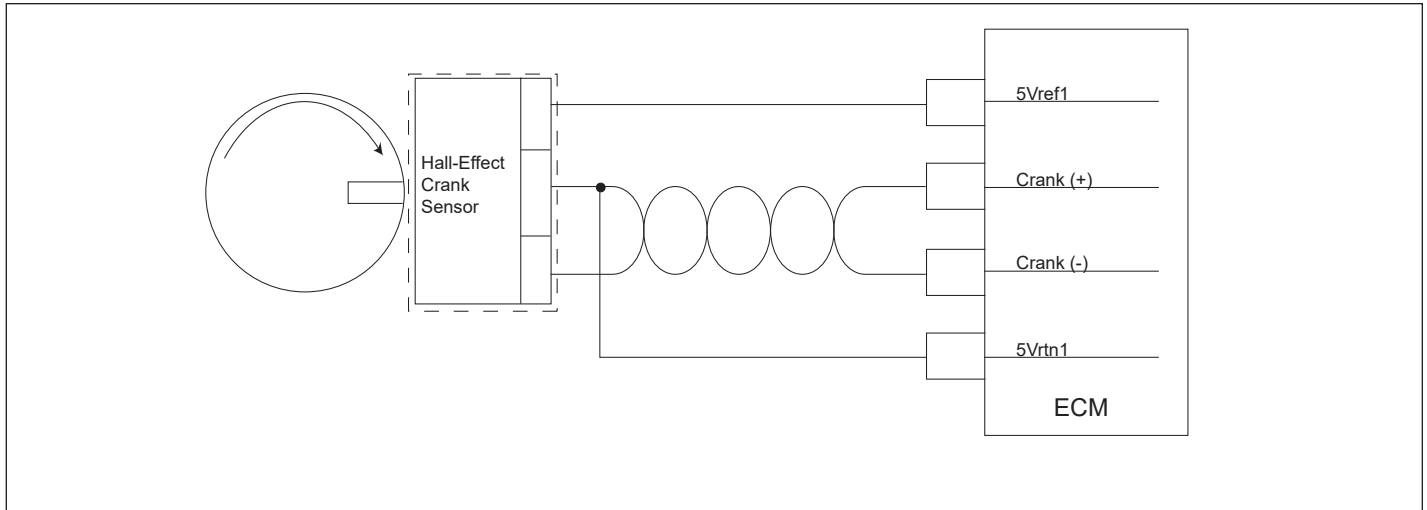
Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- Injectors - System will be rich if an injector driver or driver circuit fails shorted-to-ground. The system will also be rich if an injector fails in an open.
- Fuel Pressure - System will be rich if fuel pressure is too high. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- If all tests are OK, replace the HO2S sensor with a known good part and retest.

Diagnostics

DTC 1311 - Misfire Detected Cylinder #1 SPN - 1323; FMI - 11



- Cylinder #1 Misfire Detected - Driveability/Performance
- *Check Condition* - Key On, Engine Running
- *Fault Condition* - Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in poor driveability but not necessarily catalyst damage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that bank's aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

- 1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
- 2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

DTC 1311 - Misfire Detected Cylinder #1

SPN - 1323; FMI - 11

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

Diagnostic Aids

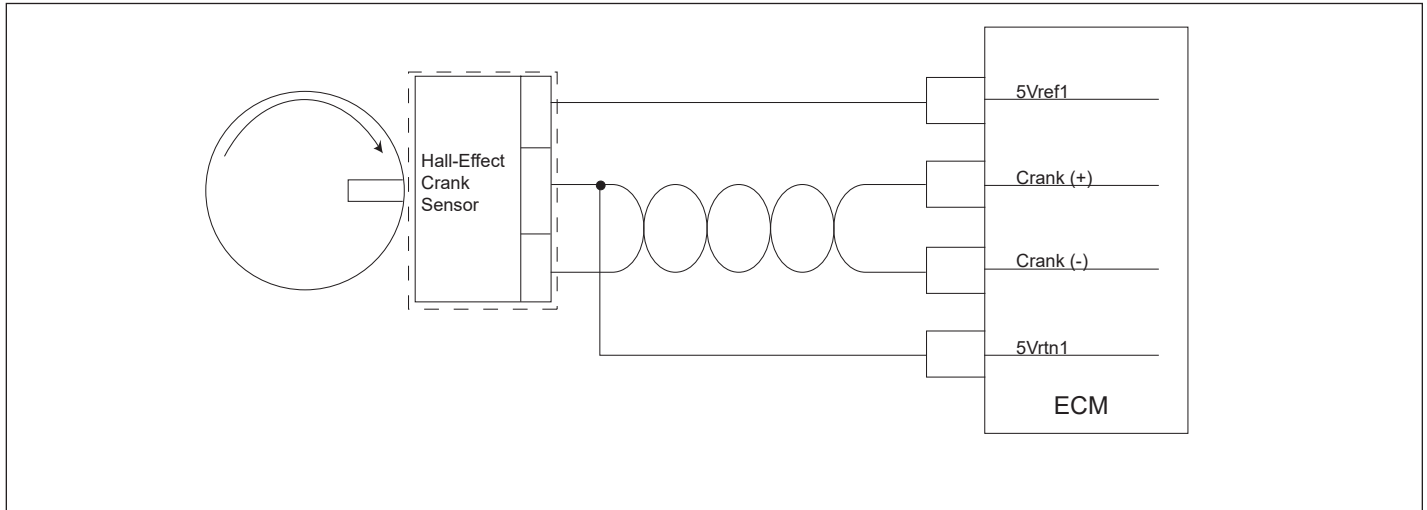
NOTE: If any other DTCs are present, diagnose those first.

- ❑ Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- ❑ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ❑ Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
- ❑ Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
- ❑ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ❑ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ❑ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

Diagnostics

DTC 1312 - Misfire Detected Cylinder #2

SPN - 1324; FMI - 11



- Cylinder #2 Misfire Detected - Driveability/Performance
- *Check Condition* - Key On, Engine Running
- *Fault Condition* - Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in poor driveability but not necessarily catalyst damage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that bank's aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

- 1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
- 2) Emissions are higher than allowed by legislation due to the presence of misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

DTC 1312 - Misfire Detected Cylinder #2 SPN - 1324; FMI - 11

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

Diagnostic Aids

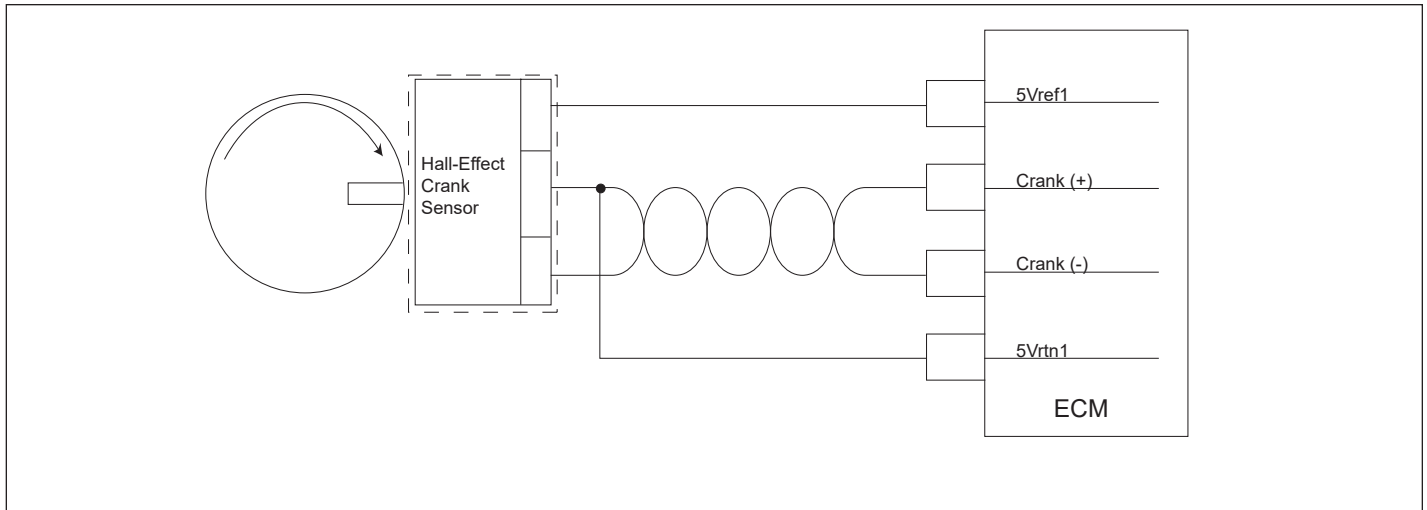
NOTE: If any other DTCs are present, diagnose those first.

- ❑ Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- ❑ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ❑ Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
- ❑ Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
- ❑ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ❑ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ❑ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

Diagnostics

DTC 1313 - Misfire Detected Cylinder #3

SPN - 1325; FMI - 11



- Cylinder #3 Misfire Detected - Driveability/Performance
- *Check Condition* - Key On, Engine Running
- *Fault Condition* - Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in poor driveability but not necessarily catalyst damage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that bank's aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

- 1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
- 2) Emissions are higher than allowed by legislation due to the presence of misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

DTC 1313 - Misfire Detected Cylinder #3

SPN - 1325; FMI - 11

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

Diagnostic Aids

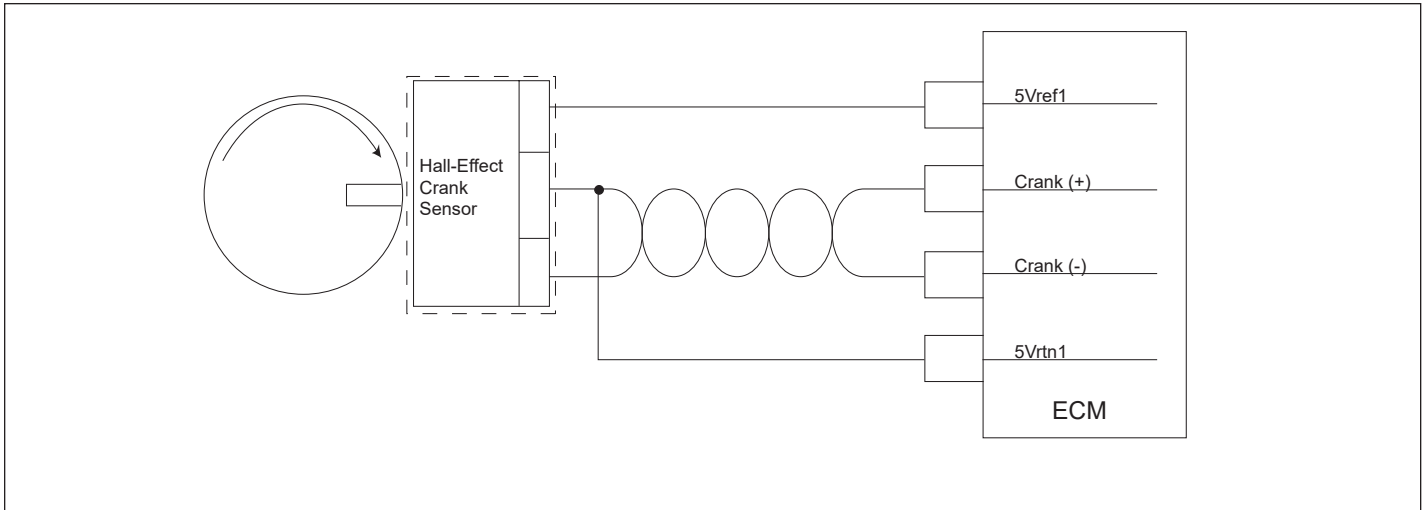
NOTE: If any other DTCs are present, diagnose those first.

- ❑ Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- ❑ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ❑ Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
- ❑ Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
- ❑ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ❑ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ❑ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

Diagnostics

DTC 1314 - Misfire Detected Cylinder #4

SPN - 1326; FMI - 11



- Cylinder #4 Misfire Detected - Driveability/Performance
- *Check Condition* - Key On, Engine Running
- *Fault Condition* - Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in poor driveability but not necessarily catalyst damage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that bank's aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

- 1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
- 2) Emissions are higher than allowed by legislation due to the presence of misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

DTC 1314 - Misfire Detected Cylinder #4 SPN - 1326; FMI - 11

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

Diagnostic Aids

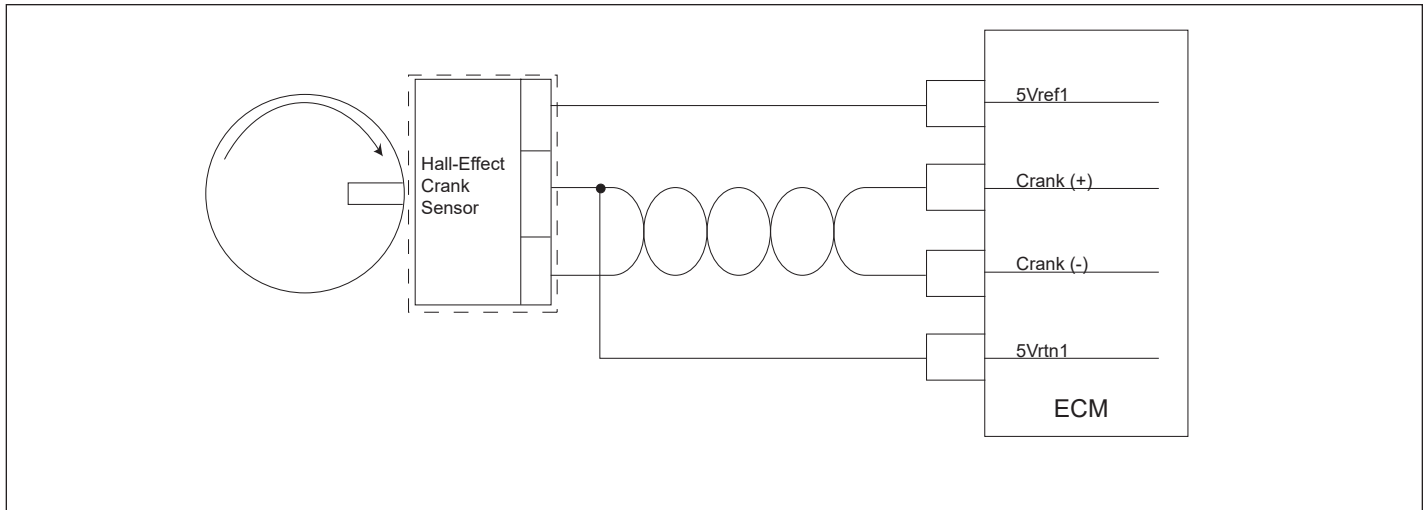
NOTE: If any other DTCs are present, diagnose those first.

- ❑ Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- ❑ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ❑ Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
- ❑ Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
- ❑ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ❑ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ❑ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

Diagnostics

DTC 1315 - Misfire Detected Cylinder #5

SPN - 1327; FMI - 11



- Cylinder #5 Misfire Detected - Driveability/Performance
- *Check Condition* - Key On, Engine Running
- *Fault Condition* - Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in poor driveability but not necessarily catalyst damage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that bank's aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

- 1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
- 2) Emissions are higher than allowed by legislation due to the presence of misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

DTC 1315 - Misfire Detected Cylinder #5**SPN - 1327; FMI - 11**

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

Diagnostic Aids

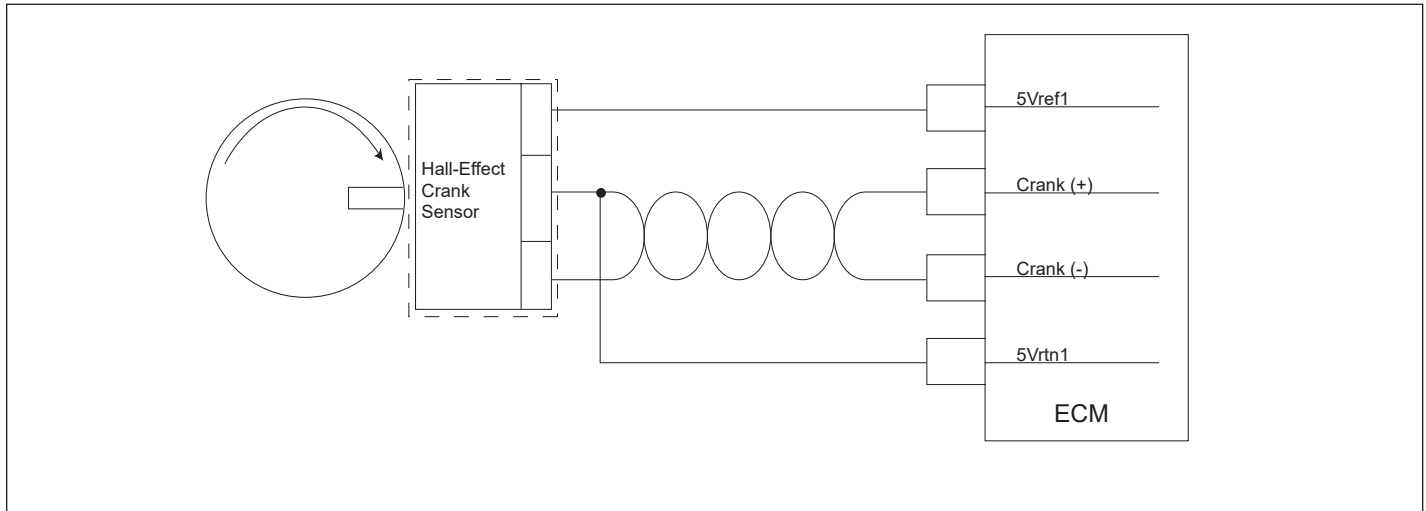
NOTE: If any other DTCs are present, diagnose those first.

- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
- Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
- Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

Diagnostics

DTC 1316 - Misfire Detected Cylinder #6

SPN - 1328; FMI - 11



- Cylinder #6 Misfire Detected - Driveability/Performance
- *Check Condition* - Key On, Engine Running
- *Fault Condition* - Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in poor driveability but not necessarily catalyst damage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that bank's aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

- 1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
- 2) Emissions are higher than allowed by legislation due to the presence of misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

DTC 1316 - Misfire Detected Cylinder #6
SPN - 1328; FMI - 11

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

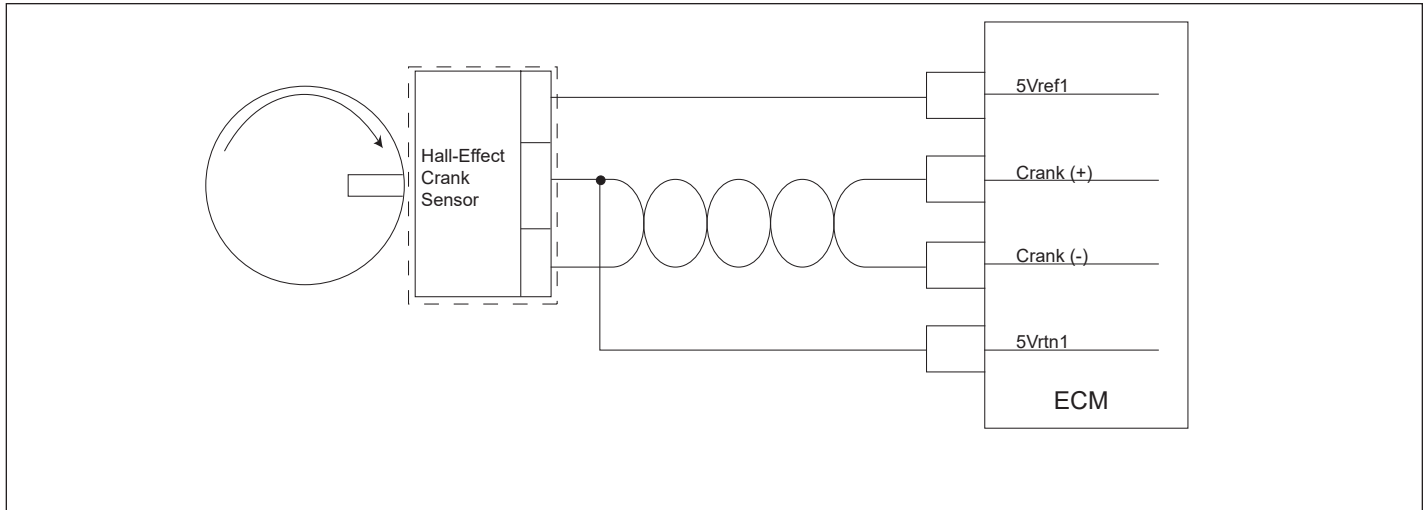
Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
- Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
- Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

Diagnostics

DTC 1317 - Misfire Detected Cylinder #7 SPN - 1329; FMI - 11



- Cylinder #7 Misfire Detected - Driveability/Performance
- *Check Condition* - Key On, Engine Running
- *Fault Condition* - Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in poor driveability but not necessarily catalyst damage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that bank's aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

- 1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
- 2) Emissions are higher than allowed by legislation due to the presence or misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

DTC 1317 - Misfire Detected Cylinder #7

SPN - 1329; FMI - 11

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

Diagnostic Aids

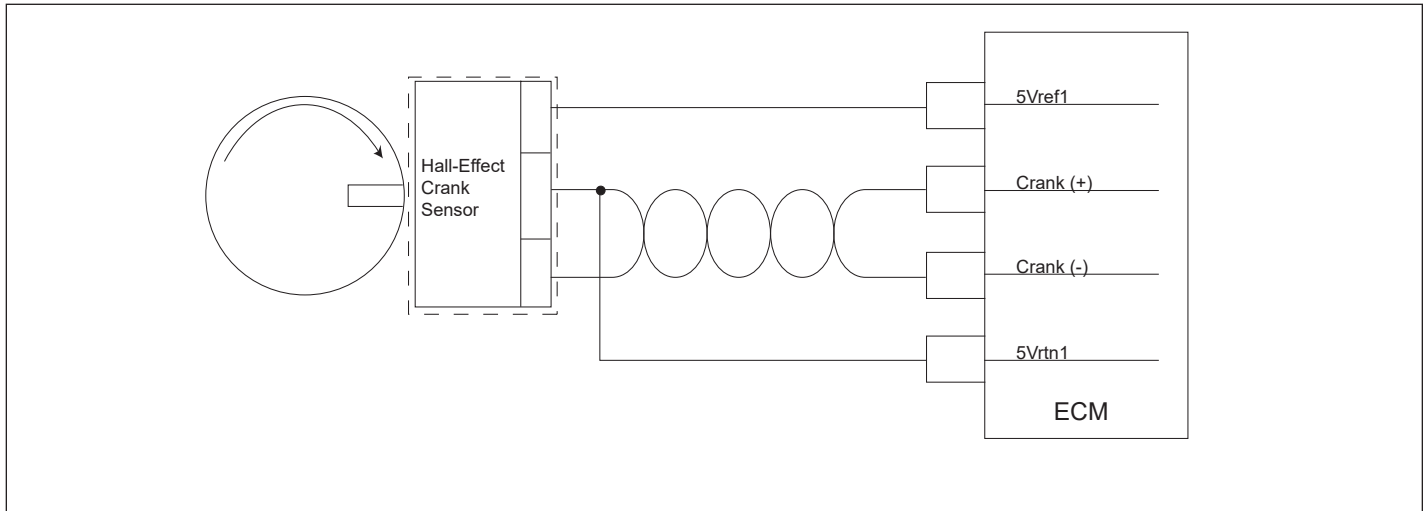
NOTE: If any other DTCs are present, diagnose those first.

- ❑ Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- ❑ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ❑ Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
- ❑ Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
- ❑ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ❑ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ❑ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

Diagnostics

DTC 1318 - Misfire Detected Cylinder #8

SPN - 1330; FMI - 11



- Cylinder #8 Misfire Detected - Driveability/Performance
- *Check Condition* - Key On, Engine Running
- *Fault Condition* - Misfire occurrences higher than allowed for each operating condition calibrated at a level that can result in poor driveability but not necessarily catalyst damage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction for key-cycle, and disable closed-loop fueling correction during active fault.
- Emissions related fault

The ECU is capable of detecting combustion misfire for certain crank-cam software modules. The ECU continuously monitors changes in crankshaft angular velocity, comparing acceleration rates on a cycle-to-cycle basis and determining if a given cylinder's rate of change is abnormal compared to other cylinders. This method of detection is better known as Instant Crank Angle Velocity (ICAV).

Misfire is of concern for four main reasons: 1) damage can occur to aftertreatment systems due to the presence of unburned fuel and oxygen causing chemical reactions resulting in extremely high temperatures causing irreversible damage to catalytic coatings and/or substrates, 2) exhaust emissions increase during misfiring, 3) the engine's driveability suffers due to inconsistent operation, and 4) fuel economy suffers due to the need for higher power operating conditions to achieve the same brake torque. The GCP has two stages of misfire faults 1) emissions/catalyst damaging misfire detected and 2) driveability or general misfire detected.

Emissions/catalyst misfire is generally thought of as a per "bank" fault as multiple cylinders misfiring on the same bank cumulatively add unburned fuel and oxygen to that bank's aftertreatment device(s). The catalyst/emissions fault is configured to set based on one or both of the following conditions:

- 1) Aftertreatment temperatures experienced during this level of misfire are high enough to cause permanent damage to emission control components
- 2) Emissions are higher than allowed by legislation due to the presence of misfire.

Therefore, if two cylinders misfire on the same bank together they both may set the misfire fault even if neither cylinder individually exceeds the catalyst/misfire threshold.

Typically the driveability level is calibrated to set prior to the emissions/catalyst level if a two stage fault is desired. This fault would set to notify the user of a problem prior to it causing damage to the exhaust aftertreatment system.

DTC 1318 - Misfire Detected Cylinder #8

SPN - 1330; FMI - 11

Misfire is typically a result of one or more factors. These factors can include but may not be limited to: 1) a fouled or damaged spark plug(s), 2) a damaged or defective ignition coil(s) or coil wire(s) resulting in weak spark generation, 3) a plugged or contaminated injector(s) that intermittently sticks closed resulting in a lean cylinder charge, 4) an injector(s) that is stuck open causing an uncontrolled rich cylinder charge, 5) low fuel supply pressure resulting in multiple lean cylinders, 6) low cylinder compression due to a failed or worn piston ring(s) or non-seating valve(s) can result in a low cylinder pressure charge that may not be ignited, and 7) an exhaust leak in close proximity to an exhaust valve permitting uncontrolled amounts of oxygen to be drawn into a cylinder generating an excessively lean charge either directly resulting in misfire or possibly causing excessive combustion temperatures resulting in burned valves and loss of compression. Misfire can be difficult to correct as it may be a function of one or more of the conditions mentioned above and may require checking and/or changing several components for each cylinder or cylinders affected.

This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

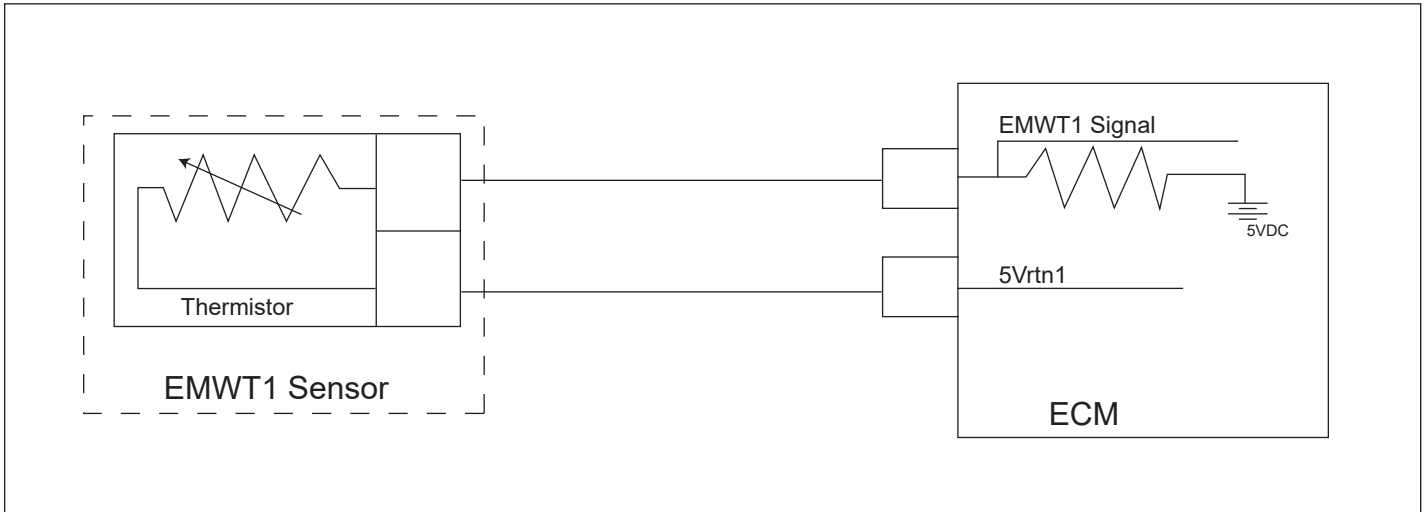
Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- ❑ Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- ❑ Oil Level- Many engines have valve trains that utilize lifters that are hydraulically actuated and require specific levels of oil to maintain proper pressure for lifter actuation. If the engine has improper oil, insufficient oil level, or has too much oil the hydraulic lifters may not function as intended causing changes in valve lift and timing. As a result, incomplete combustion may occur as a result of oil problems. Check engine oil level and oil type according to manufacture maintenance procedures.
- ❑ Spark Plug(s) – Check for fouled or damaged spark plugs. Replace and regap according to manufacture recommended procedure(s).
- ❑ Spark Plug Wire(s) – Check that spark plug wire is properly connected to ignition coil and spark plug. If equipped, ensure that spark plug terminal nut is tight to plug and that there is not substantial wear on nut. Check for cracks in insulation of spark plug wire or boot. Replace spark plug wire(s) if deemed necessary according to manufacture recommended procedure(s).
- ❑ Fuel Pressure – Check fuel rail pressure at key-on/engine-off or with External Power-All On test running. Monitor fuel rail pressure when key is turned off to determine if fuel pressure bleeds down too quickly. Run an injector fire test on a couple of injectors to monitor the pressure drop in the rail for each injector. If an injector appears to flow inconsistent compared to others, replace and retest.
- ❑ Cylinder Check – Run a compression test and cylinder leak test on suspected cylinder(s) to check mechanical integrity of piston rings and valve seats.
- ❑ Exhaust Leak – Pressurize exhaust system with 1-2 psig of air and check for pressure leaks around exhaust manifold gasket and pre-catalyst EGO sensor. Replace gasket(s) and tighten fasteners according to manufacture recommended procedure(s).

Diagnostics

DTC 1411 - Exhaust Manifold Water Temperature (EMWT) Sensor 1 Voltage High SPN - 441; FMI - 3

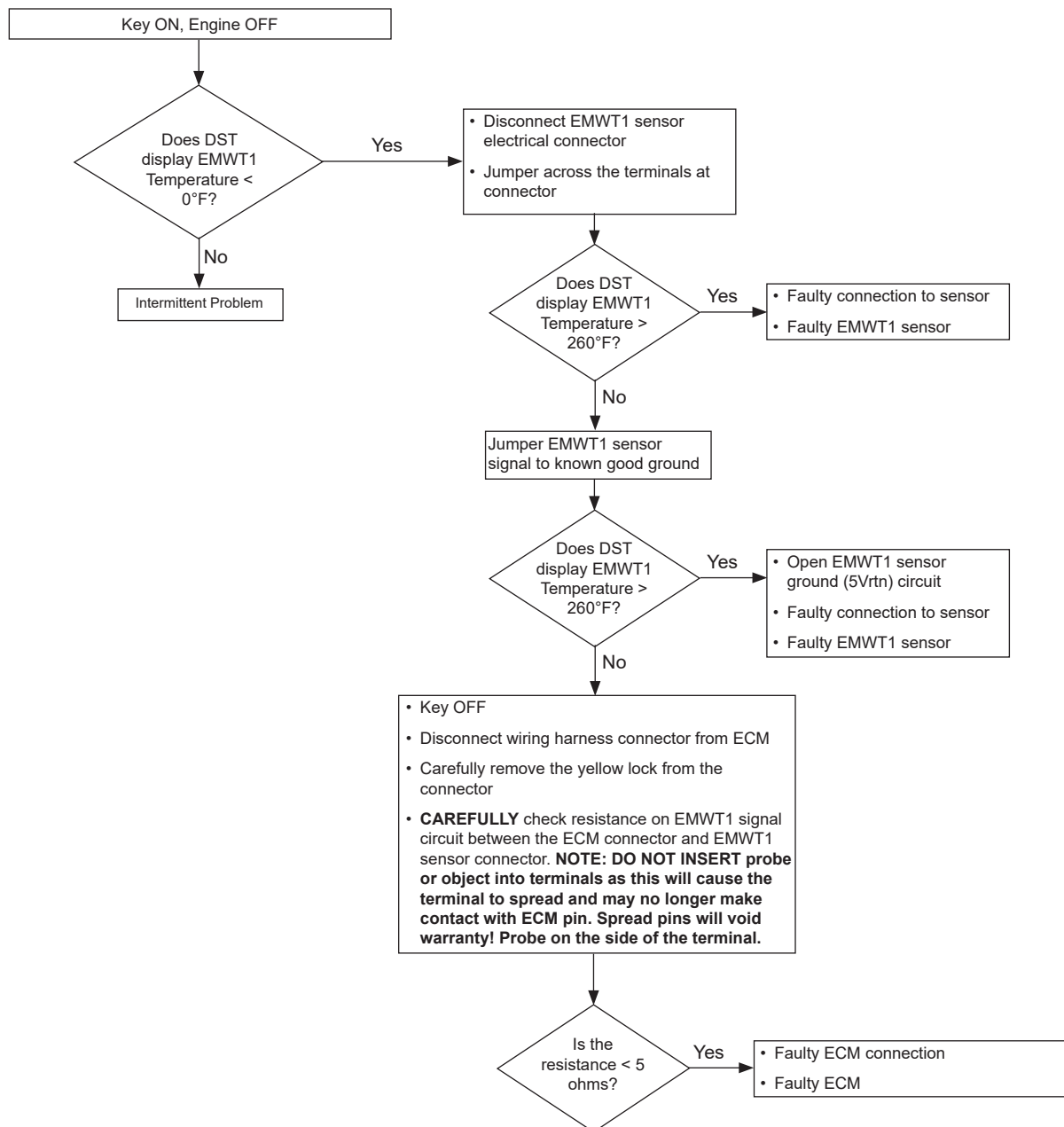


- Exhaust Manifold Water Temperature (EMWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - EMWT1 sensor voltage higher than the limit defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to the inability to sense temperature.
- Non-emissions related fault

The EMWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

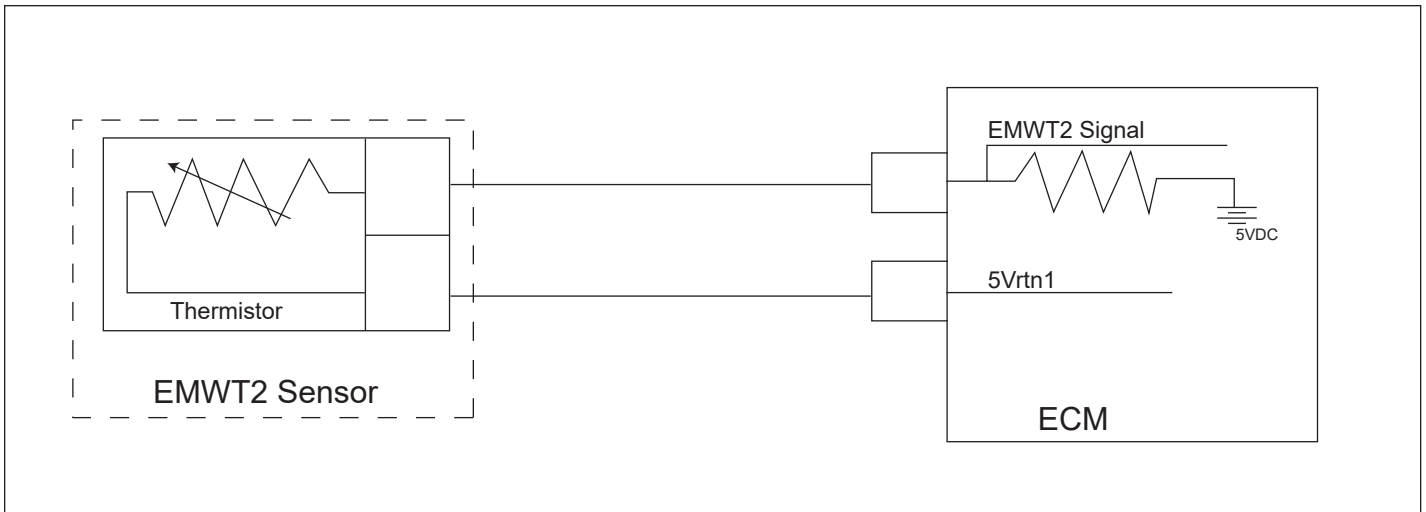
This fault will set if the signal voltage is higher than the high voltage limit as defined in the diagnostic calibration anytime the engine is running. The limit is generally set to 4.90 VDC.

DTC 1411 - Exhaust Manifold Water Temperature (EMWT) Sensor 1 Voltage High SPN - 441; FMI - 3



Diagnostics

DTC 1412 - Exhaust Manifold Water Temperature (EMWT) Sensor 2 Voltage High SPN - 442; FMI - 3

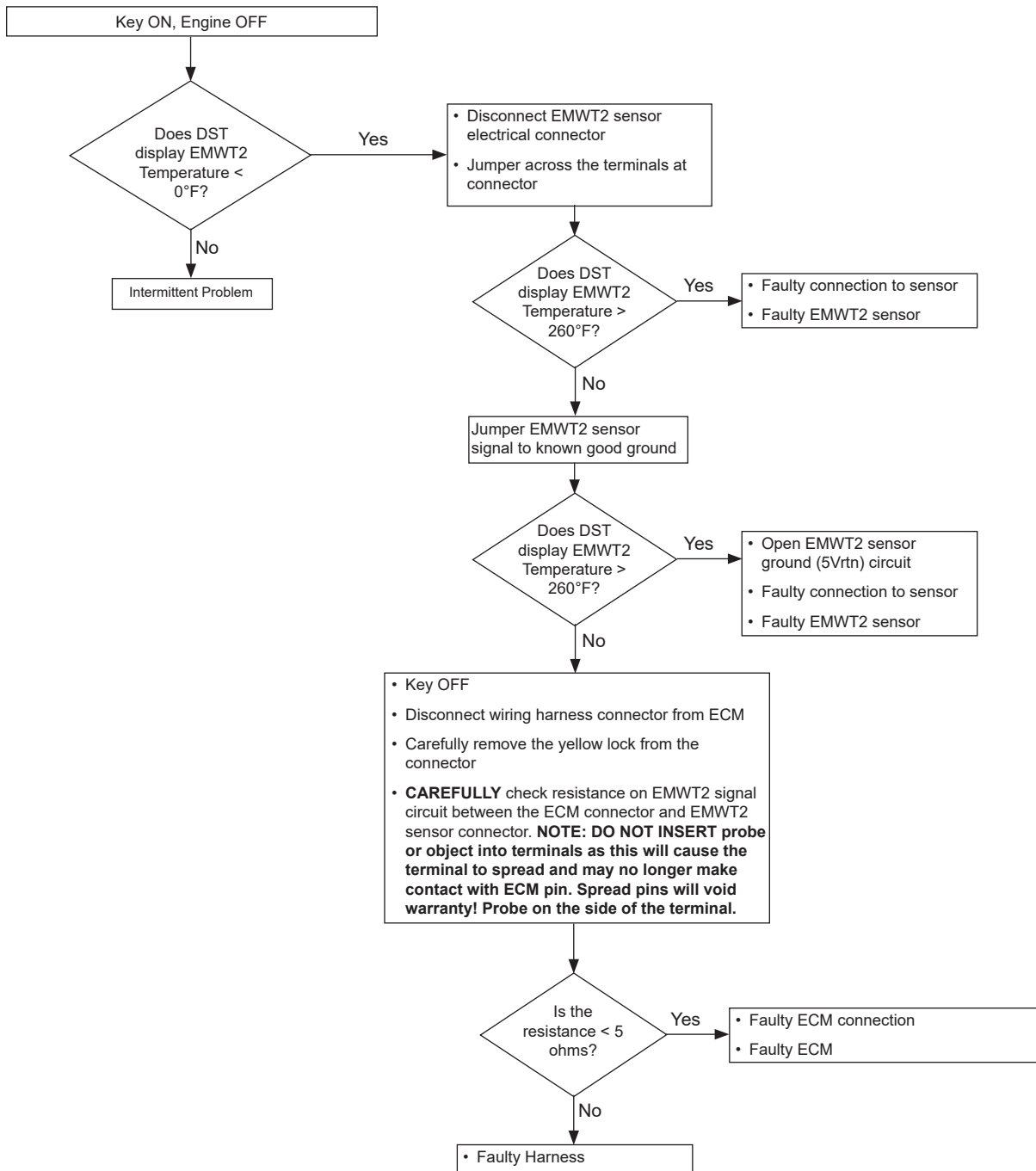


- Exhaust Manifold Water Temperature (EMWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - EMWT2 sensor voltage higher than the limit defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to the inability to sense temperature.
- Non-emissions related fault

The EMWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

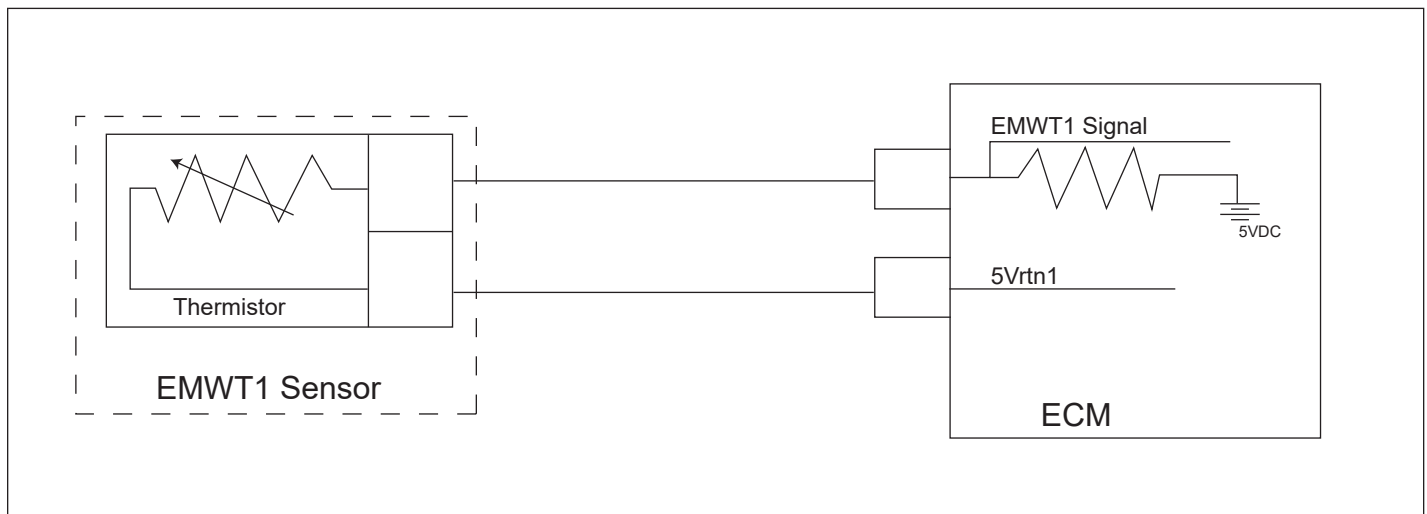
This fault will set if the signal voltage is higher than the high voltage limit as defined in the diagnostic calibration anytime the engine is running. The limit is generally set to 4.90 VDC.

DTC 1412 - Exhaust Manifold Water Temperature (EMWT) Sensor 2 Voltage High SPN - 442; FMI - 3



Diagnostics

DTC 1413 - Exhaust Manifold Water Temperature (EMWT) Sensor 1 Voltage Low SPN - 441; FMI - 4

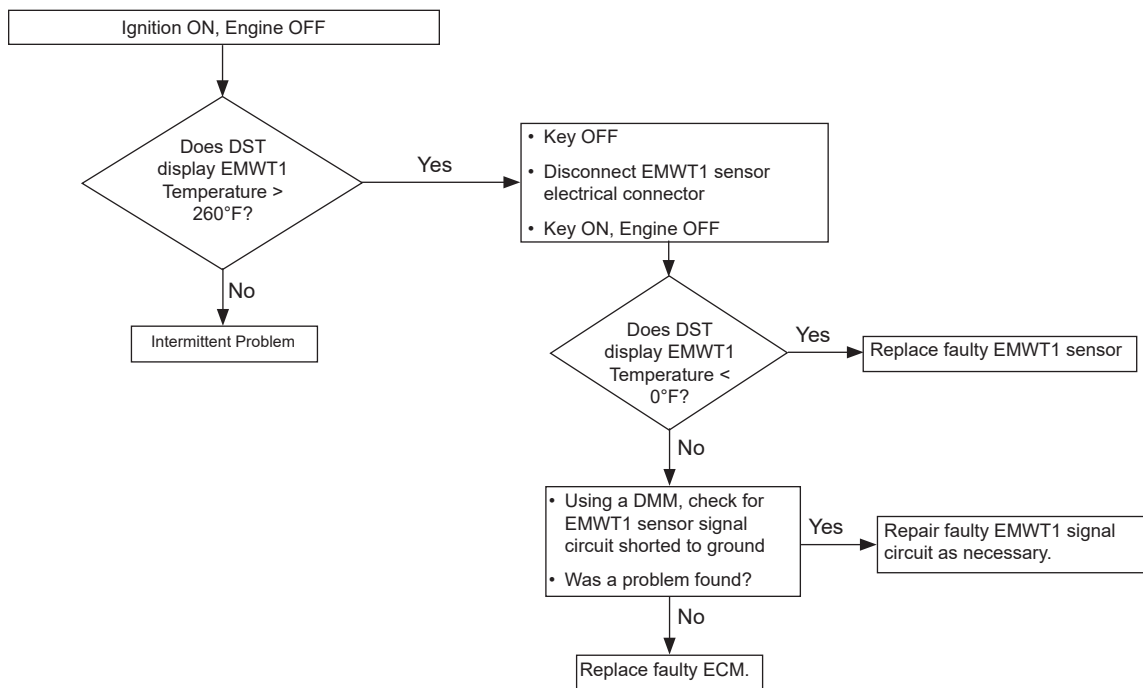


- Exhaust Manifold Water Temperature (EMWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - ECT sensor voltage less than the limit defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to the inability to sense temperature.
- Non-emissions related fault

The EMWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

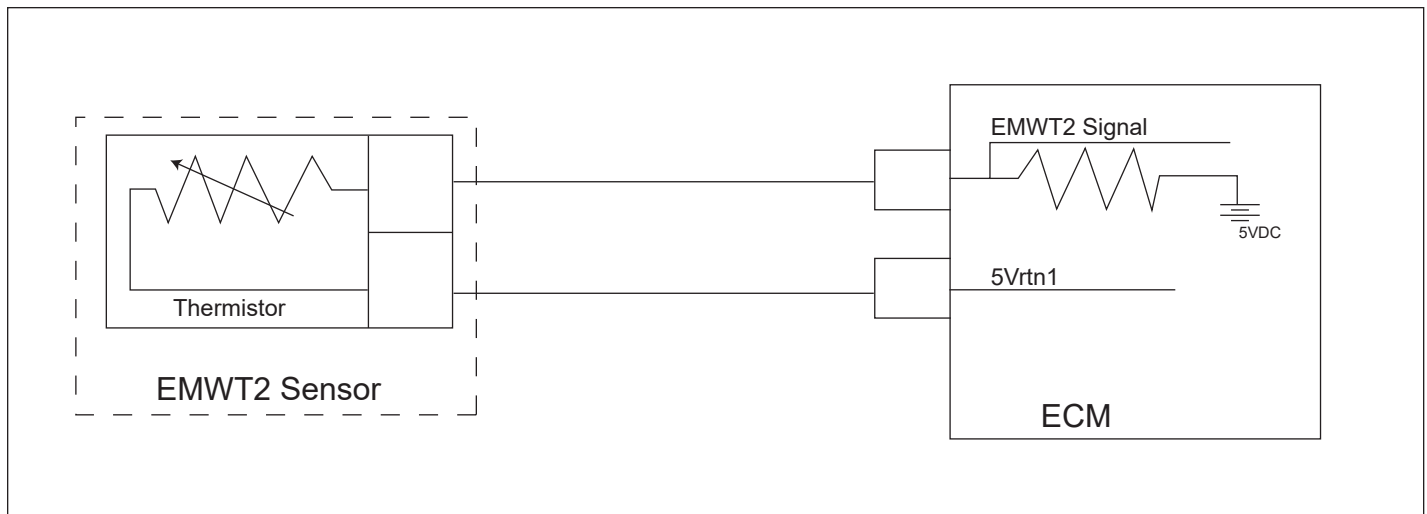
This fault will set if the signal voltage is less than the limit defined in the diagnostic calibration anytime the engine is running. The limit is generally set to 0.10 VDC.

DTC 1413 - Exhaust Manifold Water Temperature (EMWT) Sensor 1 Voltage Low SPN - 441; FMI - 4



Diagnostics

DTC 1414 - Exhaust Manifold Water Temperature (EMWT) Sensor 2 Voltage Low SPN - 442; FMI - 4

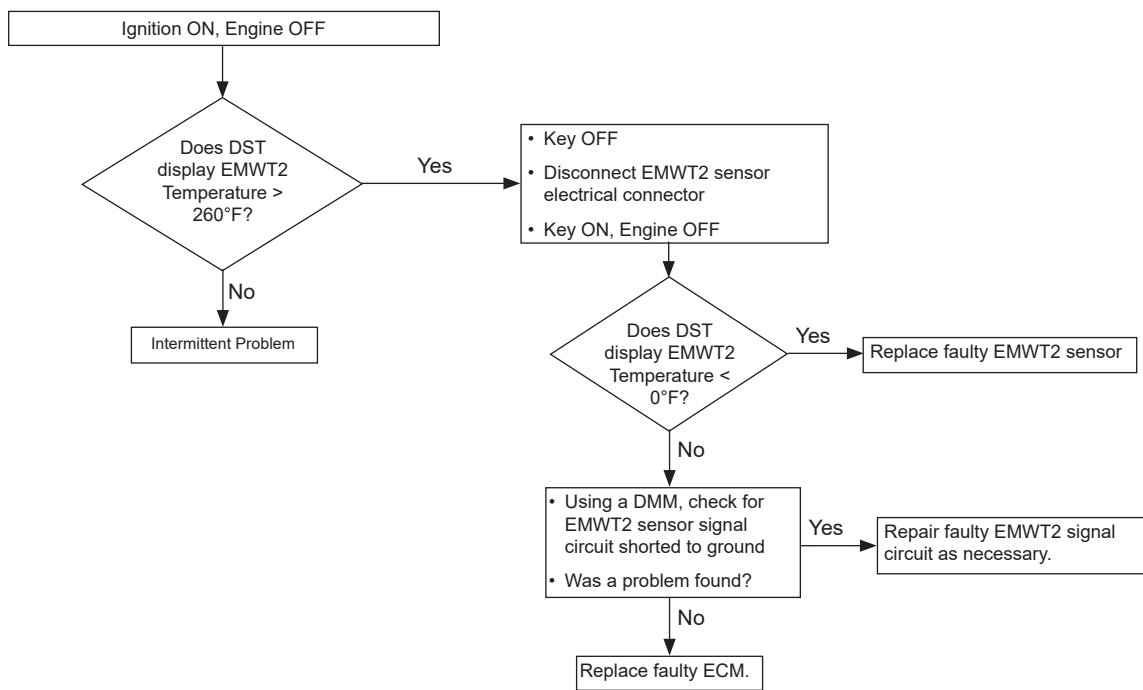


- Exhaust Manifold Water Temperature (EMWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - ECT sensor voltage less than the limit defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to the inability to sense temperature.
- Non-emissions related fault

The EMWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

This fault will set if the signal voltage is less than the limit defined in the diagnostic calibration anytime the engine is running. The limit is generally set to 0.10 VDC.

