PLEASURECRAFT® ENGINE GROUP

Crusader®

PCM®

GCP / 4G

Diagnostic Service Manual

Serial Number 470000 through Present

CWS®
CRUSADER WATERSPORTS SERIES

Levitator

L510030

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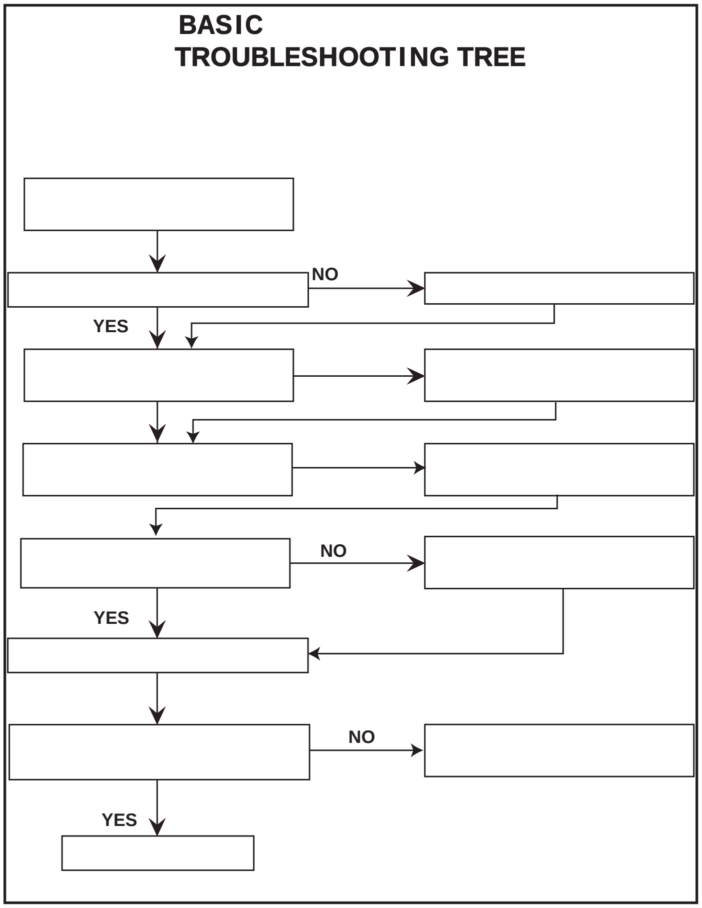
Abbreviations

AL Adaptive Learn
BP Barometric Pressure
CAN Controller Area Network
CL Closed Loop
DBW Drive-By-Wire
DMM Digital Multi-Meter (high impedance)
DST Diagnostic Scan Tool
DTC Diagnostic Trouble Code
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
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
PWM Pulse Width Modulated
RAM Random Access Memory
RPM Revolutions Per Minute
SPN Suspect Parameter Number
Tach Tachometer
TCP Throttle Control Position
TDC Top Dead Center
TPS Throttle Position Sensor
VDC Voltage, Direct Current
Vsw Switched, Ignition Voltage

OVERVIEW

This manual is intended to be used as an aid for customers troubleshooting ECM-07/08 drivability problems. This manual defines the diagnostics and recommended troubleshooting procedures associated with an ECM-07/08 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 explaination of the tests and decision branches.

DTC XXXX- Diagnostic Condition

Block Diagram of Circuit

- *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 *RECOMMENED* 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

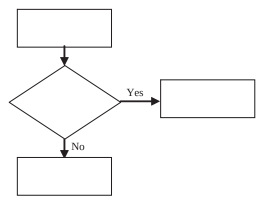
Text to identify the circuit of interest and its use for control.

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

There will be two types of diagnostic trees used for ECM07/08 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.

This diagnostic manual will assist you in troubleshooting an ECM-07/08 Engine Management System. Always begin troubleshooting with the Drivability Checklist section of this manual then refer to the appropriate section to continue diagnsosis and repair.

- o the Drivability Checklist,
- o the Main Engine Electrical System Components,
- o the Engine Fuel System Components,
- o the Engine Cooling System Components, and
- o the ECM-07/08 Engine Management System,
- o the Engine Mechanical Components (refer to the appropriate Engine Mechanical Manual - L510003-8.1L; L510015-5.7L; L510016-6.0L),