DTC 1414 - Exhaust Manifold Water Temperature (EMWT) Sensor 2 Voltage Low SPN - 442; FMI - 4

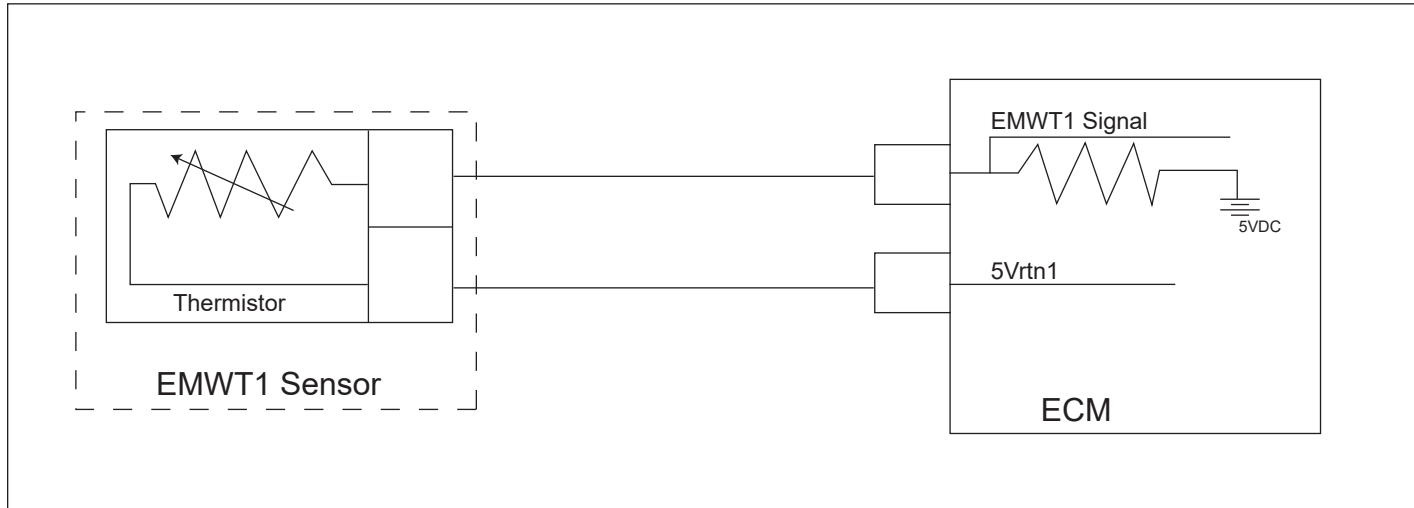


Diagnostics

DTC 1415 - Exhaust Manifold Water Temperature (EMWT) Sensor 1 Higher Than Expected

Stage 1

SPN - 441; FMI - 15



- Exhaust Manifold Water Temperature (EMWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Exhaust Manifold Water Temperature reading or estimate greater than the stage 1 limit when operating at a speed greater than defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault. Recommend a power derate 1/2 and/or a low rev limit to protect engine from possible damage.
- Non-emissions related fault

The EMWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

This fault will help protect the engine in the event of over temperature. When the coolant exceeds x deg. F and engine RPM exceeds y RPM for the latch time this fault will set.

DTC 1415 - Exhaust Manifold Water Temperature (EMWT) Sensor 1 Higher Than Expected

Stage 1

SPN - 441; FMI - 15

Diagnostic Aids

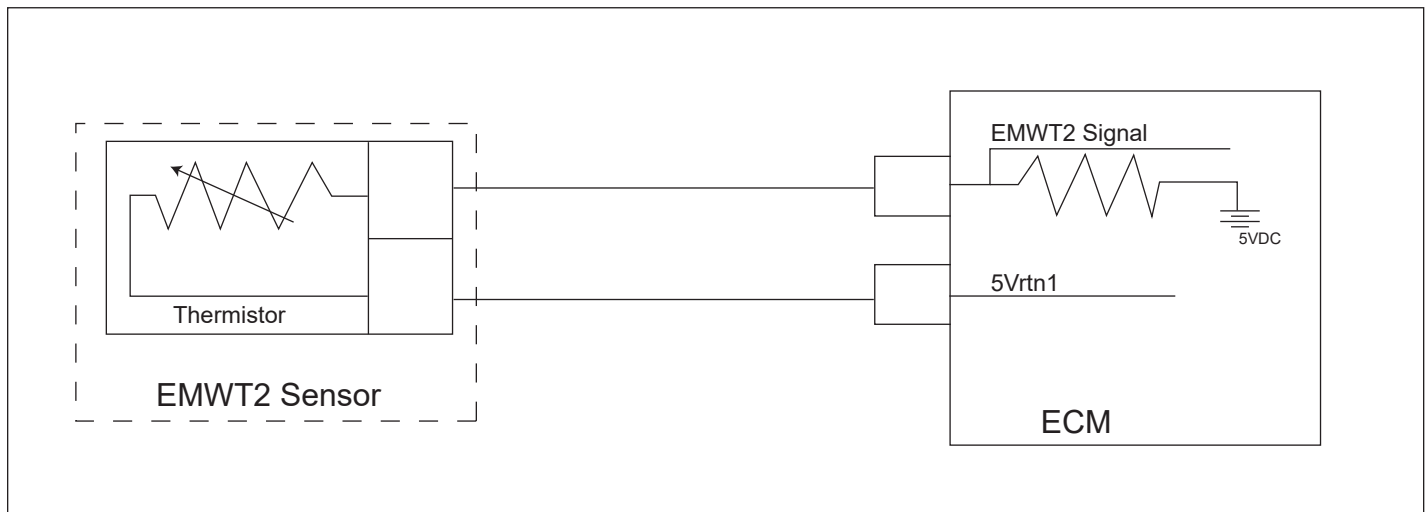
- If the “EMWT1 High Voltage” fault is also present, follow the troubleshooting procedures for that fault as it may have caused “EMWT1 Sensor Higher Than Expected 1.”
- Check that the heat exchanger has a proper amount of ethylene glycol/water and that the heat exchanger is not leaking
- Ensure that there is no trapped air in the cooling path
- Inspect the cooling system for cracks and ensure connections are leak free
- Check that the raw water pickup is not blocked/restricted by debris and that the hose is tightly connected
- Check that the thermostat is not stuck closed
- Check that the raw water pump/impeller is tact and that it is not restricted
- Verify that the proper amount of raw water flow is being achieved, both static and underway

Diagnostics

DTC 1416 - Exhaust Manifold Water Temperature (EMWT) Sensor 2 Higher Than Expected

Stage 1

SPN - 442; FMI - 15



- Exhaust Manifold Water Temperature (EMWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Exhaust Manifold Water Temperature reading or estimate greater than the stage 1 limit when operating at a speed greater than defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault. Recommend a power derate 1/2 and/or a low rev limit to protect engine from possible damage.
- Non-emissions related fault

The EMWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

This fault will help protect the engine in the event of over temperature. When the coolant exceeds x deg. F and engine RPM exceeds y RPM for the latch time this fault will set.

DTC 1416 - Exhaust Manifold Water Temperature (EMWT) Sensor 2 Higher Than Expected

Stage 1

SPN - 442; FMI - 15

Diagnostic Aids

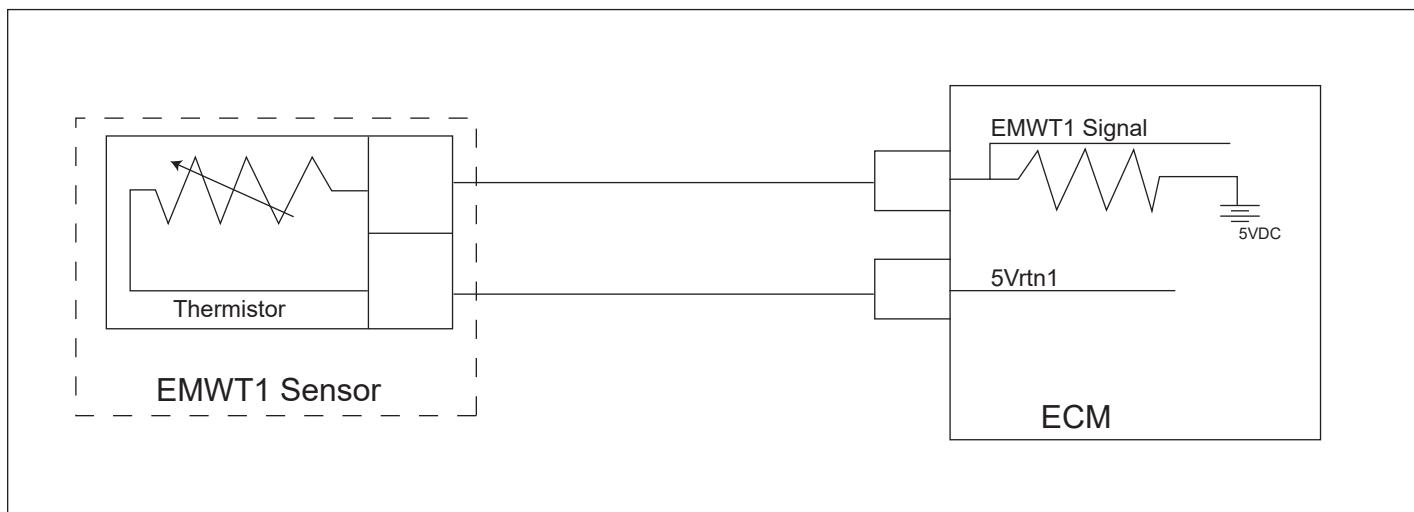
- If the “EMWT2 High Voltage” fault is also present, follow the troubleshooting procedures for that fault as it may have caused “EMWT2 Sensor Higher Than Expected 1.”
- Check that the heat exchanger has a proper amount of ethylene glycol/water and that the heat exchanger is not leaking
- Ensure that there is no trapped air in the cooling path
- Inspect the cooling system for cracks and ensure connections are leak free
- Check that the raw water pickup is not blocked/restricted by debris and that the hose is tightly connected
- Check that the thermostat is not stuck closed
- Check that the raw water pump/impeller is tact and that it is not restricted
- Verify that the proper amount of raw water flow is being achieved, both static and underway

Diagnostics

DTC 1417 - Exhaust Manifold Water Temperature (EMWT) Sensor 1 Higher Than Expected

Stage 2

SPN - 441; FMI - 0



- Exhaust Manifold Water Temperature (EMWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Exhaust Manifold Water Temperature reading or estimate greater than the stage 1 limit when operating at a speed greater than defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault. Recommend a power derate 1/2 and/or a low rev limit to protect engine from possible damage.
- Non-emissions related fault

The EMWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

This fault will help protect the engine in the event of over temperature. When the coolant exceeds x deg. F and engine RPM exceeds y RPM for the latch time this fault will set.

DTC 1417 - Exhaust Manifold Water Temperature (EMWT) Sensor 1 Higher Than Expected Stage 2 SPN - 441; FMI - 0

Diagnostic Aids

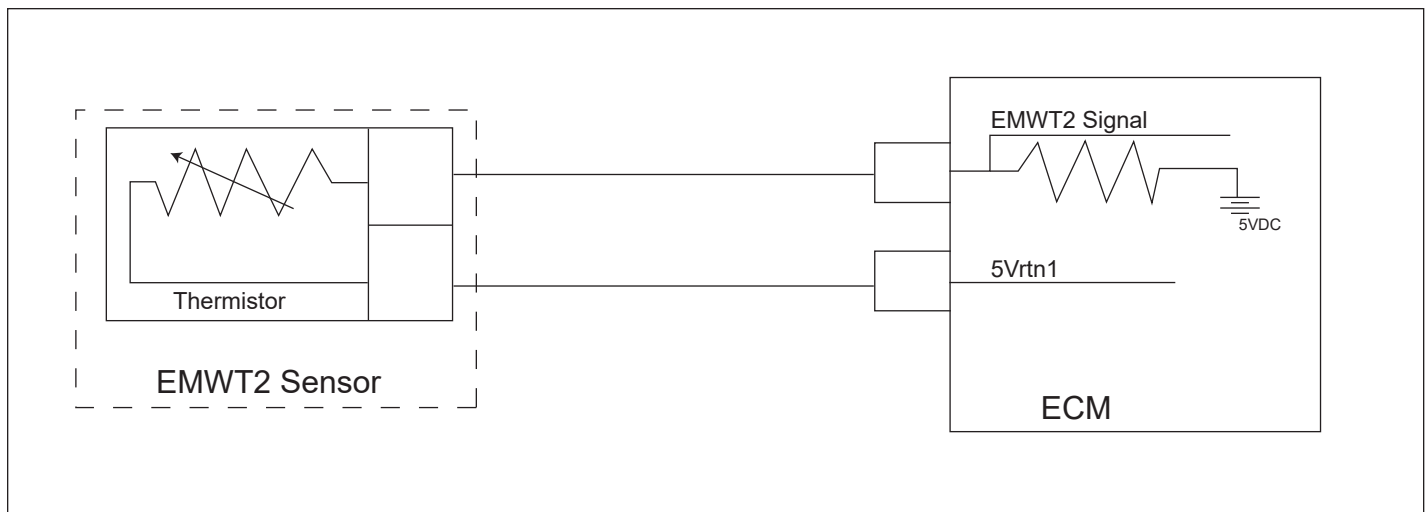
- If the “EMWT1 High Voltage” fault is also present, follow the troubleshooting procedures for that fault as it may have caused “EMWT1 Sensor Higher Than Expected 2.”
- Check that the heat exchanger has a proper amount of ethylene glycol/water and that the heat exchanger is not leaking
- Ensure that there is no trapped air in the cooling path
- Inspect the cooling system for cracks and ensure connections are leak free
- Check that the raw water pickup is not blocked/restricted by debris and that the hose is tightly connected
- Check that the thermostat is not stuck closed
- Check that the raw water pump/impeller is tact and that it is not restricted
- Verify that the proper amount of raw water flow is being achieved, both static and underway

Diagnostics

DTC 1418 - Exhaust Manifold Water Temperature (EMWT) Sensor 2 Higher Than Expected

Stage 2

SPN - 442; FMI - 0



- Exhaust Manifold Water Temperature (EMWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Exhaust Manifold Water Temperature reading or estimate greater than the stage 1 limit when operating at a speed greater than defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault. Recommend a power derate 1/2 and/or a low rev limit to protect engine from possible damage.
- Non-emissions related fault

The EMWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

This fault will help protect the engine in the event of over temperature. When the coolant exceeds x deg. F and engine RPM exceeds y RPM for the latch time this fault will set.

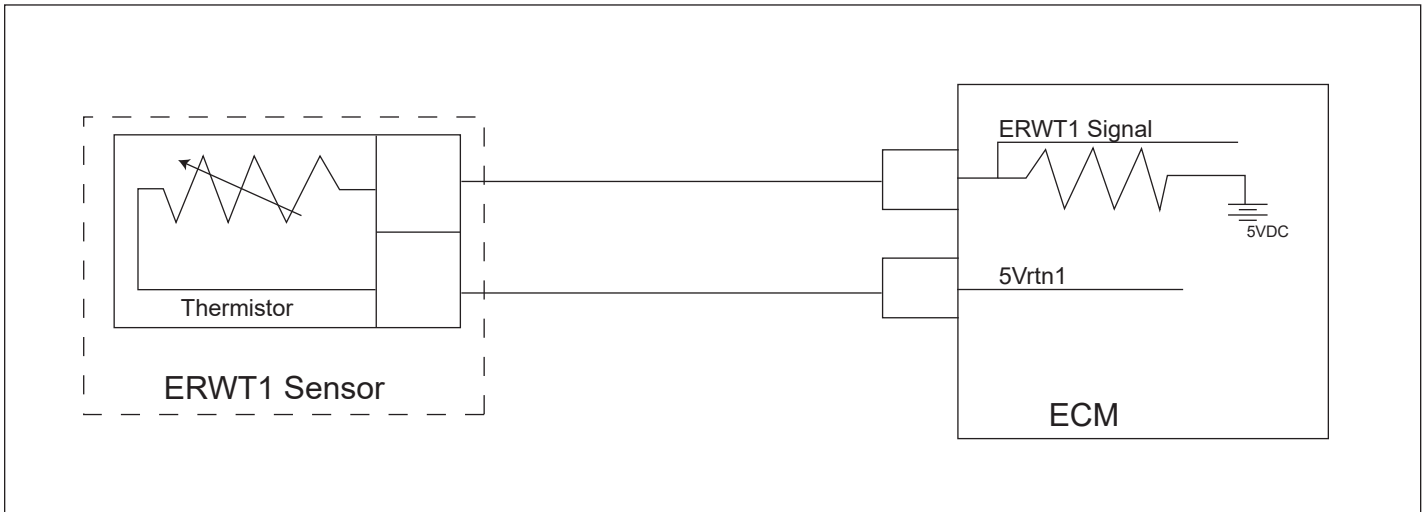
DTC 1418 - Exhaust Manifold Water Temperature (EMWT) Sensor 2 Higher Than Expected Stage 2 SPN - 442; FMI - 0

Diagnostic Aids

- If the “EMWT2 High Voltage” fault is also present, follow the troubleshooting procedures for that fault as it may have caused “EMWT2 Sensor Higher Than Expected 2.”
- Check that the heat exchanger has a proper amount of ethylene glycol/water and that the heat exchanger is not leaking
- Ensure that there is no trapped air in the cooling path
- Inspect the cooling system for cracks and ensure connections are leak free
- Check that the raw water pickup is not blocked/restricted by debris and that the hose is tightly connected
- Check that the thermostat is not stuck closed
- Check that the raw water pump/impeller is tact and that it is not restricted
- Verify that the proper amount of raw water flow is being achieved, both static and underway

Diagnostics

DTC 1421 - Exhaust Riser Water Temperature (ERWT) Sensor 1 Voltage High SPN - 1385; FMI - 3

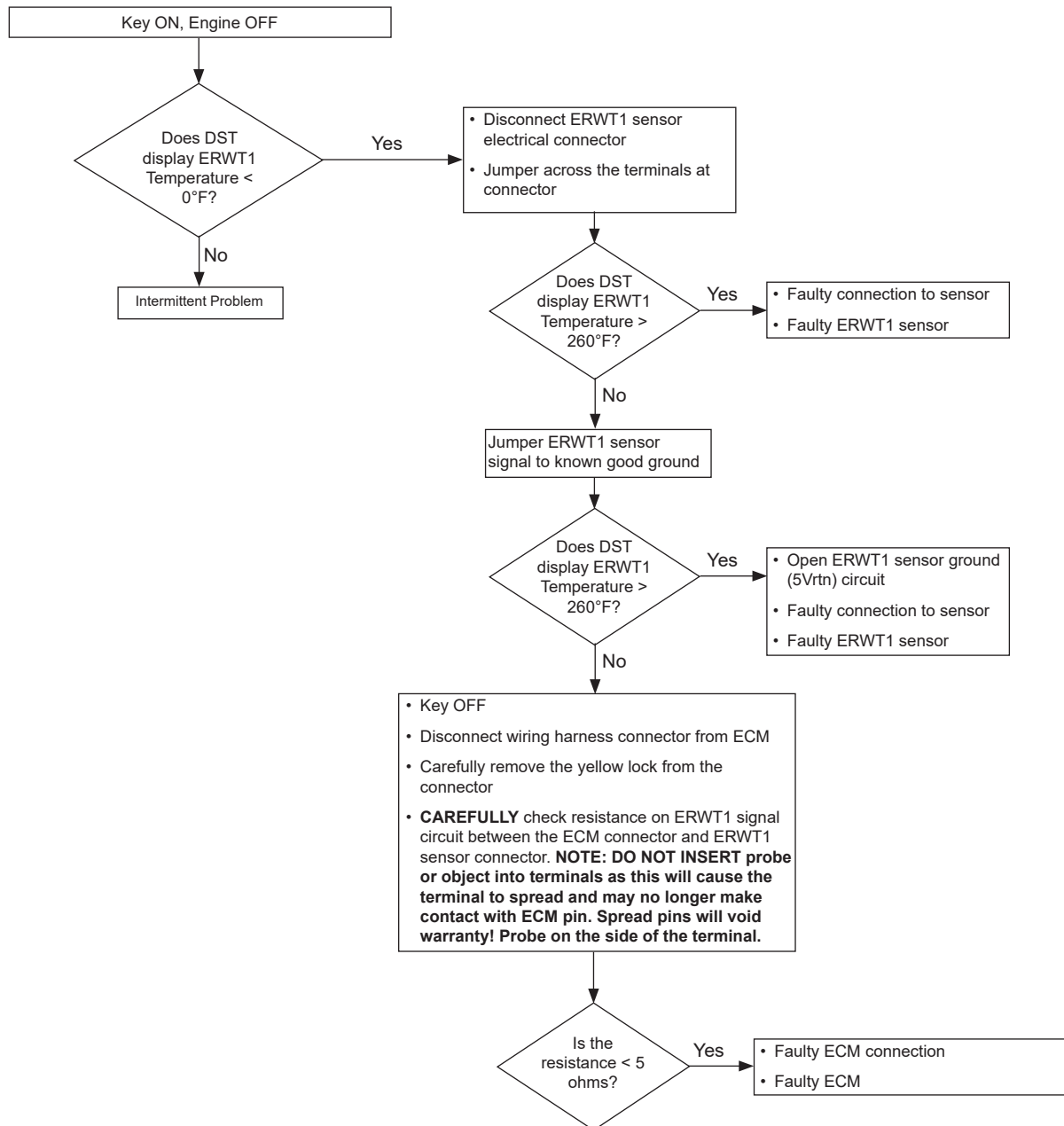


- Exhaust Riser Water Temperature (ERWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - ERWT1 sensor voltage higher than the limit defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to the inability to sense temperature.
- Non-emissions related fault

The ERWT sensor is a thermistor (temperature sensitive resistor) located in the top the exhaust manifolds. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

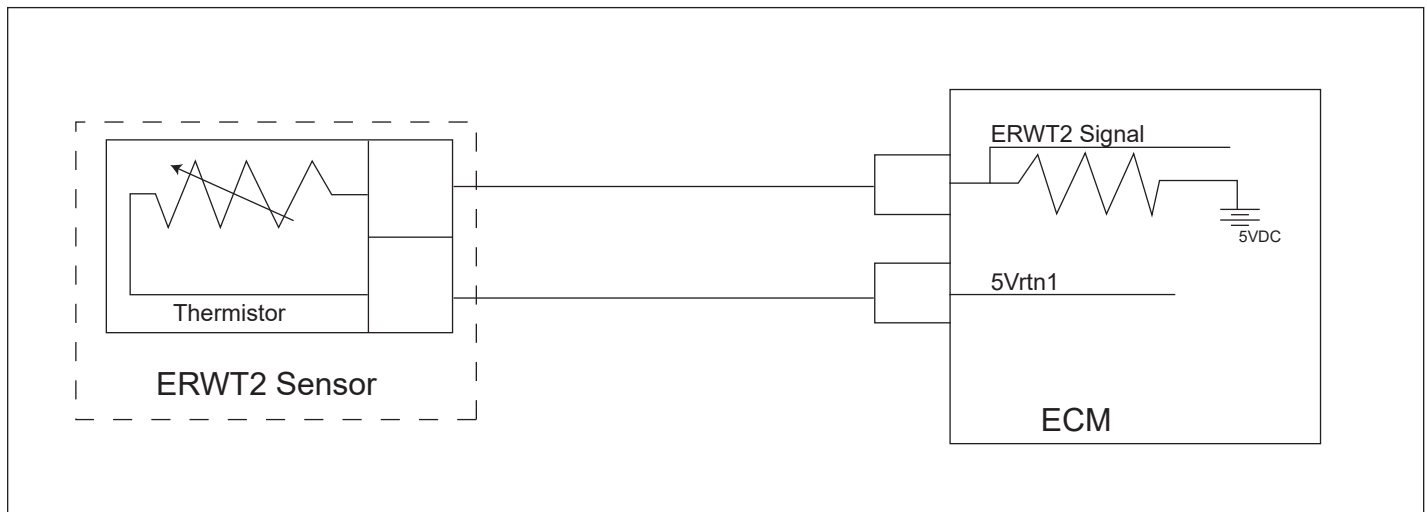
This fault will set if the signal voltage is higher than the high voltage limit as defined in the diagnostic calibration anytime the engine is running. The limit is generally set to 4.90 VDC.

DTC 1421 - Exhaust Riser Water Temperature (ERWT) Sensor 1 Voltage High SPN - 1385; FMI - 3



Diagnostics

DTC 1422 - Exhaust Riser Water Temperature (ERWT) Sensor 2 Voltage High SPN - 1386; FMI - 3

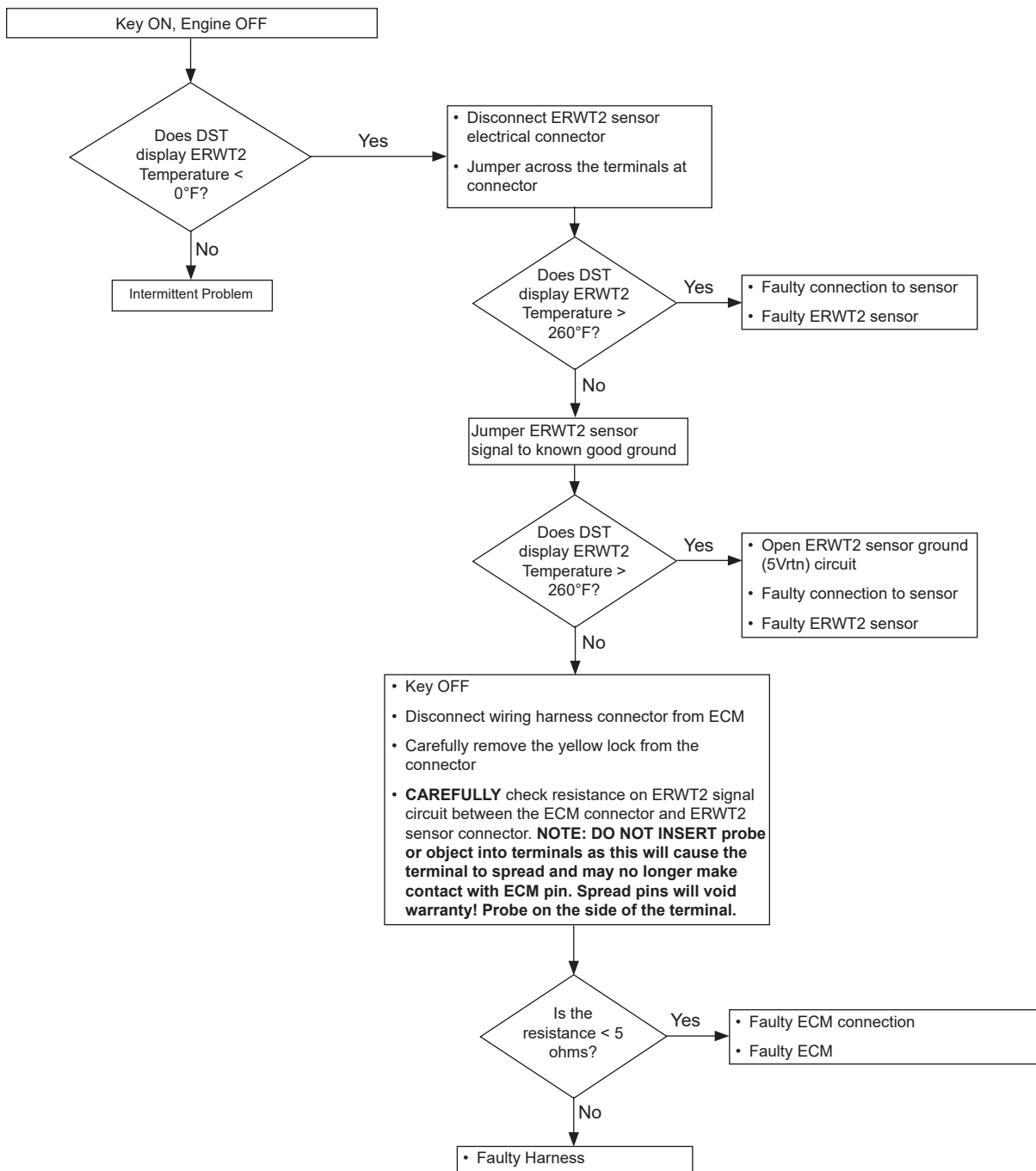


- Exhaust Riser Water Temperature (ERWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - ERWT2 sensor voltage higher than the limit defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to the inability to sense temperature.
- Non-emissions related fault

The ERWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

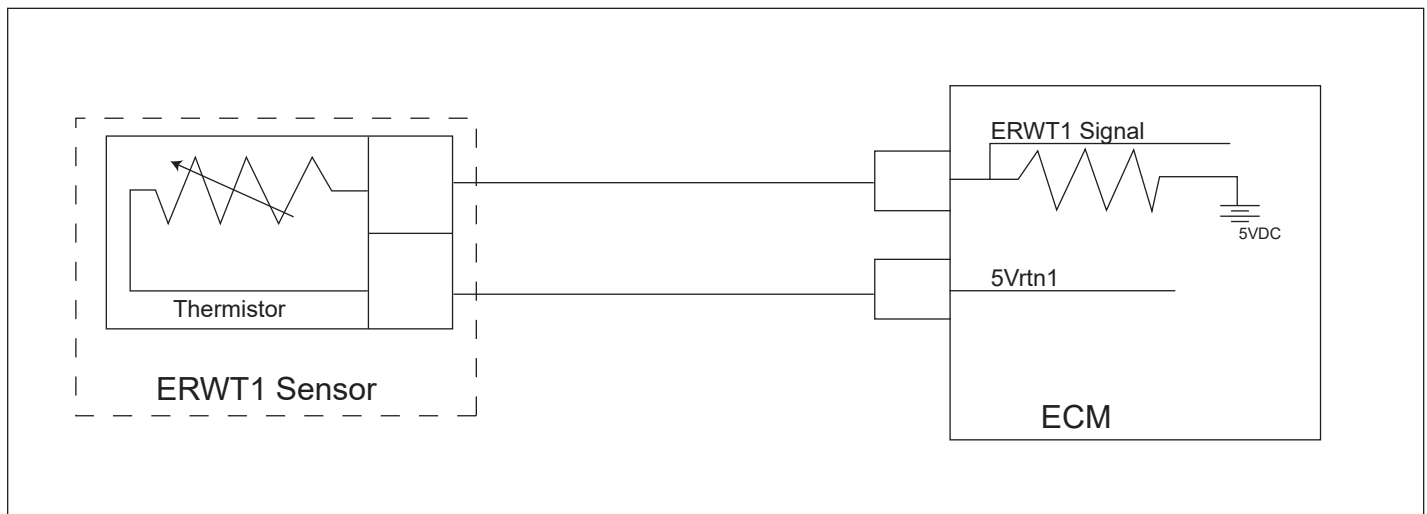
This fault will set if the signal voltage is higher than the high voltage limit as defined in the diagnostic calibration anytime the engine is running. The limit is generally set to 4.90 VDC.

DTC 1422 - Exhaust Riser Water Temperature (ERWT) Sensor 2 Voltage High SPN - 1386; FMI - 3



Diagnostics

DTC 1423 - Exhaust Riser Water Temperature (ERWT) Sensor 1 Voltage Low SPN - 1385; FMI - 4

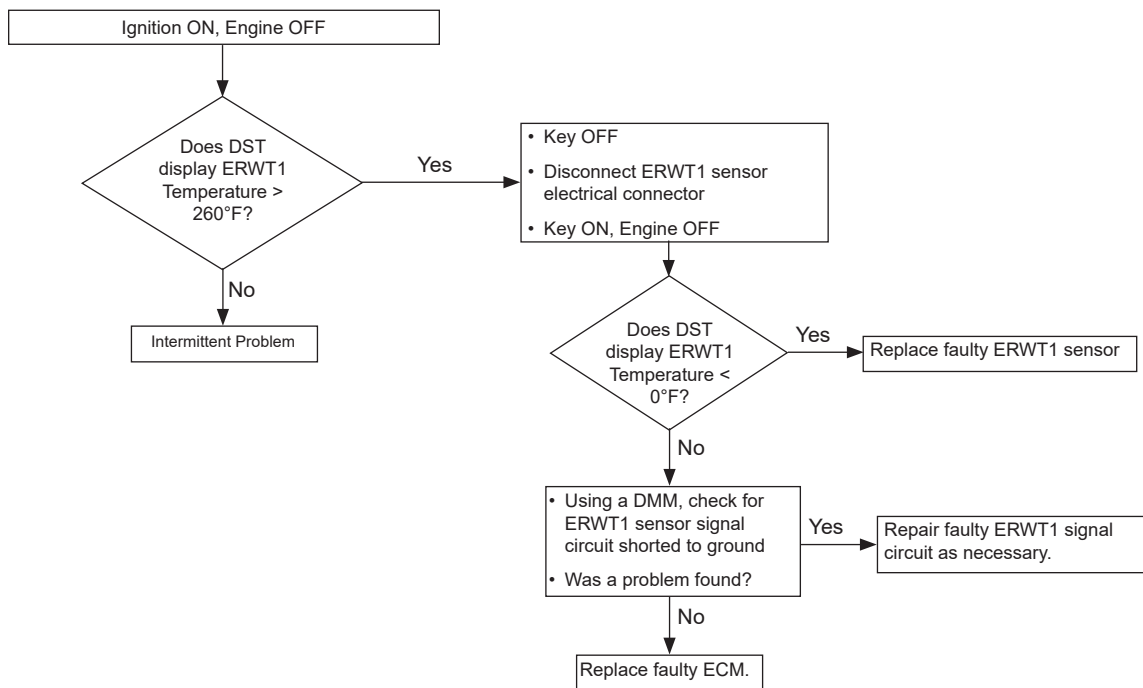


- Exhaust Riser Water Temperature (ERWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - ECT sensor voltage less than the limit defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to the inability to sense temperature.
- Non-emissions related fault

The ERWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

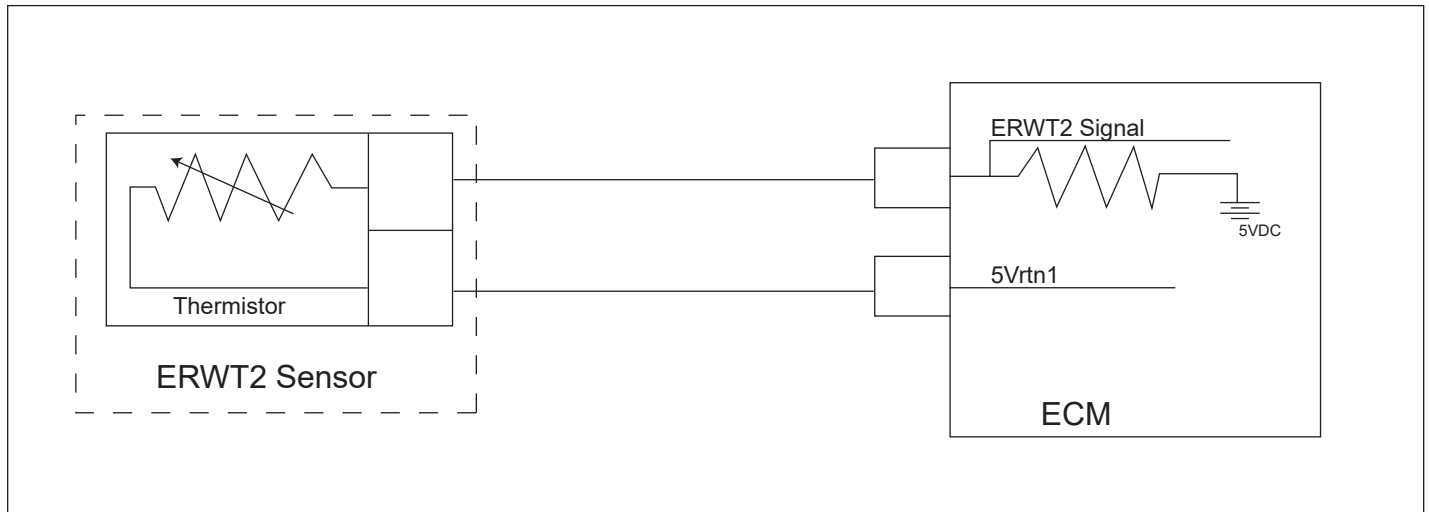
This fault will set if the signal voltage is less than the limit defined in the diagnostic calibration anytime the engine is running. The limit is generally set to 0.10 VDC.

DTC 1423 - Exhaust Riser Water Temperature (ERWT) Sensor 1 Voltage Low SPN - 1385; FMI - 4



Diagnostics

DTC 1424 - Exhaust Riser Water Temperature (ERWT) Sensor 2 Voltage Low SPN - 1386; FMI - 4

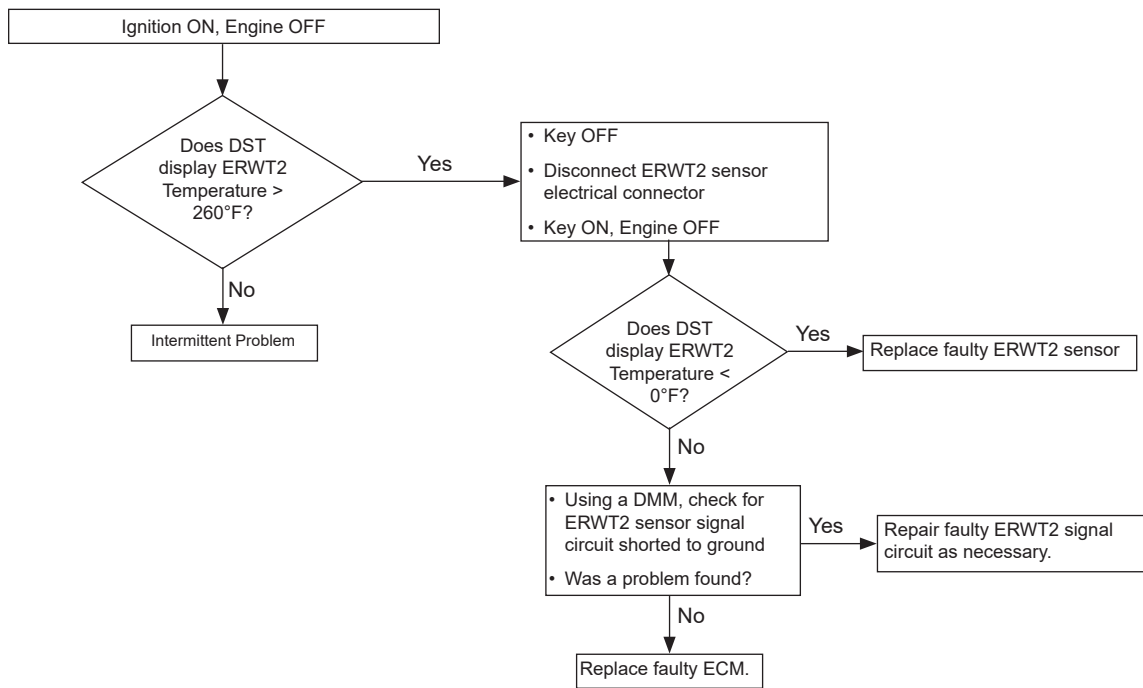


- Exhaust Riser Water Temperature (ERWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - ECT sensor voltage less than the limit defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to the inability to sense temperature.
- Non-emissions related fault

The ERWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

This fault will set if the signal voltage is less than the limit defined in the diagnostic calibration anytime the engine is running. The limit is generally set to 0.10 VDC.

DTC 1424 - Exhaust Riser Water Temperature (ERWT) Sensor 2 Voltage Low SPN - 1386; FMI - 4

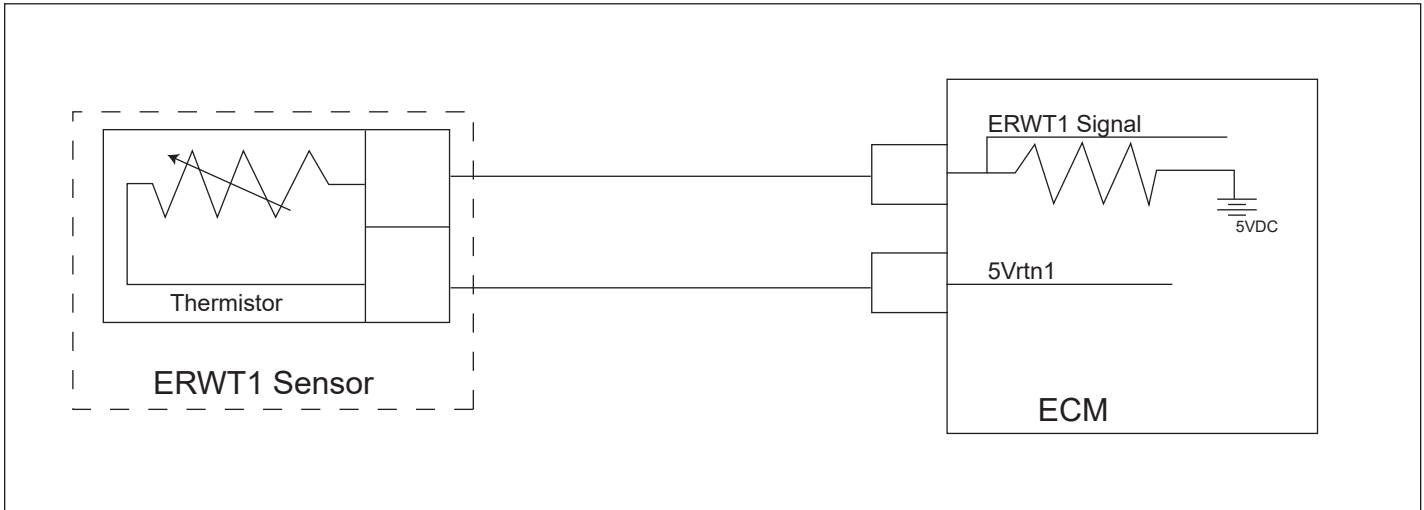


Diagnostics

DTC 1425 - Exhaust Manifold Water Temperature (ERWT) Sensor 1 Higher Than Expected

Stage 1

SPN - 1385; FMI - 15



- Exhaust Riser Water Temperature (ERWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Exhaust Manifold Water Temperature reading or estimate greater than the stage 1 limit when operating at a speed greater than defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault. Recommend a power derate 1/2 and/or a low rev limit to protect engine from possible damage.
- Non-emissions related fault

The ERWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

This fault will help protect the engine in the event of over temperature. When the coolant exceeds x deg. F and engine RPM exceeds y RPM for the latch time this fault will set.

DTC 1425 - Exhaust Manifold Water Temperature (ERWT) Sensor 1 Higher Than Expected

Stage 1

SPN - 1385; FMI - 15

Diagnostic Aids

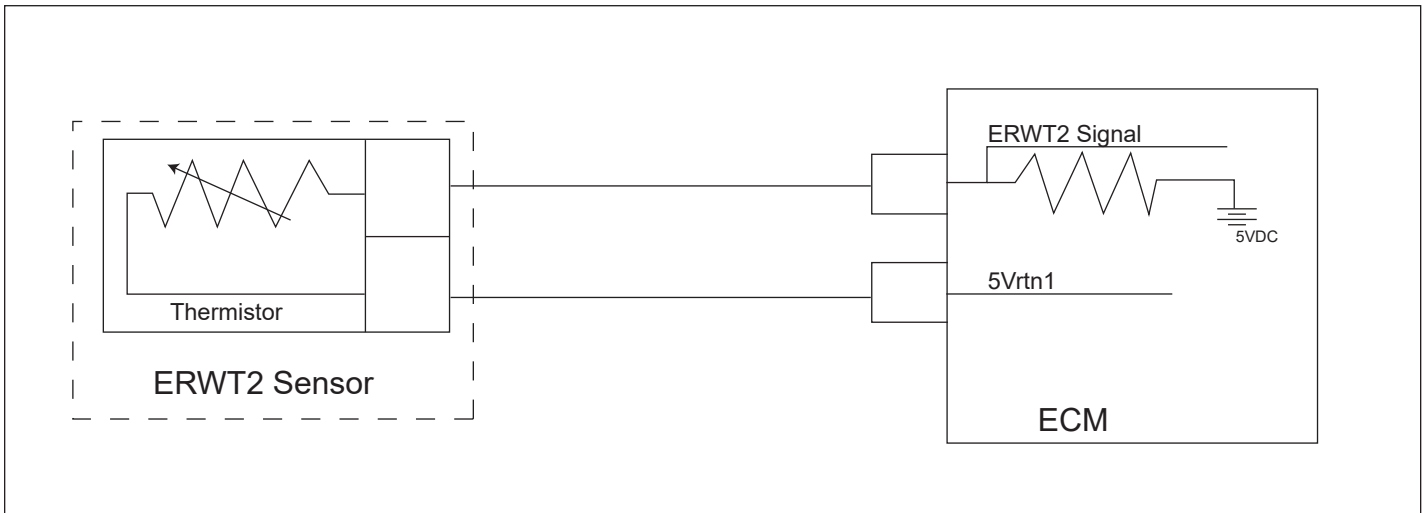
- If the “ERWT1 High Voltage” fault is also present, follow the troubleshooting procedures for that fault as it may have caused “ERWT1 Sensor Higher Than Expected 1.”
- Check that the heat exchanger has a proper amount of ethylene glycol/water and that the heat exchanger is not leaking
- Ensure that there is no trapped air in the cooling path
- Inspect the cooling system for cracks and ensure connections are leak free
- Check that the raw water pickup is not blocked/restricted by debris and that the hose is tightly connected
- Check that the thermostat is not stuck closed
- Check that the raw water pump/impeller is tact and that it is not restricted
- Verify that the proper amount of raw water flow is being achieved, both static and underway

Diagnostics

DTC 1426 - Exhaust Riser Water Temperature (ERWT) Sensor 2 Higher Than Expected Stage

1

SPN - 442; FMI - 15



- Exhaust Riser Water Temperature (ERWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Exhaust Manifold Water Temperature reading or estimate greater than the stage 1 limit when operating at a speed greater than defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault. Recommend a power derate 1/2 and/or a low rev limit to protect engine from possible damage.
- Non-emissions related fault

The ERWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

This fault will help protect the engine in the event of over temperature. When the coolant exceeds x deg. F and engine RPM exceeds y RPM for the latch time this fault will set.

DTC 1426 - Exhaust Riser Water Temperature (ERWT) Sensor 2 Higher Than Expected Stage

1

SPN - 442; FMI - 15

Diagnostic Aids

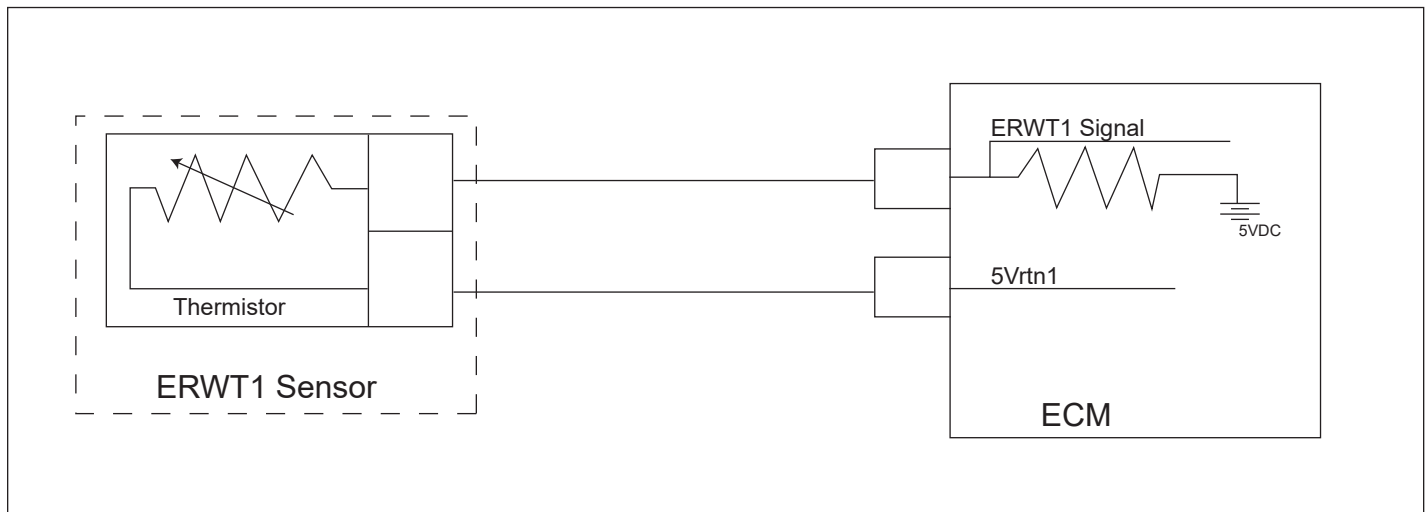
- If the “ERWT2 High Voltage” fault is also present, follow the troubleshooting procedures for that fault as it may have caused “ERWT2 Sensor Higher Than Expected 1.”
- Check that the heat exchanger has a proper amount of ethylene glycol/water and that the heat exchanger is not leaking
- Ensure that there is no trapped air in the cooling path
- Inspect the cooling system for cracks and ensure connections are leak free
- Check that the raw water pickup is not blocked/restricted by debris and that the hose is tightly connected
- Check that the thermostat is not stuck closed
- Check that the raw water pump/impeller is tact and that it is not restricted
- Verify that the proper amount of raw water flow is being achieved, both static and underway

Diagnostics

DTC 1427 - Exhaust Riser Water Temperature (ERWT) Sensor 1 Higher Than Expected Stage

2

SPN - 441; FMI - 0



- Exhaust Riser Water Temperature (EMWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Exhaust Manifold Water Temperature reading or estimate greater than the stage 1 limit when operating at a speed greater than defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault. Recommend a power derate 1/2 and/or a low rev limit to protect engine from possible damage.
- Non-emissions related fault

The ERWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

This fault will help protect the engine in the event of over temperature. When the coolant exceeds x deg. F and engine RPM exceeds y RPM for the latch time this fault will set.

DTC 1427 - Exhaust Riser Water Temperature (ERWT) Sensor 1 Higher Than Expected Stage

2

SPN - 441; FMI - 0

Diagnostic Aids

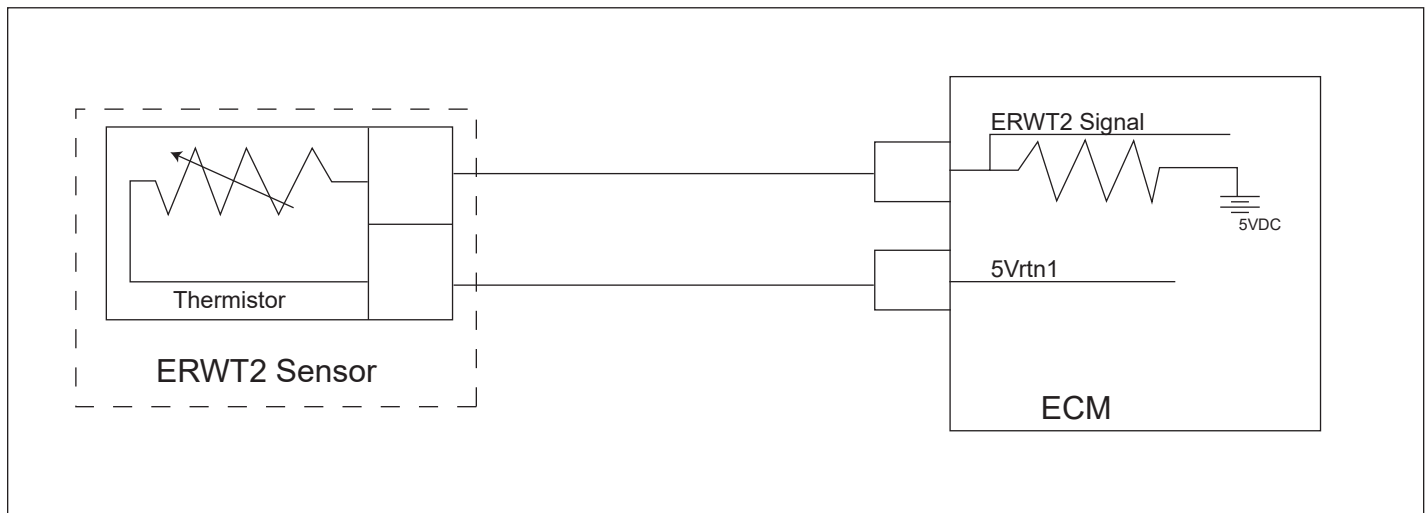
- If the “ERWT1 High Voltage” fault is also present, follow the troubleshooting procedures for that fault as it may have caused “ERWT1 Sensor Higher Than Expected 2.”
- Check that the heat exchanger has a proper amount of ethylene glycol/water and that the heat exchanger is not leaking
- Ensure that there is no trapped air in the cooling path
- Inspect the cooling system for cracks and ensure connections are leak free
- Check that the raw water pickup is not blocked/restricted by debris and that the hose is tightly connected
- Check that the thermostat is not stuck closed
- Check that the raw water pump/impeller is tact and that it is not restricted
- Verify that the proper amount of raw water flow is being achieved, both static and underway

Diagnostics

DTC 1428 - Exhaust Riser Water Temperature (ERWT) Sensor 2 Higher Than Expected Stage

2

SPN - 442; FMI - 0



- Exhaust Riser Water Temperature (ERWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Exhaust Manifold Water Temperature reading or estimate greater than the stage 1 limit when operating at a speed greater than defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault. Recommend a power derate 1/2 and/or a low rev limit to protect engine from possible damage.
- Non-emissions related fault

The ERWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

This fault will help protect the engine in the event of over temperature. When the coolant exceeds x deg. F and engine RPM exceeds y RPM for the latch time this fault will set.