DIAGNOSTIC TOOLS

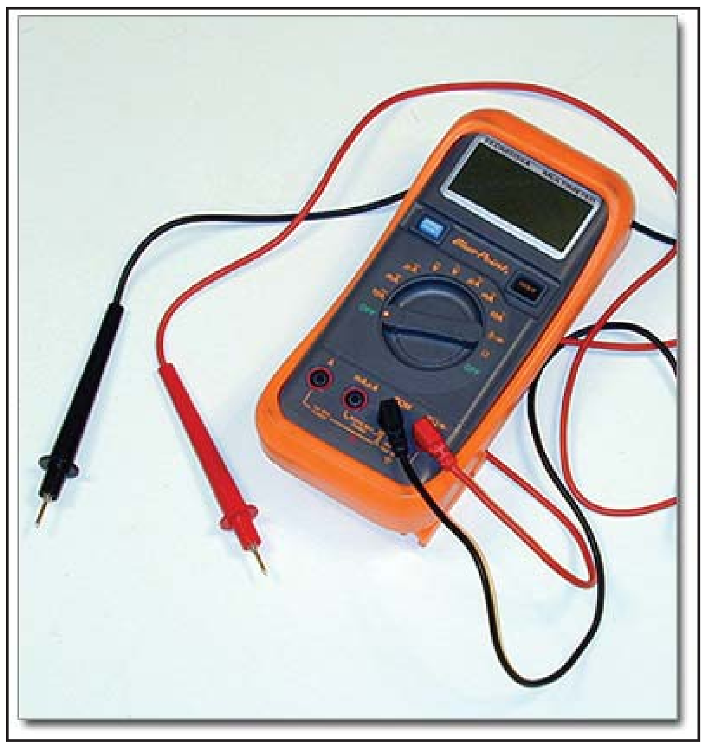
There are many different tools used to effect a repair on an engine. When troubleshooting an ECM-07/08 engine, there are three (3) required tools that are essential in the diagnosis and maintenance of these engines. Procedures and diagnostics that follow, assume these tools are available and used by the service technician.

These required tools are not unique to ECM-07/08 engines and are used for troubleshooting fuel injected engines with a wide variety of engine control systems.

The required tools are:

- Fuel Pressure Guage
- Digital Multimeter (also known as a Digital Volt/Ohm Meter)
- Diacom Diagnostic Software, Marine Edition, by Rinda Technologies.

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.



The Digital Multi-Meter (DMM or DVOM - Digital Volt/Ohm Meter), with a minimum input impedance of 10 mega-ohms (Mohms) is essential to take various measurements on the engine's electrical system.

Diacom Diagnostic Software, Marine Edition, by Rinda Technologies, Inc. (PCM P/N - RT0086); and the Diacom CAN Network Adapter (PCM P/N - RT0088). This is a PC based software package that supports various ECMs used on fuel injected engines.

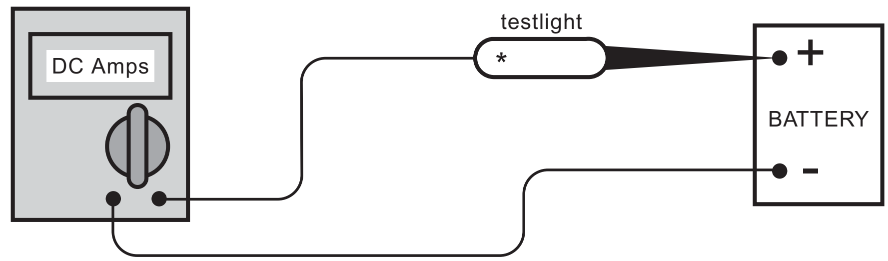
In the past, as new ECM's were introduced into the marine industry, Diacom evolved with each new generation. As the power of the ECMs has improved, new test capabilities became available through the Diacom Tests screens, making Diacom an increasingly useful and powerful tool for troubleshooting.

ECM-07/08 is no different than any previous generation of engine controller. Not only has it provided improved engine control, it has increased diagnostic capability. When Diacom is connected, there are new features and tests available that have not been available with past generations of controllers.

DIAGNOSTIC AIDS

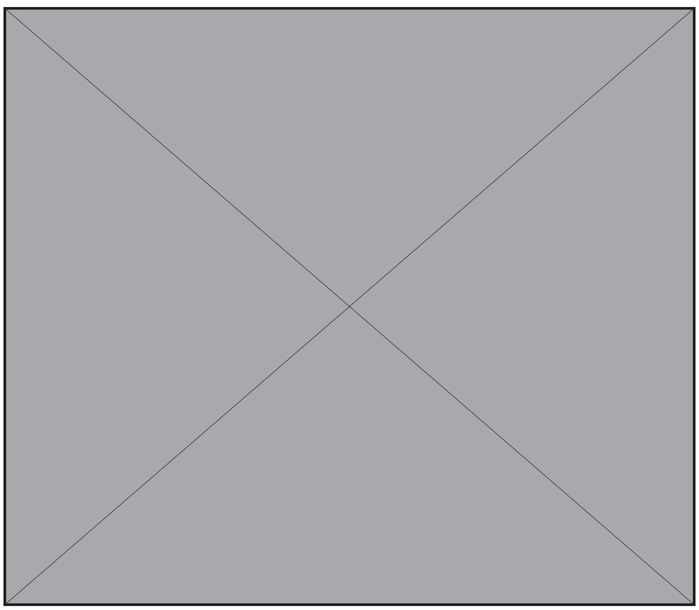
There are various and many different tools that you will find essential for troubleshooting, from time to time. Pictured below are some of the common items used. They include, but are not limited to, an inductive pickup timing light, test lamp, connector tools, injector test lamps, and various adapters and connector test harnesses.