DTC 1428 - Exhaust Riser Water Temperature (ERWT) Sensor 2 Higher Than Expected Stage

2

SPN - 442; FMI - 0

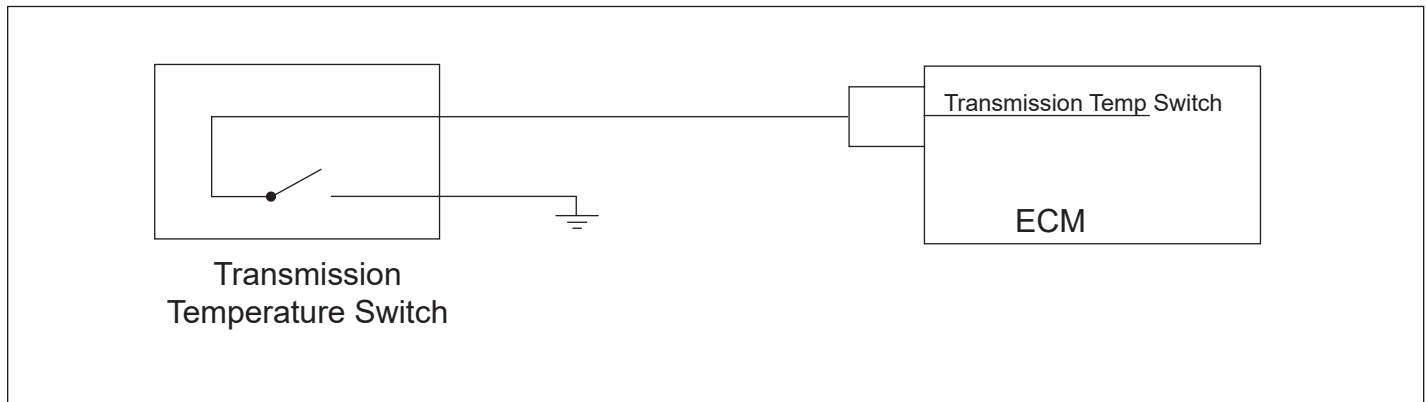
Diagnostic Aids

- If the “ERWT2 High Voltage” fault is also present, follow the troubleshooting procedures for that fault as it may have caused “ERWT2 Sensor Higher Than Expected 2.”
- Check that the heat exchanger has a proper amount of ethylene glycol/water and that the heat exchanger is not leaking
- Ensure that there is no trapped air in the cooling path
- Inspect the cooling system for cracks and ensure connections are leak free
- Check that the raw water pickup is not blocked/restricted by debris and that the hose is tightly connected
- Check that the thermostat is not stuck closed
- Check that the raw water pump/impeller is tact and that it is not restricted
- Verify that the proper amount of raw water flow is being achieved, both static and underway

Diagnostics

DTC 1542 - AUX Analog PUD 1 - Low Voltage

SPN - 704; FMI - 4



- AUX Analog PUD1 - Transmission Overtemp Switch
- *Check Condition* - Key on, Engine Cranking or Running
- *Fault Condition* - Battery voltage to ECM greater than x volts while the engine is running as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle
- Non-emissions related fault

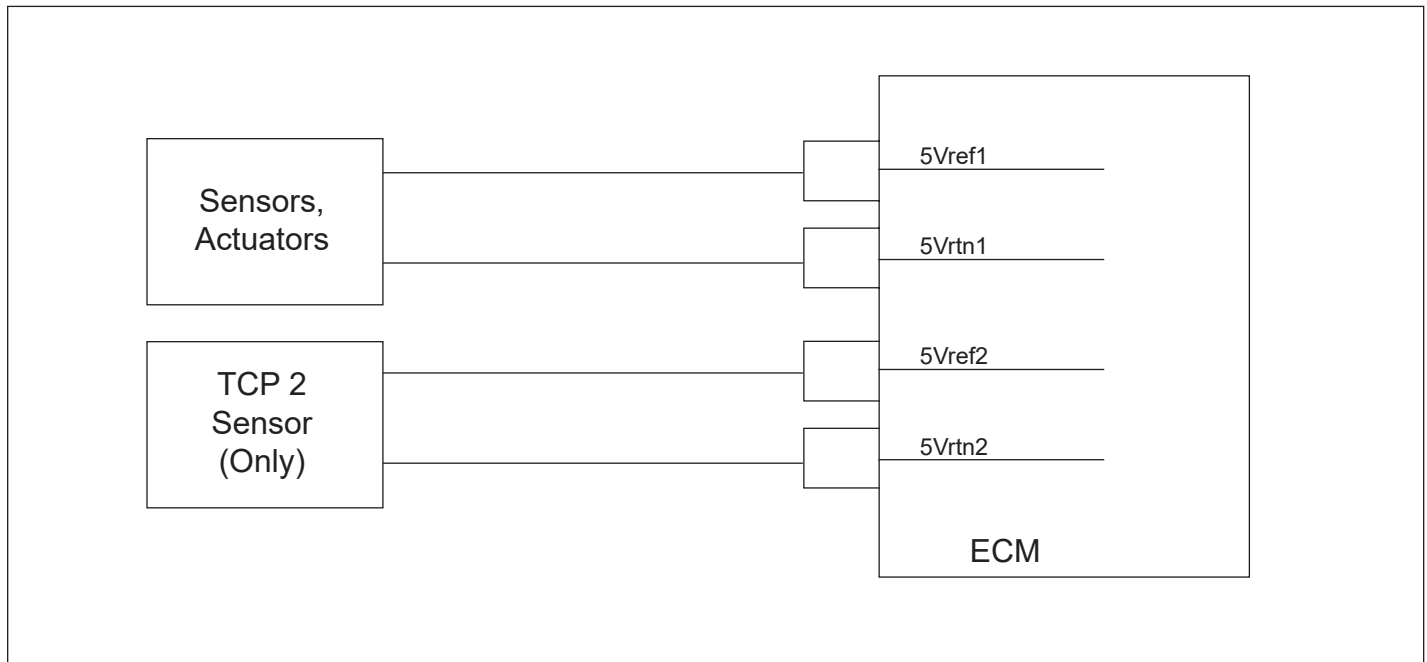
The battery voltage powers the ECM and must be within limits to correctly operate injector drivers, ignition coils, throttle, power supplies, and other powered devices that the ECM controls.

This fault will set if the ECM detects system voltage greater than x volts while the engine is running or cranking as defined in the diagnostic calibration. The adaptive learn is disabled to avoid improper adaptive learning.

DTC 1542 - AUX Analog PUD 1 - Low Voltage
SPN - 704; FMI - 4

Diagnostics

DTC 1611 - Sensor Supply Voltage (5Vref 1/2) Simultaneously Out-of-Range SPN - 1079; FMI - 31

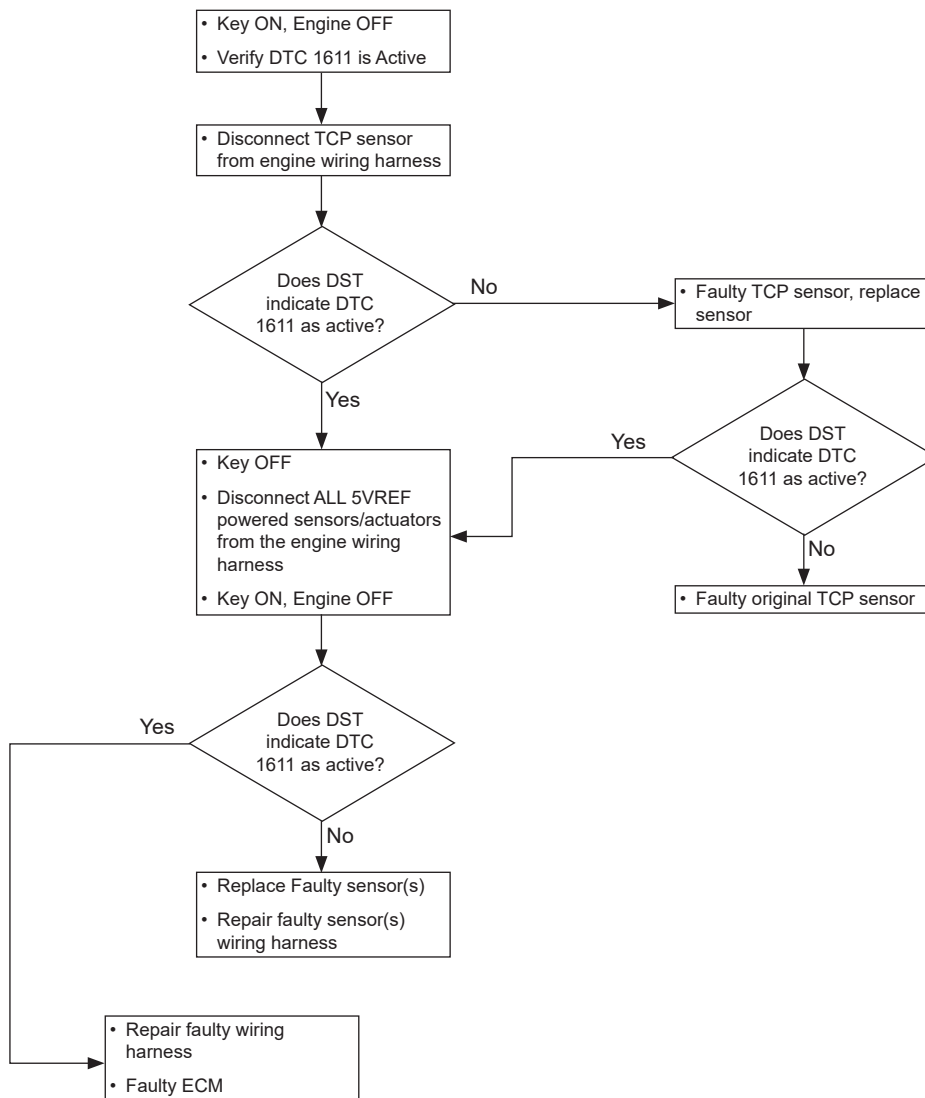


- Powered sensors/actuators and FPP2
- *Check Condition* - Engine on
- *Fault Condition* - high or low voltage feedback on both 5V_ext1 and 5V_ext2
- *Corrective Action(s)* - Illuminate MIL, sound audible warning or illuminate secondary warning lamp, and forced idle
- Non-emissions related fault

5V_ext1 is a regulated 5 VDC output that supplies power to sensors and actuators. This power is generally supplied, but is not limited to hall-effects, potentiometers, switches, and pressure transducers. 5V_ext2 is a low-current 5 VDC power supply intended solely for powering a second potentiometer used for electronic throttle control in configurations where high redundancy is required. High accuracy of the power supplies are required in order to ensure proper signal scaling. Both power supplies have a feedback voltage that is monitored by the ECM to determine if the output is overloaded, shorted, or otherwise out of specification.

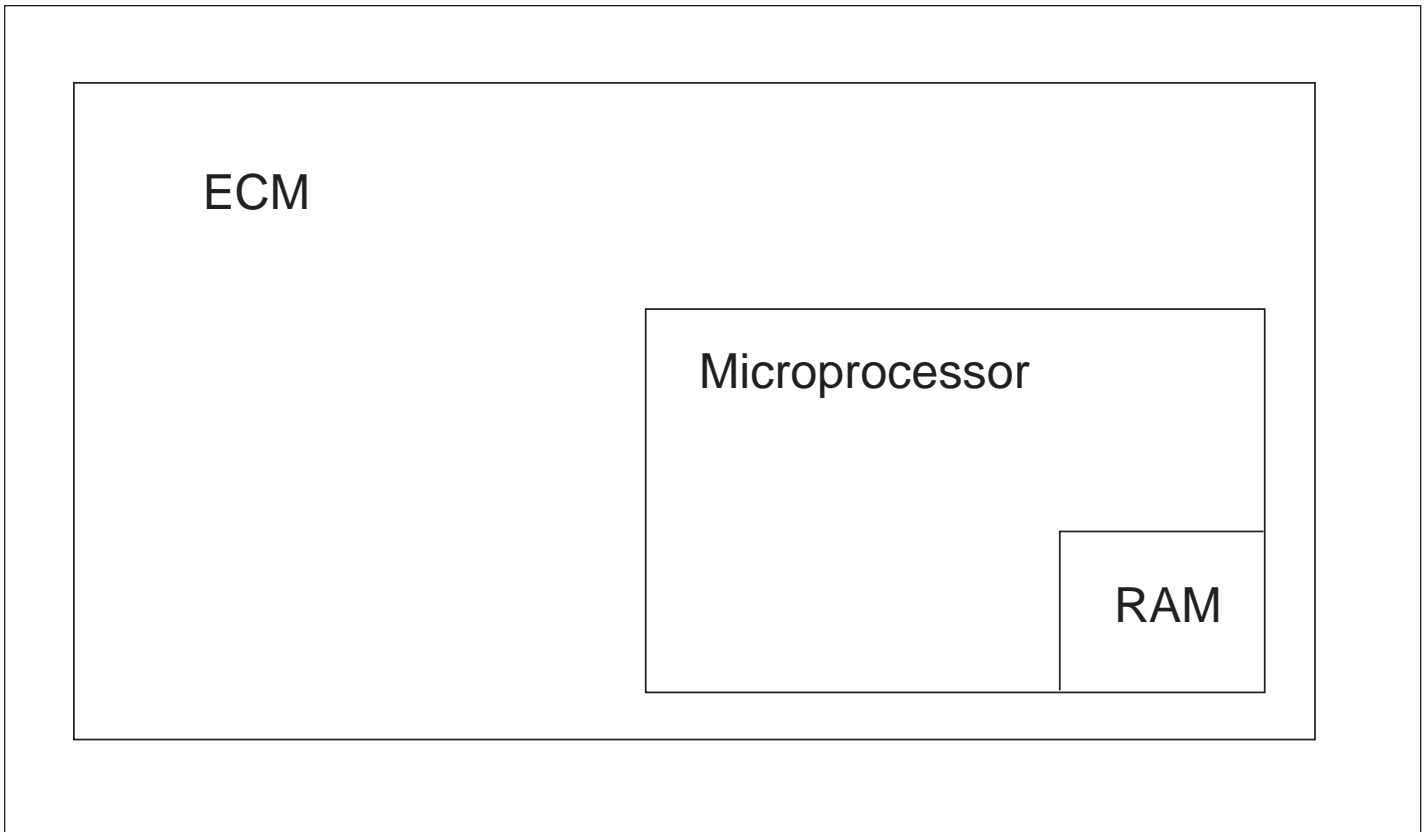
This fault indicates that both power supply feedback voltages are out-of-range as defined in the calibration. In configurations where the crank and/or camshaft position sensors are powered hall-effect sensors, the engine may stall due to loss of synchronization.

DTC 1611 - Sensor Supply Voltage (5Vref 1/2) Simultaneously Out-of-Range SPN - 1079; FMI - 31



Diagnostics

DTC 1612 - Microprocessor Failure - RTI 1 SPN - 629; FMI - 31

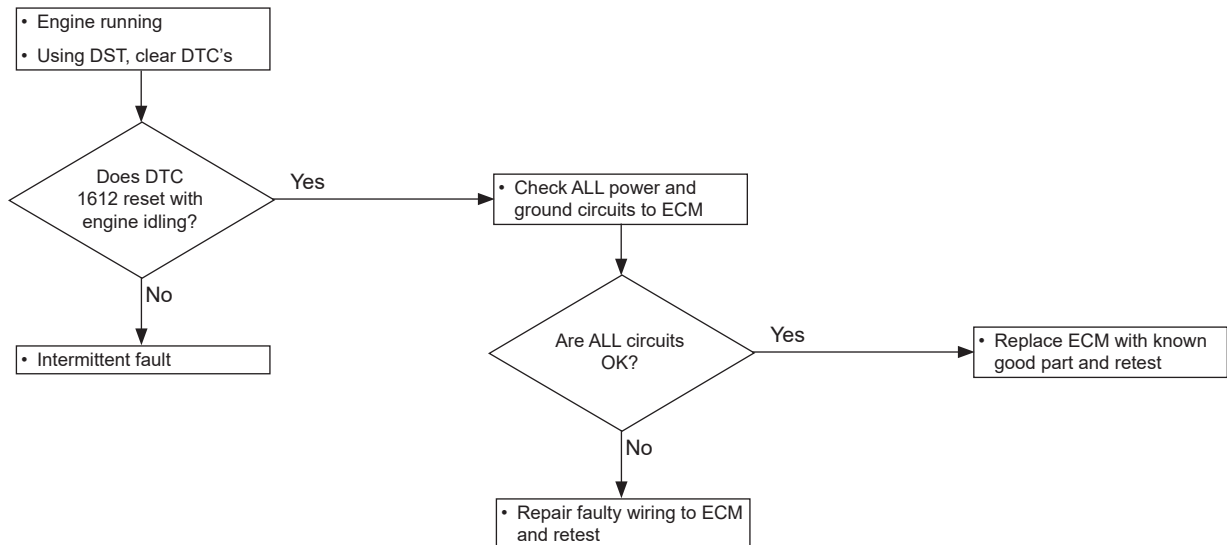


- Engine Control Module
- *Check Condition* - Key on
- *Fault Condition* - Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive - Disabled for the remainder of the key-on cycle
- Closed Loop - Enabled
- Power Derate (level 2 until fault is cleared manually)

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

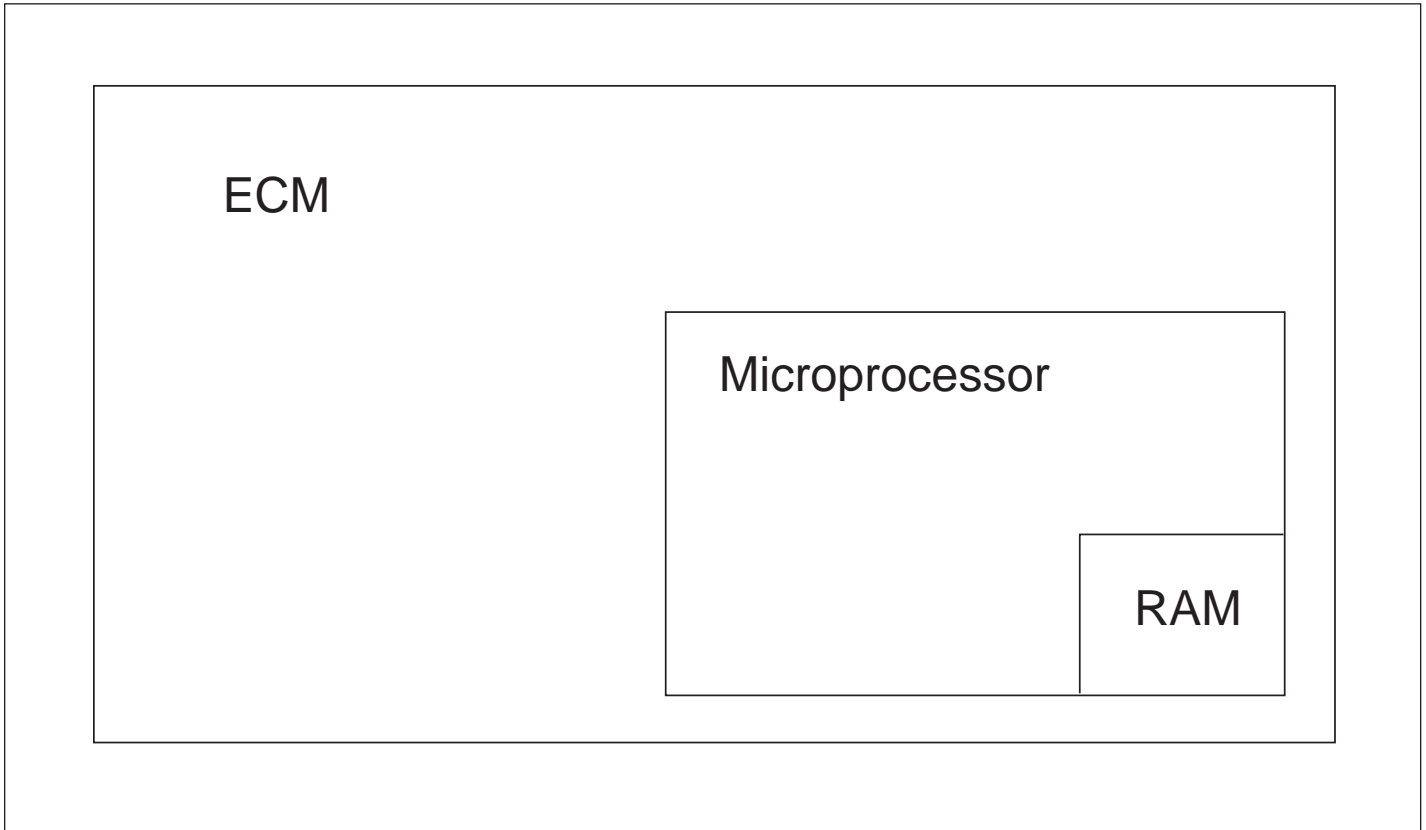
DTC 1612 - Microprocessor Failure - RTI 1 SPN - 629; FMI - 31



Diagnostics

DTC 1613 - Microprocessor Failure - RTI 2

SPN - 629; FMI - 31

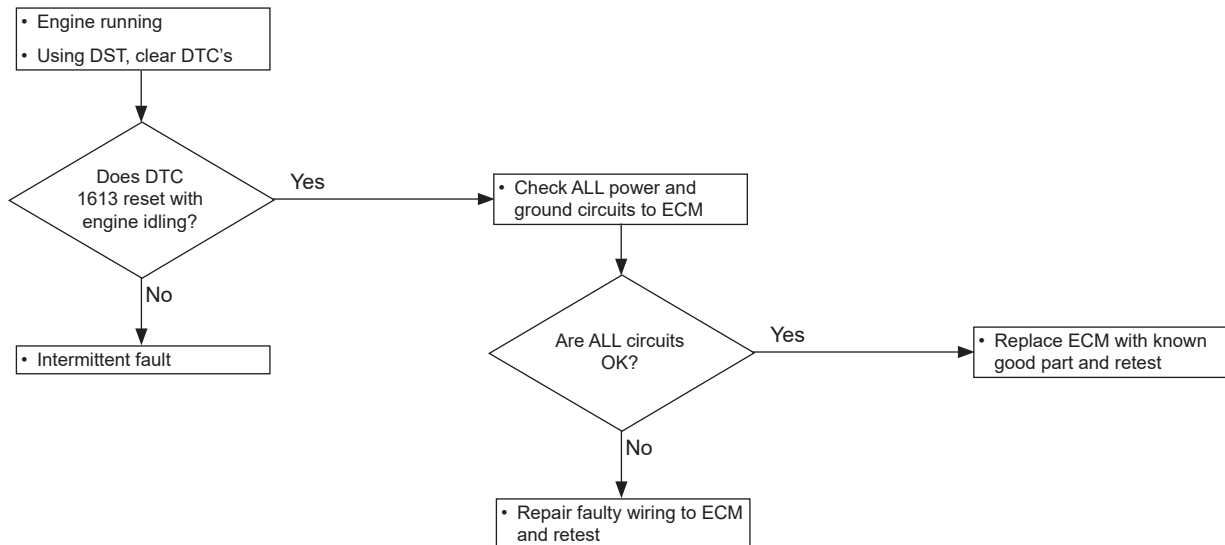


- Engine Control Module
- *Check Condition* - Key on
- *Fault Condition* - Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive - Disabled for the remainder of the key-on cycle
- Closed Loop - Enabled
- Power Derate (level 2 until fault is cleared manually)

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

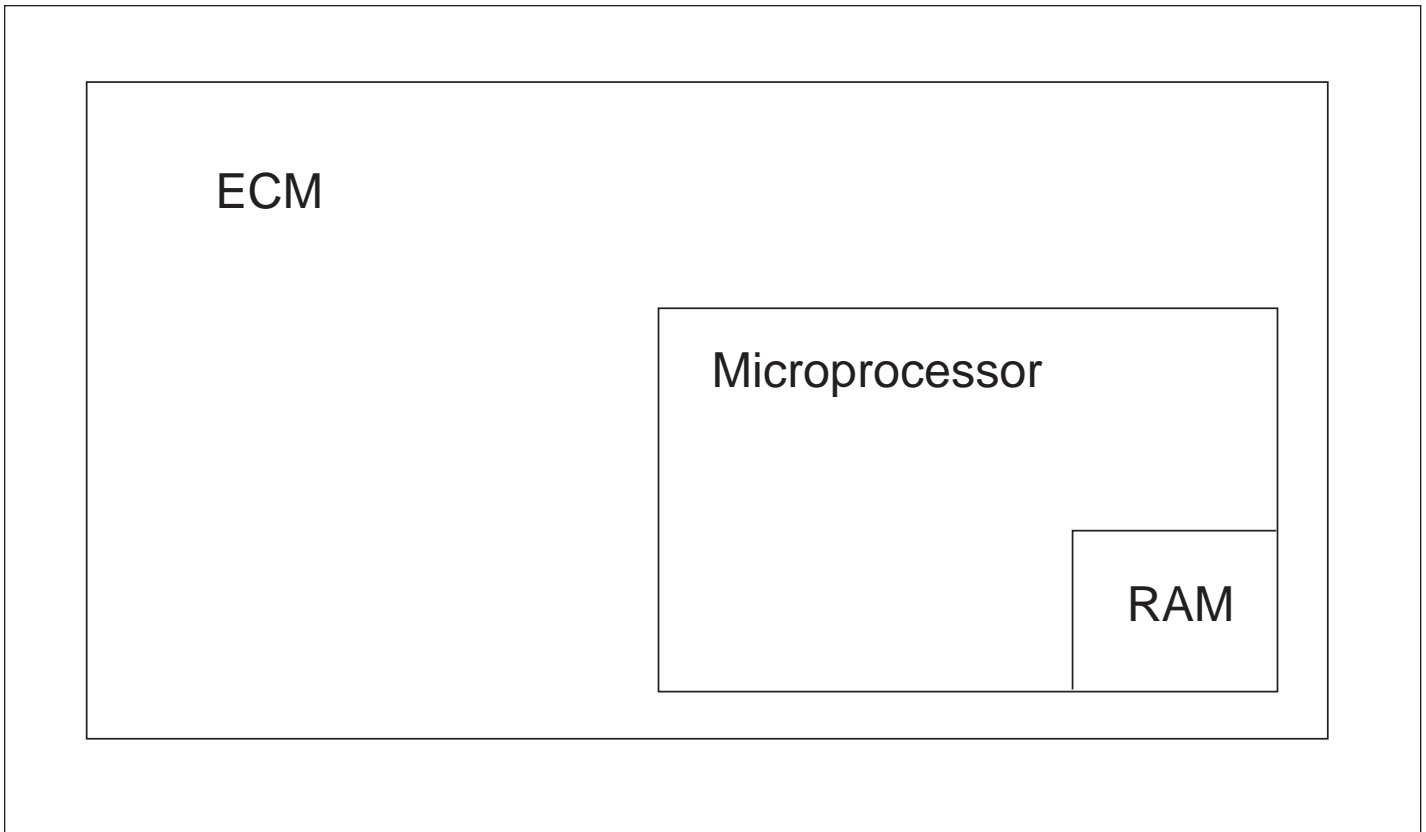
During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 1613 - Microprocessor Failure - RTI 2 SPN - 629; FMI - 31



Diagnostics

DTC 1614 - Microprocessor Failure - RTI 3 SPN - 629; FMI - 31

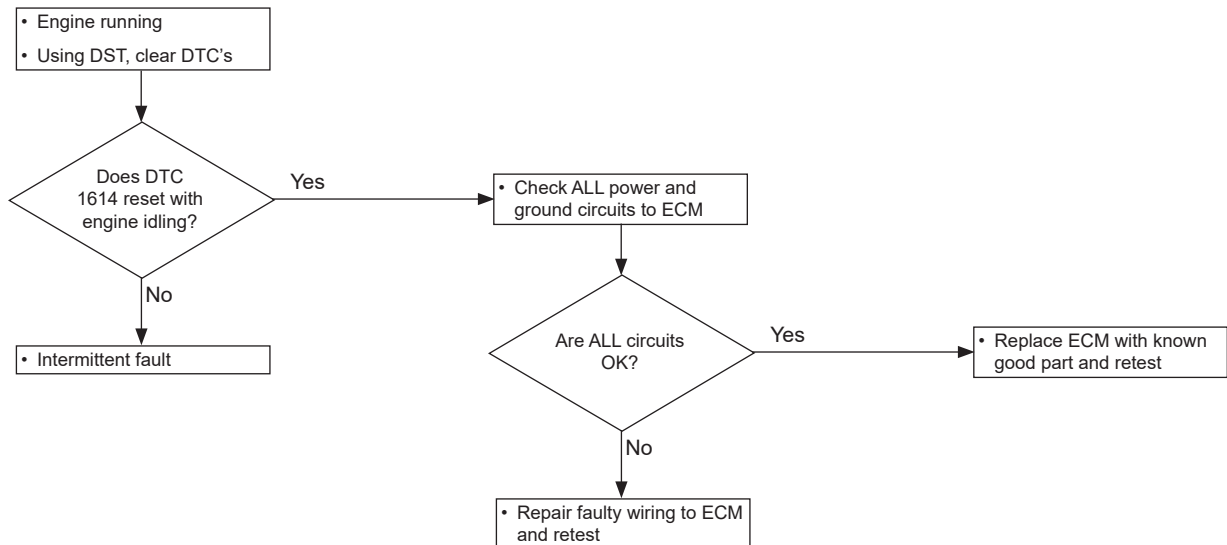


- Engine Control Module
- *Check Condition* - Key on
- *Fault Condition* - Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive - Disabled for the remainder of the key-on cycle
- Closed Loop - Enabled
- Power Derate (level 2 until fault is cleared manually)

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

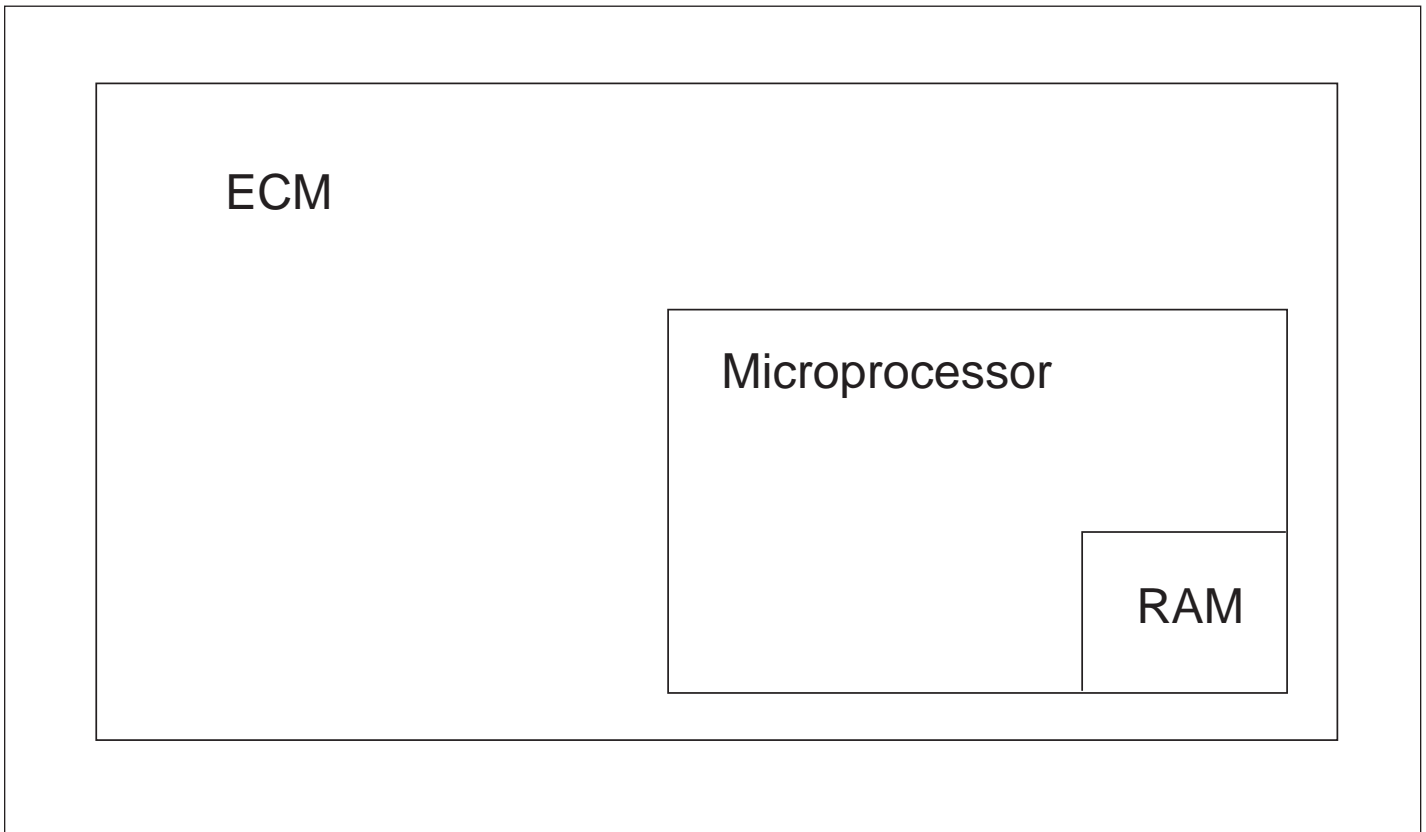
DTC 1614 - Microprocessor Failure - RTI 3 SPN - 629; FMI - 31



Diagnostics

DTC 1615 - Microprocessor Failure - A/D

SPN - 629; FMI - 31

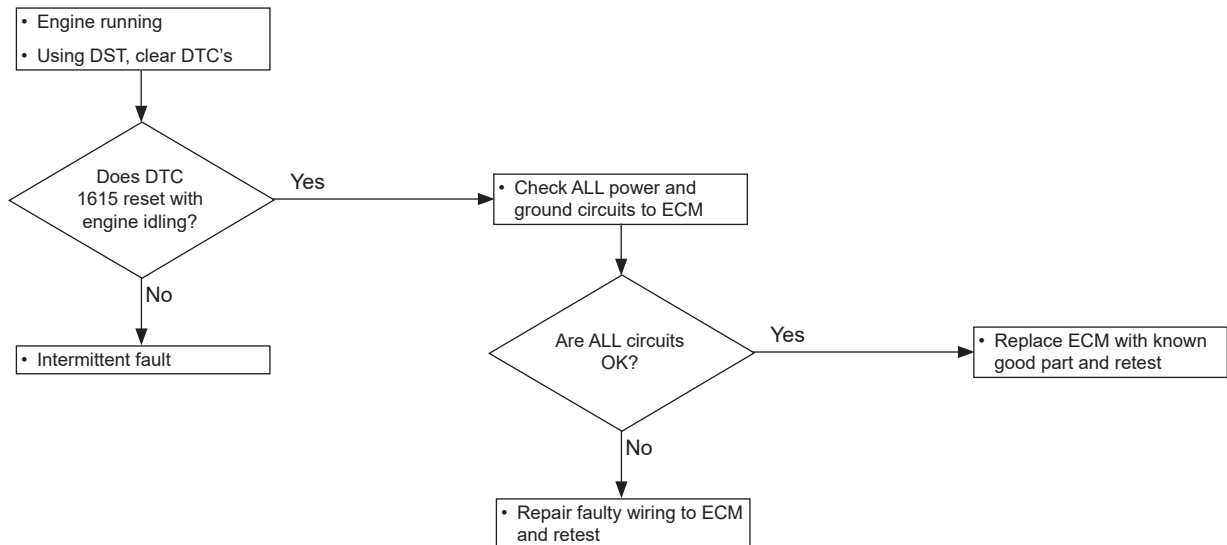


- Engine Control Module
- *Check Condition* - Key on
- *Fault Condition* - Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive - Disabled for the remainder of the key-on cycle
- Closed Loop - Enabled
- Power Derate (level 2 until fault is cleared manually)

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

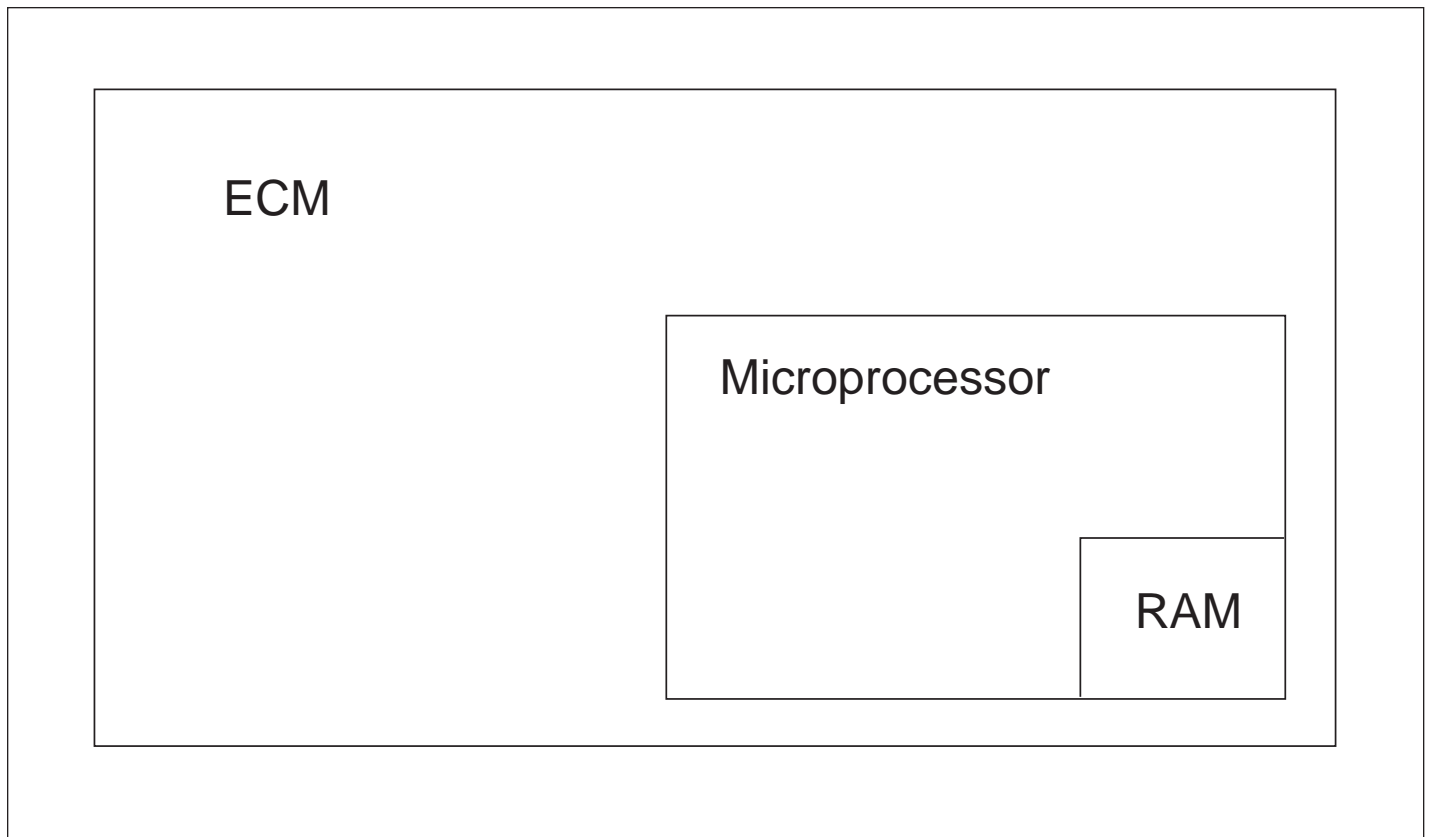
During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 1615 - Microprocessor Failure - A/D SPN - 629; FMI - 31



Diagnostics

DTC 1616 - Microprocessor Failure - Interrupt SPN - 629; FMI - 31

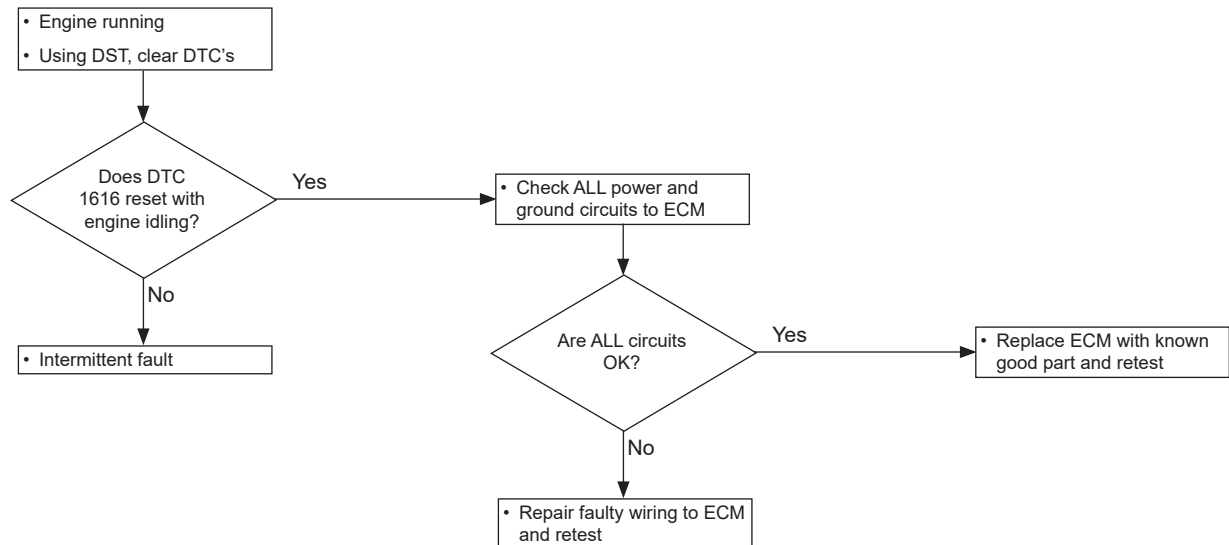


- Engine Control Module
- *Check Condition* - Key on
- *Fault Condition* - Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive - Disabled for the remainder of the key-on cycle
- Closed Loop - Enabled
- Power Derate (level 2 until fault is cleared manually)

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

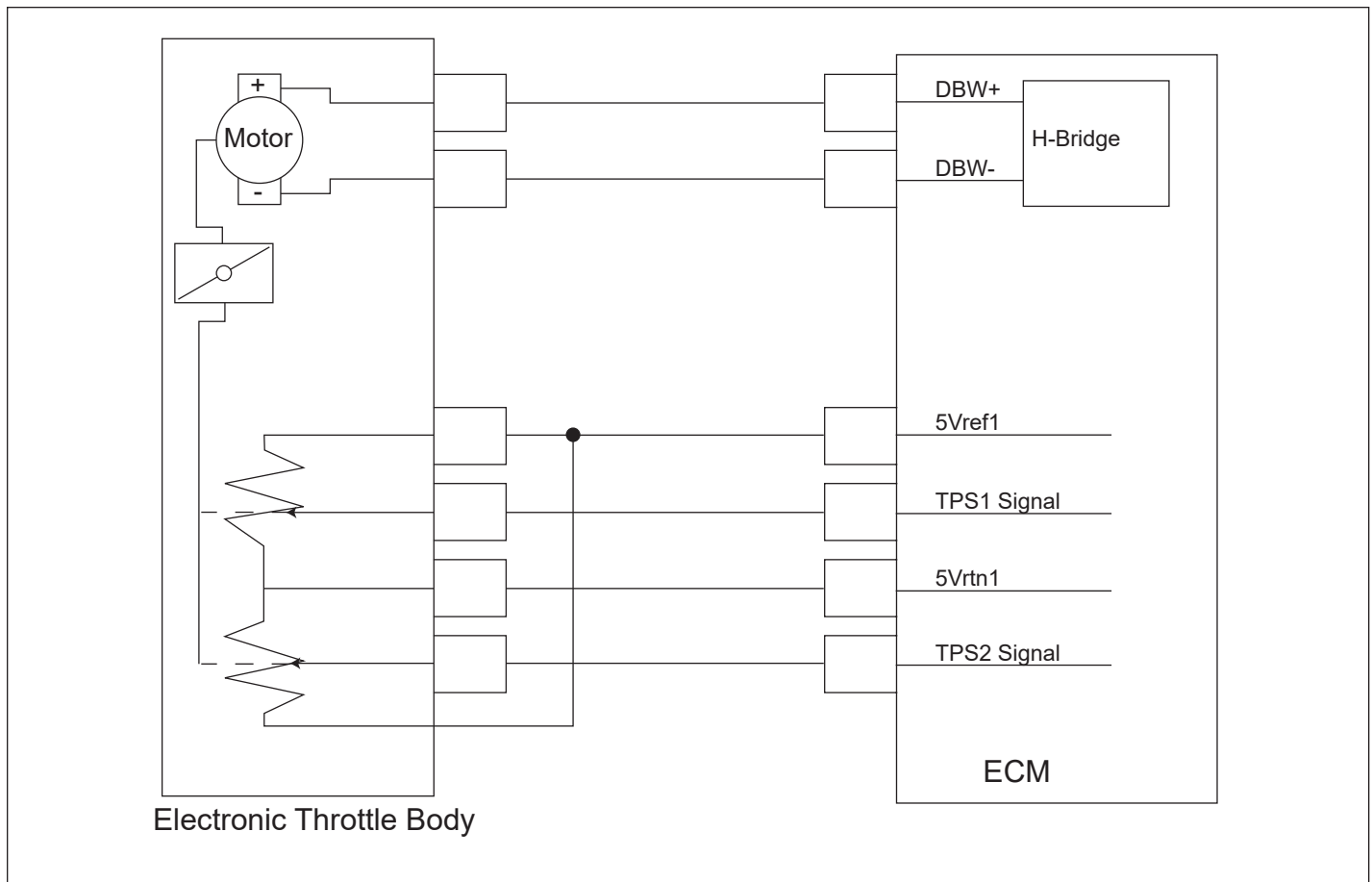
DTC 1616 - Microprocessor Failure - Interrupt SPN - 629; FMI - 31



Diagnostics

DTC 2111 - Unable to Reach Lower TPS

SPN - 51; FMI - 7

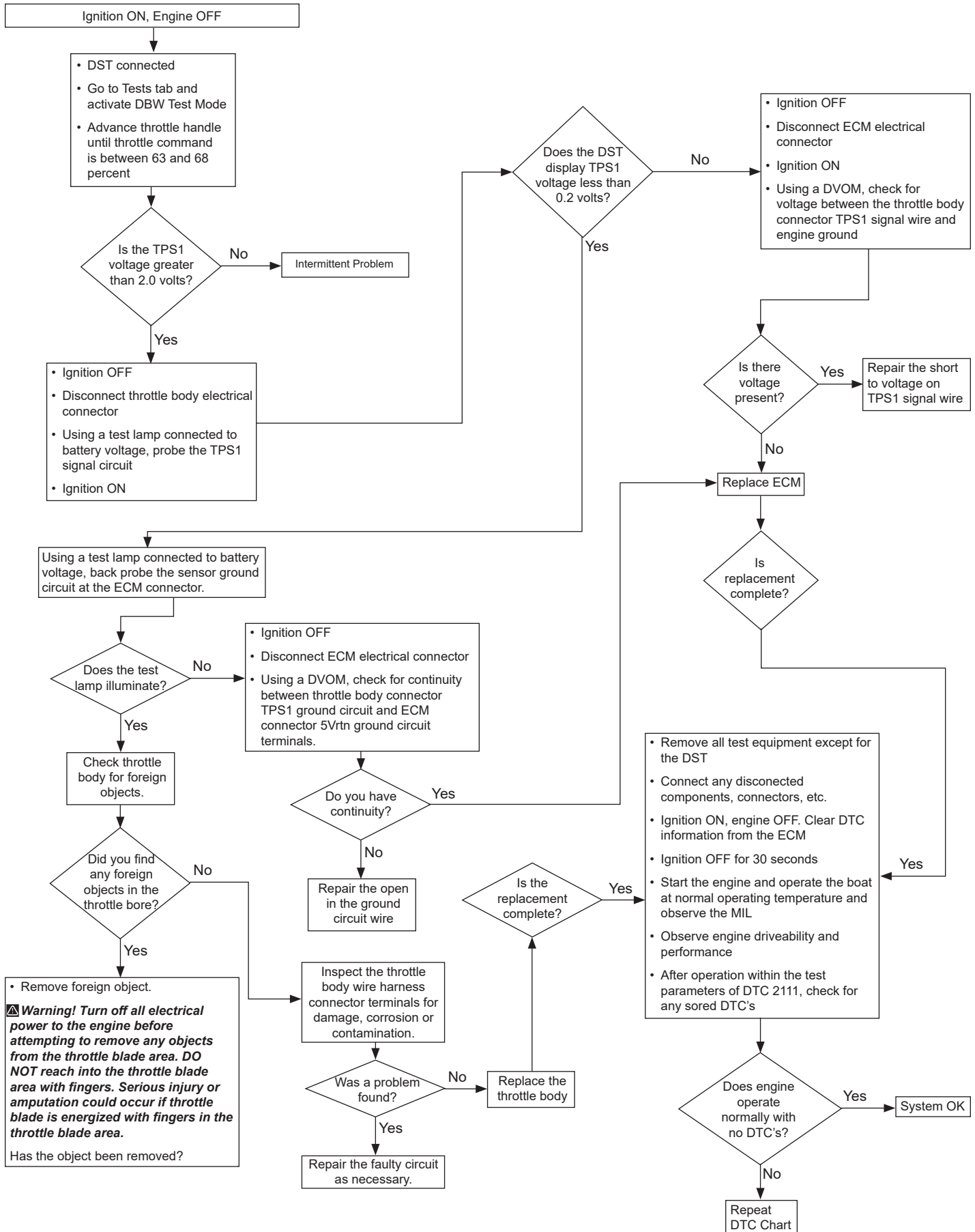


- Throttle Body / Throttle Position Sensor
- *Check Condition* - Cranking or Running
- *Fault Condition* - Throttle command is 20 percent less than the throttle position for 200ms or longer.
- MIL - On during active fault
- Buzzer - On during active fault
- Low Rev Limit and Forced Idle is activated

There are two throttle position sensors located within the throttle body which use variable resistors to determine signal voltage based on the throttle blade position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from these voltages. Although the voltages are different, the calculated values for the throttle position percentages should be very close to the same. The TPS values are used by the ECM to determine if the throttle is opening as commanded.

This fault will set if the throttle command is 20 percent less than the actual throttle position. During this active fault, the MIL will be illuminated and "forced idle" mode will be activated.