One of the more common circuit test tool used is the un-powered test lamp. While this is an extremely useful tool, you must ensure that the one you use is safe to use on ECM-07/08 circuits. 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 (refer to the test diagram that follows). 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.

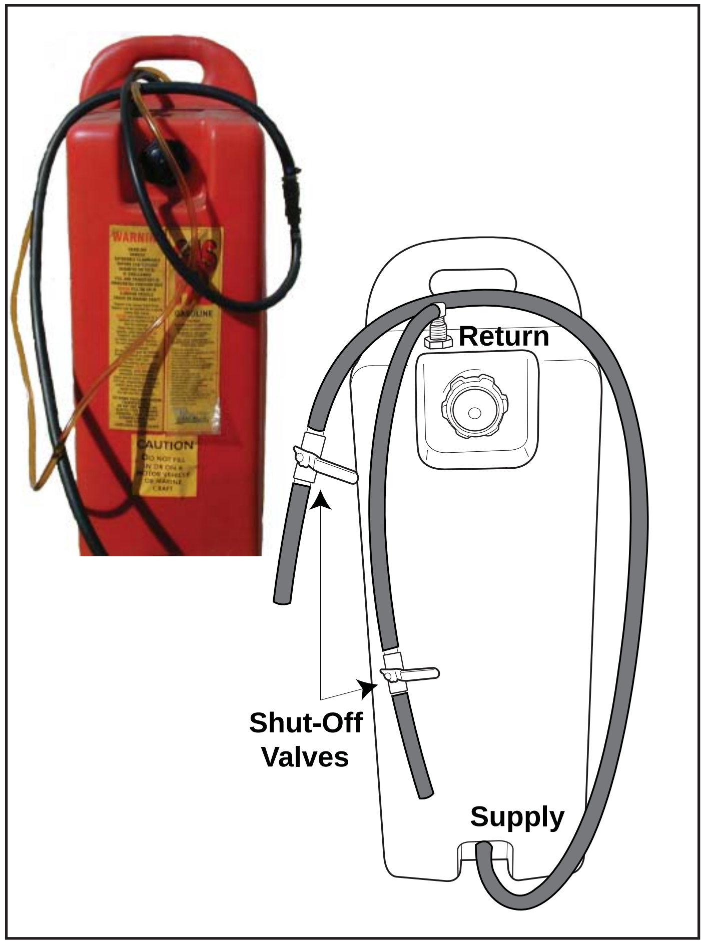


If the ammeter indicates less than 3/10 amp(.3A) current flow, the testlight is safe to use.
If the ammeter indicates more than 3/10 amp(.3A) current flow, the testlight is not safe to use.

Two of the more widely used diagnostic aids are the Remote Key Switch (RT0091) and an Auxiliary Fuel Tank equipped with both a fuel supply and fuel return line.



The Remote Key Switch (RT0091, for ECM-07/08 equipped engines), pictured above, is extremely useful for isolating the boat wiring from the engine wiring when trying to isolate electrical problems.



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.

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 an ECM-07/08 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 ECM-07/08 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 ECM-07/08 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 ECM-07/08 circuit failures cause stored codes which have a diagnostic and repair procedure designed to resolve the problem causing the code.

Analyzing and resolving ECM-07/08 and non-ECM-07/08 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 Driavability 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