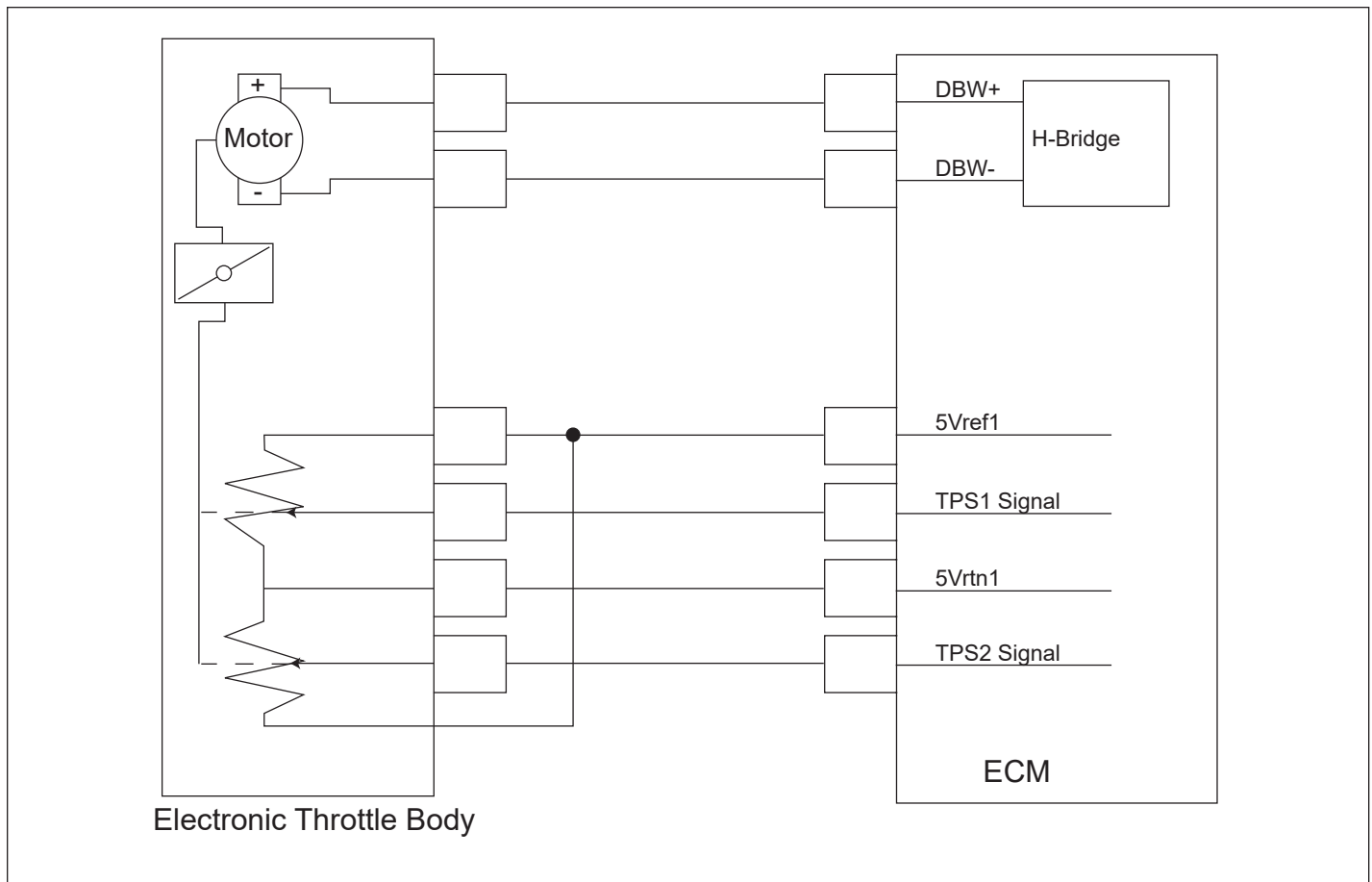
DTC 2111 - Unable to Reach Lower TPS SPN - 51; FMI - 7



Diagnostics

DTC 2112 - Unable to Reach Higher TPS

SPN - 51; FMI - 7

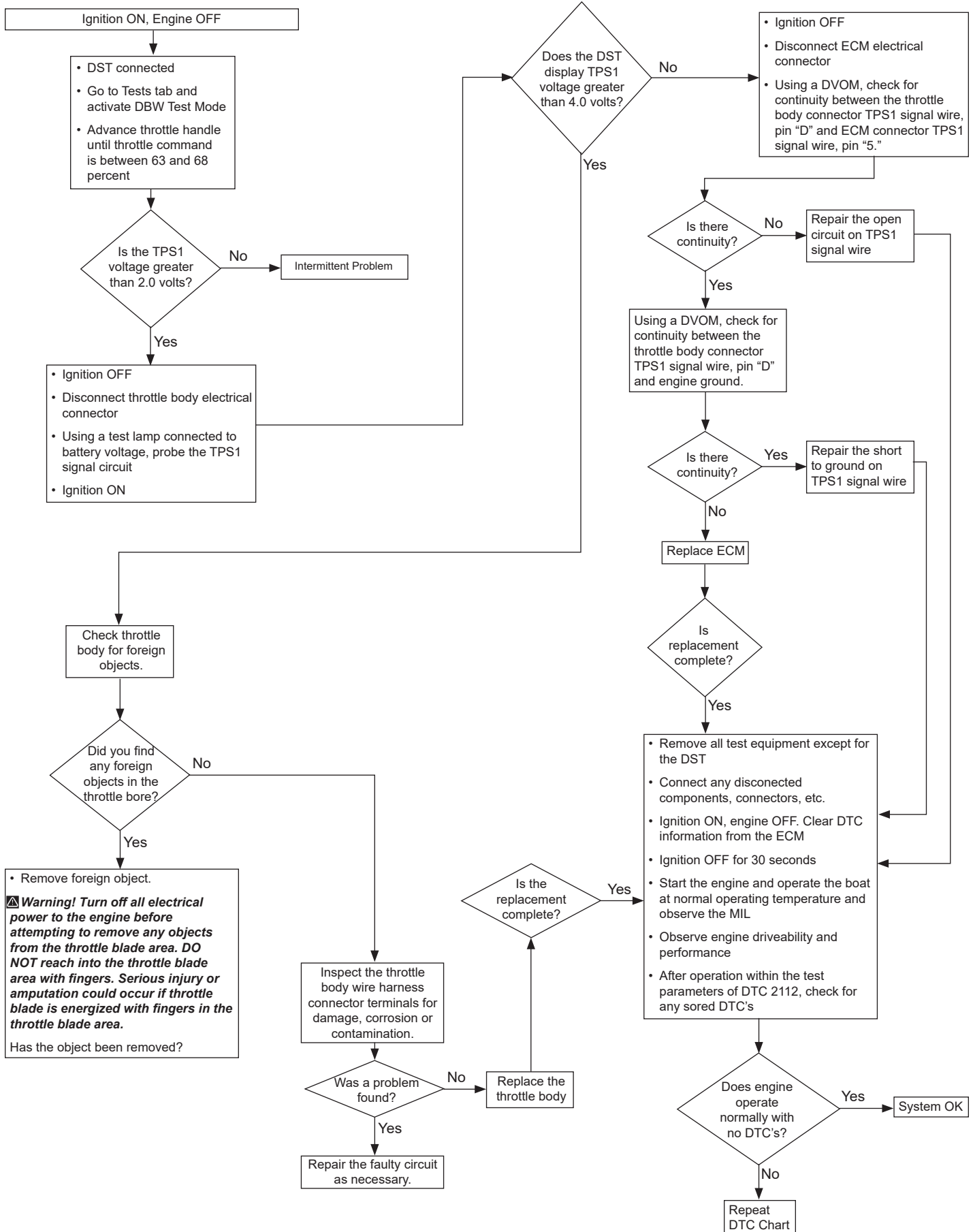


- Throttle Body / Throttle Position Sensor
- *Check Condition* - Cranking or Running
- *Fault Condition* - Throttle command is 20 percent more than the throttle position for 200ms or longer.
- MIL - On during active fault
- Buzzer - On during active fault
- Low Rev Limit and Forced Idle is activated

There are two throttle position sensors located within the throttle body which use variable resistors to determine signal voltage based on the throttle blade position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from these voltages. Although the voltages are different, the calculated values for the throttle position percentages should be very close to the same. The TPS values are used by the ECM to determine if the throttle is opening as commanded.

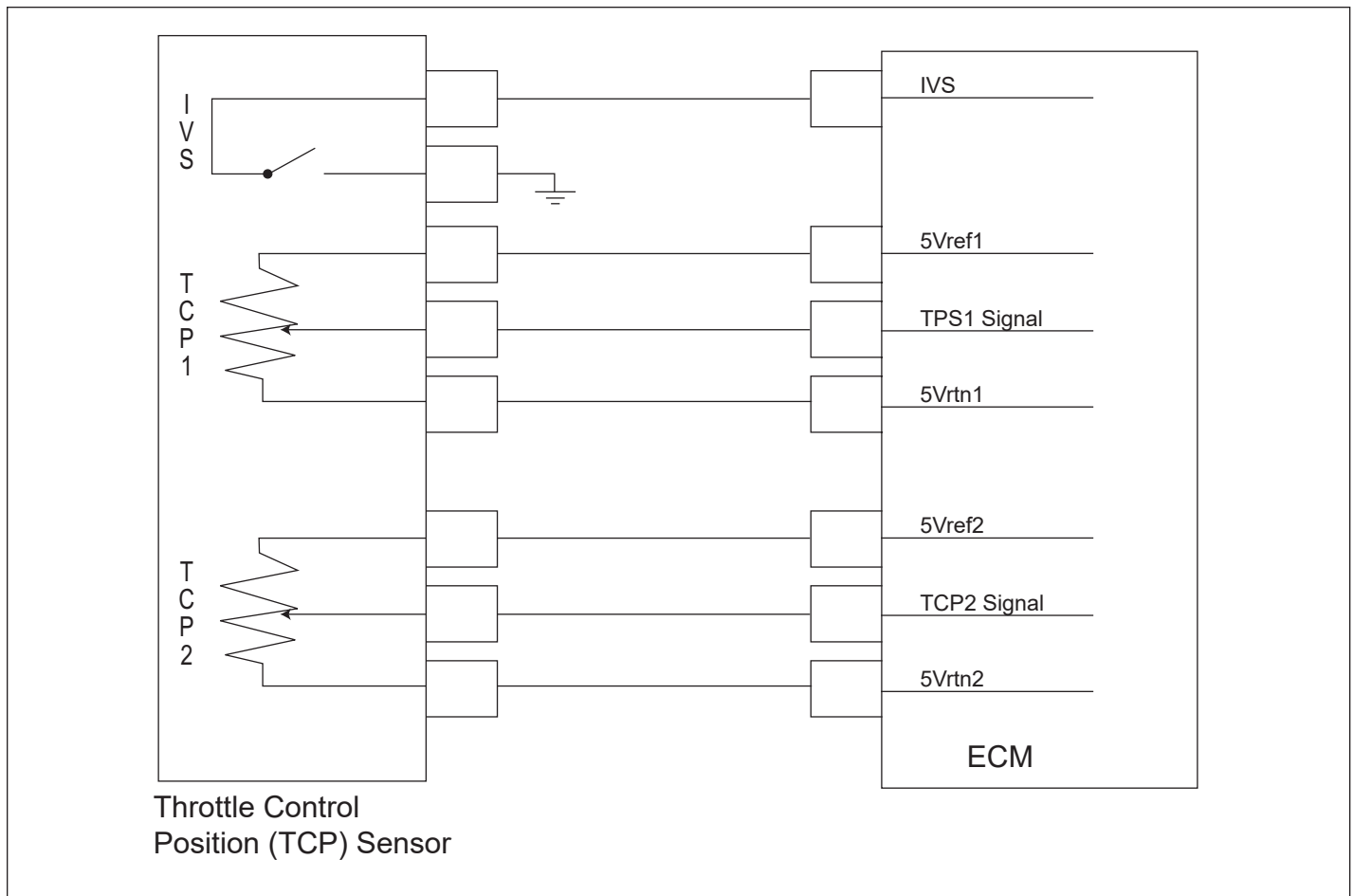
This fault will set if the throttle command is 20 percent more than the actual throttle position. During this active fault, the MIL will be illuminated and "forced idle" mode will be activated.

DTC 2112 - Unable to Reach Higher TPS SPN - 51; FMI - 7



Diagnostics

DTC 2115 - TCP Sensor 1 Higher Than IVS Limit SPN - 91; FMI - 0

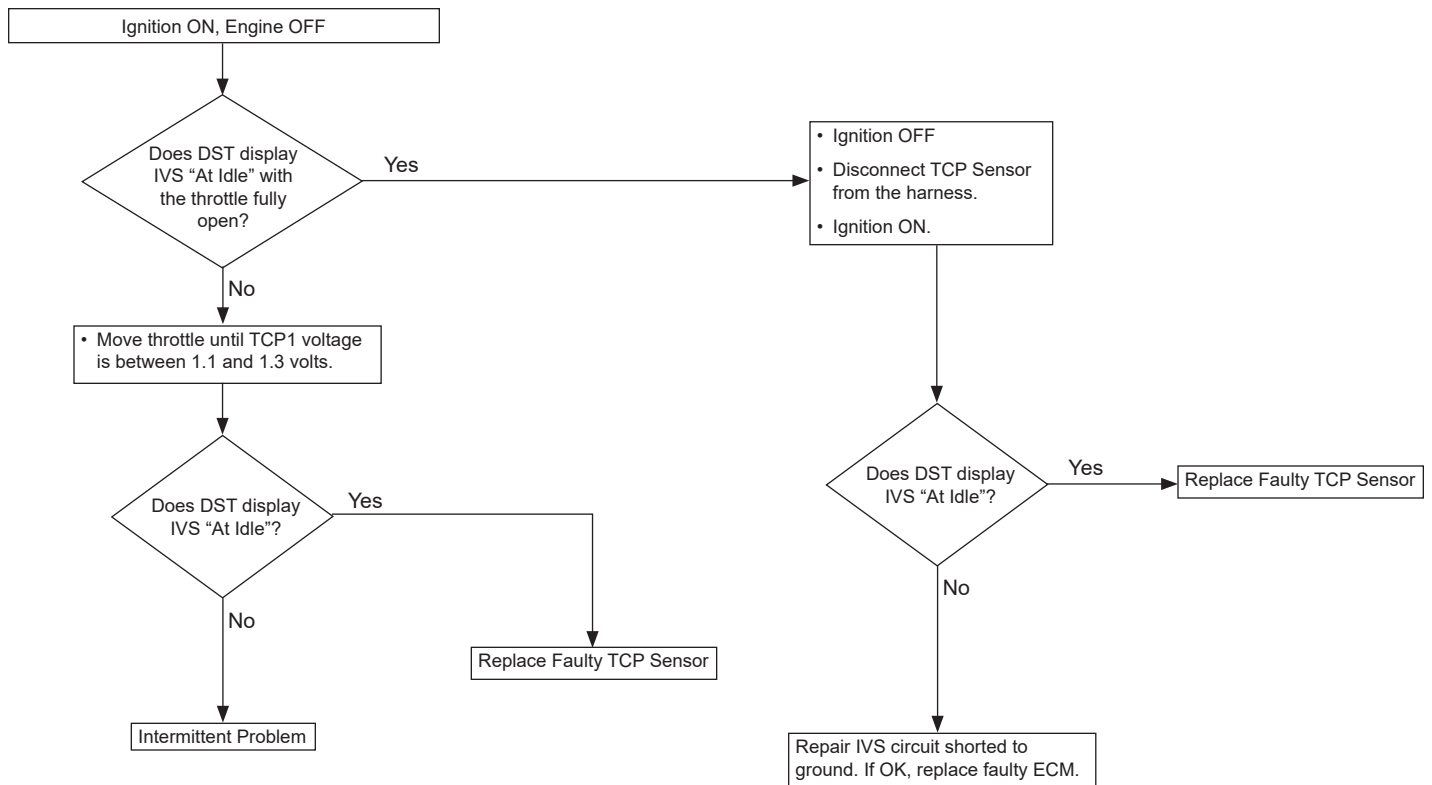


- Throttle Control Position/Idle Validation Switch (IVS)
- *Check Condition* - Engine Cranking or Running
- *Fault Condition* - IVS at idle and TCP voltage greater than 1.2 volts
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycle

The engine load command to the ECM is determined by operator depression of the electronic foot pedal. The ECM monitors the foot pedal position and controls the throttle to maintain the commanded power level. Because a problem with the foot pedal signal can result in a higher or lower power than intended by the operator, the pedal used with this control system incorporates a sensor with an idle validation switch. Checks and cross checks are constantly conducted by the ECM to determine the validity of the signals. The Idle Validation Switch (IVS) is a normally open contact (idle) that grounds (closed contacts) the IVS circuit to the ECM when the pedal is depressed more than the idle position.

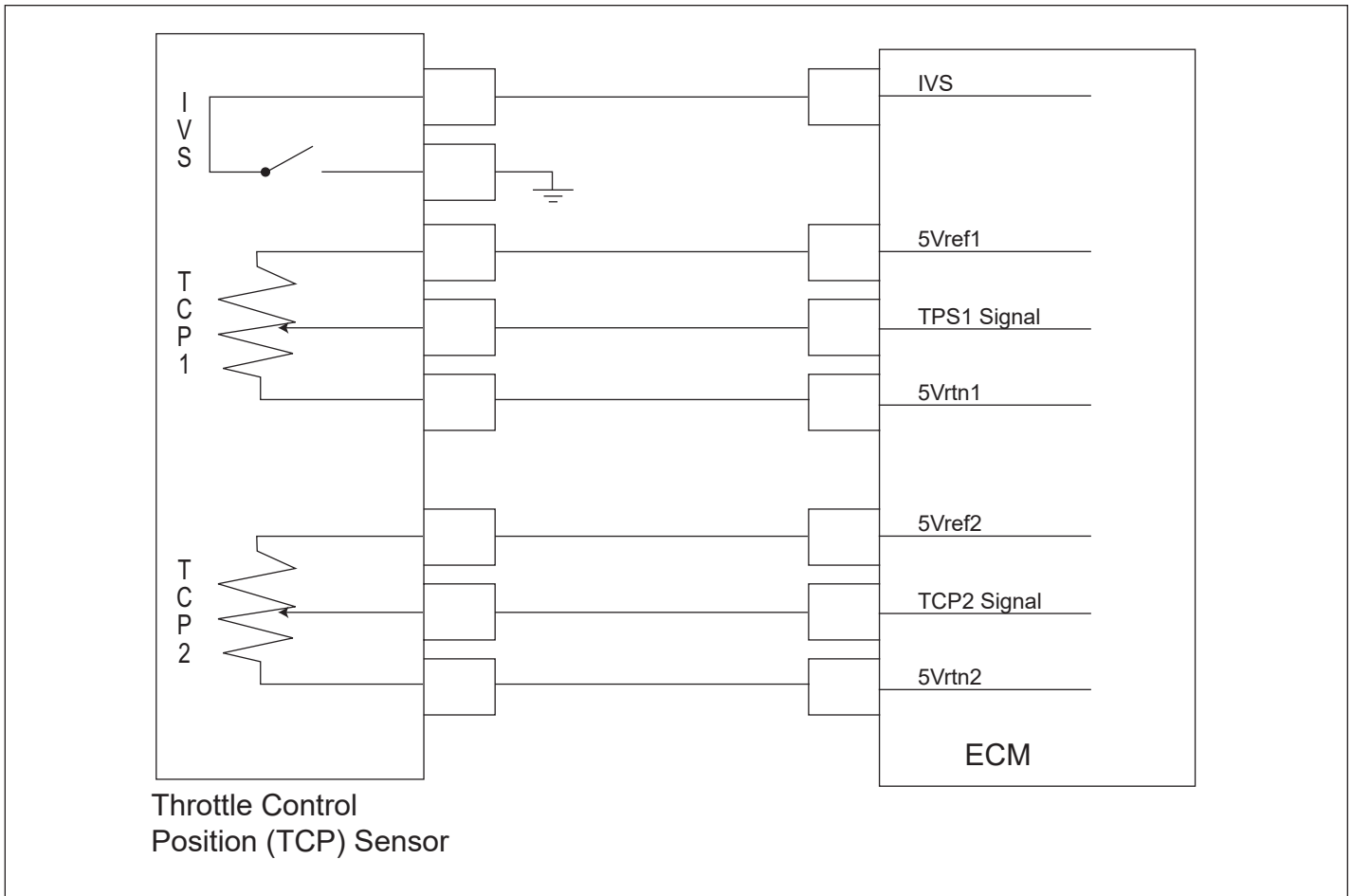
This fault will set if the IVS is at idle (open) and the TCP voltage is greater than 1.2 volts. During this fault, Power Derate (level 2) and the Low Rev Limit are enforced. When these are enforced the maximum throttle position is 20% and the maximum engine speed is 1600 RPM. The Low Rev Limit and Power Derate are enforced for the remainder of the key-on cycle. If the active fault is no longer present, the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Power Derate and Low Rev Limits are still enforced.

DTC 2115 - TCP Sensor 1 Higher Than IVS Limit SPN - 91; FMI - 0



Diagnostics

DTC 2116 - TCP Sensor 2 Higher Than IVS Limit SPN - 29; FMI - 0

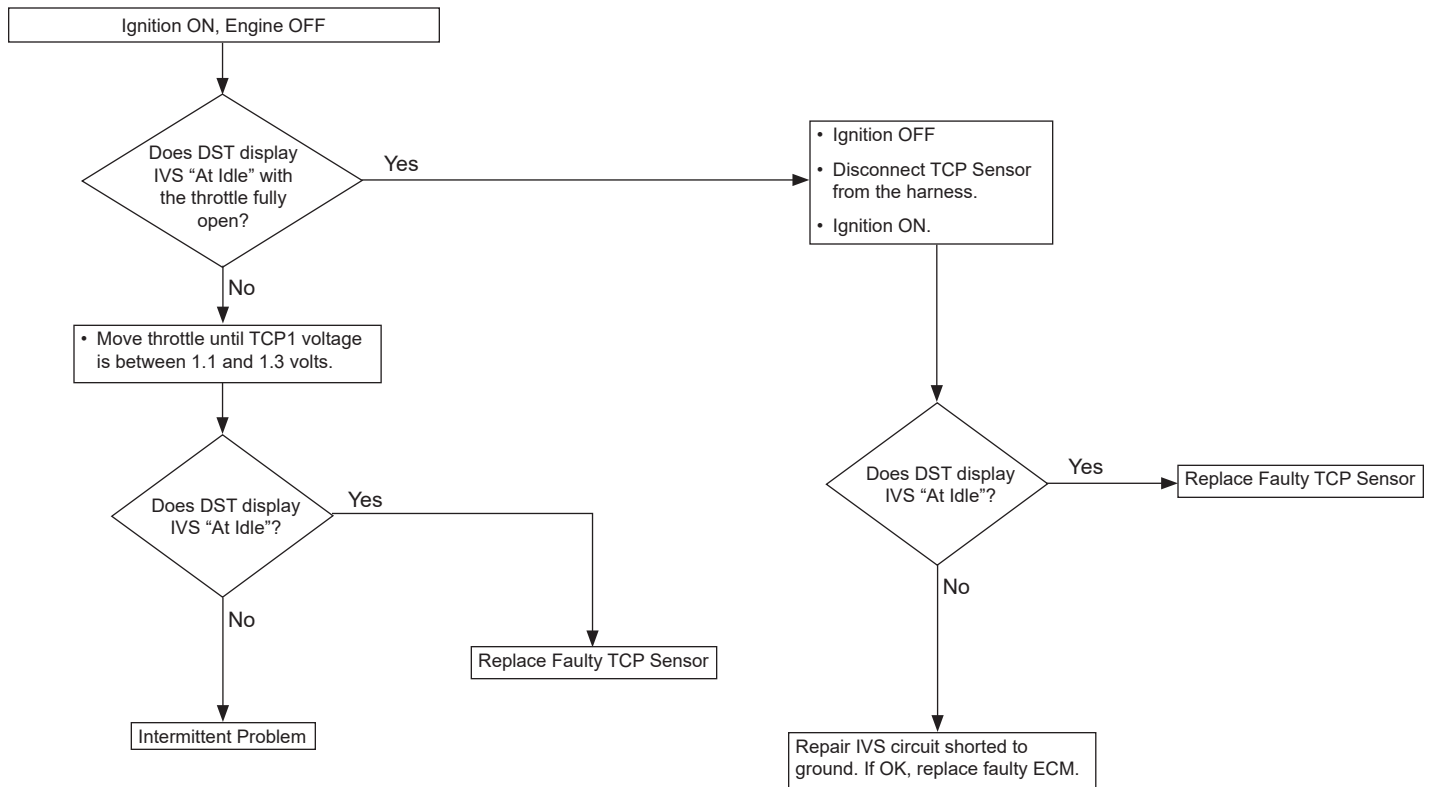


- Throttle Control Position/Idle Validation Switch (IVS)
- *Check Condition* - Engine Cranking or Running
- *Fault Condition* - IVS at idle and TCP voltage greater than 1.2 volts
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycle

The engine load command to the ECM is determined by operator depression of the electronic foot pedal. The ECM monitors the foot pedal position and controls the throttle to maintain the commanded power level. Because a problem with the foot pedal signal can result in a higher or lower power than intended by the operator, the pedal used with this control system incorporates a sensor with an idle validation switch. Checks and cross checks are constantly conducted by the ECM to determine the validity of the signals. The Idle Validation Switch (IVS) is a normally open contact (idle) that grounds (closed contacts) the IVS circuit to the ECM when the pedal is depressed more than the idle position.

This fault will set if the IVS is at idle (open) and the TCP voltage is greater than 1.2 volts. During this fault, Power Derate (level 2) and the Low Rev Limit are enforced. When these are enforced the maximum throttle position is 20% and the maximum engine speed is 1600 RPM. The Low Rev Limit and Power Derate are enforced for the remainder of the key-on cycle. If the active fault is no longer present, the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Power Derate and Low Rev Limits are still enforced.

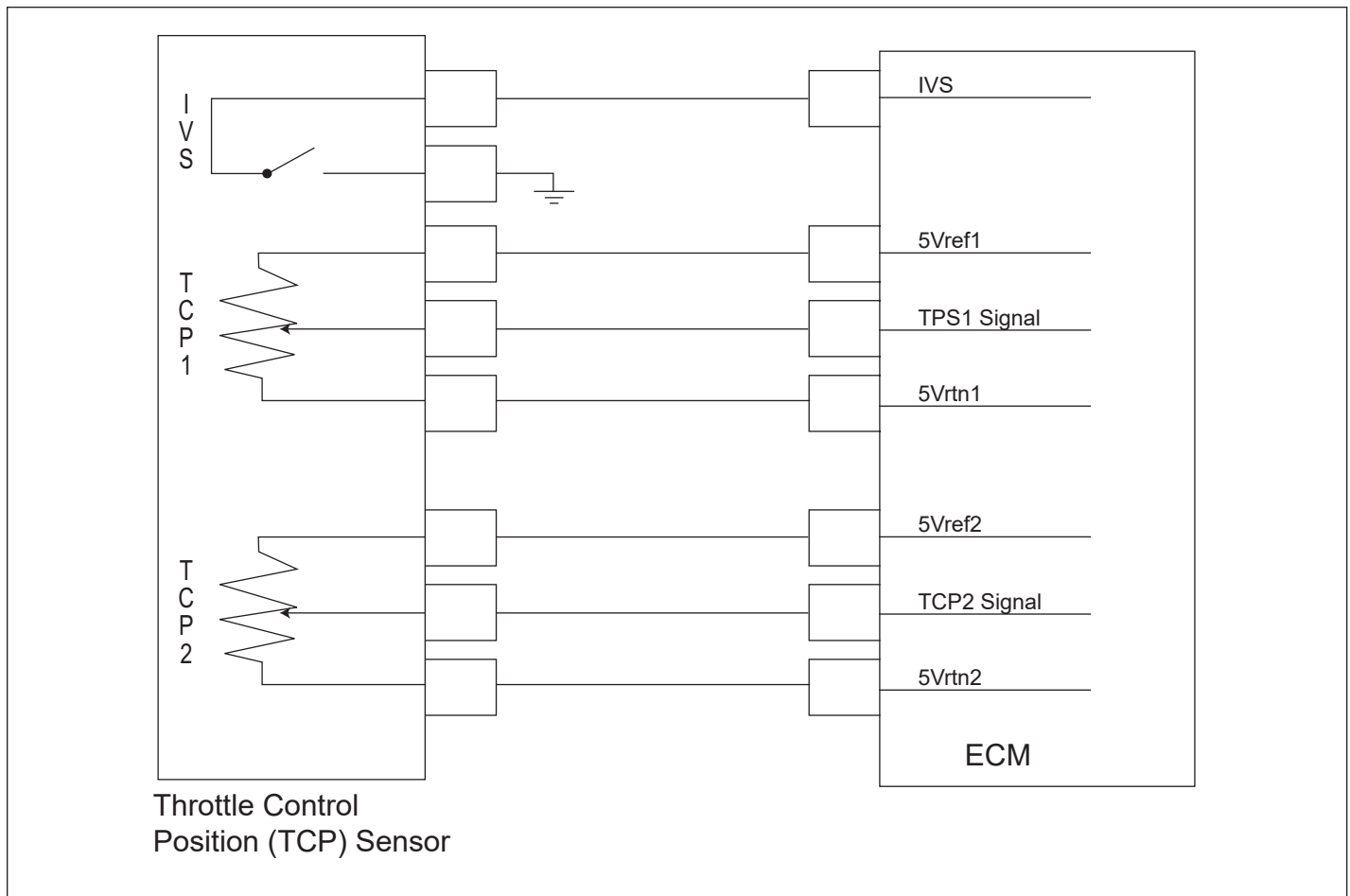
DTC 2116 - TCP Sensor 2 Higher Than IVS Limit SPN - 29; FMI - 0



Diagnostics

DTC 2120 - TCP Sensor 1 Invalid Voltage and TCP Sensor 2 Disagrees with IVS

SPN - 520199; FMI - 11



- Electronic Throttle Control Position (TCP) Sensor
- *Check Condition* - Ignition ON, Engine OFF
- *Fault Condition* - TCP1 Voltage out-of-range, TCP2% does not match IVS state
- Corrective Action(s) - Illuminate MIL, sound audible warning and forced idle
- Non-emissions related fault

The TCP sensor is an electronic device that is coupled to a mechanically driven input as commanded by the engine operator. A TCP sensor may be, but is not limited to a foot pedal assembly, a cable-lever-sensor assembly, or a rotary potentiometer. General sensor configurations consist of two potentiometers with IVS. The TCP sensor outputs are proportional to the commanded input. The ECM uses the TCP sensor inputs to control the throttle and adjust the engine's load in order to achieve the requested power. Since the TCP sensor inputs directly affect the engine's power output, redundant sensors are generally used to ensure safe, reliable operation.

This fault is only applicable with dual potentiometer/single IVS sensors and indicates that TCP1 voltage is out-of-range and TCP2% does not correlate with the IVS state resulting in a loss of redundancy.

DTC 2120 - TCP Sensor 1 Invalid Voltage and TCP Sensor 2 Disagrees with IVS SPN - 520199; FMI - 11

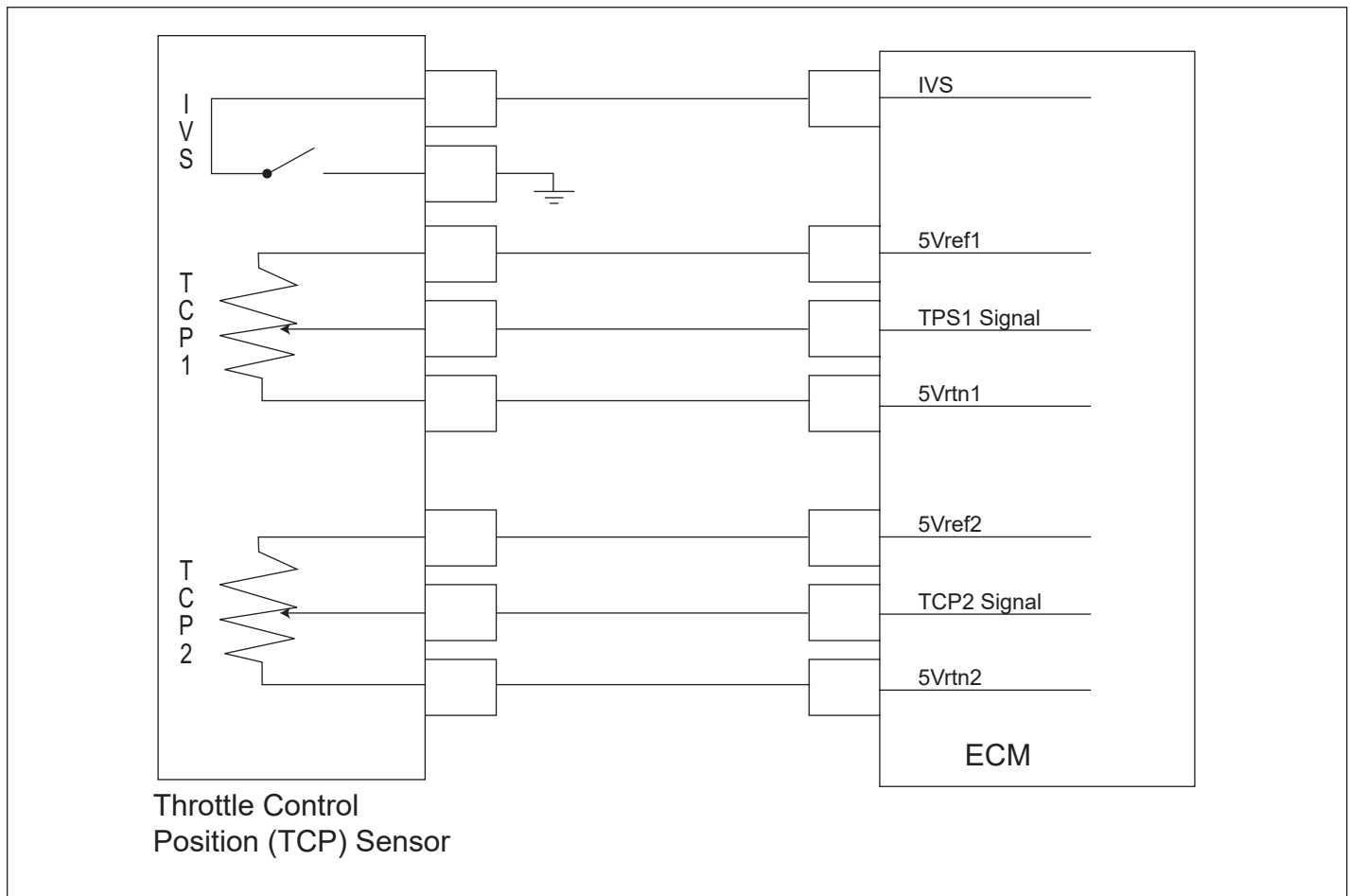
Diagnostic Aids

- **For TCP1 Invalid Voltage** - Troubleshoot according to *DTC 2122 TCP1 High Voltage* and *DTC 2123 TCP1 Low Voltage* procedures.
- **For TCP2 Disagrees with IVS** - Troubleshoot according to *DTC 2116 TCP2 Higher Than IVS Limit* and *DTC 2140 TCP2 Lower Than IVS Limit* procedures.

Diagnostics

DTC 2121 - TCP Sensor 1 Lower Than TCP Sensor 2

SPN - 91; FMI - 18

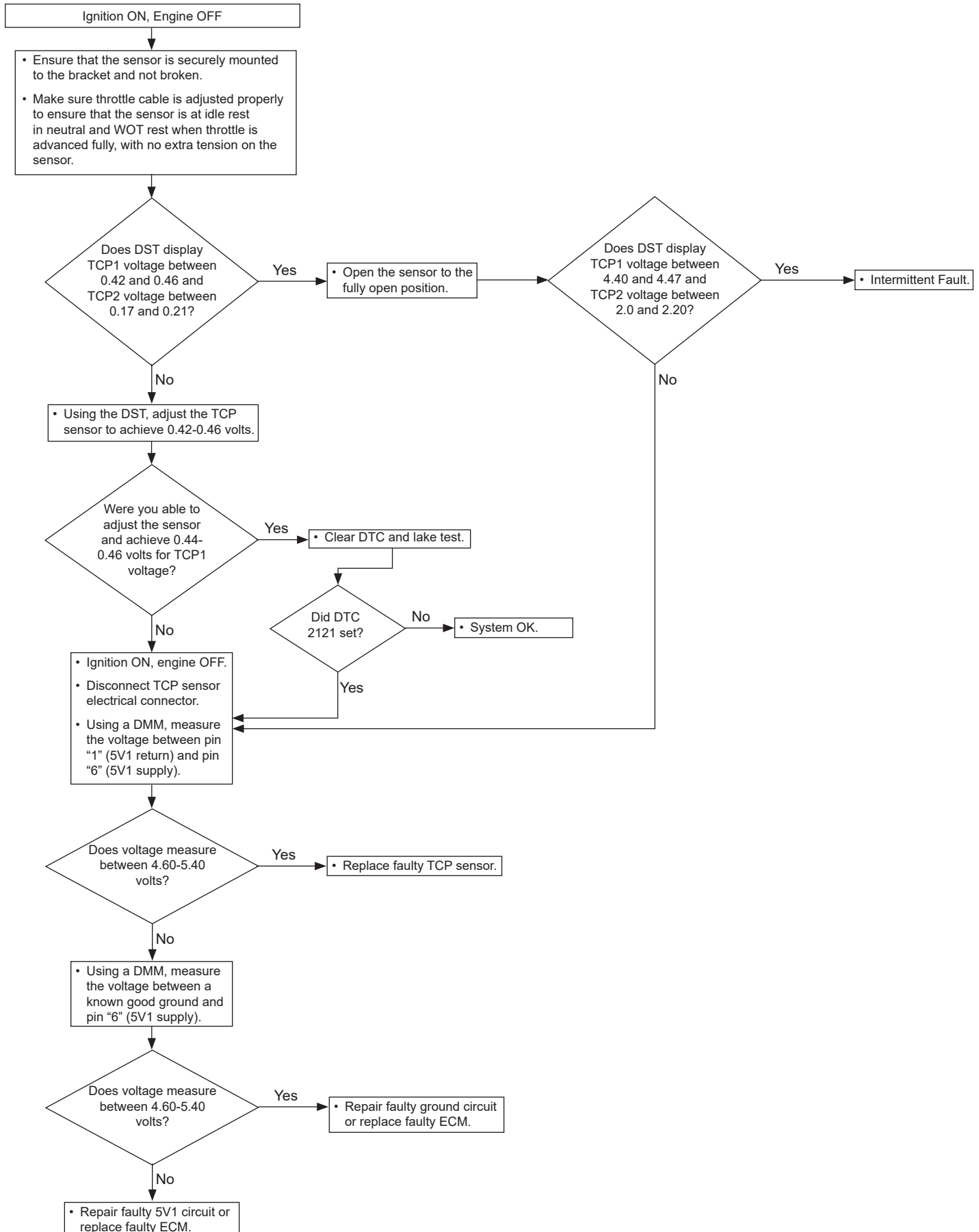


- Electronic foot pedal/throttle control sensor
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - TCP1% lower than TCP2%
- *Corrective Action(s)* - Illuminate MIL, sound audible warning and power derate, low rev limit, or forced idle
- Non-emissions related fault

The TCP sensor is an electronic device that is coupled to a mechanically driven input as commanded by the engine operator. A TCP sensor may be, but is not limited to a foot pedal assembly, a cable-lever-sensor assembly, or a rotary potentiometer. General sensor configurations consist of two potentiometers with IVS. The TCP sensor outputs are proportional to the commanded input. The ECM uses the TCP sensor inputs to control the throttle and adjust the engine's load in order to achieve the requested power. Since the TCP sensor inputs directly affect the engine's power output, redundant sensors are generally used to ensure safe, reliable operation.

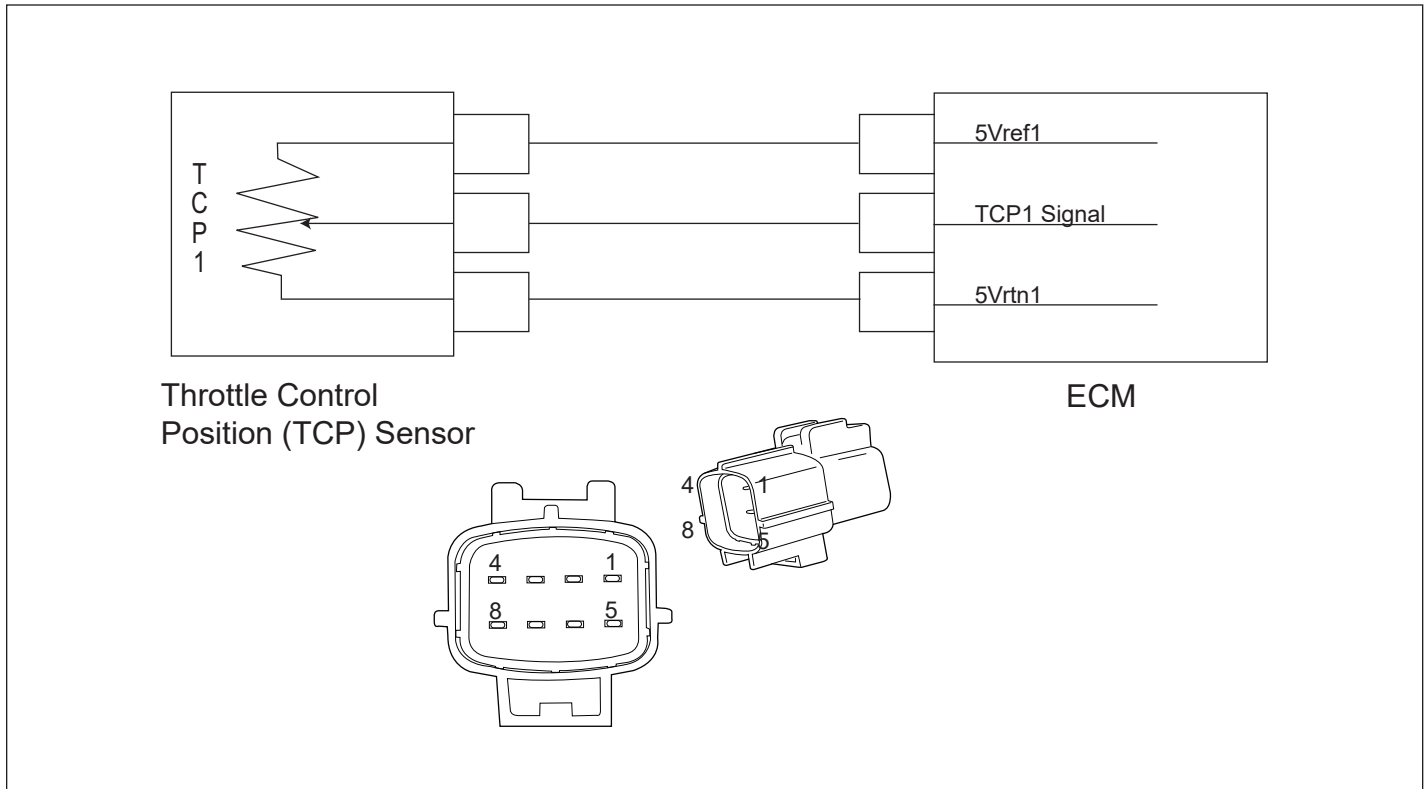
This fault indicates that the measured % deflection of sensor 1 is less than sensor 2 by an amount defined in calibration.

DTC 2121 - TCP Sensor 1 Lower Than TCP Sensor 2 SPN - 91; FMI - 18



Diagnostics

DTC 2122 - TCP Sensor 1 High Voltage SPN - 91; FMI - 3

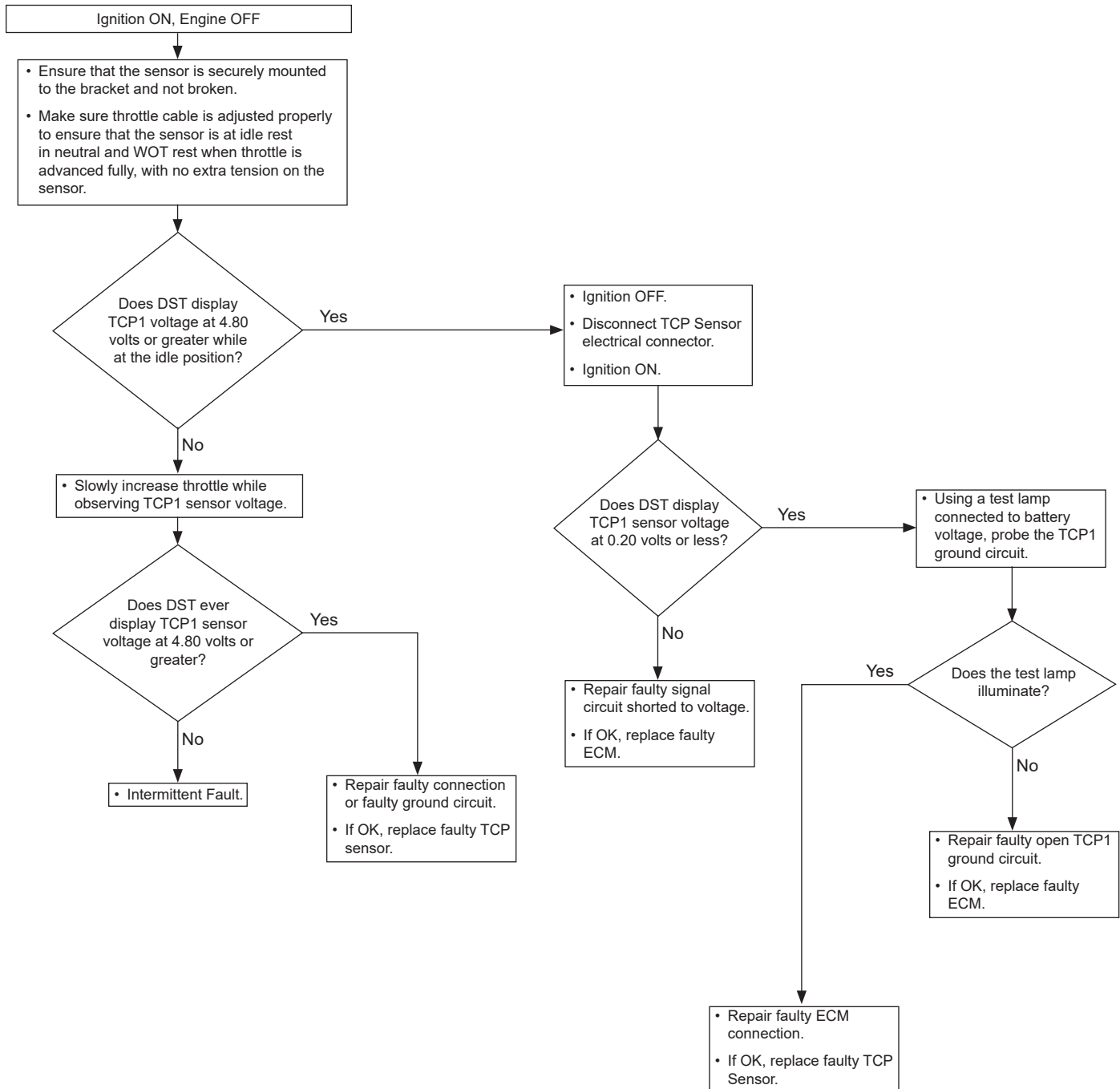


- Throttle Control Position (TCP) Sensor
- *Check Condition* - Ignition ON
- *Fault Condition* - TCP1 sensor voltage exceeds 4.8
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycled

The Throttle Control Position (TCP) sensor uses a variable resistor to determine signal voltage based on throttle lever position. Less movement of the throttle lever results in lower voltage, and greater movement results in higher voltage.

This fault will set if voltage is over 4.8 volts at any operating condition while the key is on. If the voltage exceeds 4.8, then TCP1 is considered to be out of specifications. At this point the ECM does not have a valid signal, and must therefore enforce the low rev limit and Power Derate (level 1). When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1600 RPM. The Low Rev Limit is enforced for the remainder of the key-on cycle. Rev limit is still enforced if the active fault is no longer present; the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Low Rev Limit is still enforced.

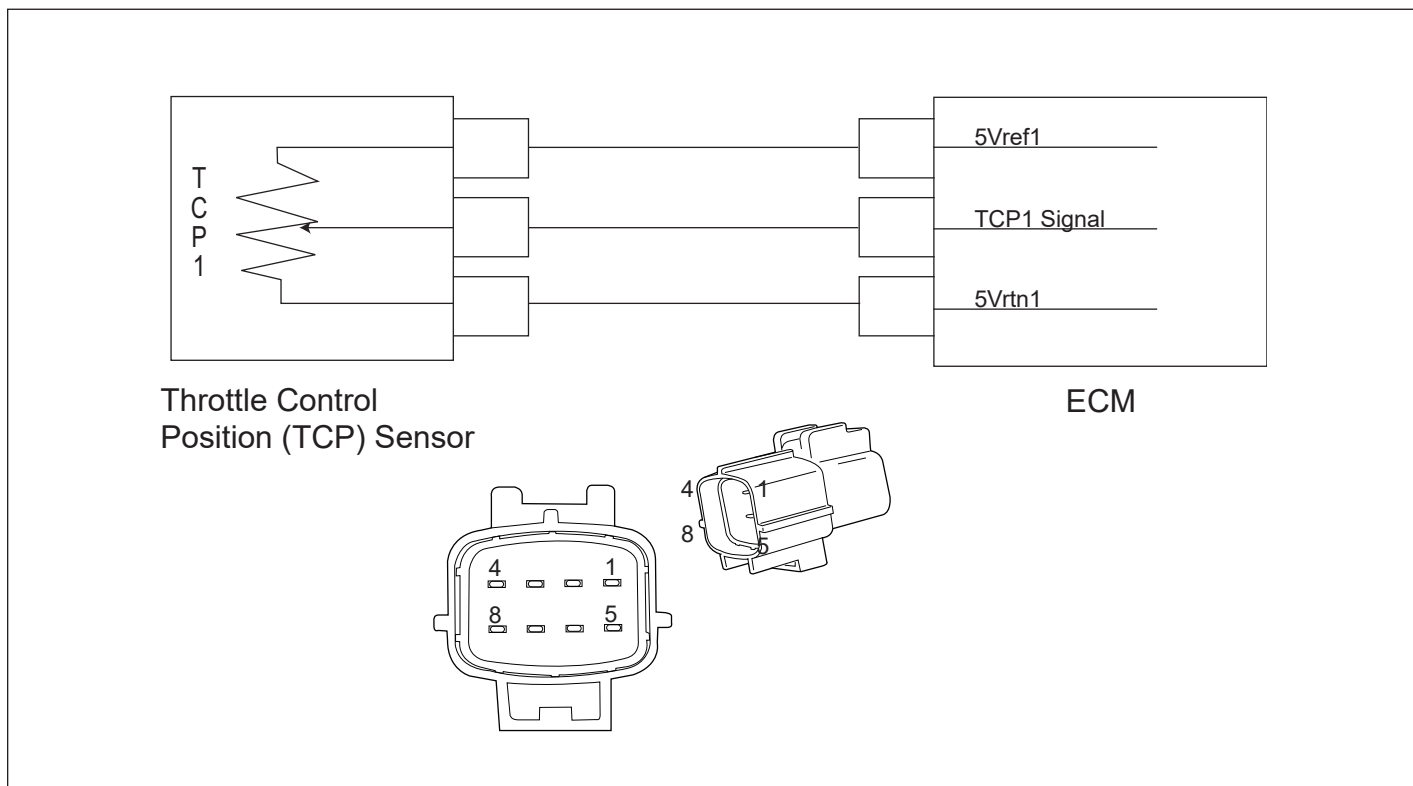
DTC 2122 - TCP Sensor 1 High Voltage SPN - 91; FMI - 3



Diagnostics

DTC 2123 - TCP Sensor 1 Low Voltage

SPN - 91; FMI - 4

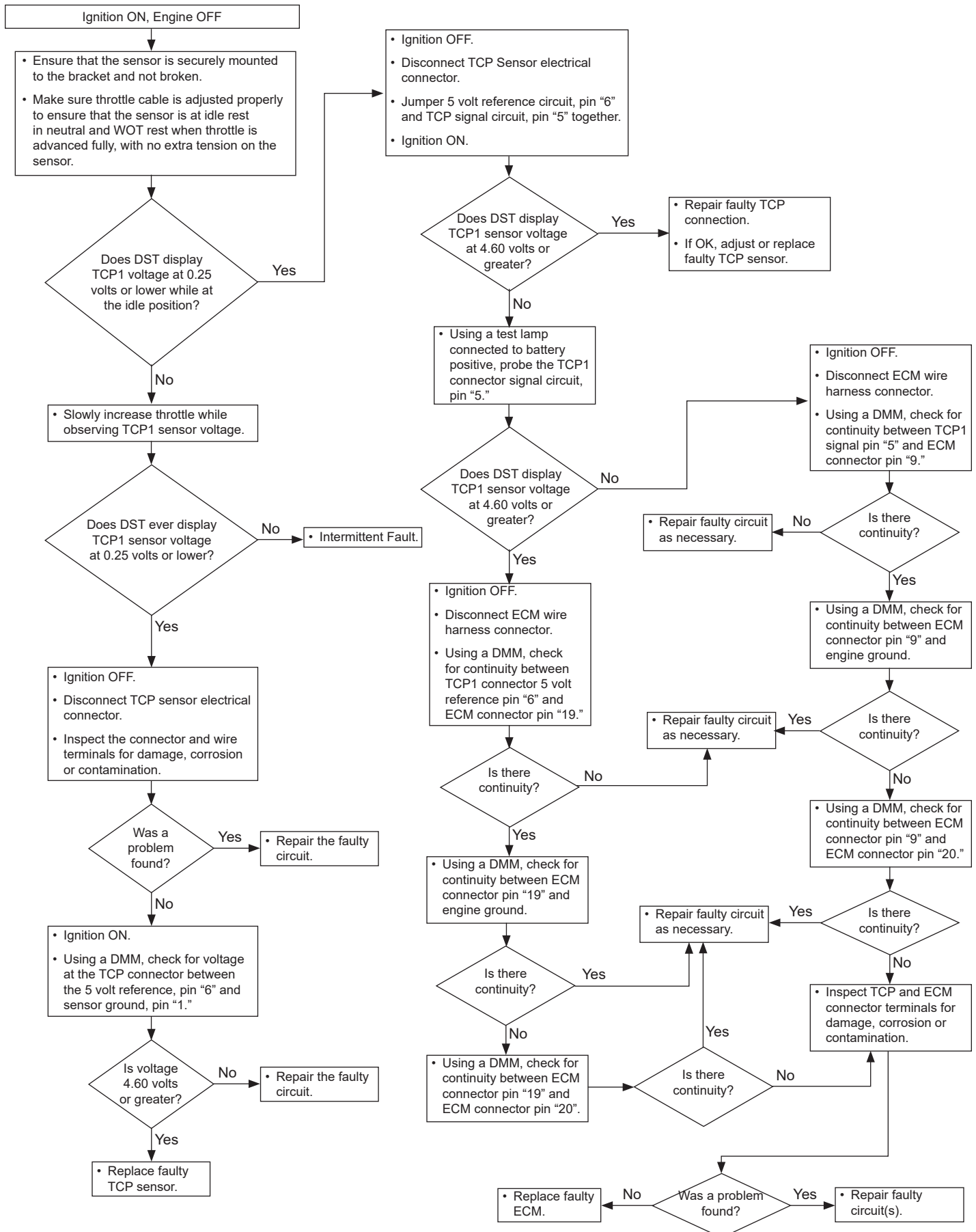


- Throttle Control Position (TCP) Sensor
- *Check Condition* - Ignition ON
- *Fault Condition* - TCP1 sensor voltage lower than 0.2 volts
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycled

The Throttle Control Position (TCP) sensor uses a variable resistor to determine signal voltage based on throttle lever position. Less movement of the throttle lever results in lower voltage, and greater movement results in higher voltage.