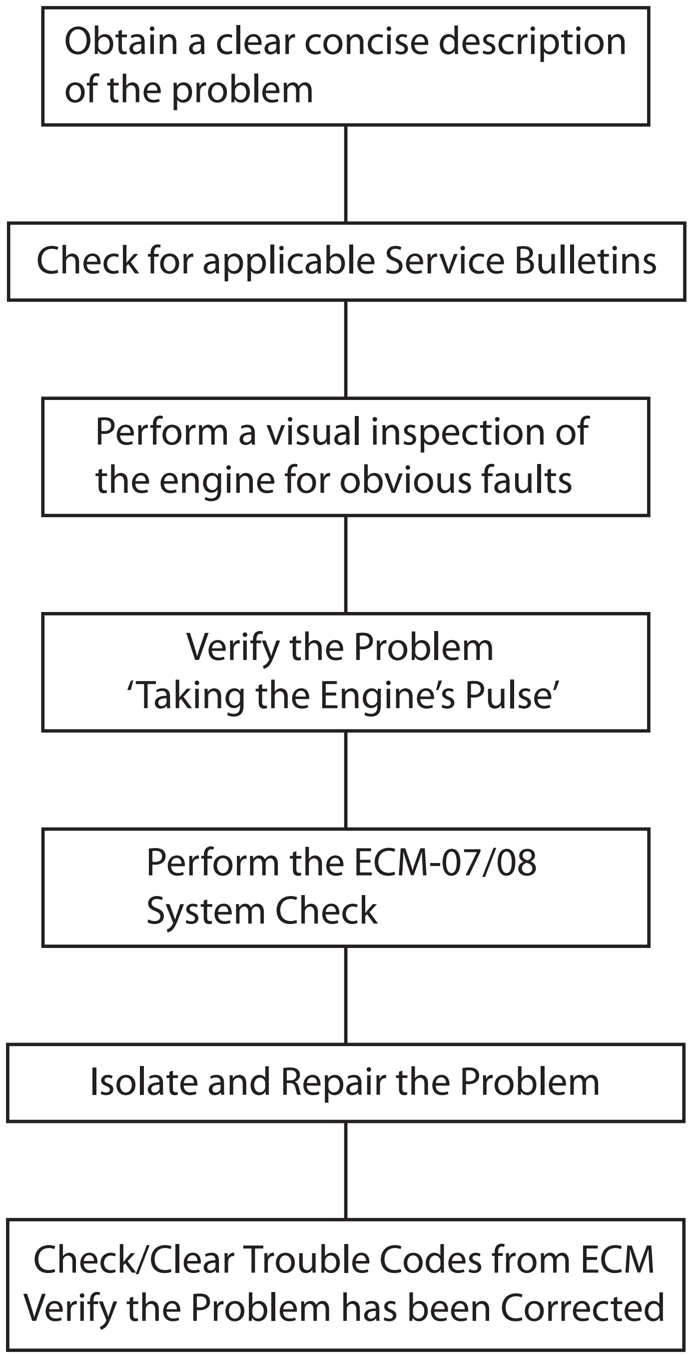


Figure 2-1 Basic Troubleshooting Approach Tree

DRIVABILITY CHECKLIST
TROUBLESHOOTING TREE

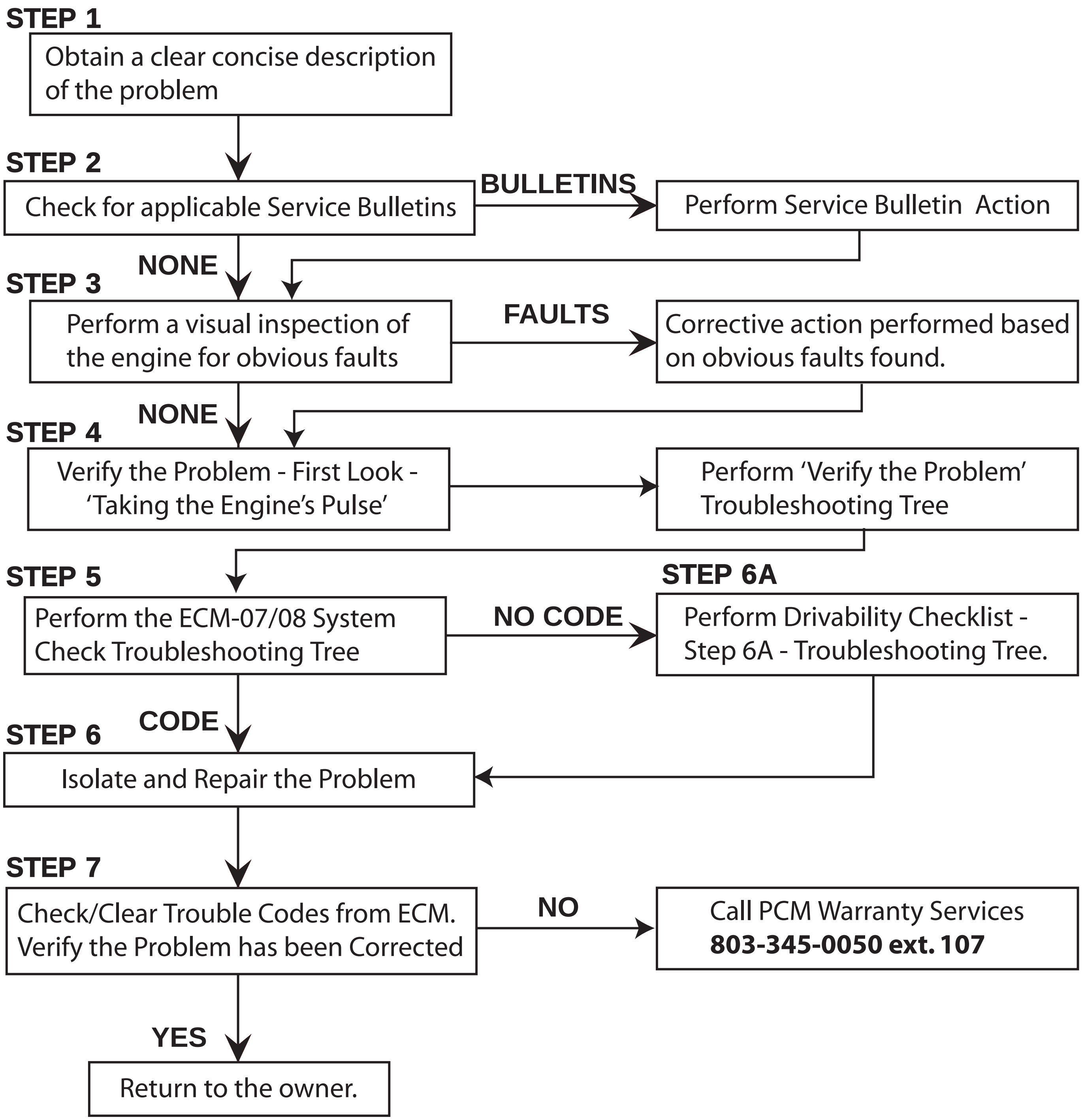


Figure 2-2 Drivability Checklist Troubleshooting Tree

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

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 ECM-07/08 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:

a loss of power,

a loss of top end rpm, or

a possible low oil pressure reading.