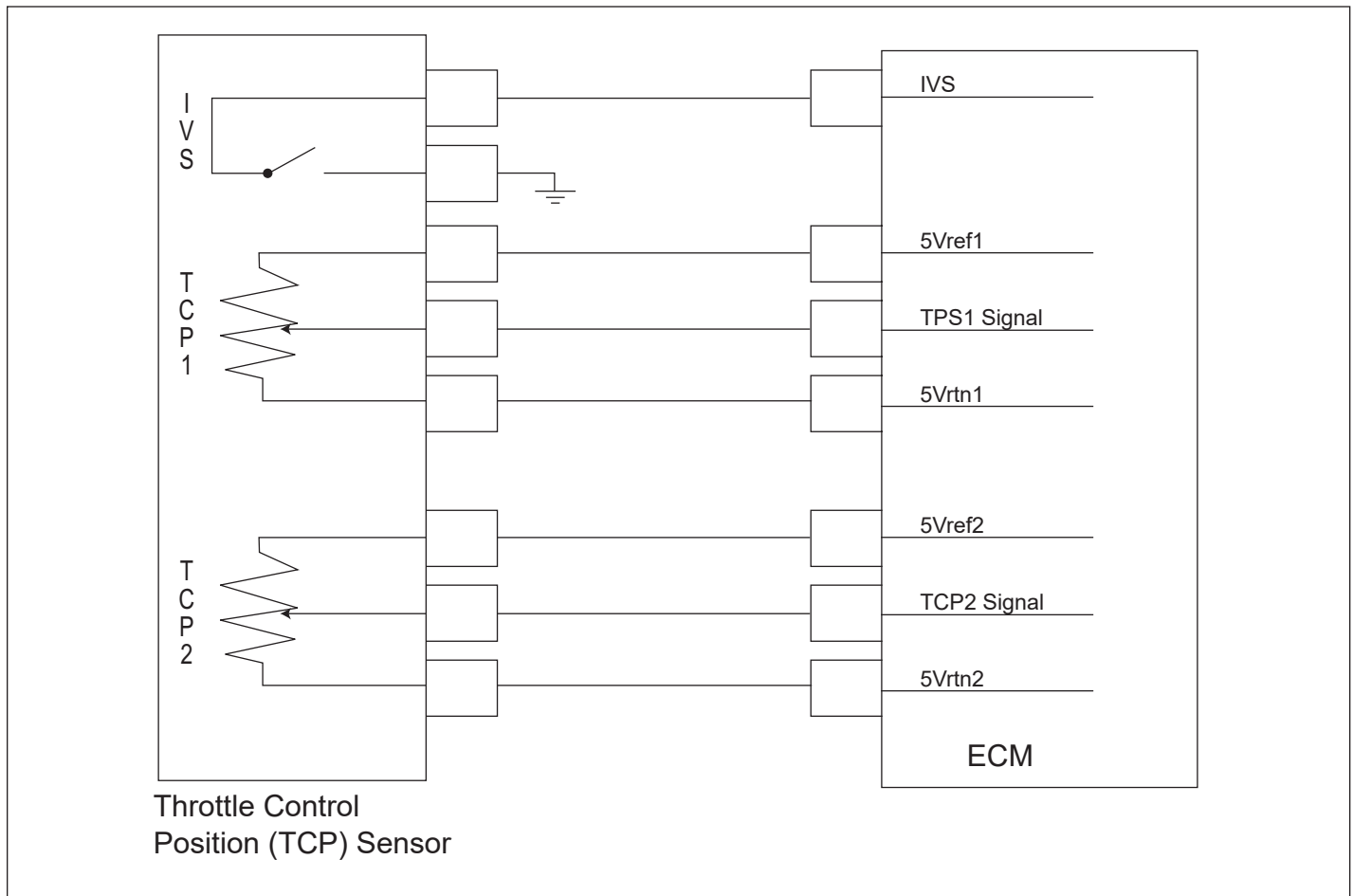
This fault will set if voltage is less than 0.2 volts at any operating condition while the key is on. If the voltage goes lower than 0.2 volts, then TCP1 is considered to be out of specifications. At this point the ECM does not have a valid signal, and must therefore enforce the low rev limit and Power Derate (level 1). When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1600 RPM. The Low Rev Limit is enforced for the remainder of the key-on cycle. Rev limit is still enforced if the active fault is no longer present; the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Low Rev Limit is still enforced.

DTC 2123 - TCP Sensor 1 Low Voltage SPN - 91; FMI - 4



Diagnostics

DTC 2125 - TCP Sensor 2 Invalid Voltage and TCP Sensor 1 Disagrees with IVS SPN - 520199; FMI - 11



- Electronic Throttle Control Position (TCP) Sensor
- *Check Condition* - Ignition On, Engine Off
- *Fault Condition* - TCP2 Voltage out-of-range, TCP1% does not match IVS state
- Corrective Action(s) - Illuminate MIL, sound audible warning and forced idle
- Non-emissions related fault

The TCP sensor is an electronic device that is coupled to a mechanically driven input as commanded by the vehicle/engine operator. A TCP sensor may be, but is not limited to a foot pedal assembly, a cable-lever-sensor assembly, or a rotary potentiometer. General sensor configurations consist of two potentiometers with IVS. The TCP sensor outputs are proportional to the commanded input. The ECM uses the TCP sensor inputs to control the throttle and adjust the engine's load in order to achieve the requested power. Since the TCP sensor inputs directly affect the engine's power output, redundant sensors are generally used to ensure safe, reliable operation.

This fault is only applicable with dual potentiometer/single IVS sensors and indicates that TCP2 voltage is out-of-range and TCP1% does not correlate with the IVS state resulting in a loss of redundancy.

DTC 2125 - TCP Sensor 2 Invalid Voltage and TCP Sensor 1 Disagrees with IVS SPN - 520199; FMI - 11

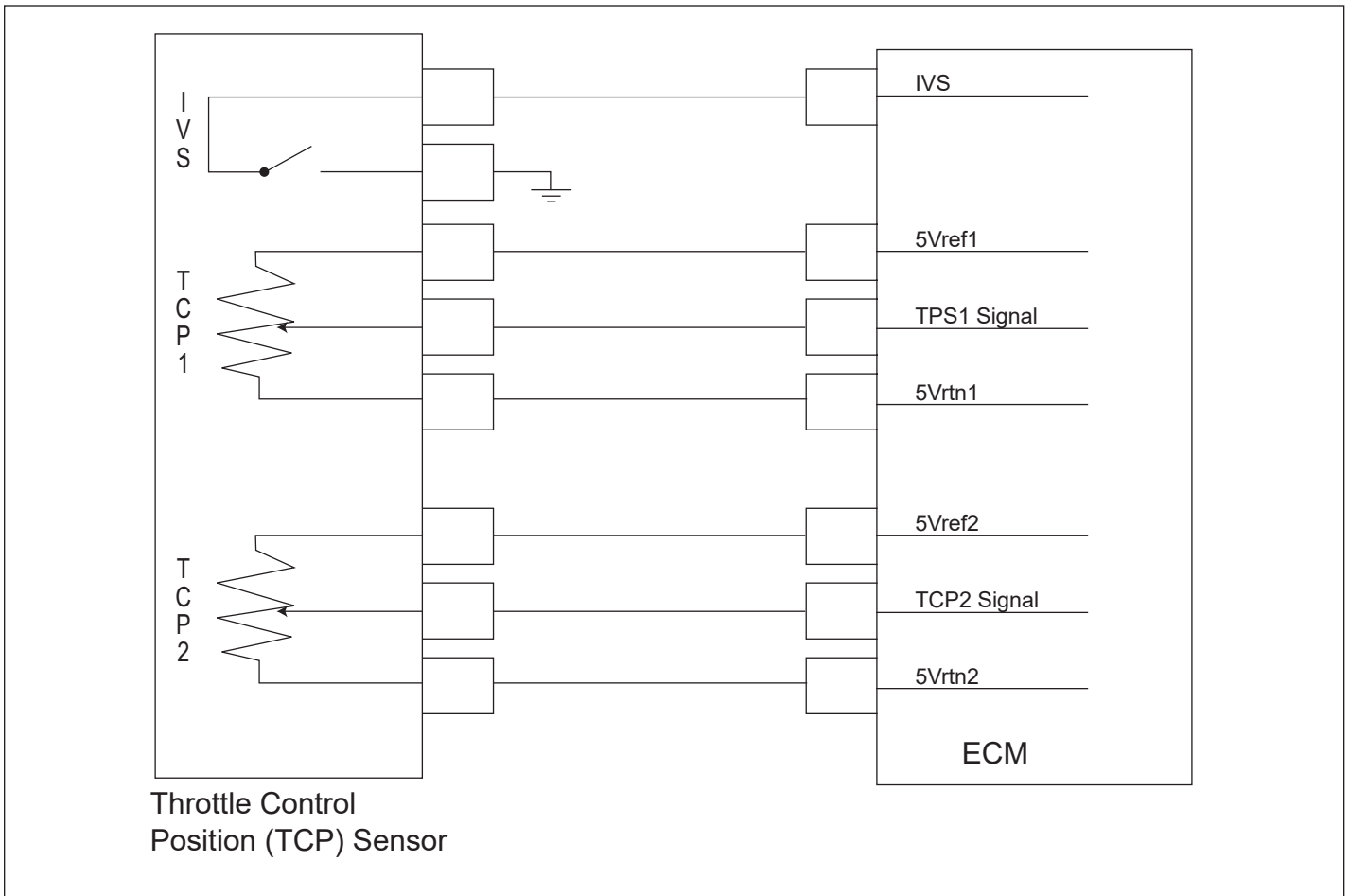
Diagnostic Aids

- **For TCP2 Invalid Voltage** - Troubleshoot according to *DTC 2127 TCP2 Low Voltage* and *DTC 2128 TCP2 High Voltage* procedures.
- **For TCP1 Disagrees with IVS** - Troubleshoot according to *DTC 2115 TCP1 Higher Than IVS Limit* and *DTC 2139 TCP1 Lower Than IVS Limit* procedures.

Diagnostics

DTC 2126 - TCP Sensor 1 Higher Than TCP Sensor 2

SPN - 91; FMI - 16

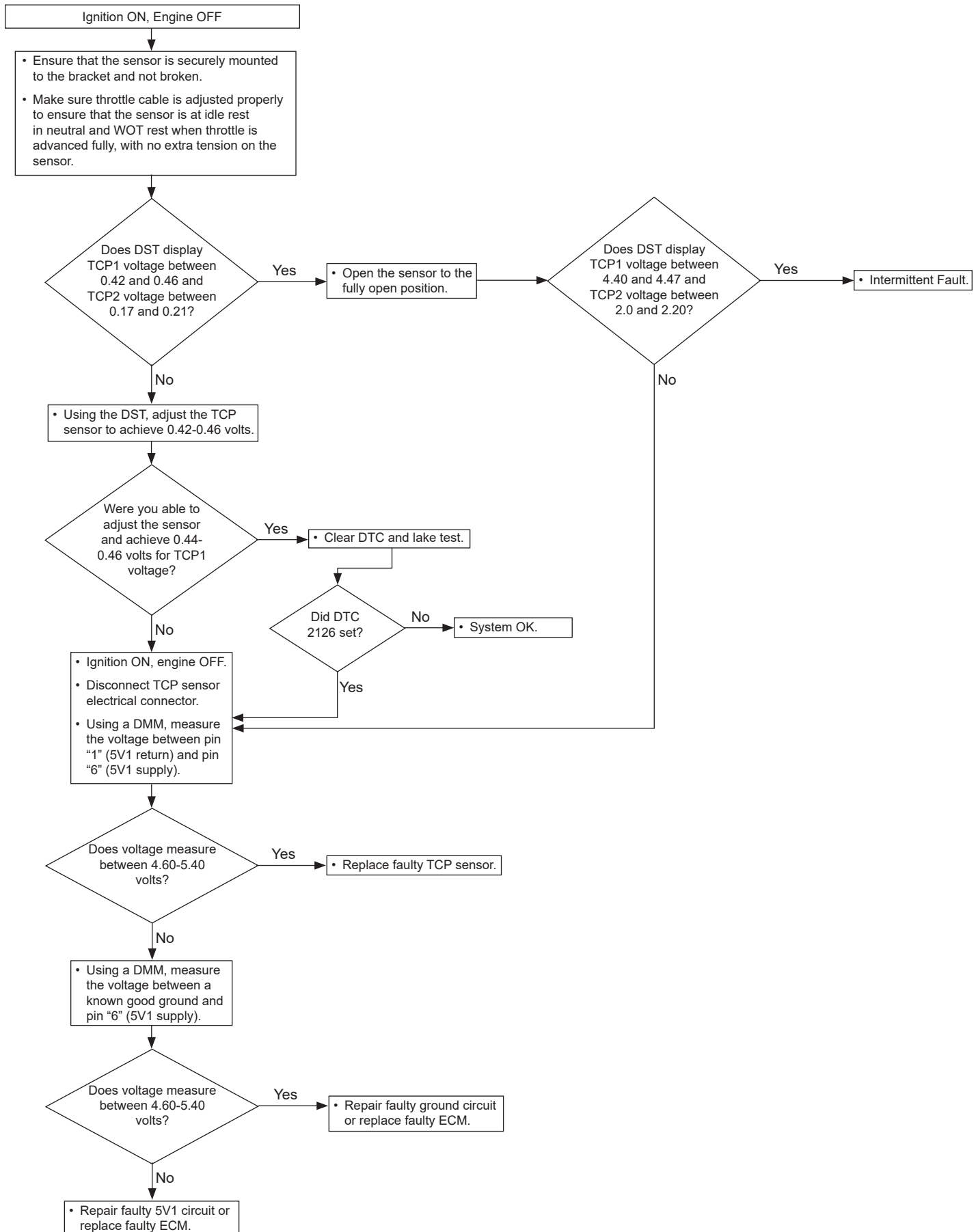


- Electronic foot pedal/throttle control sensor
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - TCP1% higher than TCP2%
- Corrective Action(s) - Illuminate MIL, sound audible warning and power derate, low rev limit, or forced idle
- Non-emissions related fault

The engine load command to the ECM is determined by the operator advancement of the Throttle Control Position (TCP) sensor. The ECM monitors the TCP and controls the throttle to maintain the commanded power level. Because a problem with the TCP signal can result in a higher or lower power than intended by the operator, the TCP incorporates a sensor with an Idle Validation Switch (IVS). Checks and cross checks are constantly conducted by the ECM to determine the validity of the signals. The Idle Validation Switch is a normally open contact (idle) that grounds (closed contacts) the IVS circuit to the ECM when the throttle is advanced off the idle position.

This fault will set if throttle control position sensor 1 is 20% higher than throttle control position sensor 2.

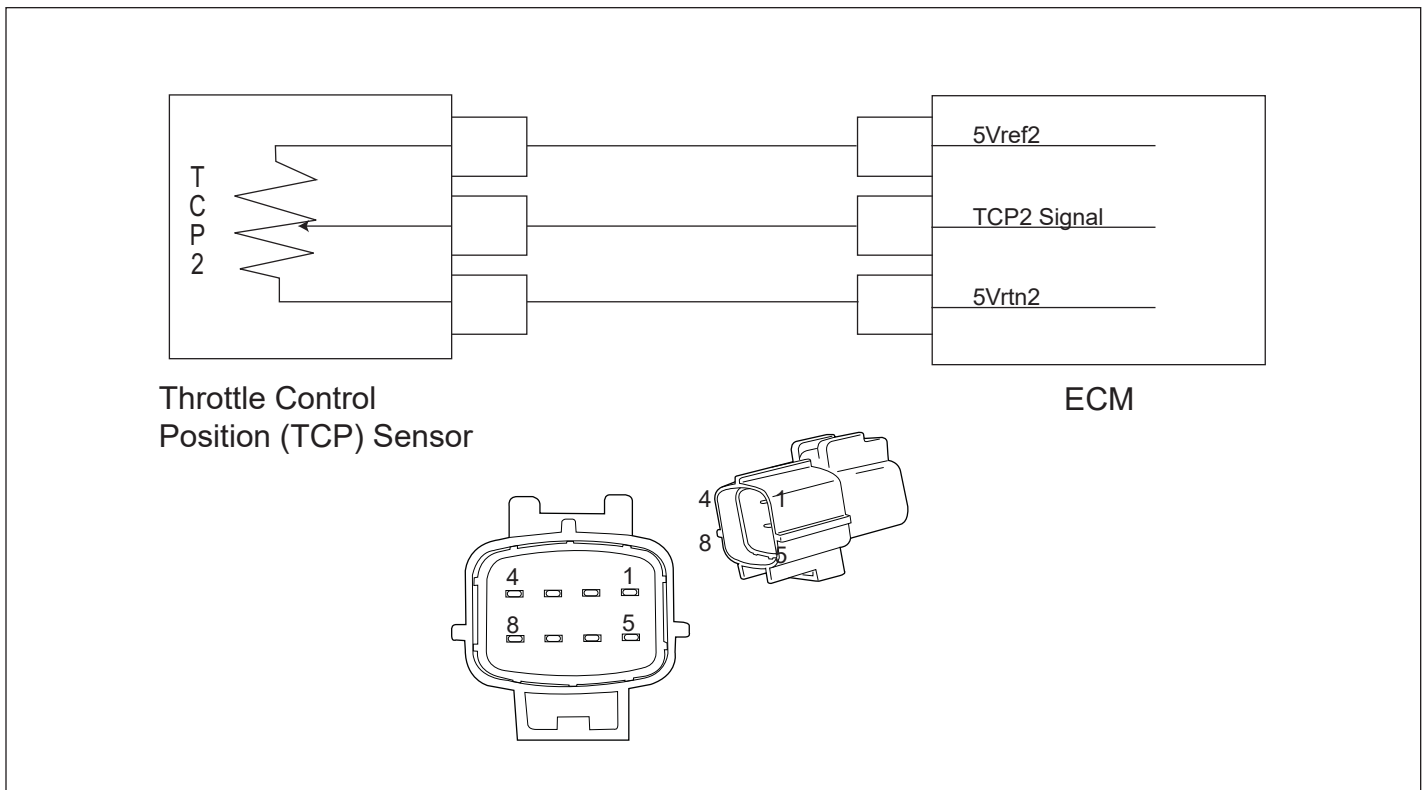
DTC 2126 - TCP Sensor 1 Higher Than TCP Sensor 2 SPN - 91; FMI - 16



Diagnostics

DTC 2127 - TCP Sensor 2 Low Voltage

SPN - 29; FMI - 4

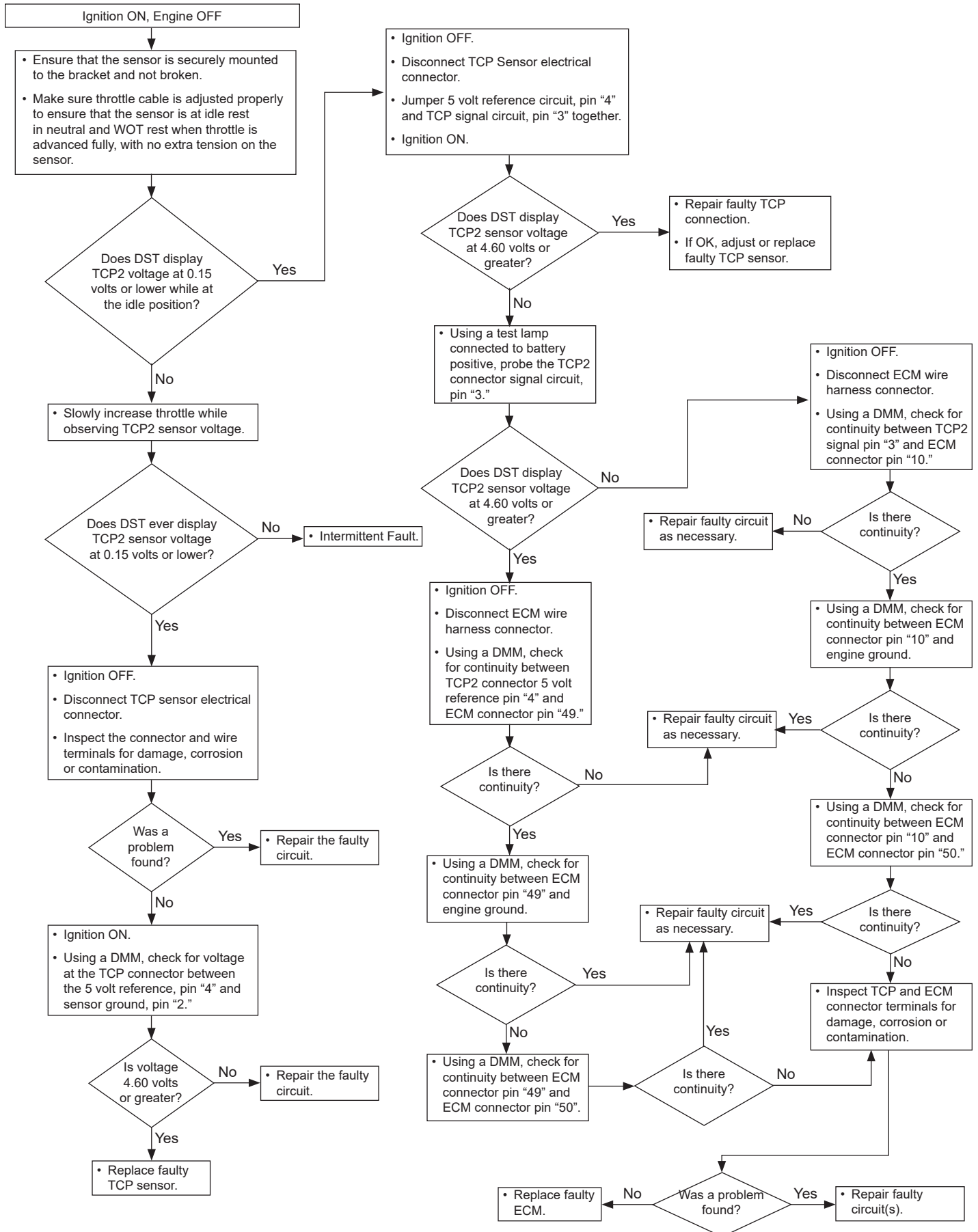


- Throttle Control Position (TCP) Sensor
- *Check Condition* - Ignition ON
- *Fault Condition* - TCP2 sensor voltage lower than 0.15 volts
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycled

The Throttle Control Position (TCP) sensor uses a variable resistor to determine signal voltage based on throttle lever position. Less movement of the throttle lever results in lower voltage, and greater movement results in higher voltage.

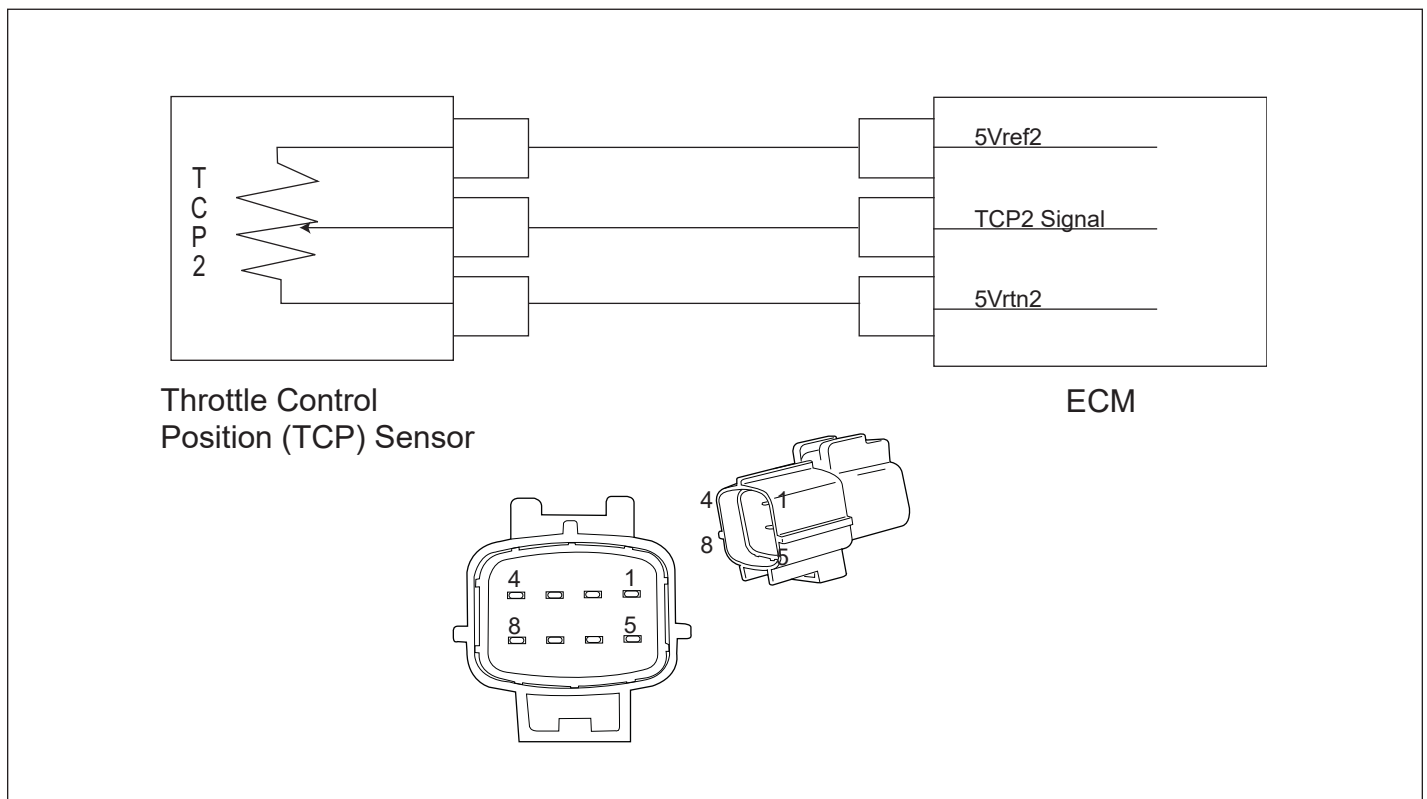
This fault will set if voltage is less than 0.15 volts at any operating condition while the key is on. If the voltage goes lower than 0.15 volts, then TCP2 is considered to be out of specifications. At this point the ECM does not have a valid signal, and must therefore enforce the low rev limit and Power Derate (level 1). When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1600 RPM. The Low Rev Limit is enforced for the remainder of the key-on cycle. Rev limit is still enforced if the active fault is no longer present; the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Low Rev Limit is still enforced.

DTC 2127 - TCP Sensor 2 Low Voltage SPN - 29; FMI - 4



Diagnostics

DTC 2128 - TCP Sensor 2 High Voltage SPN - 29; FMI - 3

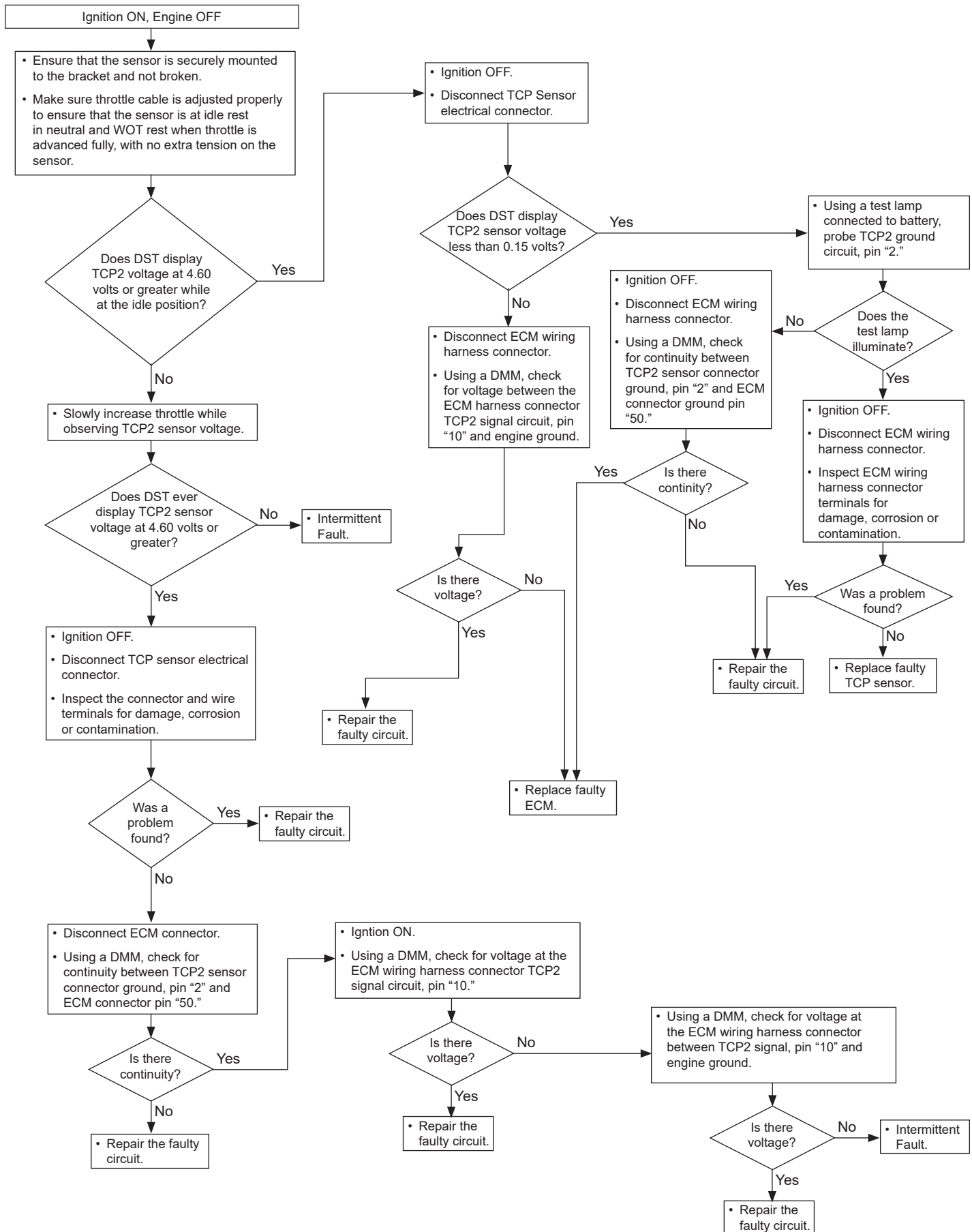


- Throttle Control Position (TCP) Sensor
- *Check Condition* - Ignition ON
- *Fault Condition* - TCP2 sensor voltage lower than 0.15 volts
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycled

The Throttle Control Position (TCP) sensor uses a variable resistor to determine signal voltage based on throttle lever position. Less movement of the throttle lever results in lower voltage, and greater movement results in higher voltage.

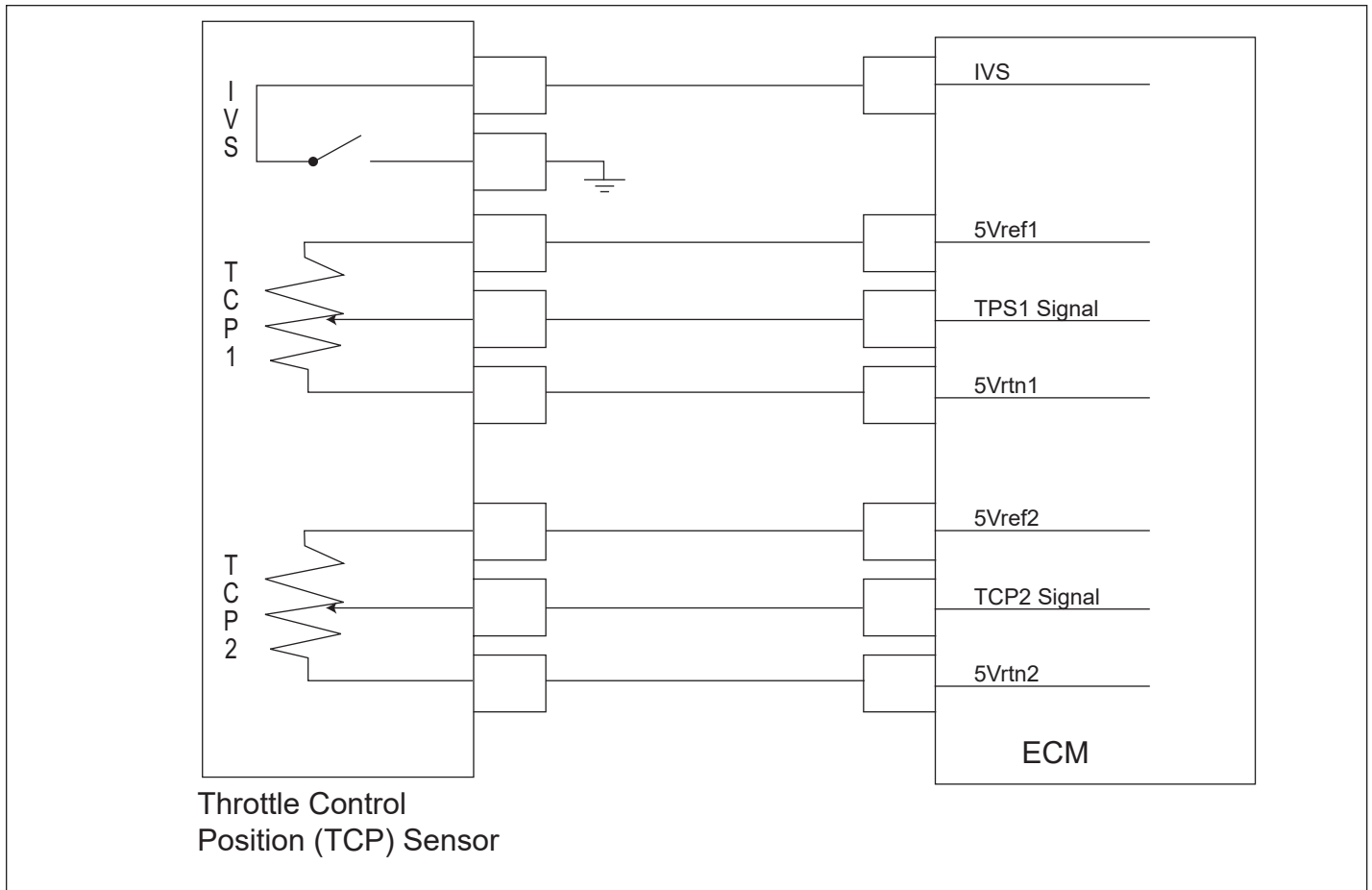
This fault will set if voltage is more than 4.80 volts at any operating condition while the key is on. If the voltage goes higher than 4.80 volts, then TCP2 is considered to be out of specifications. At this point the ECM does not have a valid signal, and must therefore enforce the low rev limit and Power Derate (level 1). When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1600 RPM. The Low Rev Limit is enforced for the remainder of the key-on cycle. Rev limit is still enforced if the active fault is no longer present; the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Low Rev Limit is still enforced.

DTC 2128 - TCP Sensor 2 High Voltage SPN - 29; FMI - 3



Diagnostics

DTC 2130 - IVS Stuck At Idle, TCP Sensors 1/2 Match SPN - 558; FMI - 5

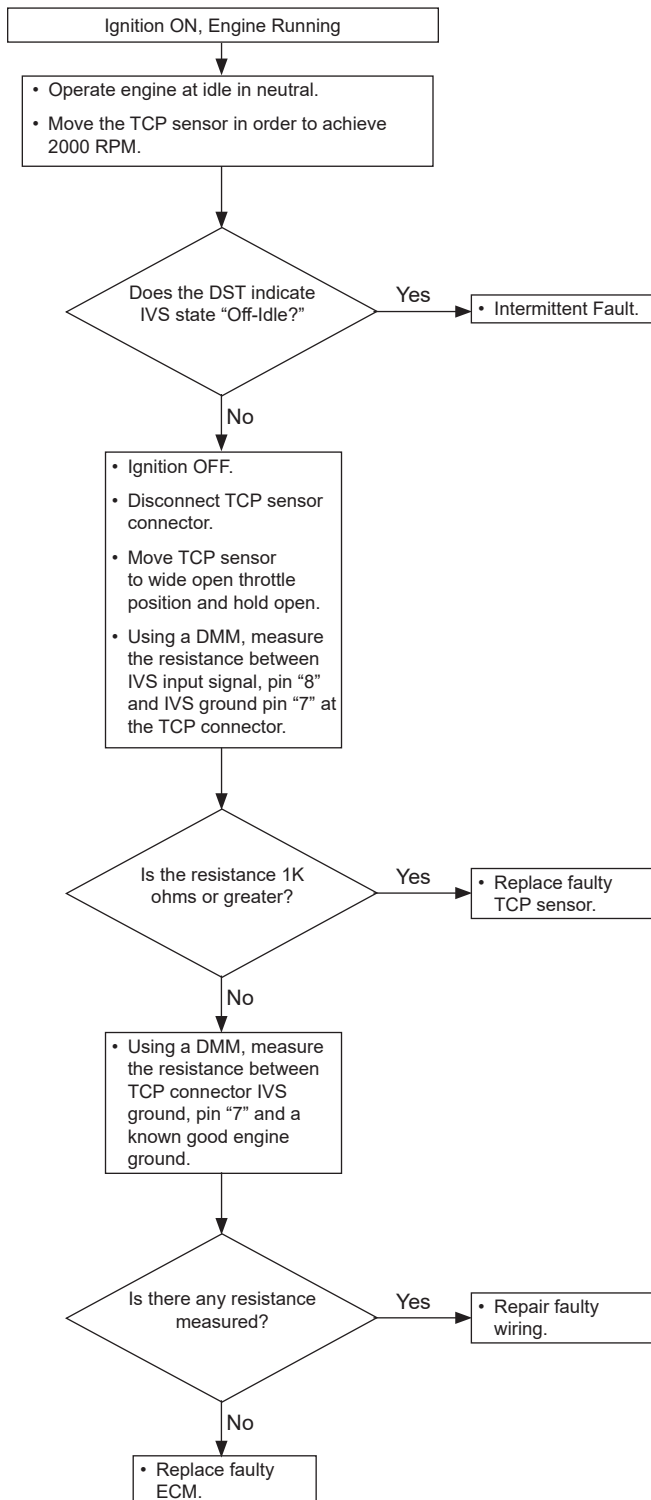


- Throttle Control Position (TCP) Sensor
- *Check Condition* - Ignition ON, engine running
- *Fault Condition* - TCP1 % is approximately TCP2 % and both are greater than TCP idle validation % and IVS = at idle
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycled

The Throttle Control Position (TCP) sensor consists of two potentiometers and an Idle Validation Switch (IVS). The TCP sensor outputs are proportional to the commanded input. The ECM uses the TCP sensor inputs to control the throttle and adjust the engine's load in order to achieve the requested power. Since the TCP sensor inputs directly affect the engine's power output, redundant sensors are used to ensure safe and reliable operation.

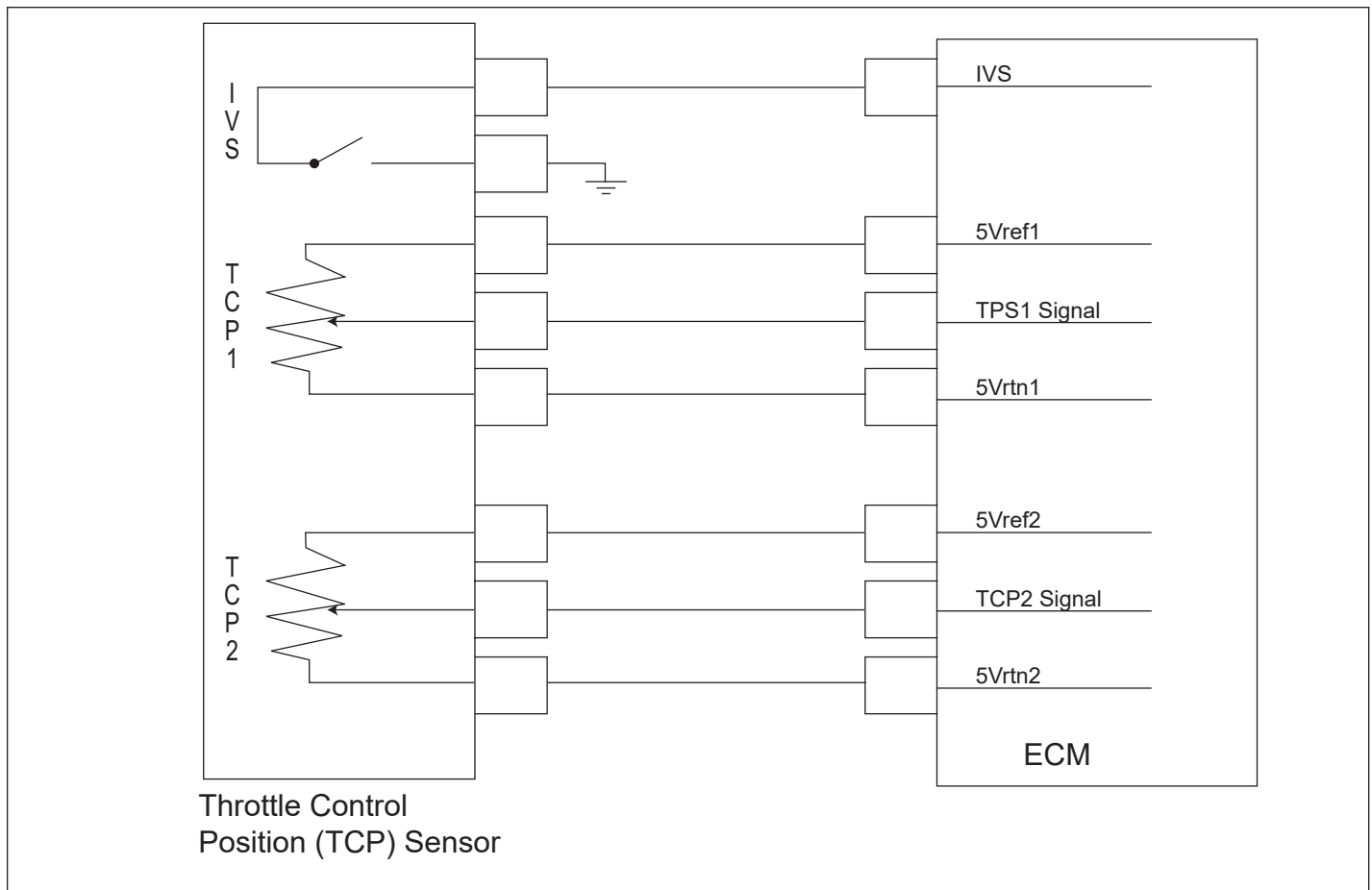
This fault indicates that the two TCP percentages correlate and register an off-idle condition but the IVS state reads at-idle throughout the entire operating range.

DTC 2130 - IVS Stuck At Idle, TCP Sensors 1/2 Match SPN - 558; FMI - 5



Diagnostics

DTC 2131 - IVS Stuck Off Idle, TCP Sensors 1/2 Match SPN - 558; FMI - 6

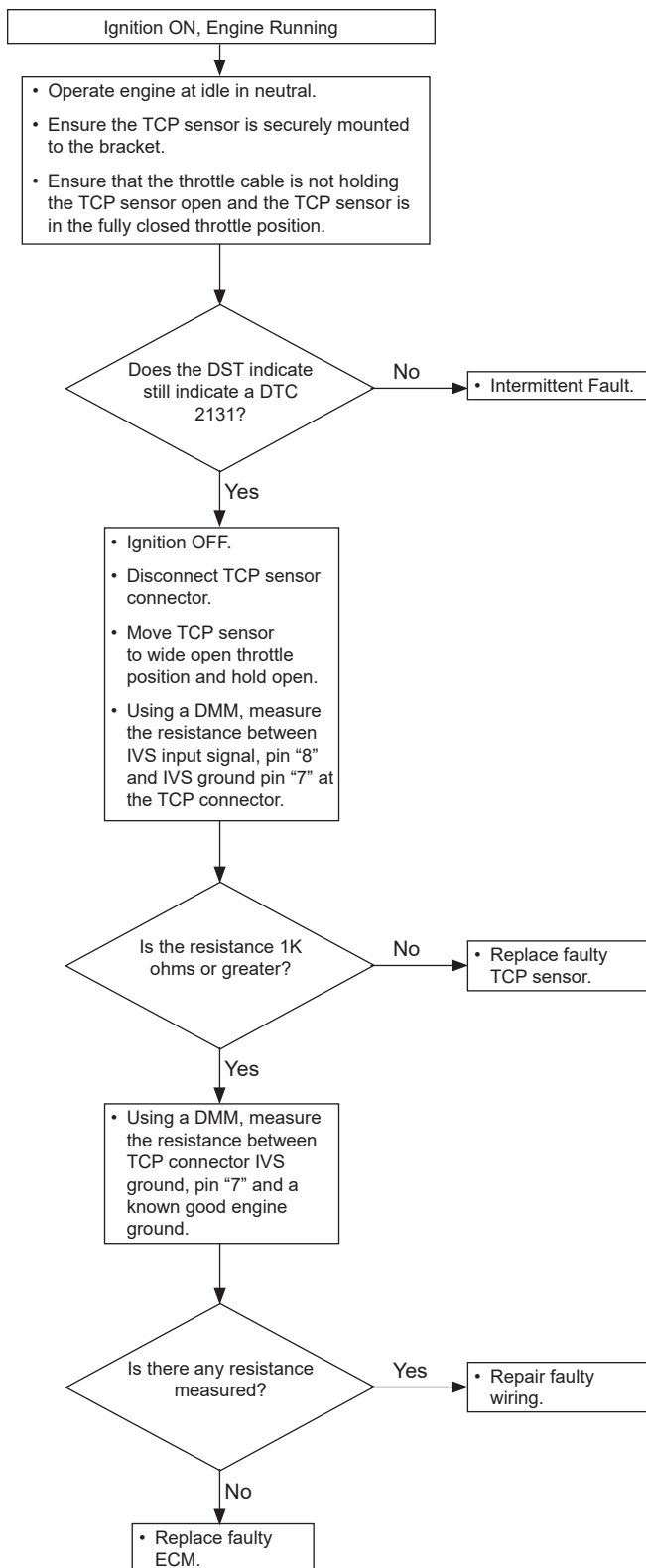


- Throttle Control Position (TCP) Sensor
- *Check Condition* - Ignition ON, engine running
- *Fault Condition* - TCP1 % is approximately TCP2 % and both are less than TCP idle validation % and IVS = off-idle
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycled

The Throttle Control Position (TCP) sensor consists of two potentiometers and an Idle Validation Switch (IVS). The TCP sensor outputs are proportional to the commanded input. The ECM uses the TCP sensor inputs to control the throttle and adjust the engine's load in order to achieve the requested power. Since the TCP sensor inputs directly affect the engine's power output, redundant sensors are used to ensure safe and reliable operation.

This fault indicates that the two TCP percentages correlate and register an at-idle condition but the IVS state reads off-idle throughout the entire operating range.

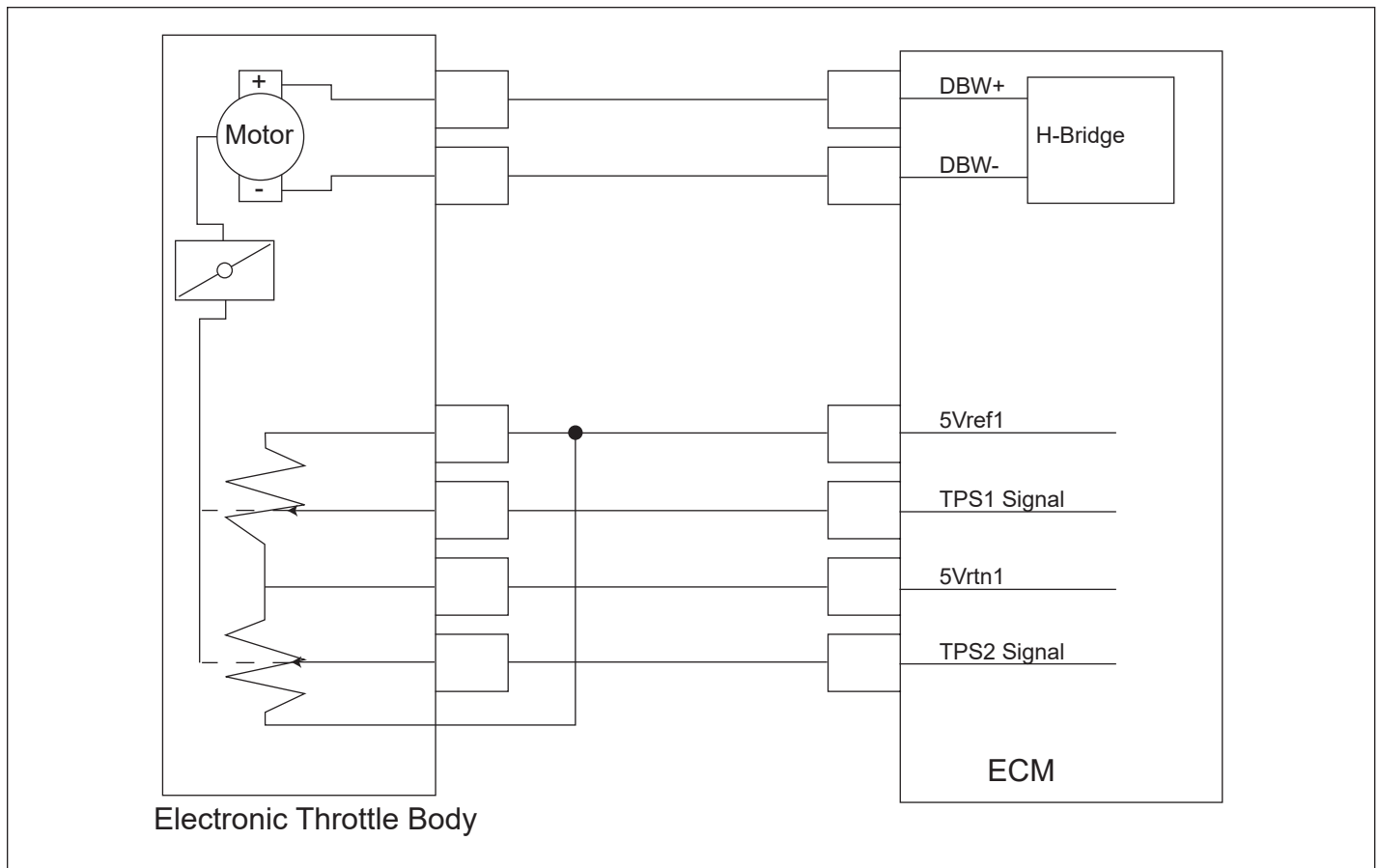
DTC 2131 - IVS Stuck Off Idle, TCP Sensors 1/2 Match SPN - 558; FMI - 6



Diagnostics

DTC 2135 - TPS 1/2 Simultaneous Voltages Out of Range

SPN - 51; FMI - 31



- Throttle Position (TP) Sensor
- *Check Condition* - Engine cranking
- *Fault Condition* - Throttle position on TPS1 and TPS2 are greater than 4.80 volts or less than 0.20 volts
- MIL-On during active fault

There are two throttle position sensors located within the throttle body which use variable resistors to determine the signal voltage based on throttle plate position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from these voltages. Although the voltages are different, the calculated values for the throttle position percentages should be very close to the same. The TPS values are used by the ECM to determine if the throttle is opening as commanded.

This fault will set if the throttle position and redundancy is lost. During this active fault, the MIL will be on and Engine Shutdown is activated.

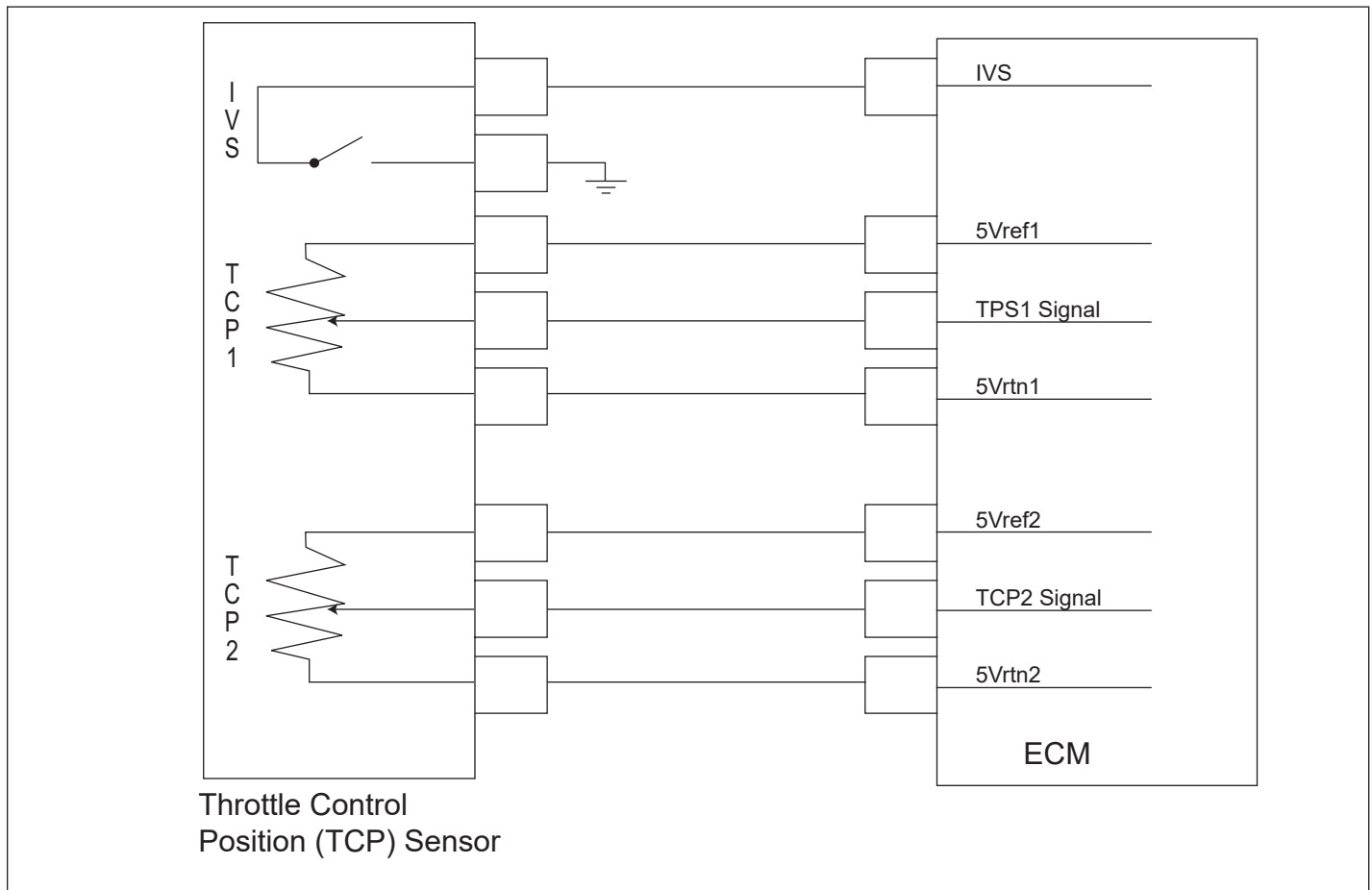
DTC 2135 - TPS 1/2 Simultaneous Voltages Out of Range SPN - 51; FMI - 31

Diagnostic Aids

- **For TPS1 Voltage Out of Range** - Troubleshoot according to *DTC 0122 TPS1 Signal Voltage High* and *DTC 0123 TPS1 Signal Voltage Low* procedures.
- **For TPS2 Voltage Out of Range** - Troubleshoot according to *DTC 0222 TPS2 Signal Voltage High* and *DTC 0223 TPS2 Signal Voltage Low* procedures.

Diagnostics

DTC 2139 - TCP Sensor 1 Lower Than IVS Limit SPN - 91; FMI - 1

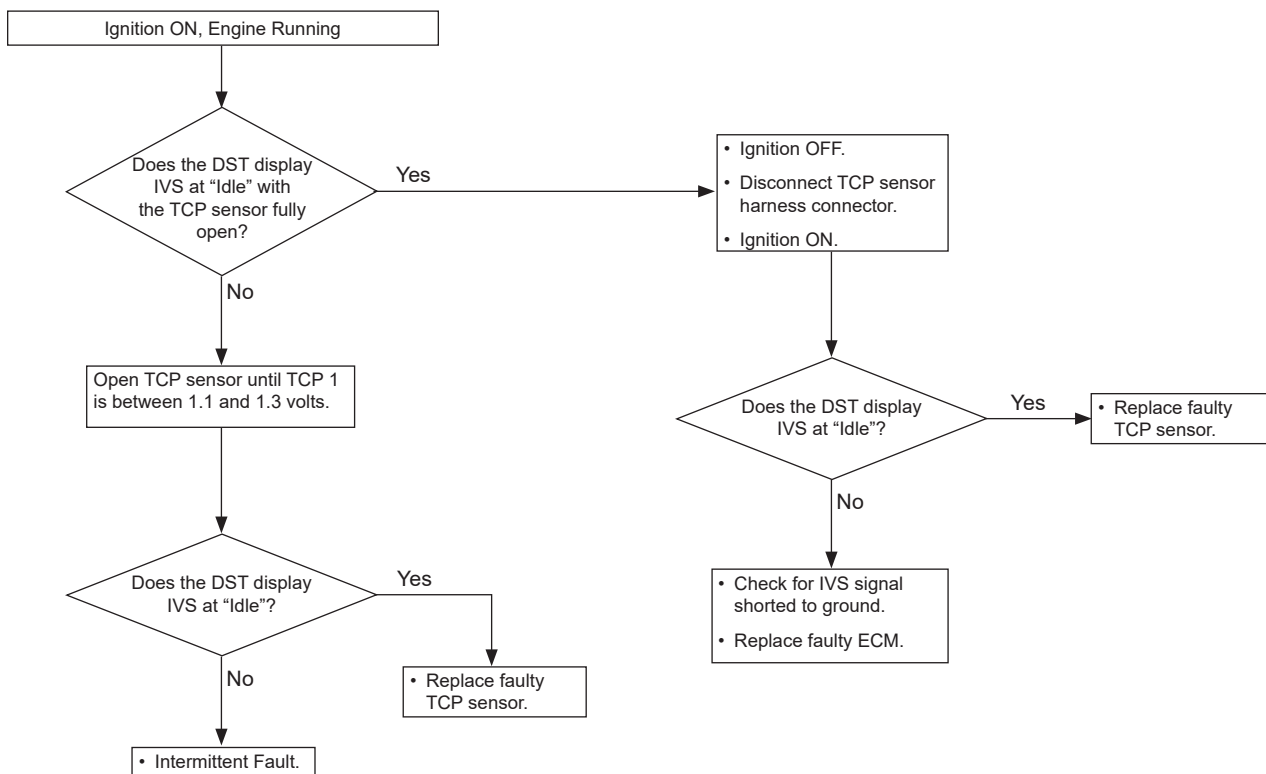


- Throttle Control Position (TCP) Sensor
- *Check Condition* - Ignition ON, engine running
- *Fault Condition* - IVS off-idle and TCP Sensor 1 voltage lower than expected
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycled

The engine load command to the ECM is determined by operator advancement of the throttle control position (TCP) sensor. The ECM monitors the TCP and controls the throttle to maintain the commanded power level. Because a problem with the TCP signal can result in a higher or lower power than intended by the operator, the TCP used with this control system incorporates a sensor with an idle validation switch (IVS). Checks and cross checks are constantly conducted by the ECM to determine the validity of the signals. The IVS is a normally open contact (idle) that grounds (closed contacts) the IVS circuit to the ECM when the throttle is advanced more than idle position.

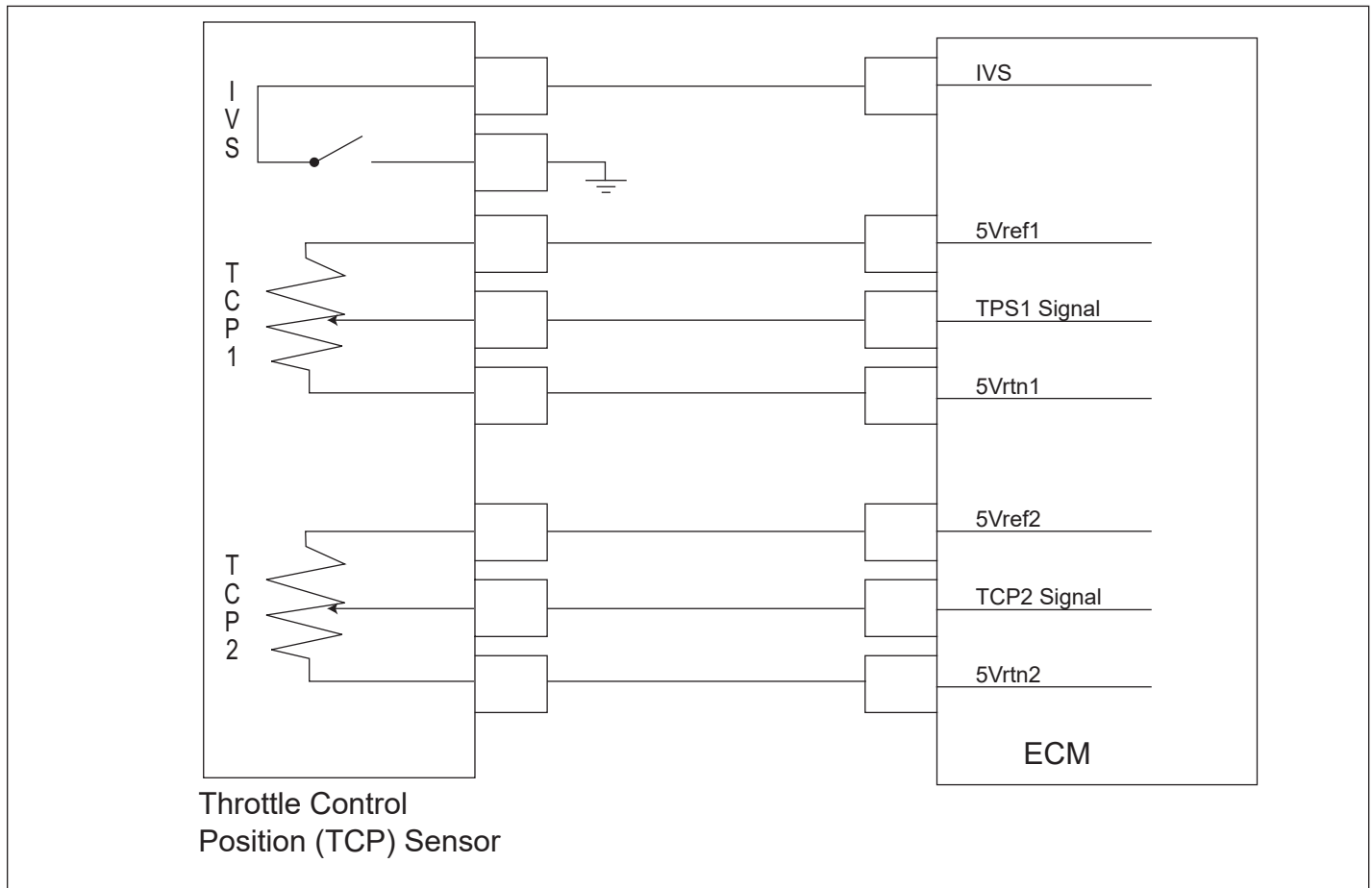
This fault will set if the IVS is at idle (open) and the TCP1 voltage is lower than expected.

DTC 2139 - TCP Sensor 1 Lower Than IVS Limit SPN - 91; FMI - 1



Diagnostics

DTC 2140 - TCP Sensor 2 Lower Than IVS Limit SPN - 29; FMI - 1

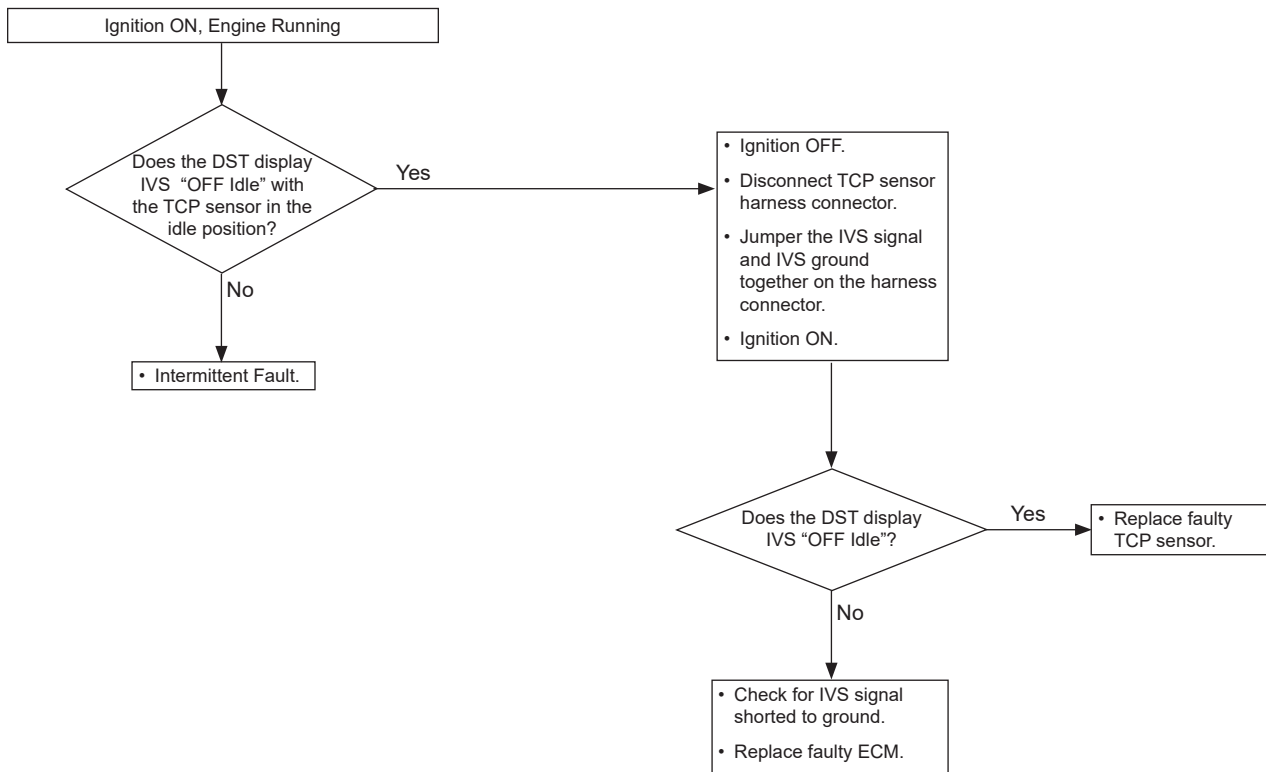


- Throttle Control Position (TCP) Sensor
- *Check Condition* - Ignition ON, engine running
- *Fault Condition* - IVS off-idle and TCP Sensor 2 voltage lower than expected
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycled

The engine load command to the ECM is determined by operator advancement of the throttle control position (TCP) sensor. The ECM monitors the TCP and controls the throttle to maintain the commanded power level. Because a problem with the TCP signal can result in a higher or lower power than intended by the operator, the TCP used with this control system incorporates a sensor with an idle validation switch (IVS). Checks and cross checks are constantly conducted by the ECM to determine the validity of the signals. The IVS is a normally open contact (idle) that grounds (closed contacts) the IVS circuit to the ECM when the throttle is advanced more than idle position.

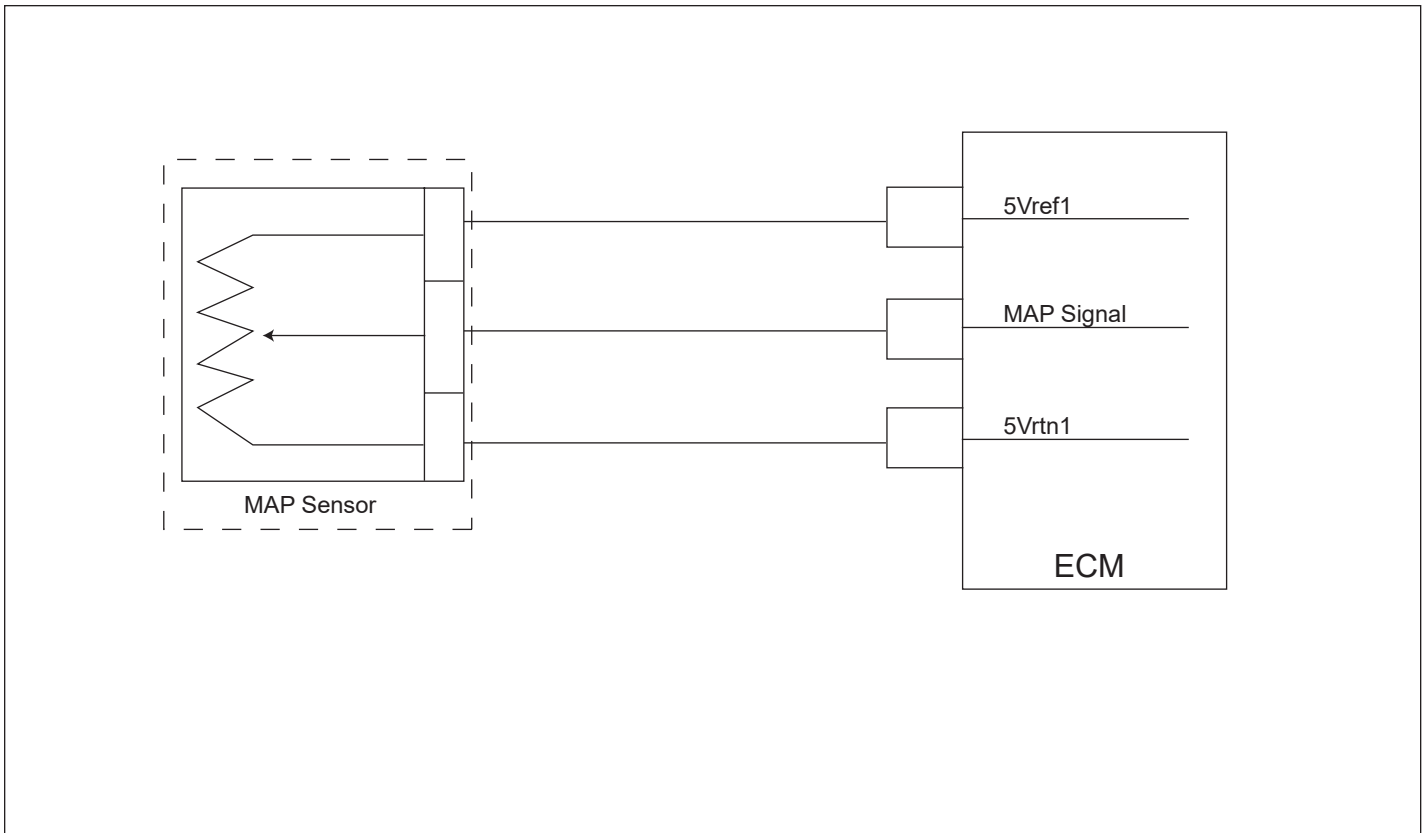
This fault will set if the IVS is at idle (open) and the TCP2 voltage is lower than expected.

DTC 2140 - TCP Sensor 2 Lower Than IVS Limit SPN - 29; FMI - 1



Diagnostics

DTC 2229 - Barometric Pressure High SPN - 108; FMI - 0



- Manifold Absolute Pressure (MAP) sensor
- *Check Condition* - Ignition ON, engine OFF
- *Fault Condition* - Barometric Pressure (BP) higher than expected

Barometric Pressure is estimated from the MAP sensor during ignition ON. The barometric pressure value is used for fuel and airflow calculations and equivalence ratio targets based on altitude.

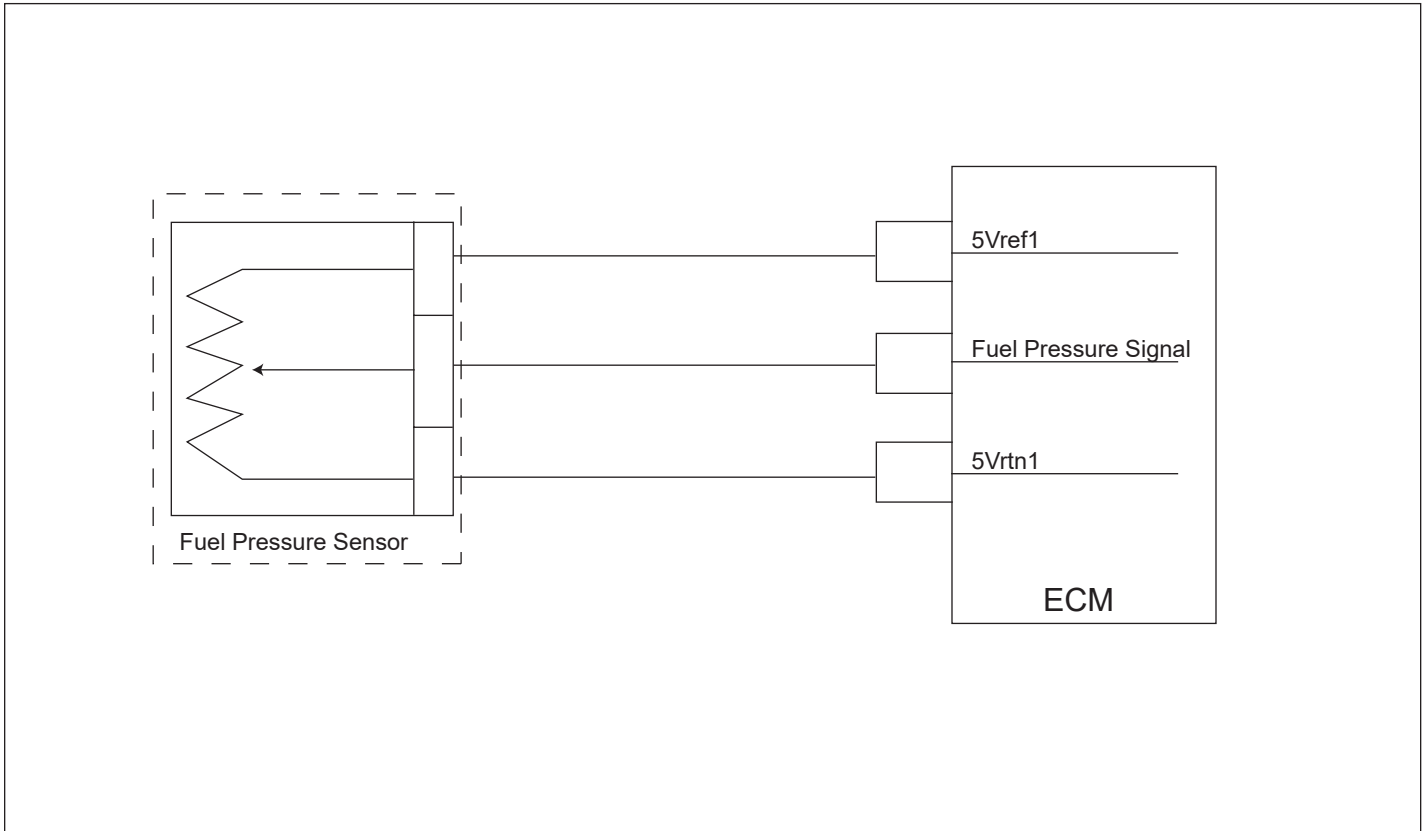
This fault sets if Barometric Pressure is higher than expected.

DTC 2229 - Barometric Pressure High
SPN - 108; FMI - 0

Diagnostics

DTC 2295 - Secondary Fuel Pressure Sensor Circuit Low Voltage (Direct Injection)

SPN - 94; FMI - 4



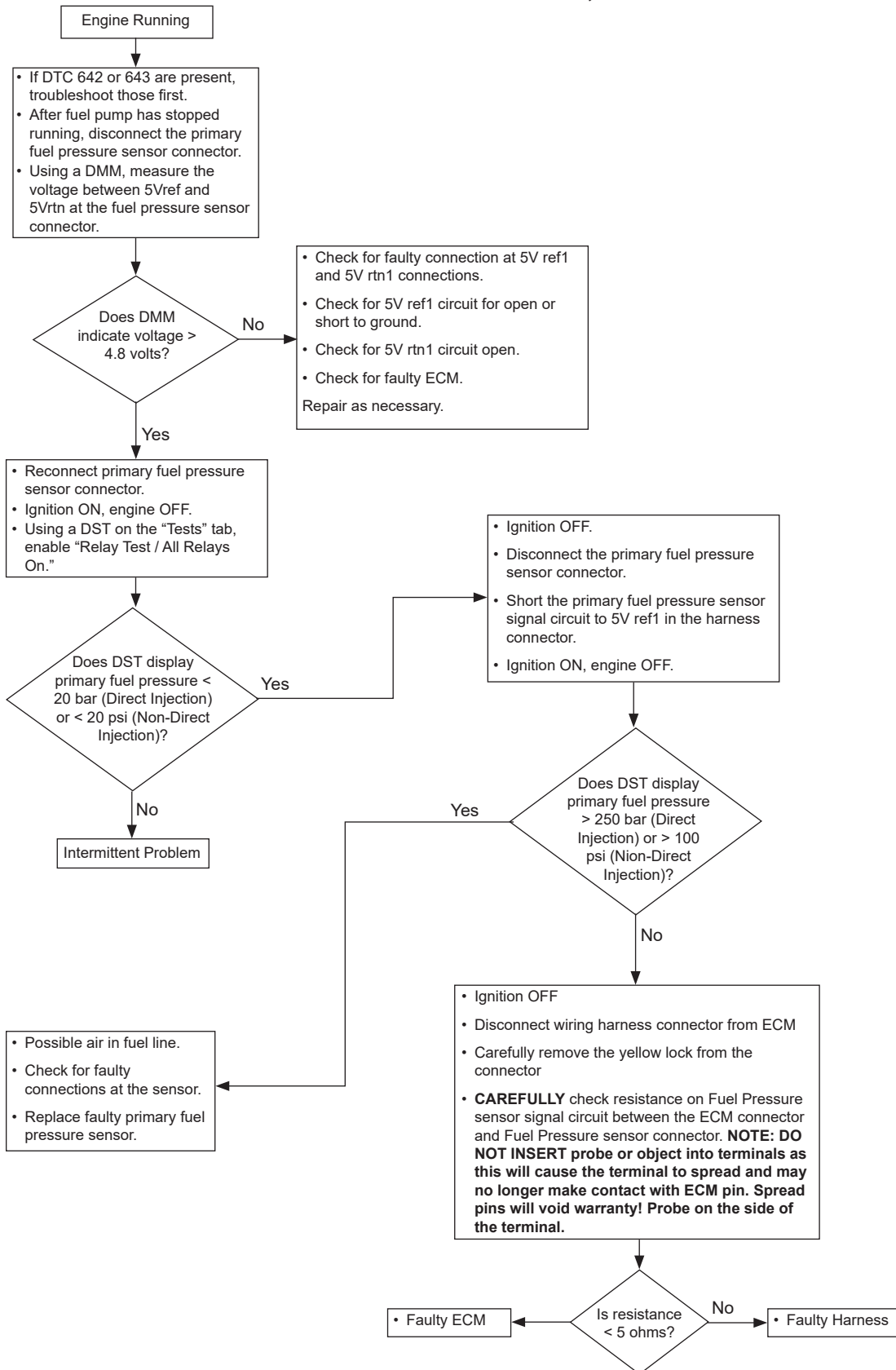
- Secondary Fuel Pressure Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Secondary Fuel Pressure sensor voltage < 0.20 volts
- *Corrective Action(s)* - Illuminate MIL, disable adaptive learn and closed loop fueling correction.
- Emissions related fault

The Secondary Fuel Pressure sensor is the Fuel Control Cell fuel pressure. This value is steady between 59-62 psi. This value does not vary with RPM.

This fault will set when the fuel pressure sensor circuit voltage is less than 0.20 volts.

DTC 2295 - Secondary Fuel Pressure Sensor Circuit Low Voltage (Direct Injection)

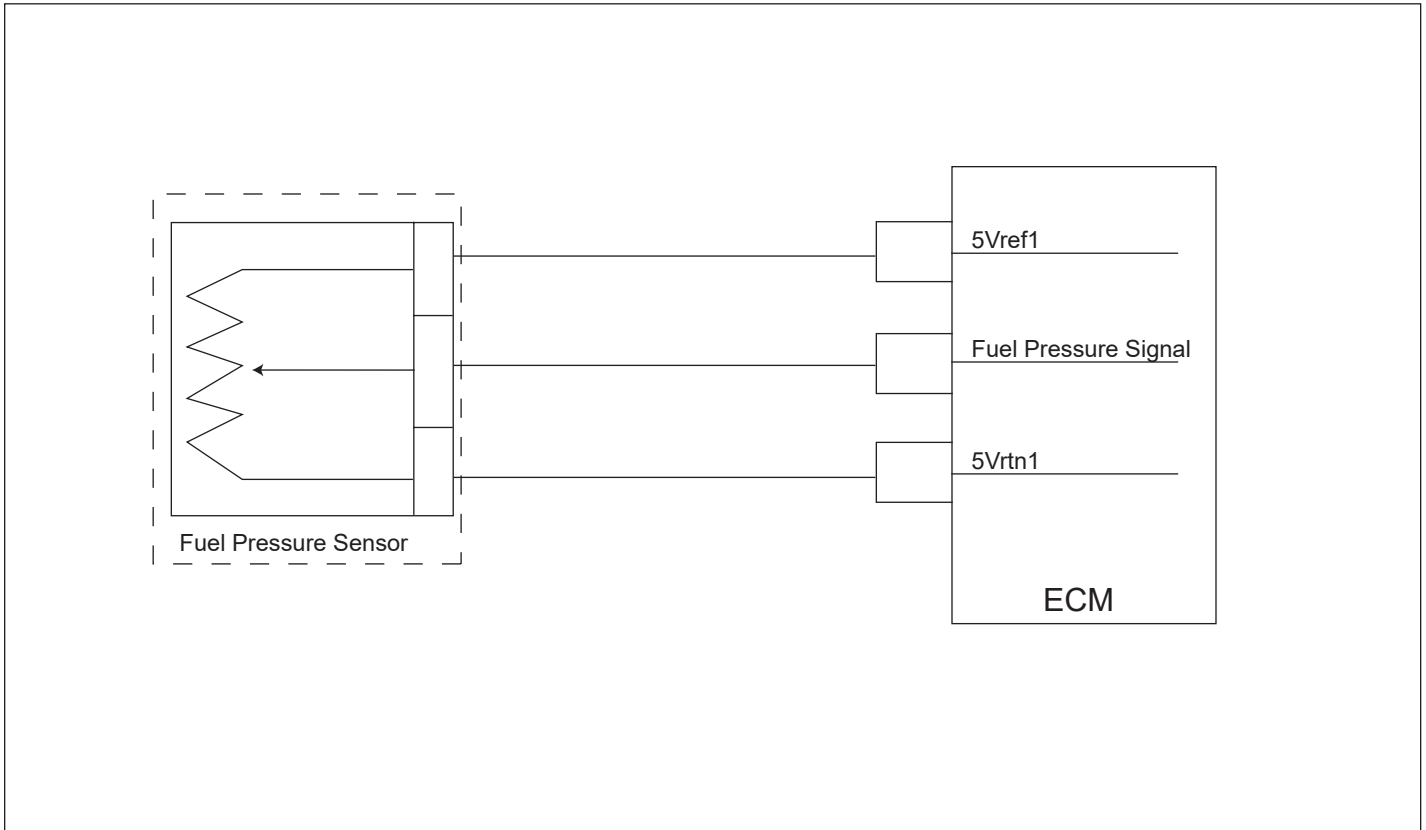
SPN - 94; FMI - 4



Diagnostics

DTC 2296 - Secondary Fuel Pressure Sensor Circuit High Voltage (Direct Injection)

SPN - 94; FMI - 3



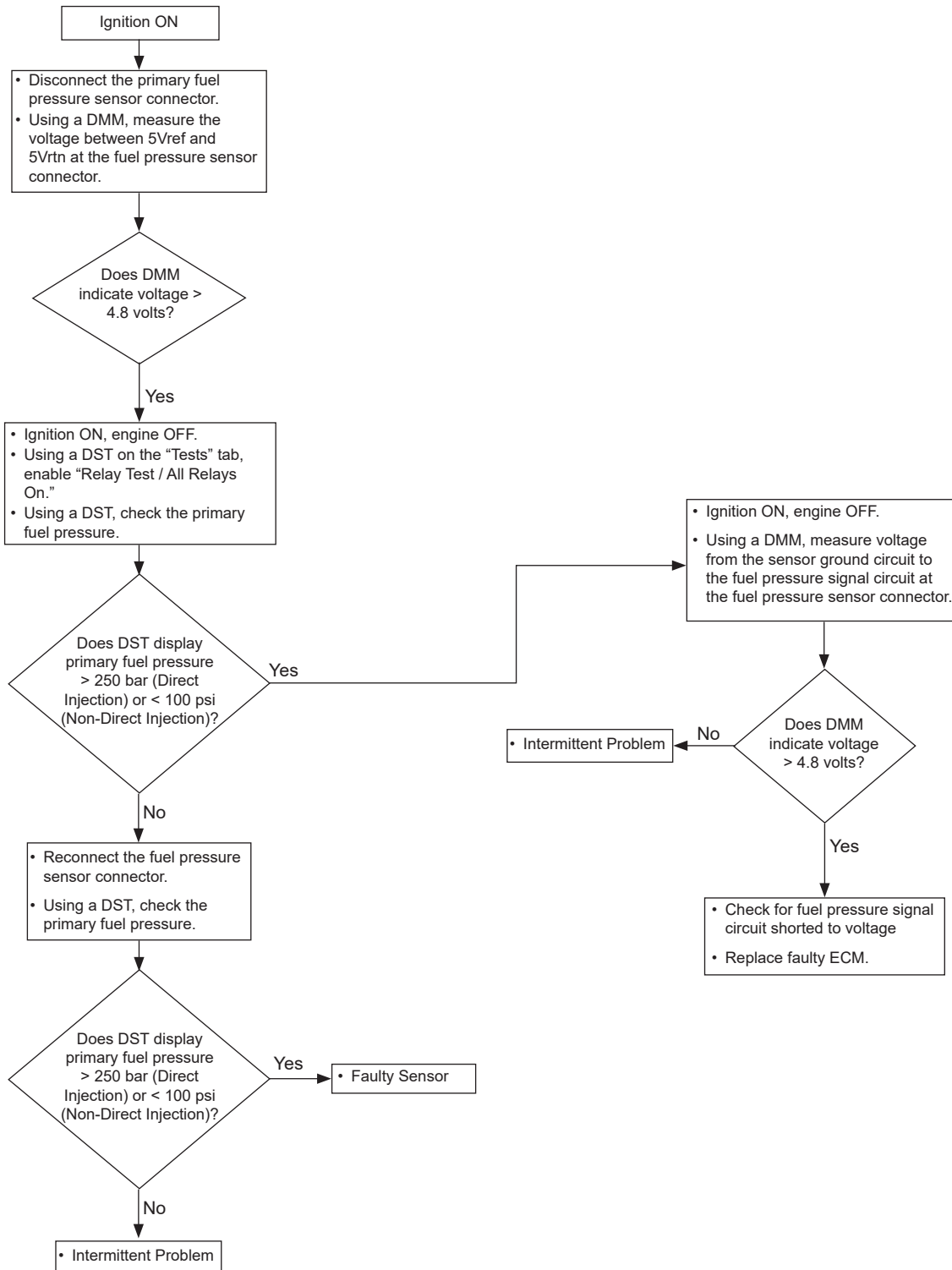
- Secondary Fuel Pressure Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - Secondary Fuel Pressure sensor voltage > 4.80 volts
- *Corrective Action(s)* - Illuminate MIL, disable adaptive learn and closed loop fueling correction.
- Emissions related fault

The Secondary Fuel Pressure sensor is the Fuel Control Cell fuel pressure. This value is steady between 59-62 psi. This value does not vary with RPM.

This fault will set when the fuel pressure sensor circuit voltage is greater than 4.80 volts.

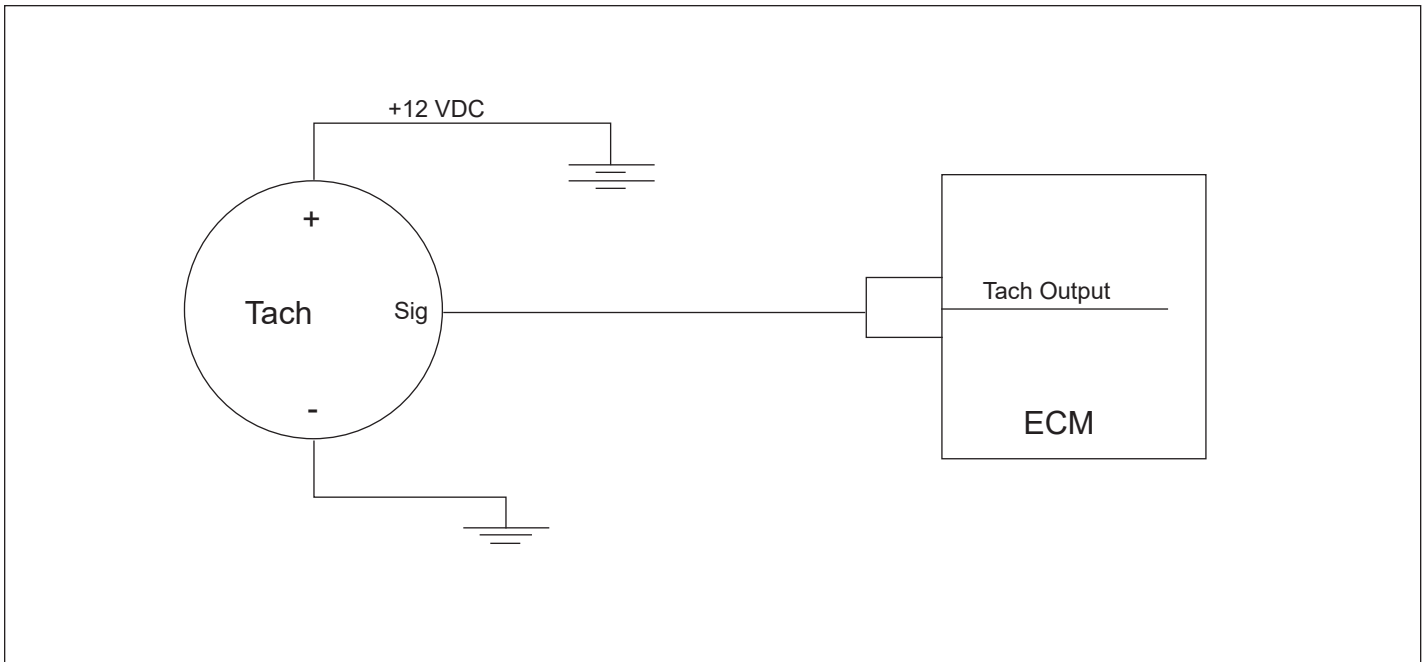
DTC 2296 - Secondary Fuel Pressure Sensor Circuit High Voltage (Direct Injection)

SPN - 94; FMI - 3



Diagnostics

DTC 2618 - TACH Output Short to Ground SPN - 645; FMI - 4

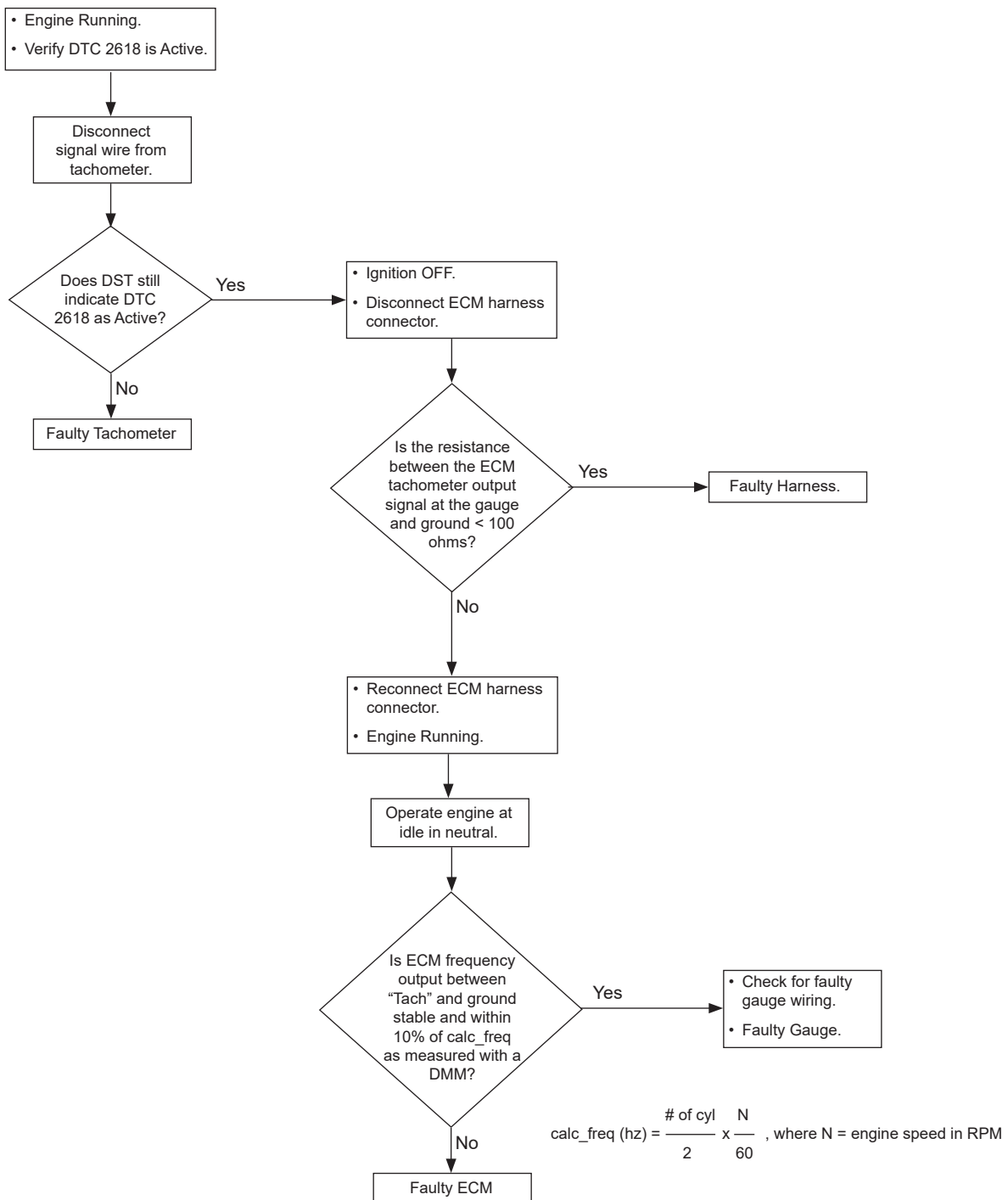


- Tachometer Gauge
- *Check Condition* - Ignition ON, engine OFF
- *Fault Condition* - Low-side feedback is less than expected.

This ECM output is a 0-12 volt constant duty-cycle, variable frequency square-wave used to drive a digital tachometer.

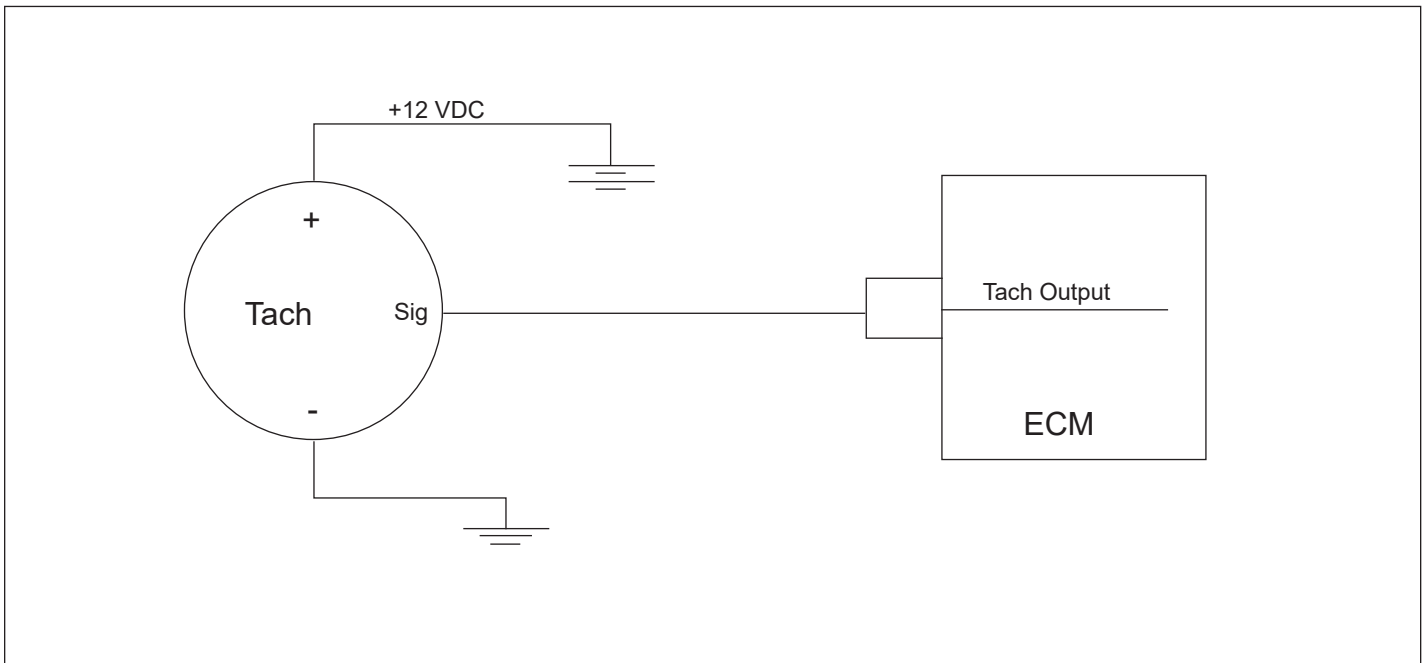
This fault sets if the ECM tachometer output senses a short to ground.

DTC 2618 - TACH Output Short to Ground SPN - 645; FMI - 4



Diagnostics

DTC 2619 - TACH Output Short to Power SPN - 645; FMI - 3

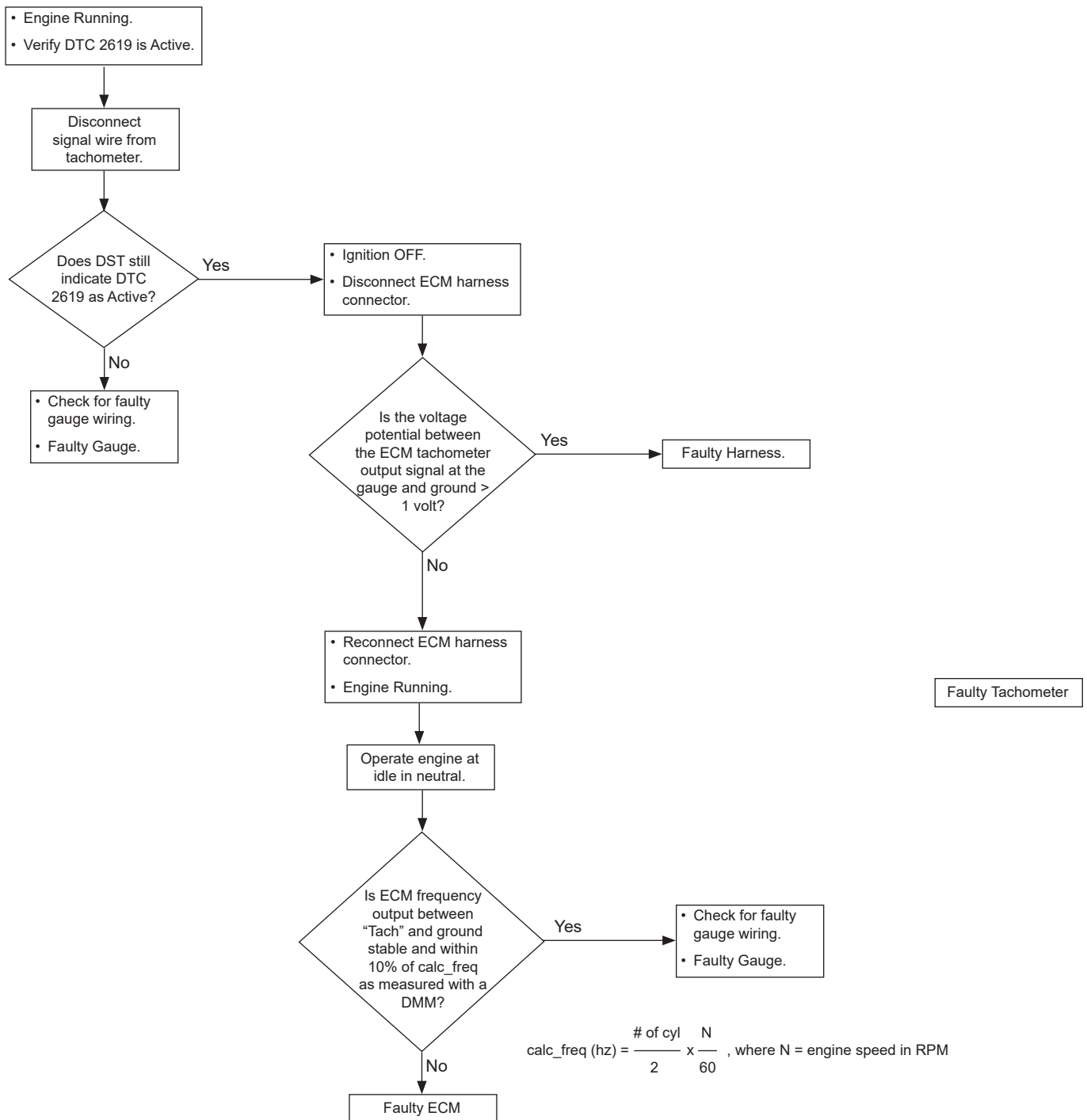


- Tachometer Gauge
- *Check Condition* - Ignition ON, engine OFF
- *Fault Condition* - Low-side feedback is greater than expected.

This ECM output is a 0-12 volt constant duty-cycle, variable frequency square-wave used to drive a digital tachometer.

This fault sets if the ECM tachometer output senses a short to power.

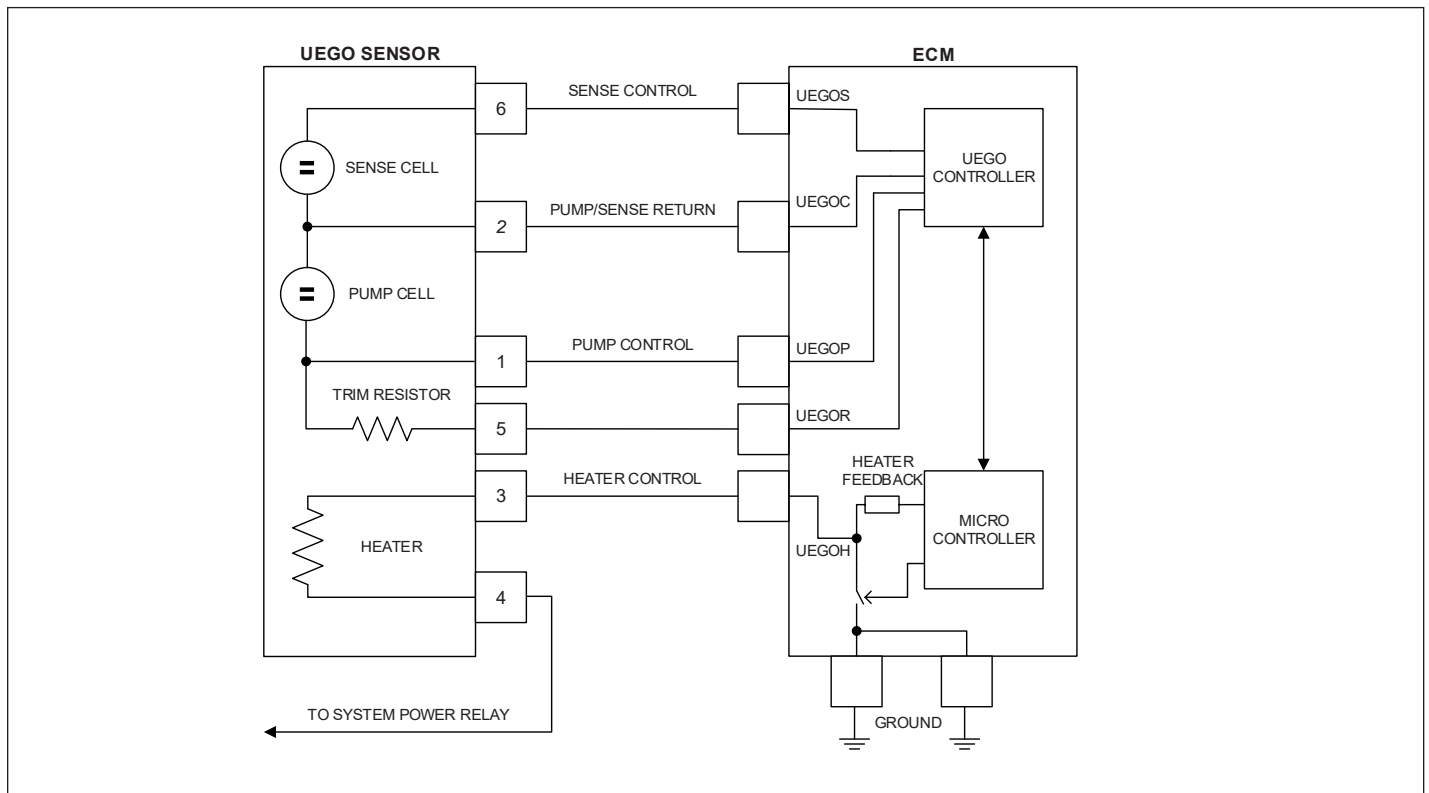
DTC 2619 - TACH Output Short to Power SPN - 645; FMI - 3



$$\text{calc_freq (hz)} = \frac{\text{\# of cyl}}{2} \times \frac{N}{60}, \text{ where } N = \text{engine speed in RPM}$$

Diagnostics

DTC 8901 - UEGO 1 Internal Processor Fault SPN - 3221; FMI - 31



- Universal Exhaust Gas Oxygen (UEGO) 1 Sensor (Bank 1, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Break in communication has occurred between the UEGO controller and the main microcontroller (both devices internal to the ECM). The UEGO controller is no longer responsive.