- **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 ECM-07/08 System Check. The ECM-07/08 System Check is an organized approach to identifying a problem created by an electronic engine control system malfunction. This check verifies the following:

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

If DTC's are present, the ECM-07/08 System Check will direct you to the next procedure you need to perform. Details of the ECM-07/08 System Check will be covered in the ECM-07/08 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:

- Checked all the components in a system,
- Properly completed the Drivability Checklist procedures through Step 5,
- 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,
- An engine that starts and runs but still exhibits a symptom, and
- 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.

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 - 'TAKING THE ENGINE'S PULSE'

	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

DRIVABILITY CHECKLIST

5) PERFORM THE ECM-07/08 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.

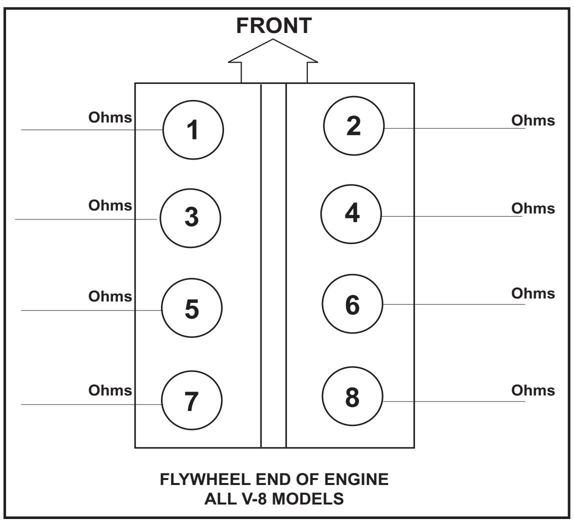
6A) NO CODES - ENGINE RUNS - DRIVABILITY SYMPTOM STILL PRESENT

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 - newer = 15 ± 2 degrees



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

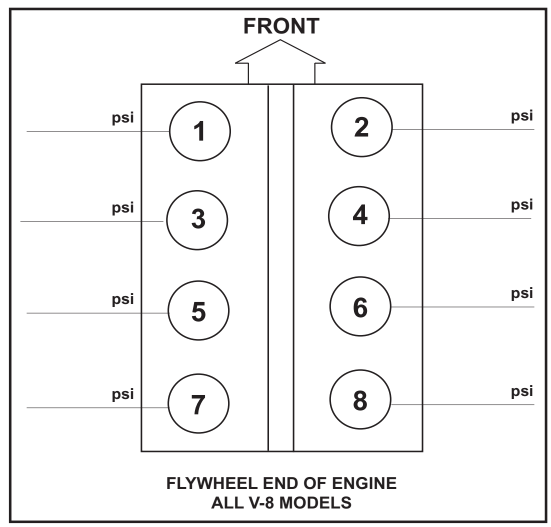
COMPRESSION PRESSURE:

5.0/5.7L - 130-215 psi

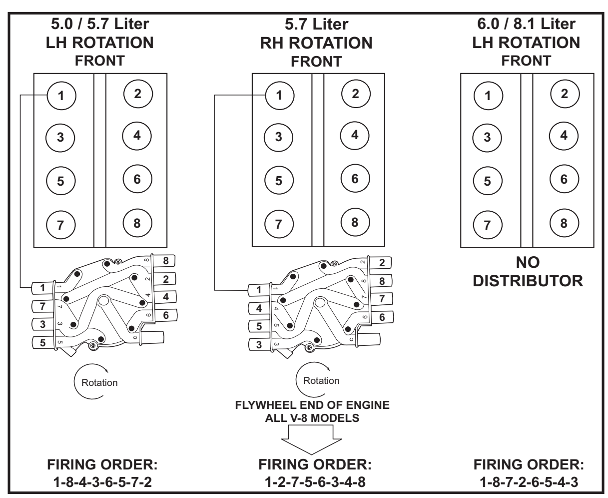
6.0L - 130-215 psi

8.1L - 130-175 psi

Lowest pressure should be within 70% of highest pressure. Minimum cylinder pressure - 100 psi.



COMPRESSION CHECK



REFERENCES:

Master Engine Specification Sheet

ECM-07/08 Diagnostic Manual

L510005P - MEFI 4/4B Diagnostic Manual

L510005P-S1 - DTC Diagnostic Supplement

L510003 - 8.1L Engine Mechanical Service Manual

L510015 - 5.0/5.7L Engine Mechanical Service Manual

L510016 - 6.0L Engine Mechanical Service Manual

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 "Take the Engine's Pulse", so to speak, 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 ECM-07/08/08 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 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 ECM-07/08/08. 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

“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 ECM-07/08/08/08. 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 ECM-07/08/08 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 al 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 ECM-07/08/08 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 ECM-07/08 System based on your test results.