A UEGO sensor measures the exhaust content across a wide range of air-fuel ratios with a linear output proportional to air-fuel ratio. Internal to the ECM, there is an application specific integrated circuit/controller that controls the sensor. The UEGO controller communicates internally within the ECM to the main microcontroller. The UEGO controller must always be functioning and communicating with the main microcontroller for proper emissions control.

This fault may set if the power supplied to the ECM (alternator or battery power) is excessively noisy and exhibits low voltage dips or dropouts. It may also indicate an internal failure within the ECM.

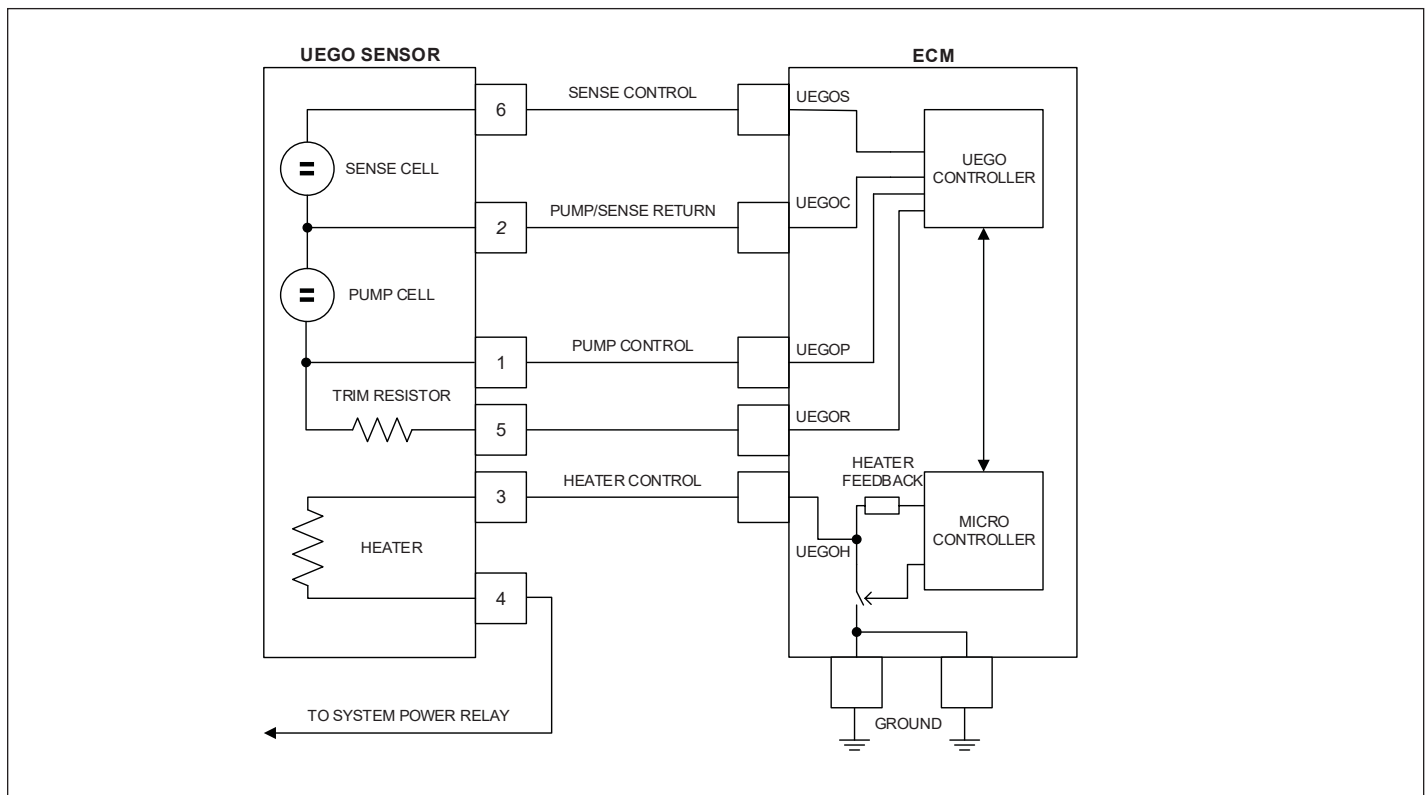
DTC 8901 - UEGO 1 Internal Processor Fault SPN - 3221; FMI - 31

Diagnostic Aids

- Verify that the alternator is working properly and there is not excessive noise on the alternator output or battery power from other loads. This fault may occur if power repeatedly dips but does not completely drop to zero.
- Verify ECM grounds are sufficient (clean and tight to the engine block).
- Swap ECM with a known good part, run engine for 10 minutes, and then retest.

Diagnostics

DTC 8902 - UEGO 1 Heater Supply High Voltage Fault SPN - 3222; FMI - 3

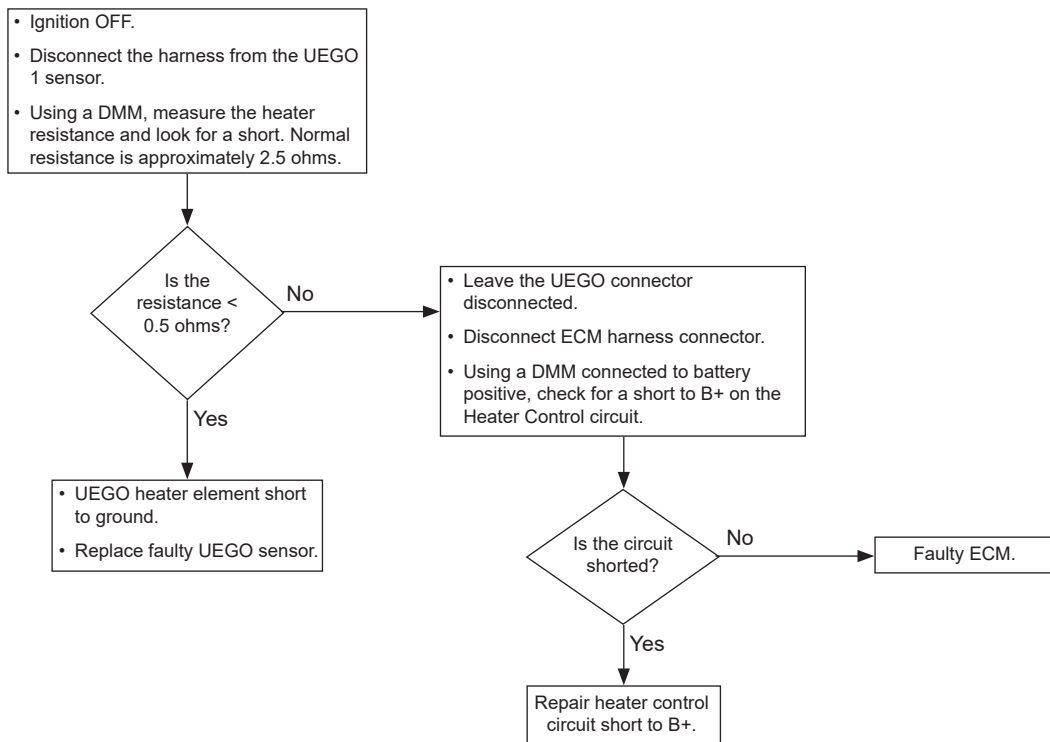


- Universal Exhaust Gas Oxygen (UEGO) 1 Sensor (Bank 1, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - UEGO 1 Heater Supply Voltage is higher than expected.

A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to air-fuel ratio. The sensor is heated with an internal resistor element that is supplied by the battery voltage and switched on/off by the ECM. The ECM will pull the heater control signal to ground when turning on the heater. The ECM monitors the heater control signal for a short to Vbattery. If the control signal does not reach zero volts when the heater is turned on then the circuit is not functioning properly. The UEGO heater circuit must always be functioning for proper emissions control.

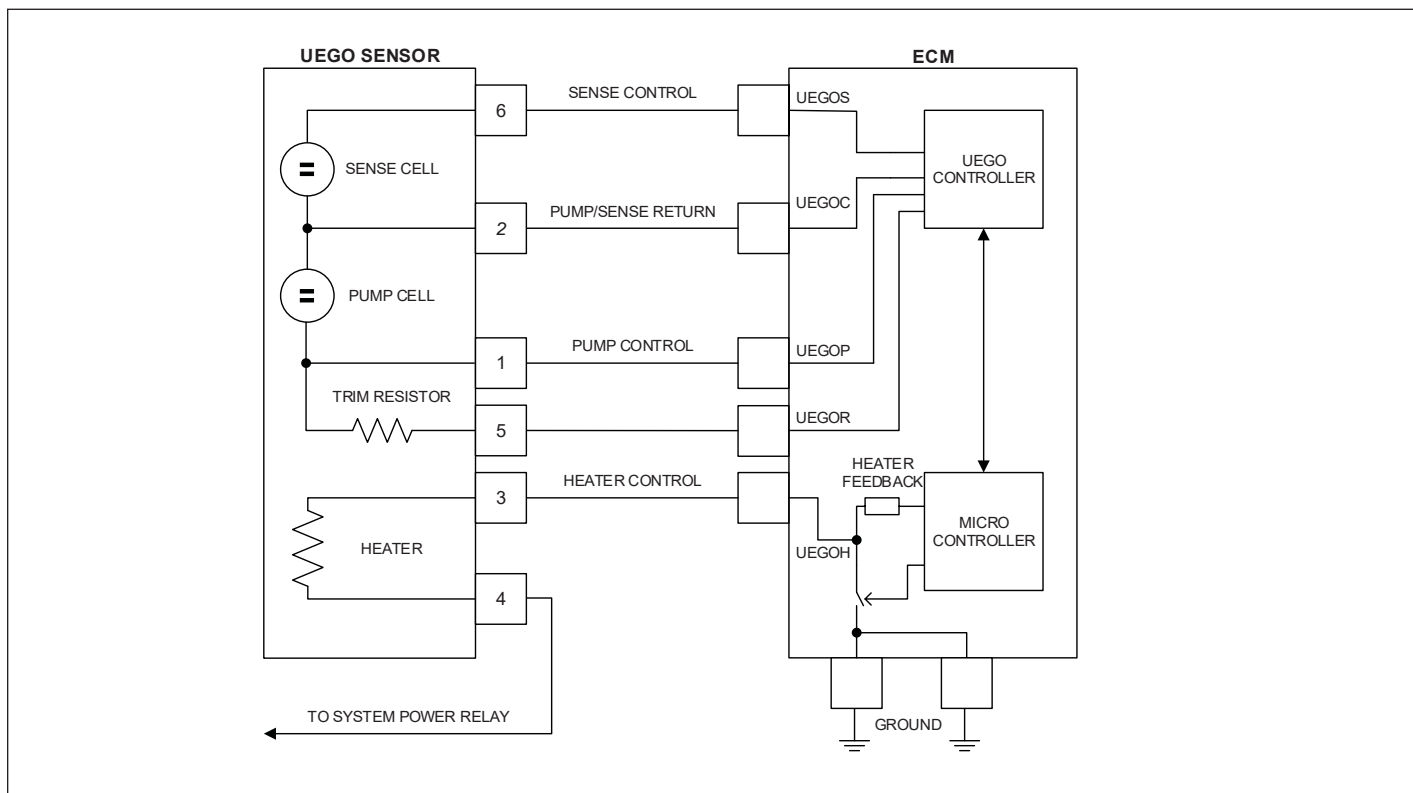
This fault will set when the UEGO 1 heater control signal does not achieve zero volts when the heater is switched on. This may be caused by an internal fault within the ECM.

DTC 8902 - UEGO 1 Heater Supply High Voltage Fault SPN - 3222; FMI - 3



Diagnostics

DTC 8903 - UEGO 1 Heater Supply Low Voltage Fault SPN - 3222; FMI - 4

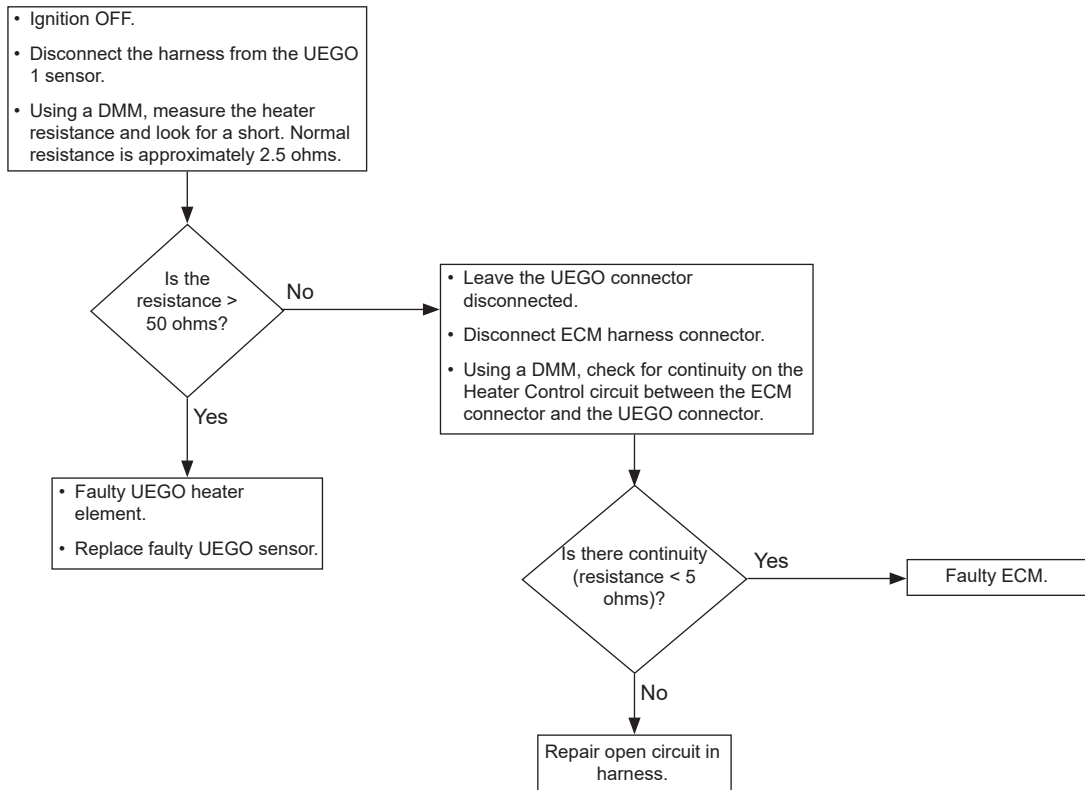


- Universal Exhaust Gas Oxygen (UEGO) 1 Sensor (Bank 1, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - UEGO 1 Heater Supply Voltage is higher than expected.

A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to air-fuel ratio. The sensor is heated with an internal resistor element that is supplied by the battery voltage and switched on/off by the ECM. The ECM will pull the heater control signal to ground when turning on the heater. The ECM monitors the heater control signal for a short to V_{battery}. If the control signal does not reach zero volts when the heater is turned on then the circuit is not functioning properly. The UEGO heater circuit must always be functioning for proper emissions control.

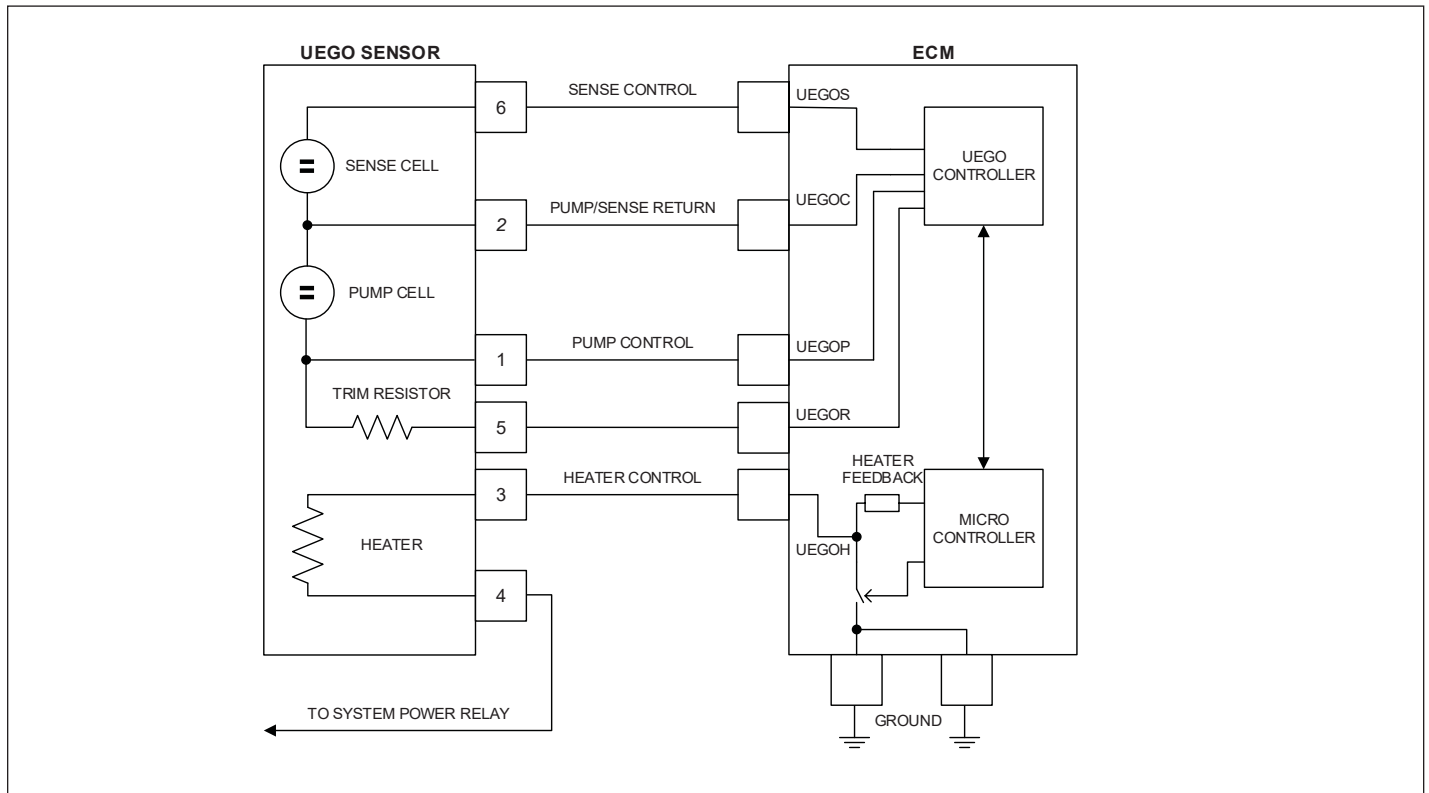
This fault will set when the UEGO 1 heater control signal does not achieve B+ when the heater is switched off. This may be caused by a bad heater element in the UEGO sensor, an open in the heater supply or control circuits, or an internal fault within the ECM.

DTC 8903 - UEGO 1 Heater Supply Low Voltage Fault SPN - 3222; FMI - 4



Diagnostics

DTC 8908 - UEGO 1 Pump Voltage Shorted High Fault SPN - 3218; FMI - 3

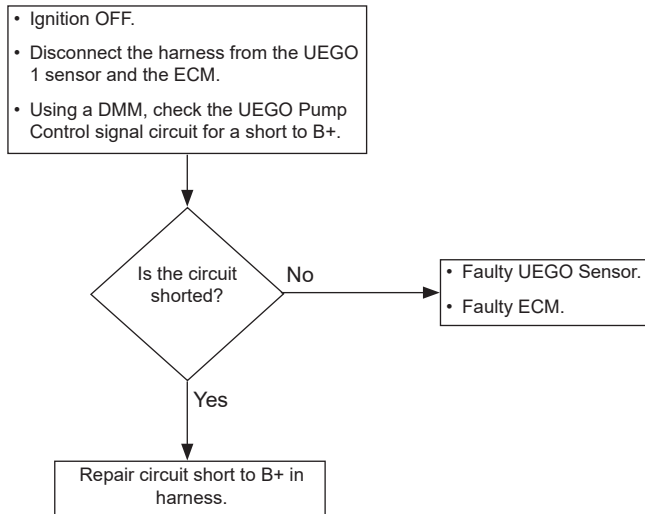


- Universal Exhaust Gas Oxygen (UEGO) 1 Sensor (Bank 1, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Voltage feedback from the UEGO 1 sensor pump control signal is equal to battery or supply voltage (short to Vbattery).

A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to air-fuel ratio. The sensor has a pump control signal between the pump cell and the ECM. The ECM monitors the pump control signal for a short to B+. The UEGO 1 pump circuit must always be functioning for proper emissions control.

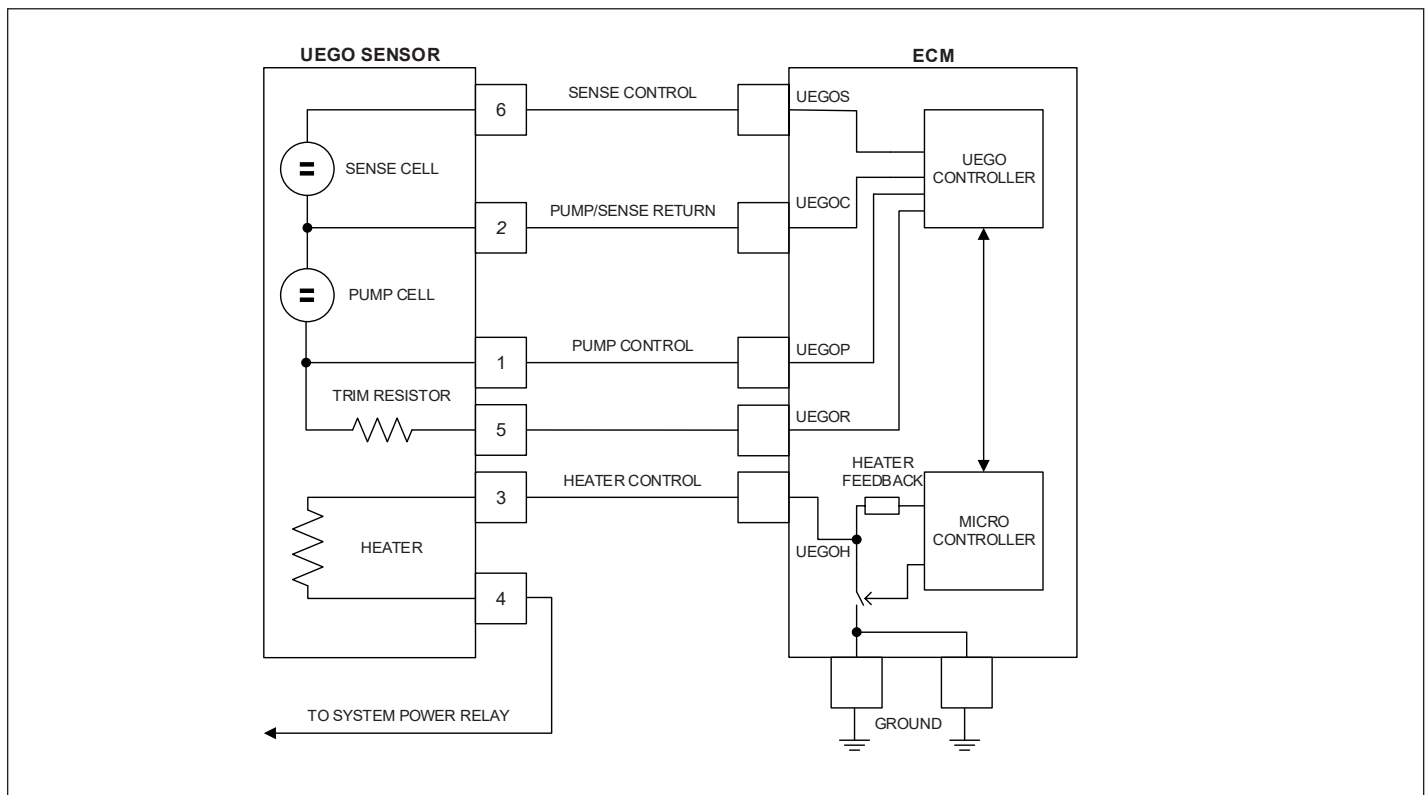
This fault will set when the UEGO pump control signal is continuously equal to battery voltage (short to B+). This may be caused by a faulty UEGO sensor or a short in the harness to B+.

DTC 8908 - UEGO 1 Pump Voltage Shorted High Fault SPN - 3218; FMI - 3



Diagnostics

DTC 8909 - UEGO 1 Pump Voltage Shorted Low Fault SPN - 3218; FMI - 4

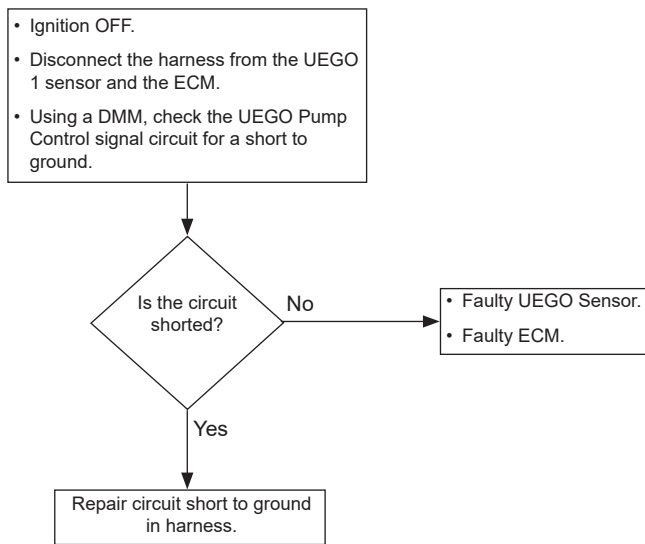


- Universal Exhaust Gas Oxygen (UEGO) 1 Sensor (Bank 1, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Voltage feedback from the UEGO 1 sensor pump control signal is equal to ground voltage (short to ground).

A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to air-fuel ratio. The sensor has a pump control signal between the pump cell and the ECM. The ECM monitors the pump control signal for a short to B+. The UEGO 1 pump circuit must always be functioning for proper emissions control.

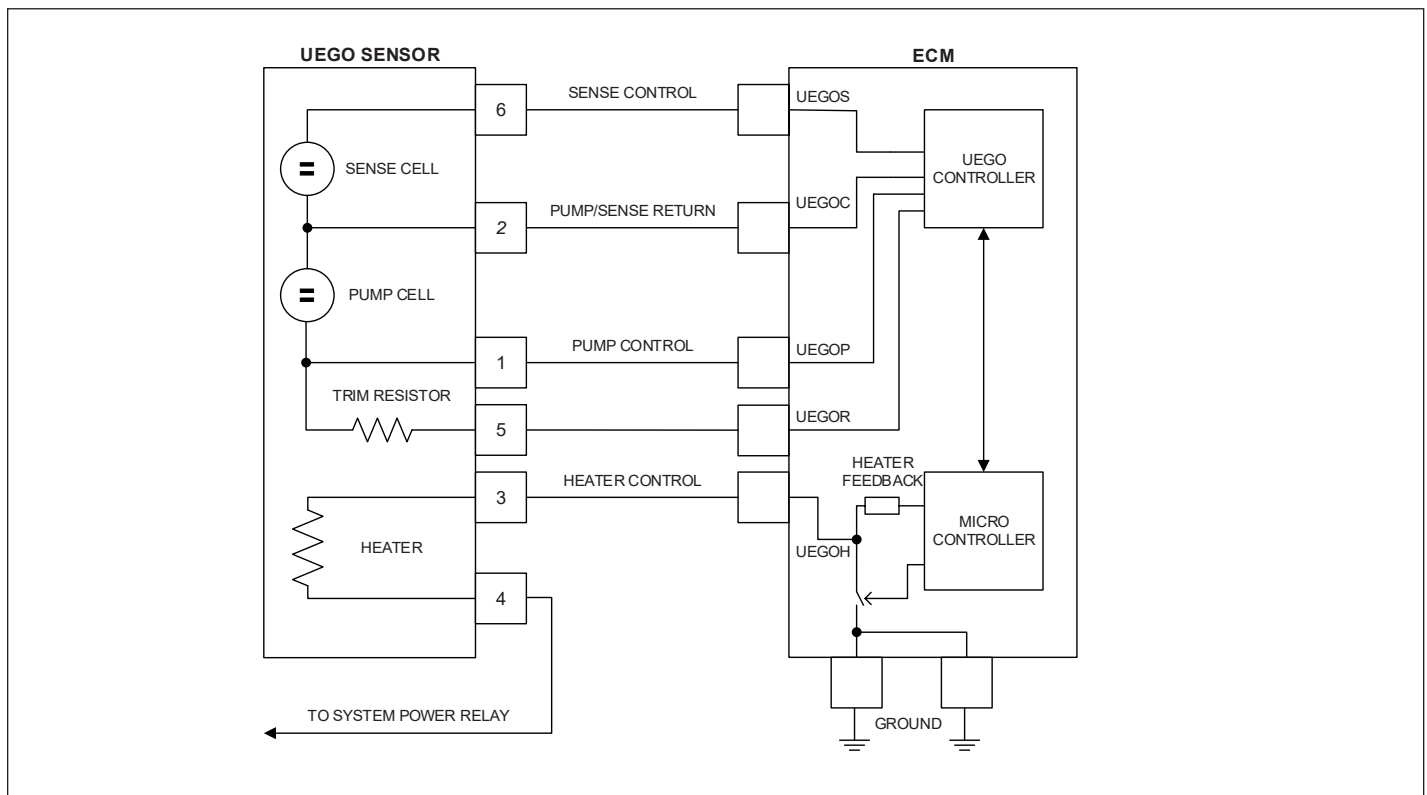
This fault will set when the UEGO pump control signal is continuously equal to ground voltage (short to ground). This may be caused by a faulty UEGO sensor or a short in the harness to ground.

DTC 8909 - UEGO 1 Pump Voltage Shorted Low Fault SPN - 3218; FMI - 4



Diagnostics

DTC 8910 - UEGO 1 Sense Cell Voltage High Fault SPN - 3217; FMI - 3

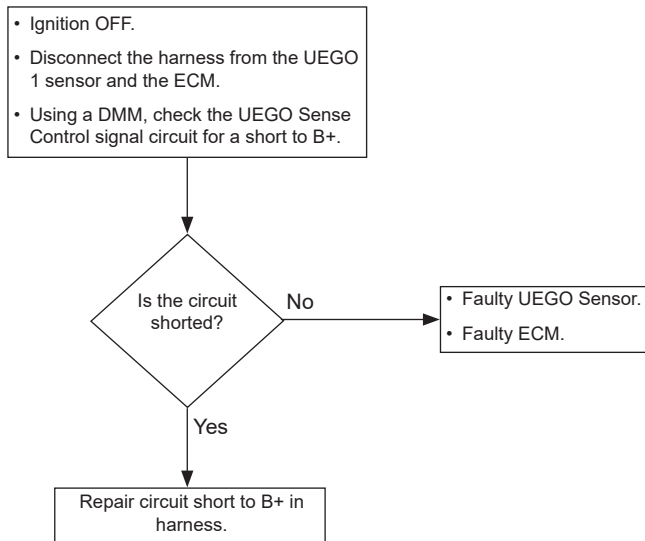


- Universal Exhaust Gas Oxygen (UEGO) 1 Sensor (Bank 1, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Voltage feedback from the UEGO 1 sensor sense control signal is equal to battery or supply voltage (short to B+).

A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to air-fuel ratio. The sensor has a sense control signal between the sense cell and the ECM. The ECM monitors the sense control signal for a short to Vbattery. The UEGO sense circuit must always be functioning for proper emissions control.

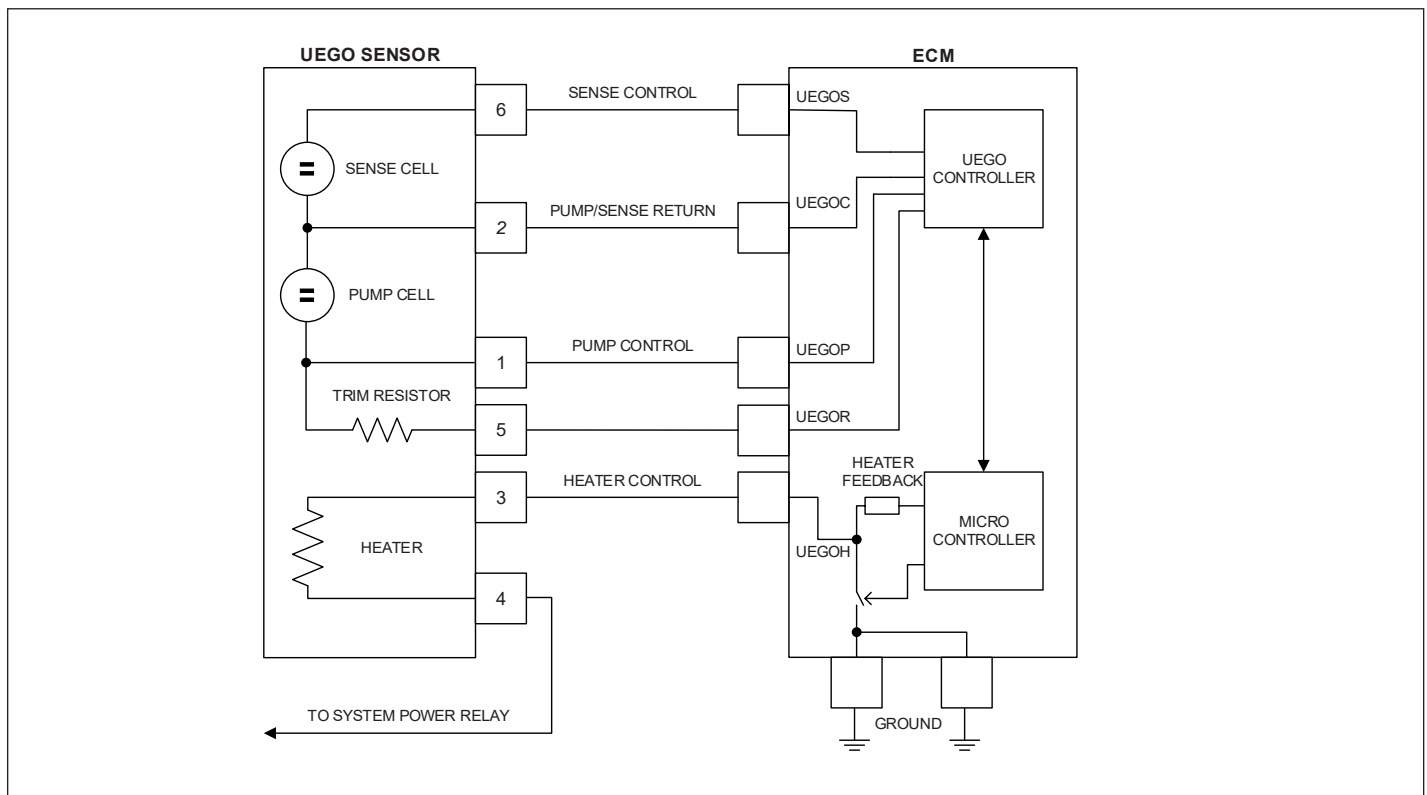
This fault will set when the UEGO sense control signal is continuously equal to battery voltage (short to B+). This may be caused by a faulty UEGO sensor 1 or a short in the harness to B+.

DTC 8910 - UEGO 1 Sense Cell Voltage High Fault SPN - 3217; FMI - 3



Diagnostics

DTC 8911 - UEGO 1 Sense Cell Voltage Low Fault SPN - 3217; FMI - 4

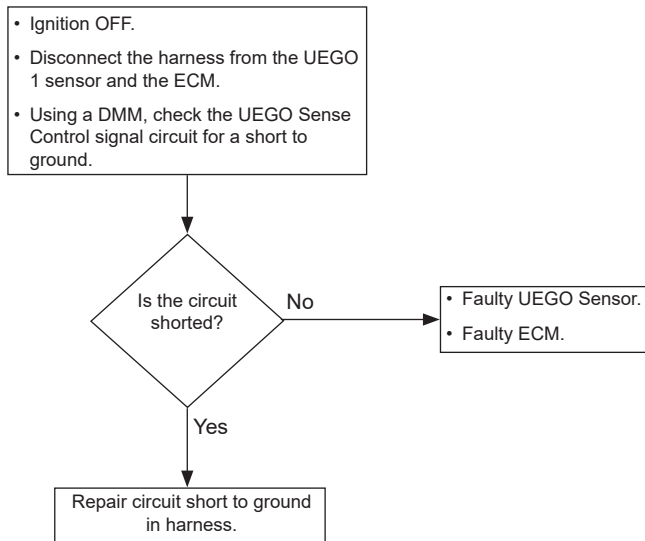


- Universal Exhaust Gas Oxygen (UEGO) 1 Sensor (Bank 1, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Voltage feedback from the UEGO 1 sensor sense control signal is equal to ground voltage (short to ground).

A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to air-fuel ratio. The sensor has a sense control signal between the sense cell and the ECM. The ECM monitors the sense control signal for a short to Vbattery. The UEGO sense circuit must always be functioning for proper emissions control.

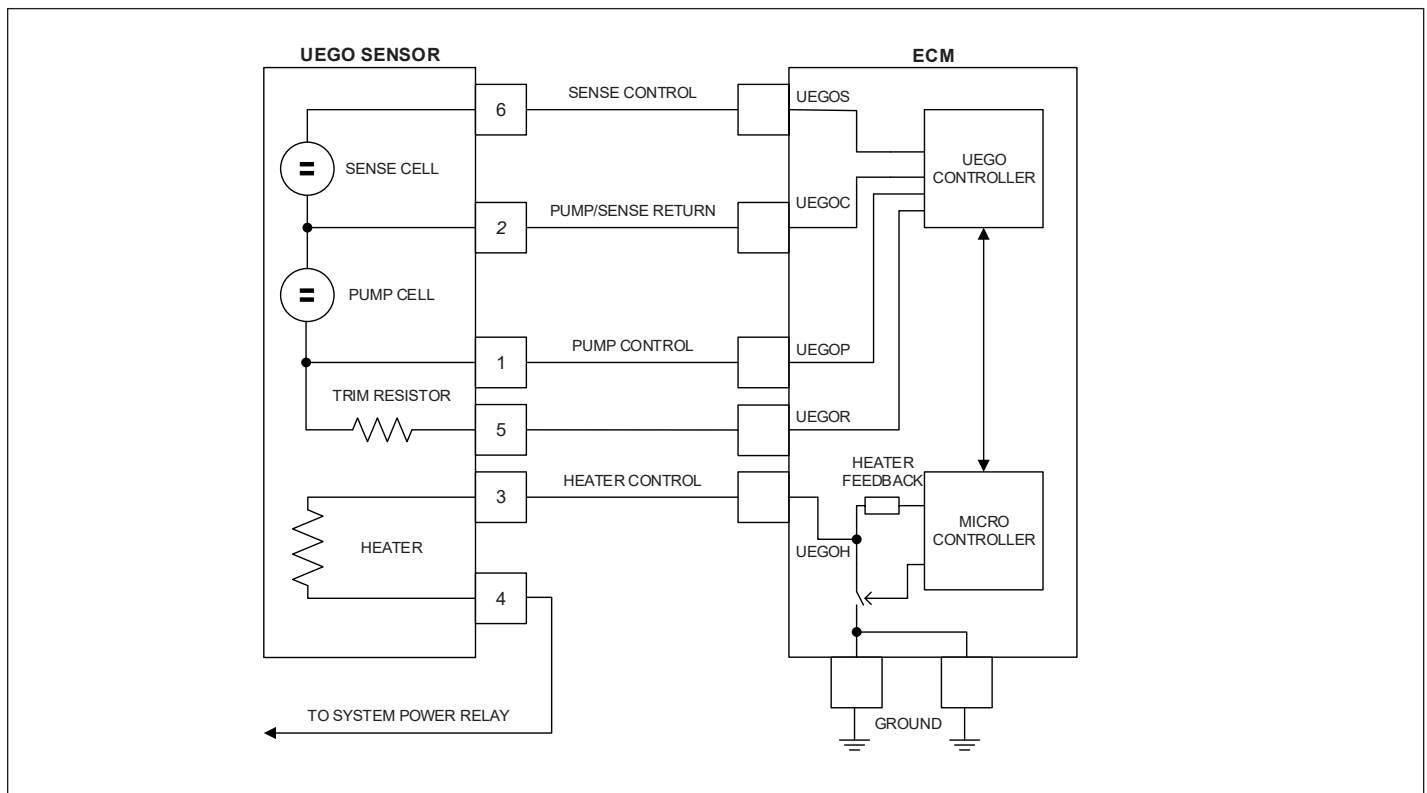
This fault will set when the UEGO sense control signal is continuously equal to ground voltage (short to ground). This may be caused by a faulty UEGO sensor 1 or a short in the harness to ground.

DTC 8911 - UEGO 1 Sense Cell Voltage Low Fault SPN - 3217; FMI - 4



Diagnostics

DTC 8919 - UEGO 2 Internal Processor Fault SPN - 67049; FMI - 31



- Universal Exhaust Gas Oxygen (UEGO) 2 Sensor (Bank 2, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Break in communication has occurred between the UEGO controller and the main microcontroller (both devices internal to the ECM). The UEGO controller is no longer responsive.

A UEGO sensor measures the exhaust content across a wide range of air-fuel ratios with a linear output proportional to air-fuel ratio. Internal to the ECM, there is an application specific integrated circuit/controller that controls the sensor. The UEGO controller communicates internally within the ECM to the main microcontroller. The UEGO controller must always be functioning and communicating with the main microcontroller for proper emissions control.

This fault may set if the power supplied to the ECM (alternator or battery power) is excessively noisy and exhibits low voltage dips or dropouts. It may also indicate an internal failure within the ECM.

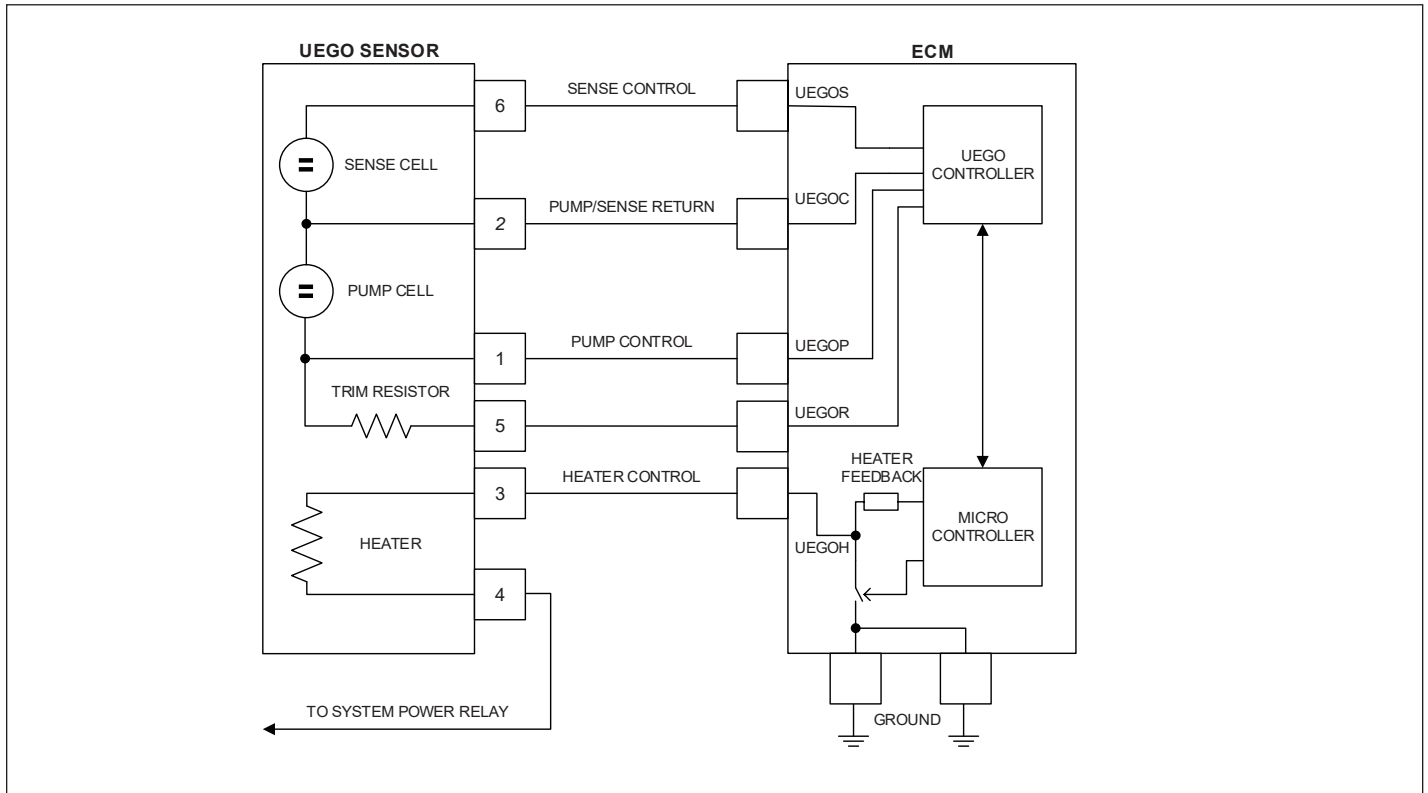
DTC 8919 - UEGO 2 Internal Processor Fault SPN - 67049; FMI - 31

Diagnostic Aids

- Verify that the alternator is working properly and there is not excessive noise on the alternator output or battery power from other loads. This fault may occur if power repeatedly dips but does not completely drop to zero.
- Verify ECM grounds are sufficient (clean and tight to the engine block).
- Swap ECM with a known good part, run engine for 10 minutes, and then retest.

Diagnostics

DTC 8920 - UEGO 2 Heater Supply High Voltage Fault SPN - 67050; FMI - 3

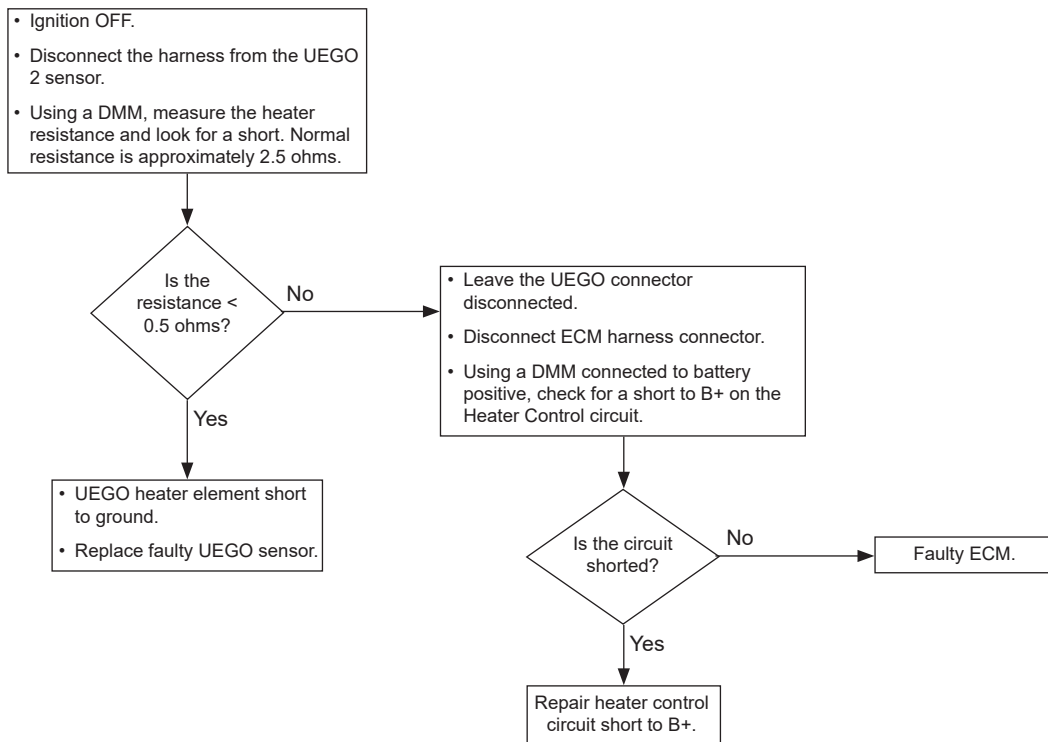


- Universal Exhaust Gas Oxygen (UEGO) 2 Sensor (Bank 2, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - UEGO 2 Heater Supply Voltage is higher than expected.

A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to air-fuel ratio. The sensor is heated with an internal resistor element that is supplied by the battery voltage and switched on/off by the ECM. The ECM will pull the heater control signal to ground when turning on the heater. The ECM monitors the heater control signal for a short to Vbattery. If the control signal does not reach zero volts when the heater is turned on then the circuit is not functioning properly. The UEGO heater circuit must always be functioning for proper emissions control.

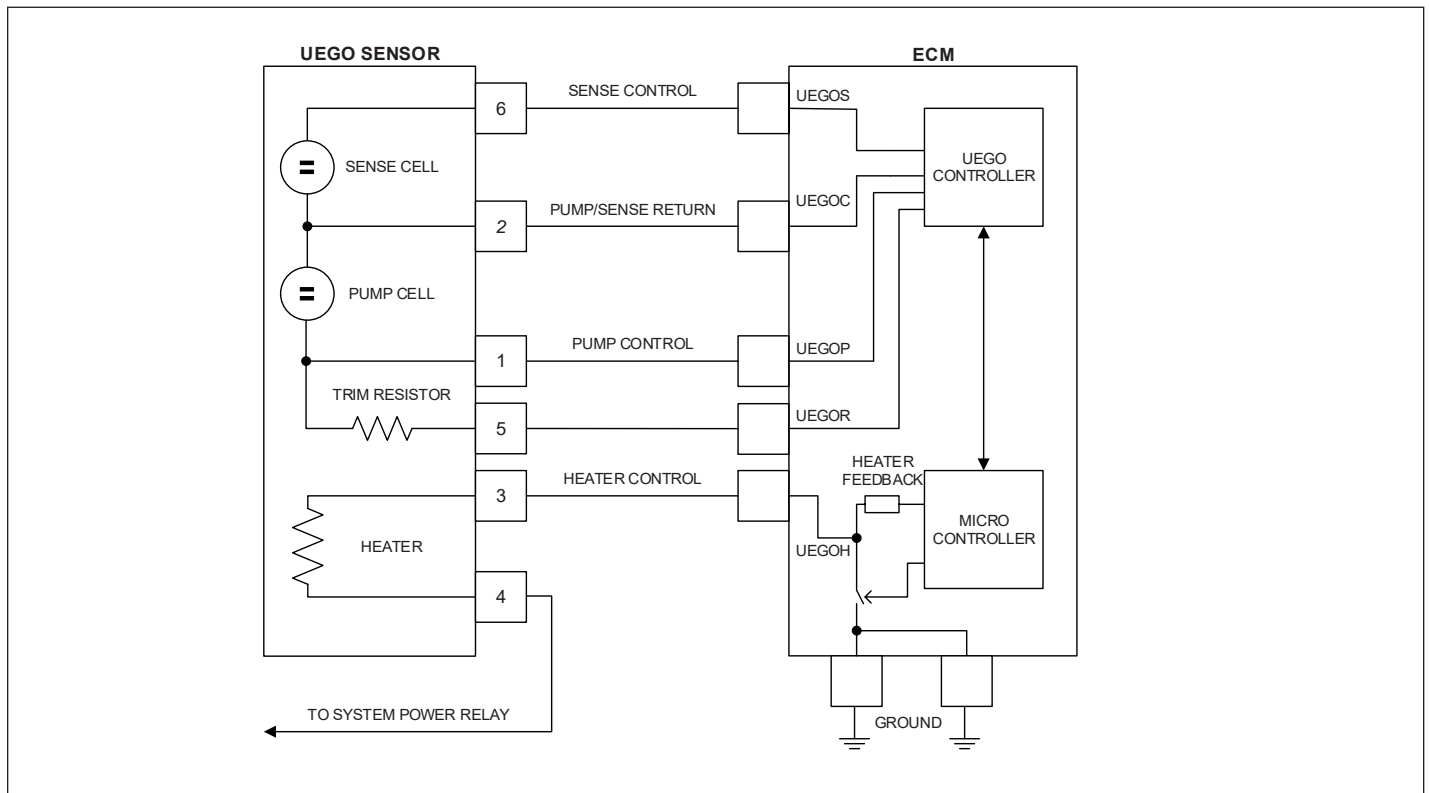
This fault will set when the UEGO 1 heater control signal does not achieve zero volts when the heater is switched on. This may be caused by an internal fault within the ECM.