STEP 4

- VERIFY THE PROBLEM -

TAKING THE ENGINES PULSE

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.

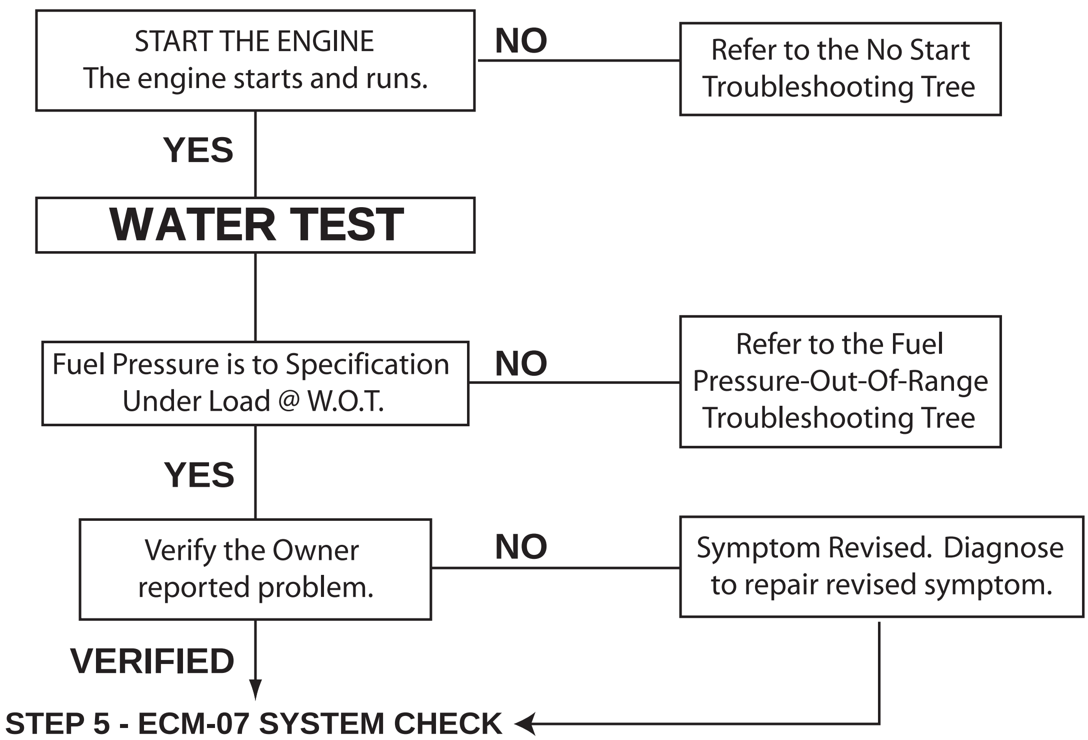


Figure 2-4 Verify the Problem - Taking the Engine's Pulse

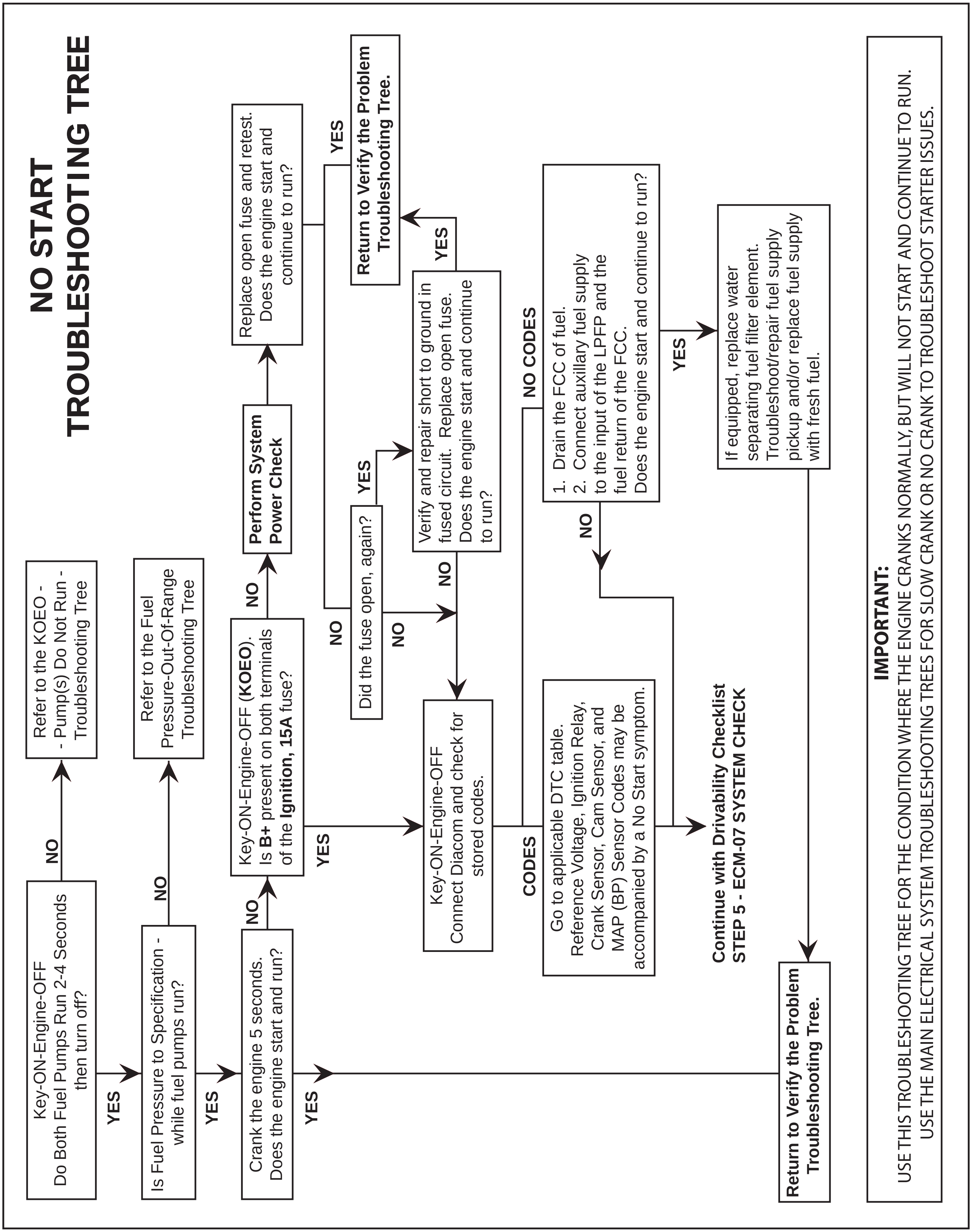


Figure 2-5 No Start Troubleshooting Tree
ECM0708

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 ECM-07/08/08 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 ECM-07/08/08 Section, Section 6, under Diacom Test Features.

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

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.