DTC 8920 - UEGO 2 Heater Supply High Voltage Fault SPN - 67050; FMI - 3



Diagnostics

DTC 8921 - UEGO 2 Heater Supply Low Voltage Fault SPN - 67051; FMI - 4

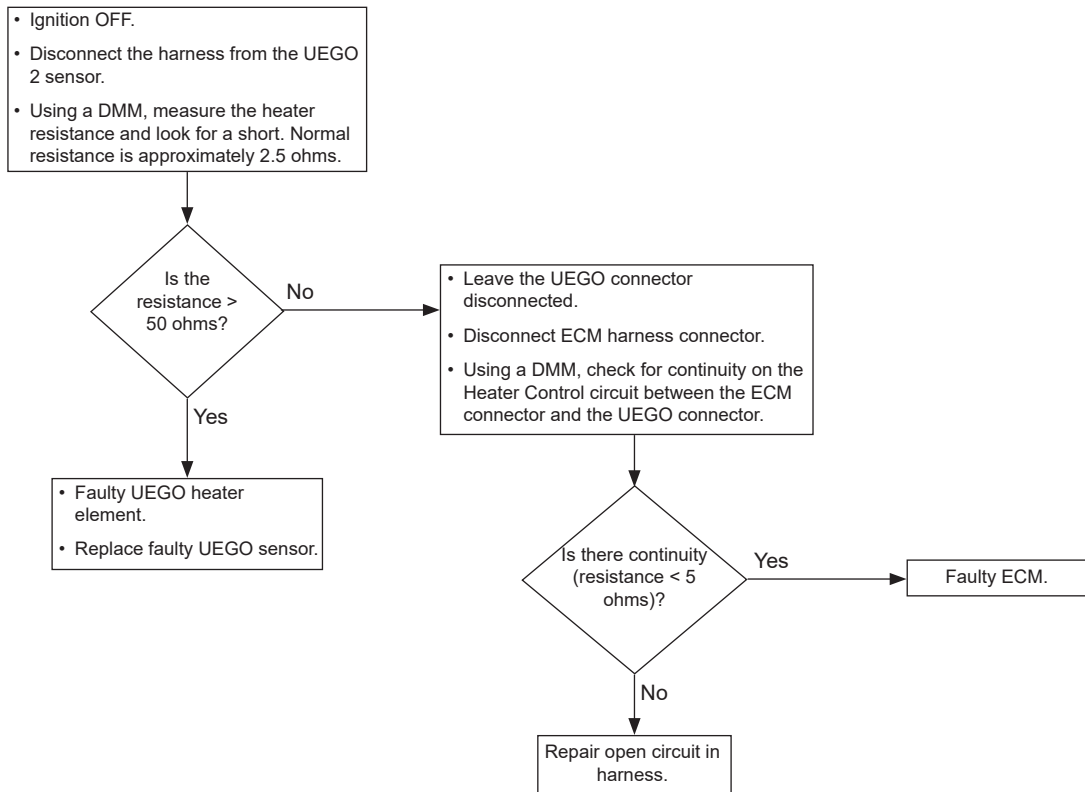


- Universal Exhaust Gas Oxygen (UEGO) 2 Sensor (Bank 2, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - UEGO 1 Heater Supply Voltage is higher than expected.

A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to air-fuel ratio. The sensor is heated with an internal resistor element that is supplied by the battery voltage and switched on/off by the ECM. The ECM will pull the heater control signal to ground when turning on the heater. The ECM monitors the heater control signal for a short to V_{battery}. If the control signal does not reach zero volts when the heater is turned on then the circuit is not functioning properly. The UEGO heater circuit must always be functioning for proper emissions control.

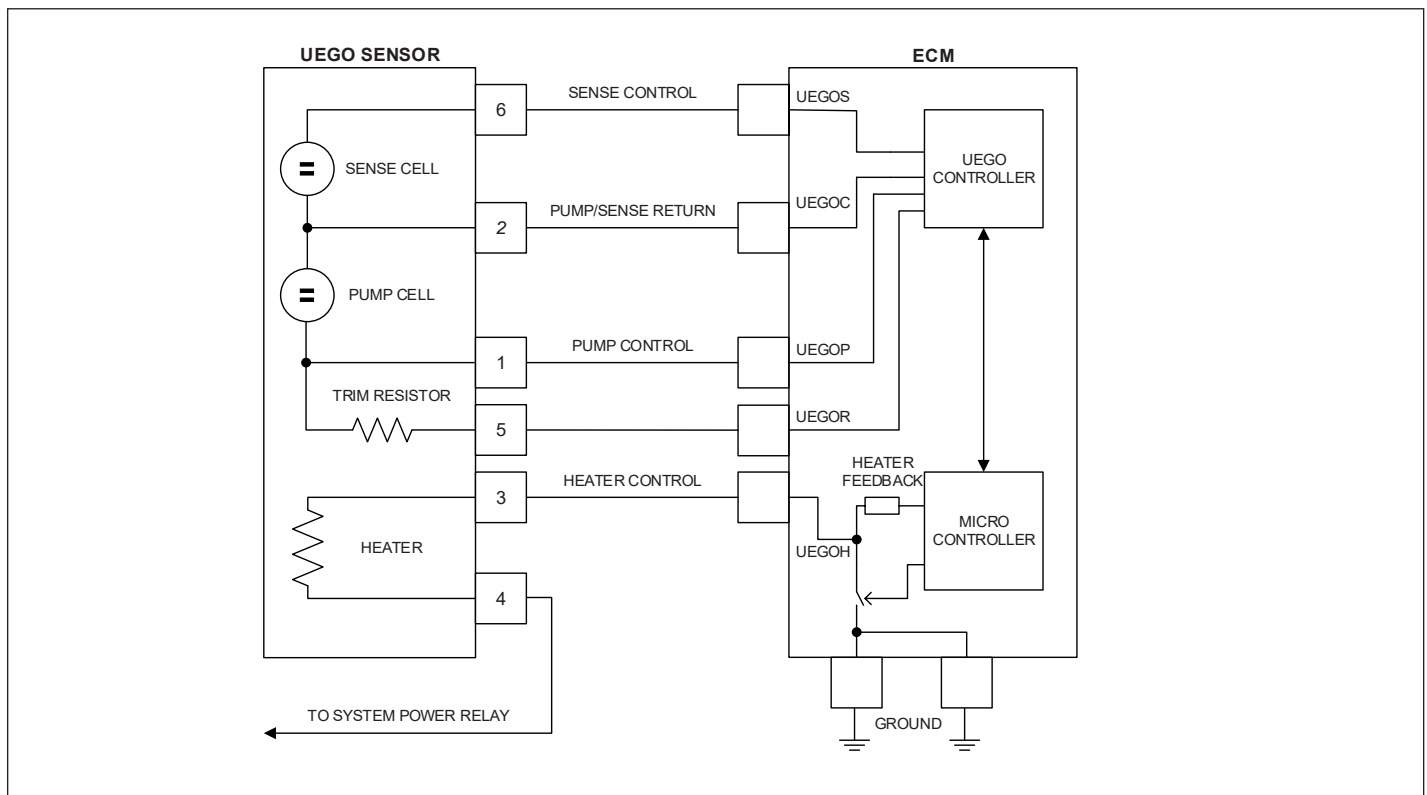
This fault will set when the UEGO 2 heater control signal does not achieve B+ when the heater is switched off. This may be caused by a bad heater element in the UEGO sensor, an open in the heater supply or control circuits, or an internal fault within the ECM.

DTC 8921 - UEGO 2 Heater Supply Low Voltage Fault SPN - 67051; FMI - 4



Diagnostics

DTC 8926 - UEGO 2 Pump Voltage Shorted High Fault SPN - 67056; FMI - 3

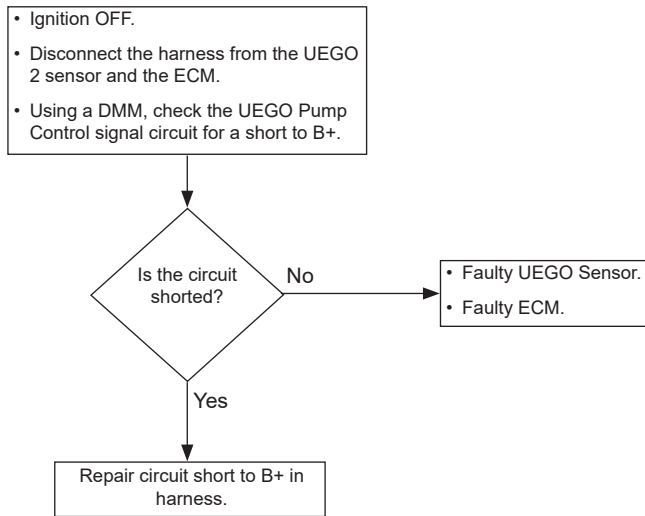


- Universal Exhaust Gas Oxygen (UEGO) 2 Sensor (Bank 2, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Voltage feedback from the UEGO 2 sensor pump control signal is equal to battery or supply voltage (short to Vbattery).

A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to air-fuel ratio. The sensor has a pump control signal between the pump cell and the ECM. The ECM monitors the pump control signal for a short to B+. The UEGO 2 pump circuit must always be functioning for proper emissions control.

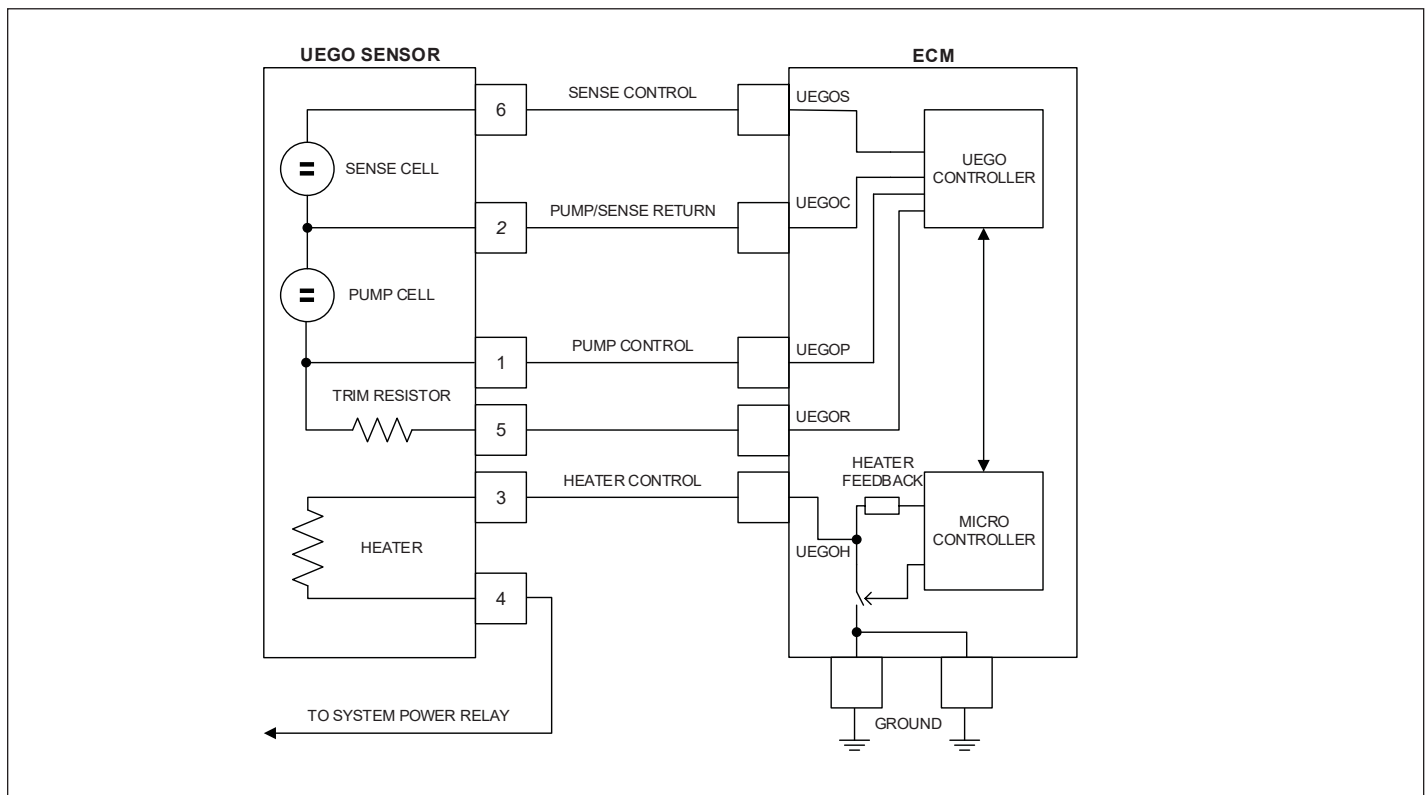
This fault will set when the UEGO pump control signal is continuously equal to battery voltage (short to B+). This may be caused by a faulty UEGO sensor or a short in the harness to B+.

DTC 8926 - UEGO 2 Pump Voltage Shorted High Fault SPN - 67056; FMI - 3



Diagnostics

DTC 8927 - UEGO 2 Pump Voltage Shorted Low Fault SPN - 67057; FMI - 4

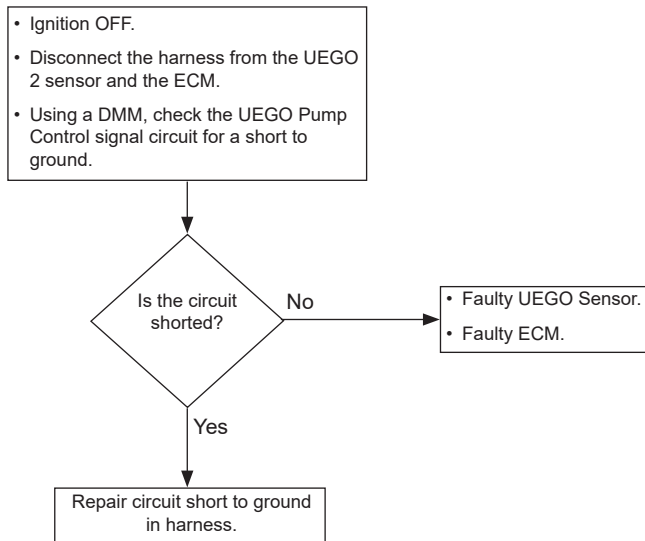


- Universal Exhaust Gas Oxygen (UEGO) 2 Sensor (Bank 2, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Voltage feedback from the UEGO 1 sensor pump control signal is equal to ground voltage (short to ground).

A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to air-fuel ratio. The sensor has a pump control signal between the pump cell and the ECM. The ECM monitors the pump control signal for a short to B+. The UEGO 2 pump circuit must always be functioning for proper emissions control.

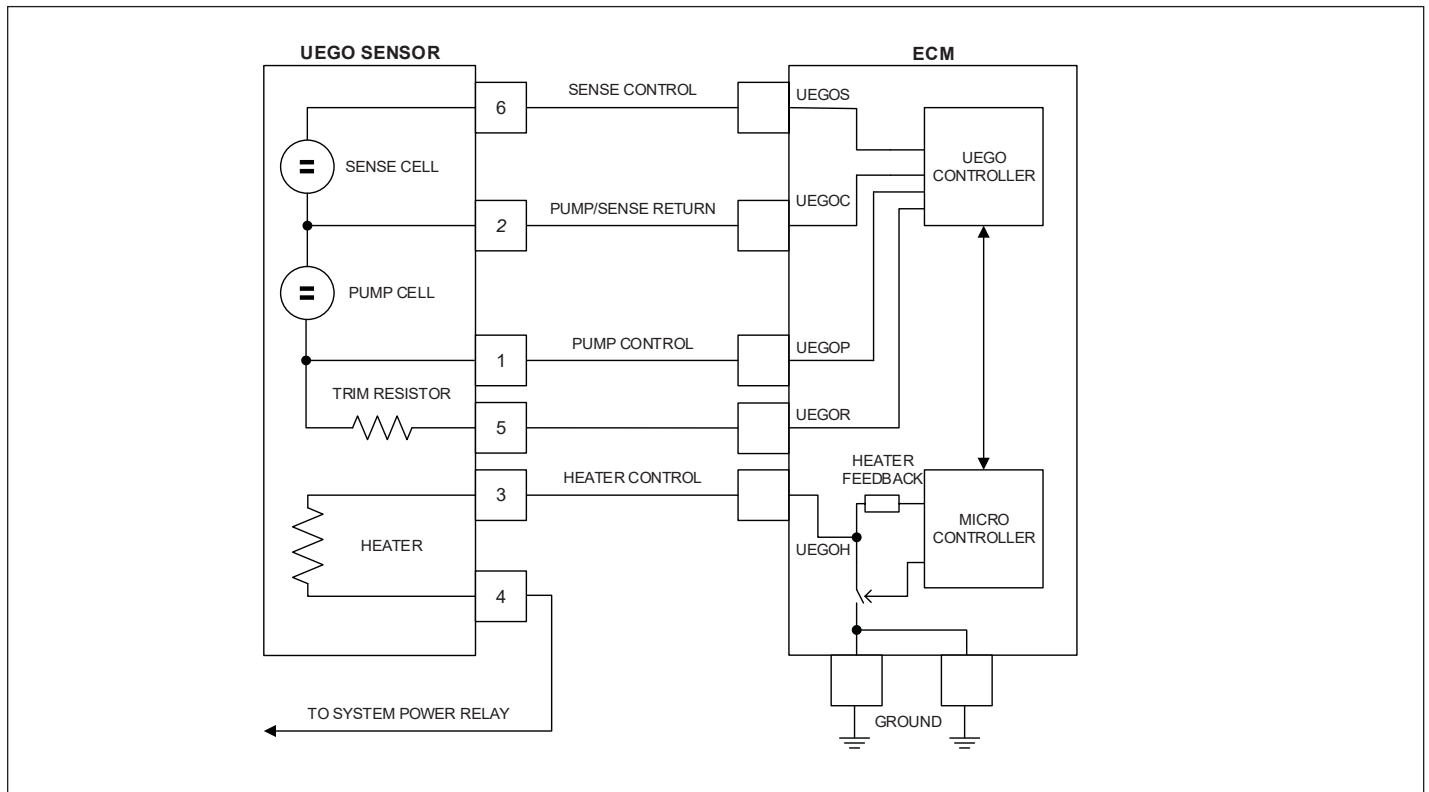
This fault will set when the UEGO pump control signal is continuously equal to ground voltage (short to ground). This may be caused by a faulty UEGO sensor or a short in the harness to ground.

DTC 8927 - UEGO 2 Pump Voltage Shorted Low Fault SPN - 67057; FMI - 4



Diagnostics

DTC 8928 - UEGO 2 Sense Cell Voltage High Fault SPN - 67058; FMI - 3

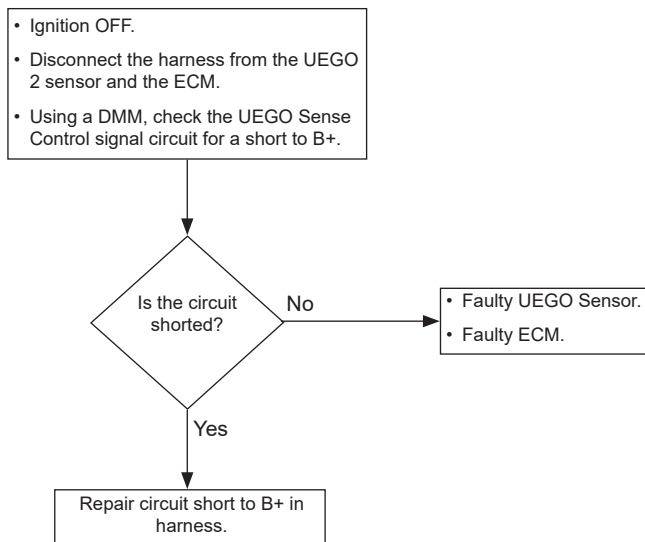


- Universal Exhaust Gas Oxygen (UEGO) 2 Sensor (Bank 2, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Voltage feedback from the UEGO 2 sensor sense control signal is equal to battery or supply voltage (short to B+).

A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to air-fuel ratio. The sensor has a sense control signal between the sense cell and the ECM. The ECM monitors the sense control signal for a short to V_{battery}. The UEGO sense circuit must always be functioning for proper emissions control.

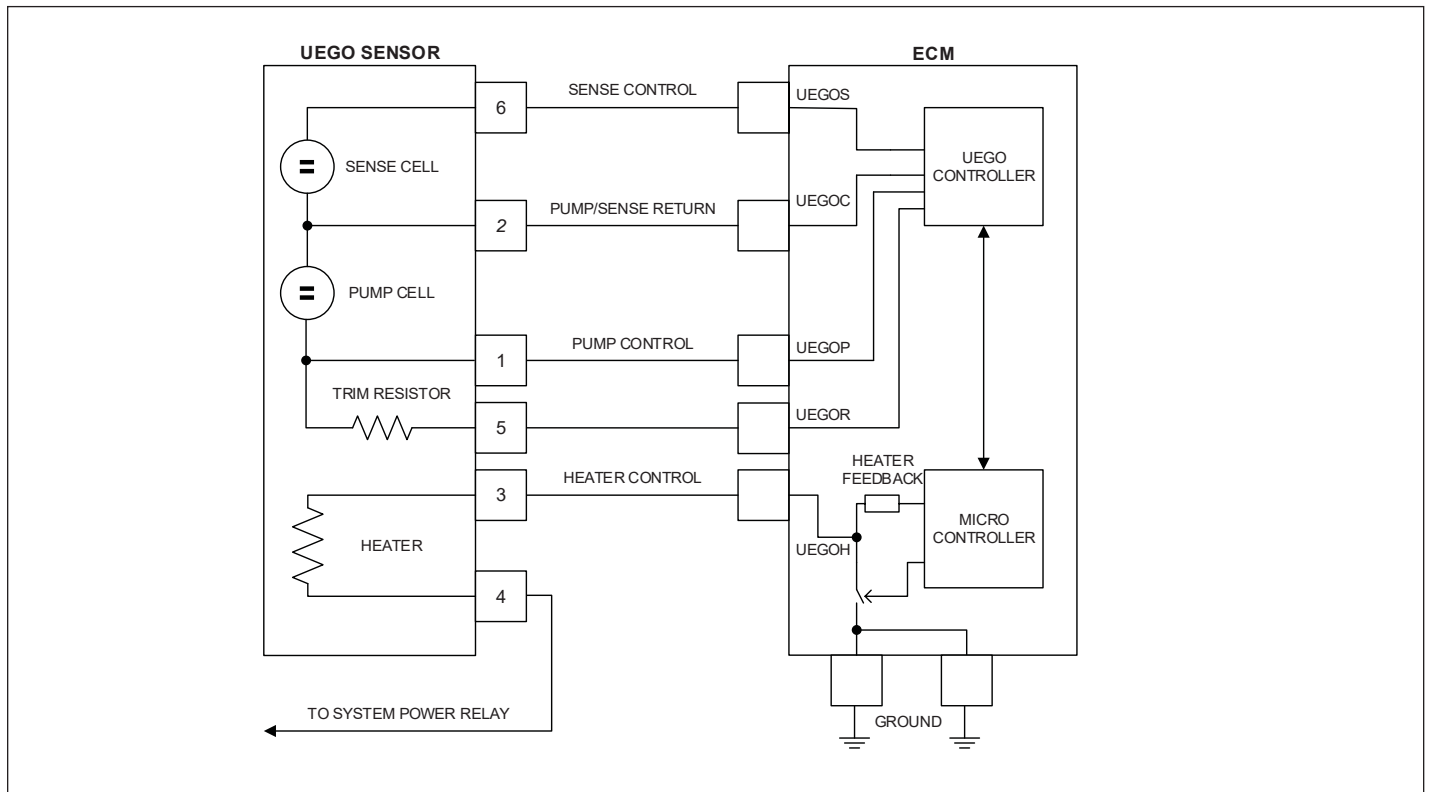
This fault will set when the UEGO sense control signal is continuously equal to battery voltage (short to B+). This may be caused by a faulty UEGO sensor 1 or a short in the harness to B+.

DTC 8928 - UEGO 2 Sense Cell Voltage High Fault SPN - 67058; FMI - 3



Diagnostics

DTC 8929 - UEGO 2 Sense Cell Voltage Low Fault SPN - 67059; FMI - 4

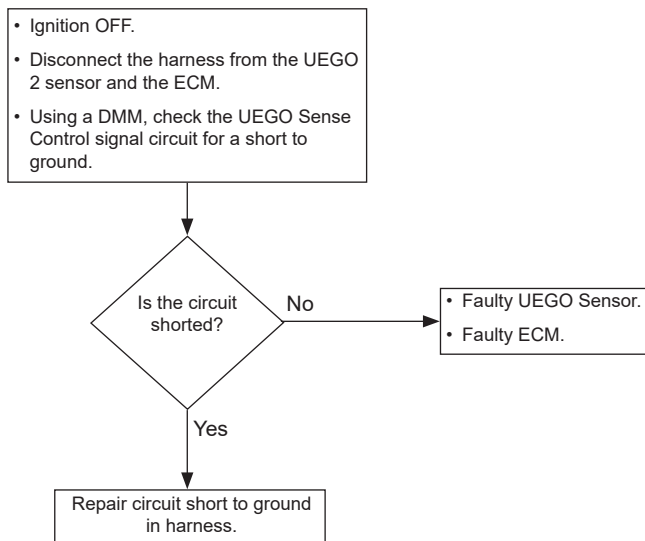


- Universal Exhaust Gas Oxygen (UEGO) 2 Sensor (Bank 2, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Voltage feedback from the UEGO 2 sensor sense control signal is equal to ground voltage (short to ground).

A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to air-fuel ratio. The sensor has a sense control signal between the sense cell and the ECM. The ECM monitors the sense control signal for a short to Vbattery. The UEGO sense circuit must always be functioning for proper emissions control.

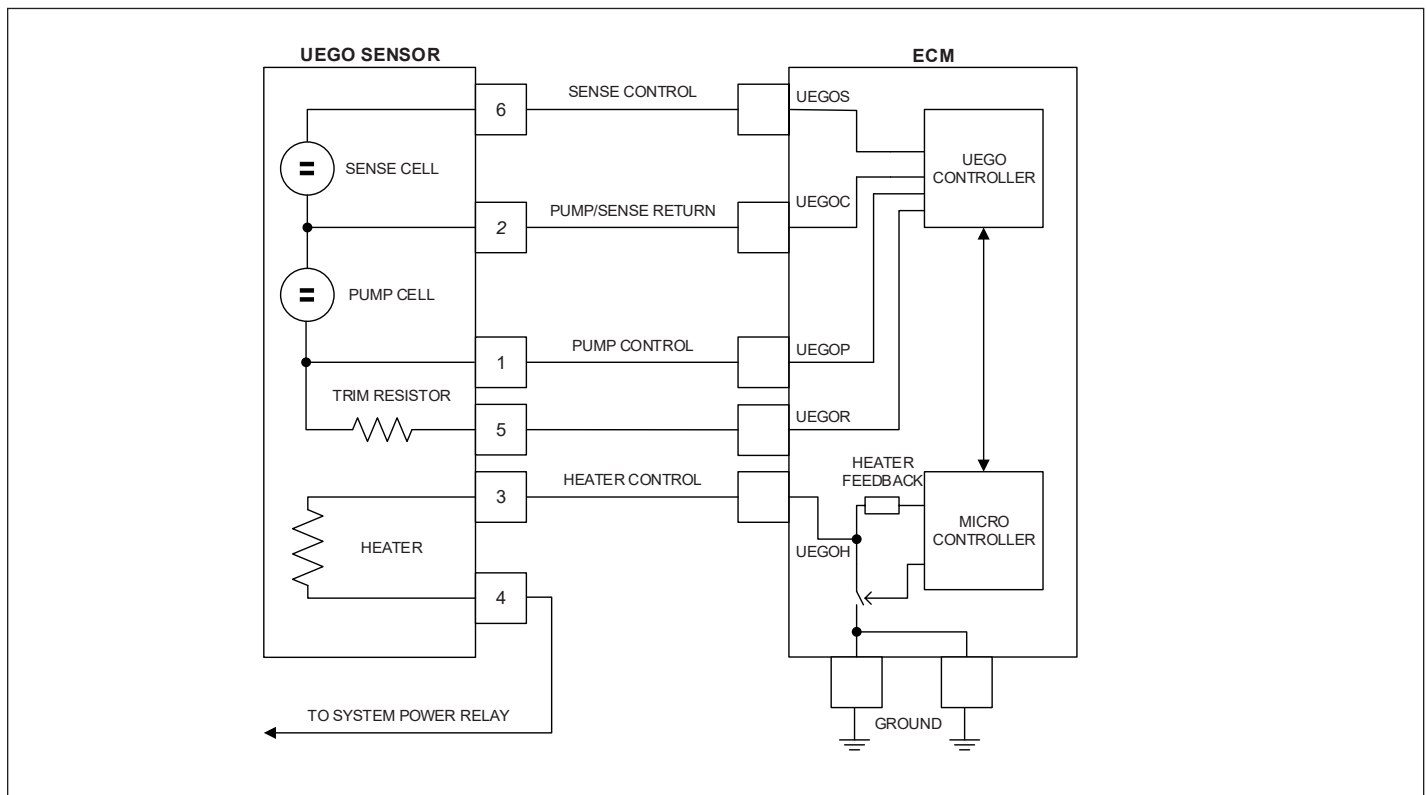
This fault will set when the UEGO sense control signal is continuously equal to battery voltage (short to ground). This may be caused by a faulty UEGO sensor 1 or a short in the harness to ground.

DTC 8929 - UEGO 2 Sense Cell Voltage Low Fault SPN - 67059; FMI - 4



Diagnostics

DTC 8937 - UEGO 1 Heater Open or Shorted to Ground Fault SPN - 3222; FMI - 4

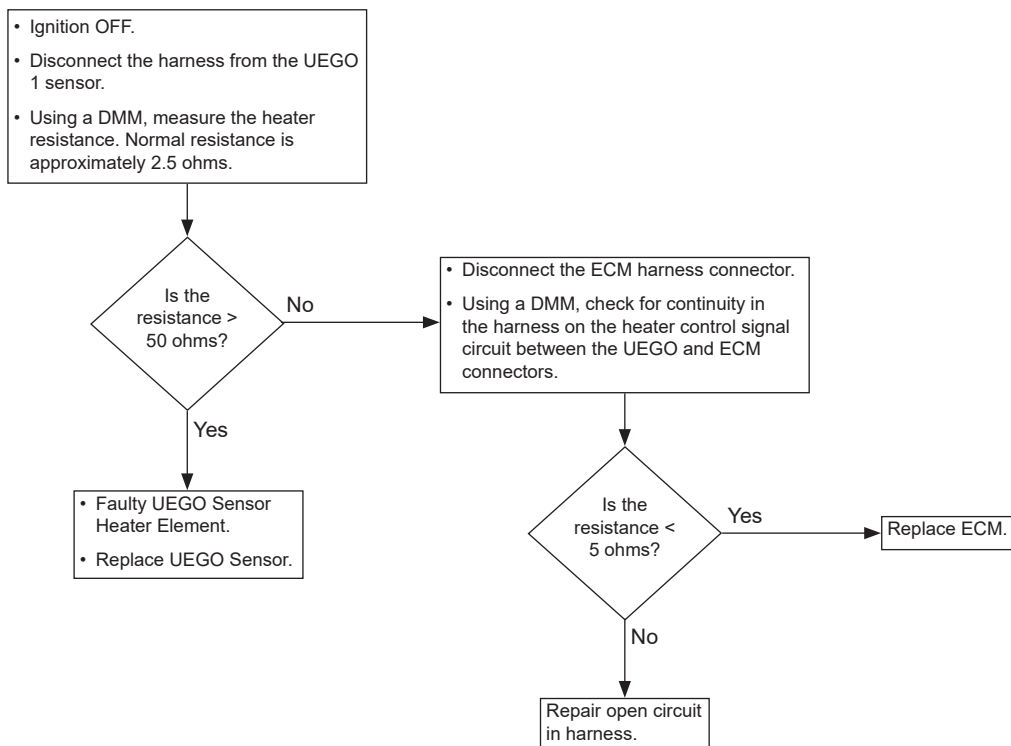


- Universal Exhaust Gas Oxygen (UEGO) 1 Sensor (Bank 1, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Voltage feedback from the UEGO 1 sensor heater is always equal to ground voltage.

A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to air-fuel ratio. The sensor is heated with an internal resistive element that is supplied by the battery voltage and switched on/off by the ECM. The ECM will pull the heater control signal to ground when turning on the heater. The ECM monitors the heater control signal for a short to ground. If the control signal is not equal to $V_{battery}$ when the heater is turned off then the circuit is not functioning properly. The UEGO heater circuit must always be functioning for proper emissions control.

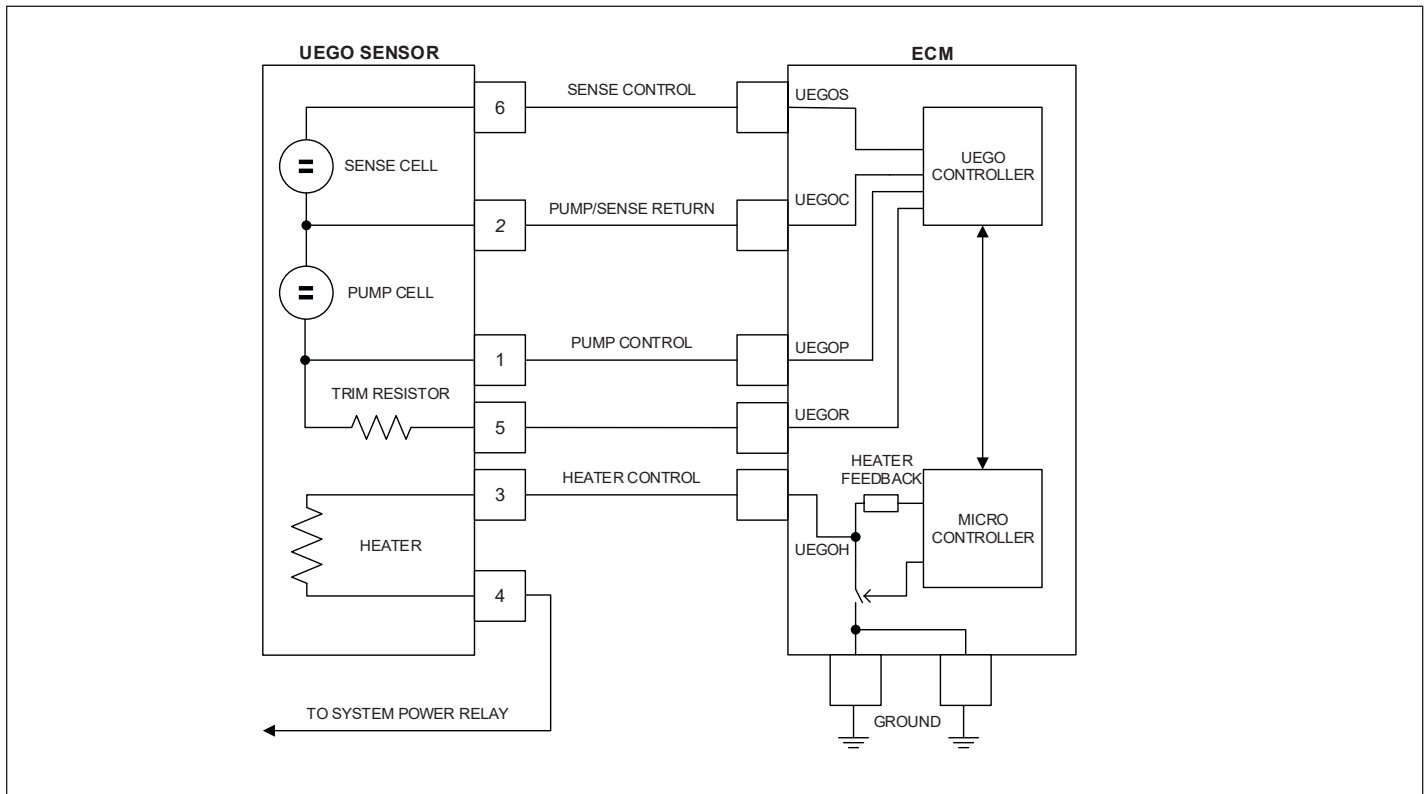
This fault will set when the UEGO heater control signal does not achieve $V_{battery}$ when the heater is switched off. This may be caused by a bad heater element in the UEGO sensor, a break in the wire harness on the heater supply or control circuits, or fault within the ECM.

DTC 8937 - UEGO 1 Heater Open or Shorted to Ground Fault SPN - 3222; FMI - 4



Diagnostics

DTC 8938 - UEGO 1 Heater Shorted to Power Fault SPN - 3222; FMI - 3

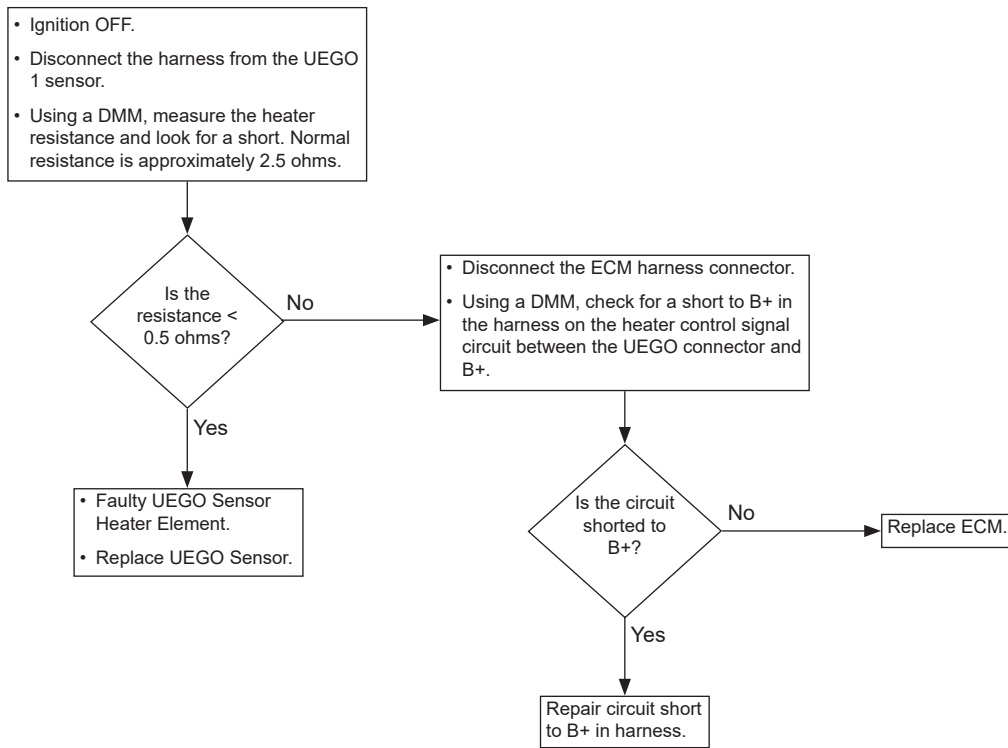


- Universal Exhaust Gas Oxygen (UEGO) 1 Sensor (Bank 1, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Voltage feedback from the UEGO 1 sensor heater is always equal to the battery or supply voltage (short to B+).

A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to air-fuel ratio. The sensor is heated with an internal resistive element that is supplied by the battery voltage and switched on/off by the ECM. The ECM will pull the heater control signal to ground when turning on the heater. The ECM monitors the heater control signal for a short to ground. If the control signal is not equal to $V_{battery}$ when the heater is turned off then the circuit is not functioning properly. The UEGO heater circuit must always be functioning for proper emissions control.

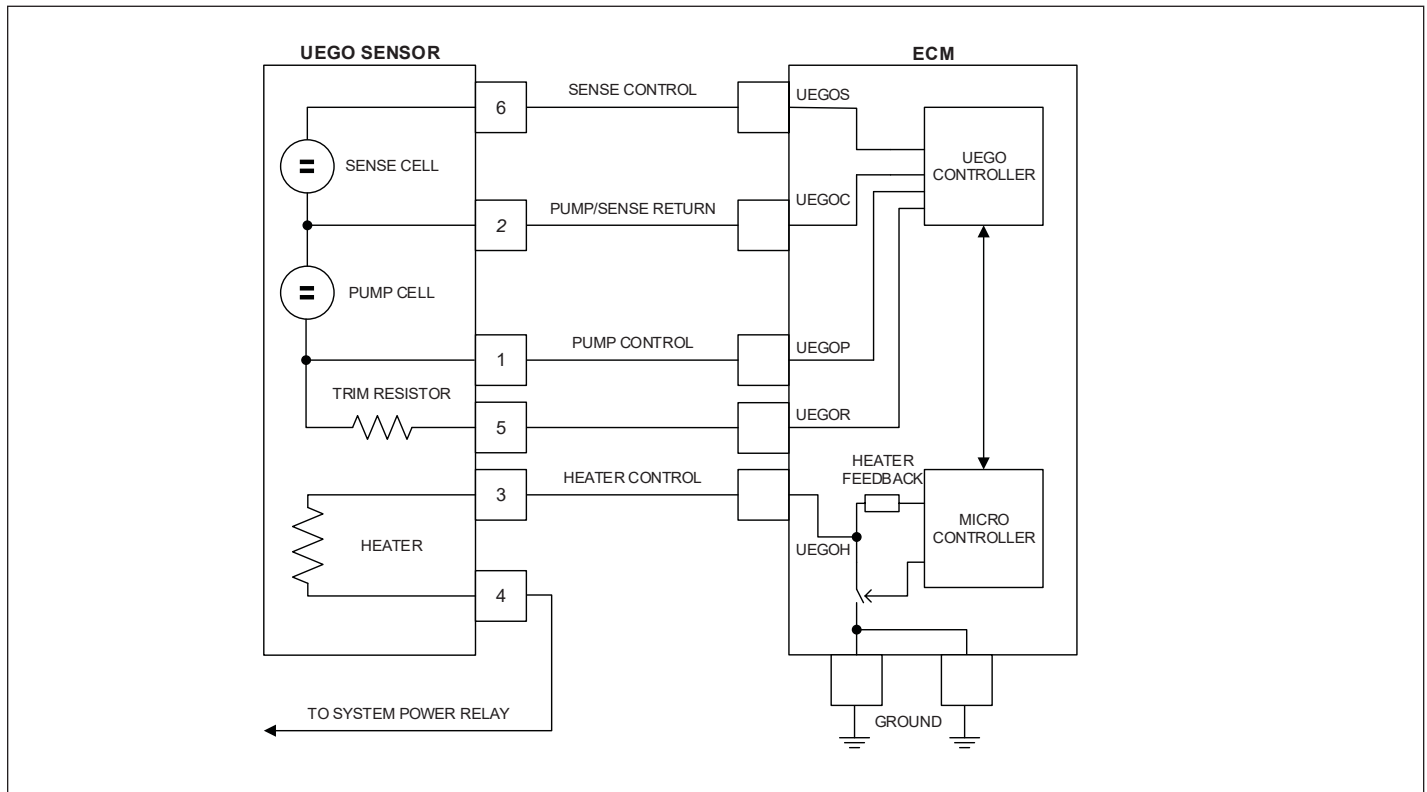
This fault will set when the UEGO heater control signal does not achieve zero volts when the heater is switched on. This may be caused by an internal fault within the ECM.

DTC 8938 - UEGO 1 Heater Shorted to Power Fault SPN - 3222; FMI - 3



Diagnostics

DTC 8940 - UEGO 2 Heater Open or Shorted to Ground Fault SPN - 3232; FMI - 4

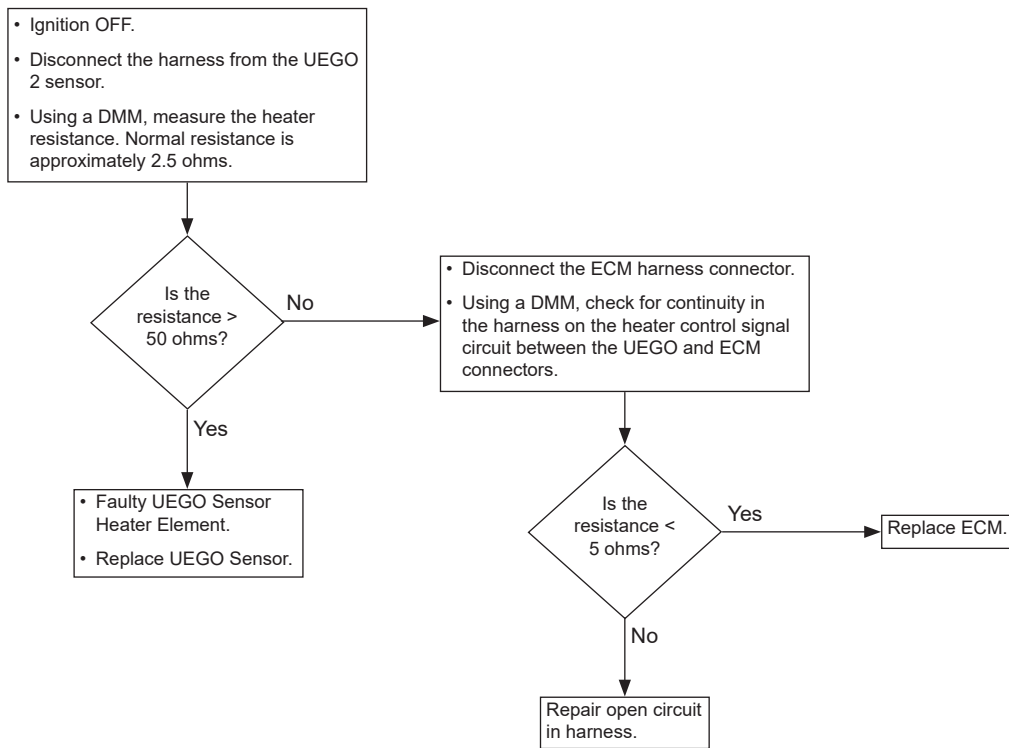


- Universal Exhaust Gas Oxygen (UEGO) 2 Sensor (Bank 2, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Voltage feedback from the UEGO 2 sensor heater is always equal to ground voltage.

A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to air-fuel ratio. The sensor is heated with an internal resistive element that is supplied by the battery voltage and switched on/off by the ECM. The ECM will pull the heater control signal to ground when turning on the heater. The ECM monitors the heater control signal for a short to ground. If the control signal is not equal to $V_{battery}$ when the heater is turned off then the circuit is not functioning properly. The UEGO heater circuit must always be functioning for proper emissions control.

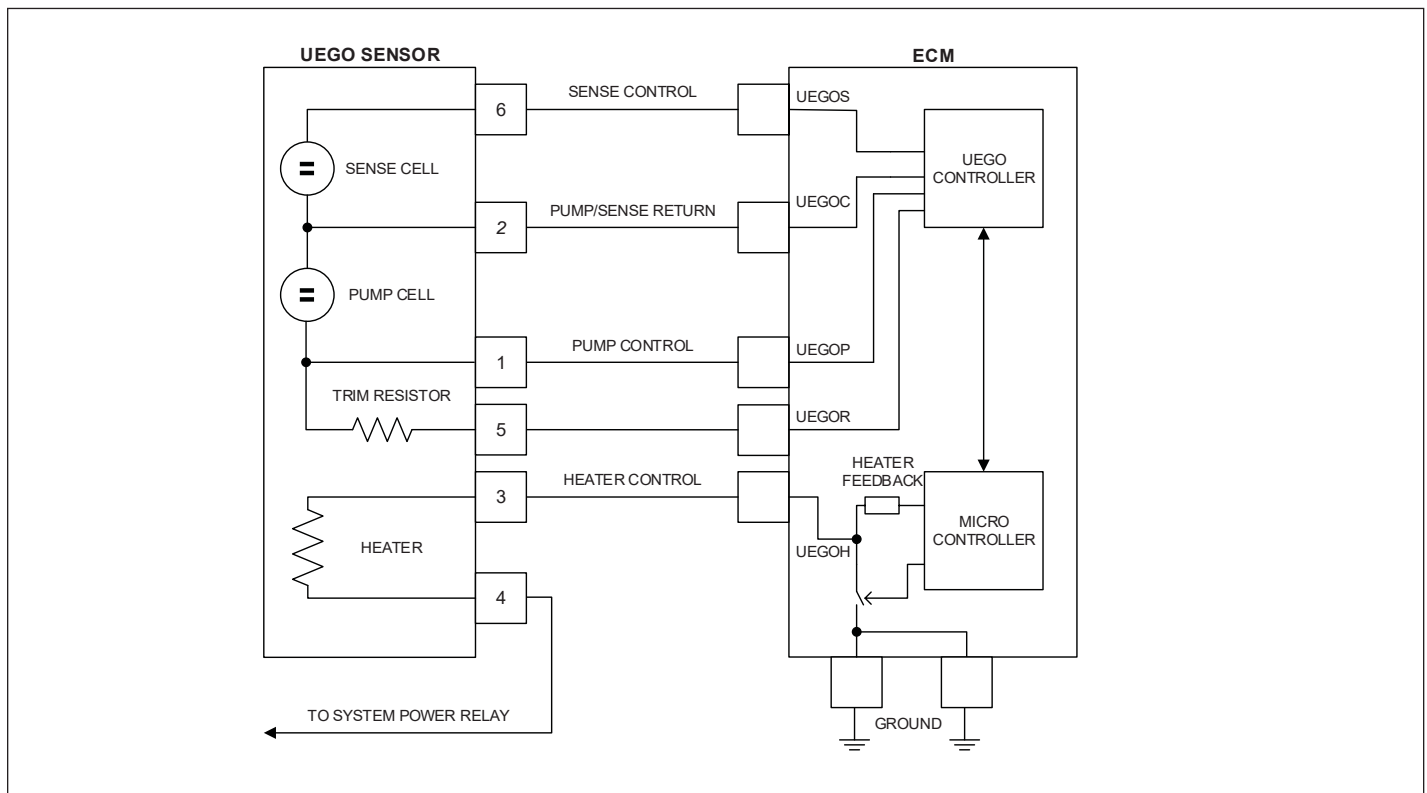
This fault will set when the UEGO heater control signal does not achieve $V_{battery}$ when the heater is switched off. This may be caused by a bad heater element in the UEGO sensor, a break in the wire harness on the heater supply or control circuits, or fault within the ECM.

DTC 8940 - UEGO 2 Heater Open or Shorted to Ground Fault SPN - 3232; FMI - 4



Diagnostics

DTC 8941 - UEGO 2 Heater Shorted to Power Fault SPN - 3232; FMI - 3



- Universal Exhaust Gas Oxygen (UEGO) 2 Sensor (Bank 2, pre-catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - Voltage feedback from the UEGO 2 sensor heater is always equal to the battery or supply voltage (short to B+).

A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to air-fuel ratio. The sensor is heated with an internal resistive element that is supplied by the battery voltage and switched on/off by the ECM. The ECM will pull the heater control signal to ground when turning on the heater. The ECM monitors the heater control signal for a short to ground. If the control signal is not equal to $V_{battery}$ when the heater is turned off then the circuit is not functioning properly. The UEGO heater circuit must always be functioning for proper emissions control.

This fault will set when the UEGO heater control signal does not achieve zero volts when the heater is switched on. This may be caused by an internal fault within the ECM.

DTC 8941 - UEGO 2 Heater Shorted to Power Fault SPN - 3232; FMI - 3