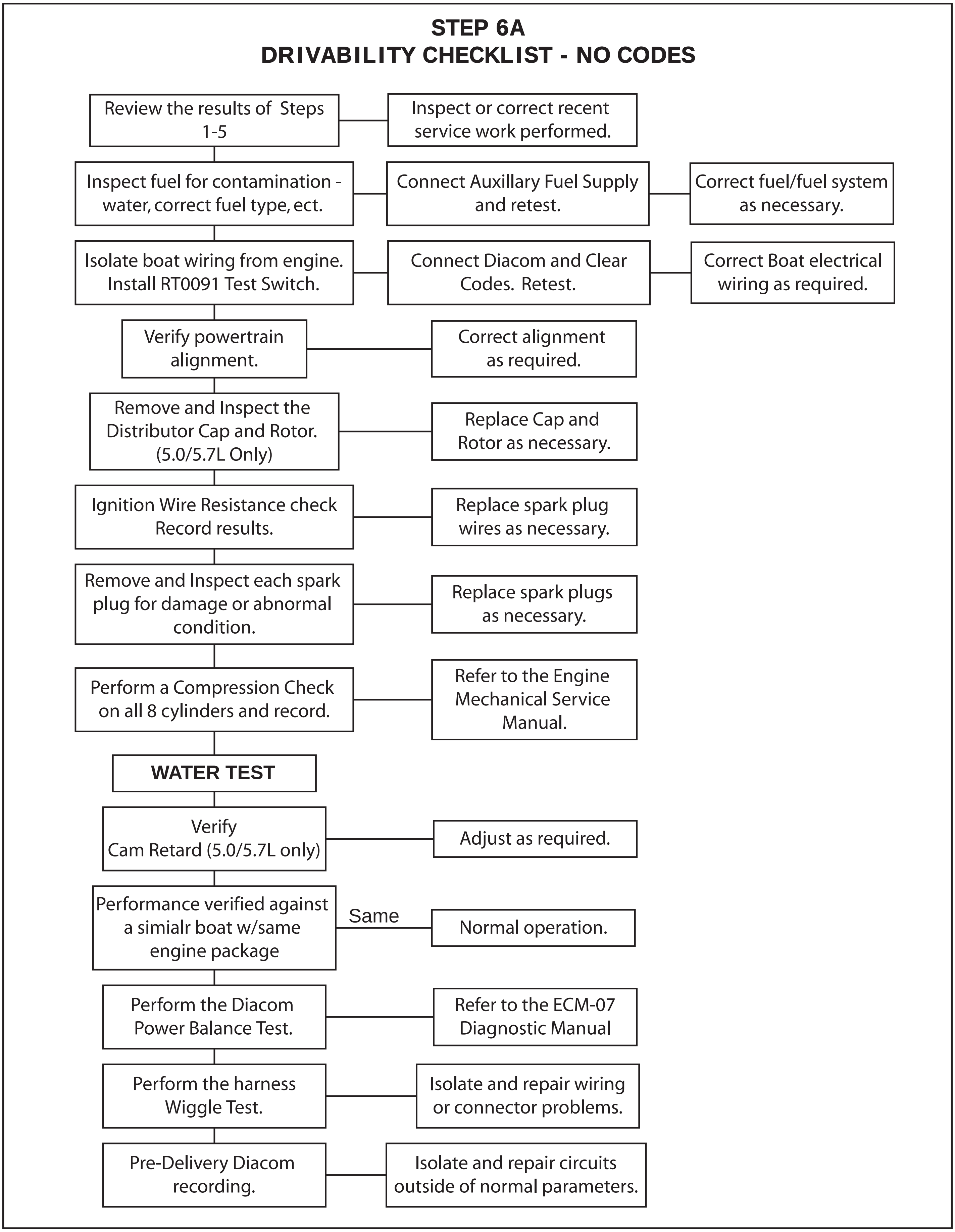


Figure 2-6 Drivability Checklist - No Codes

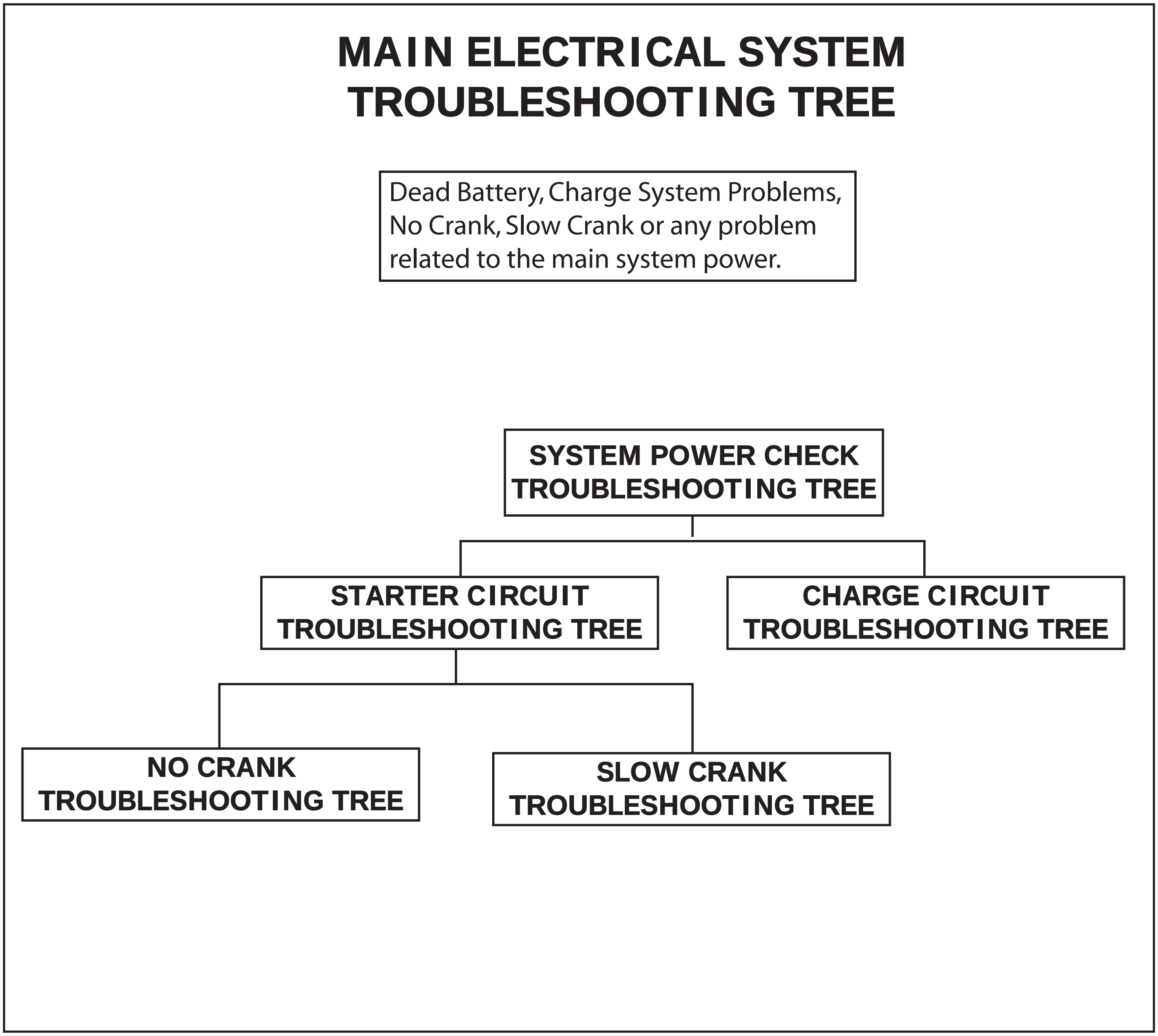


Figure 2-7 Main Electrical System Troubleshooting Tree

SYSTEM POWER CHECK
TROUBLESHOOTING TREE

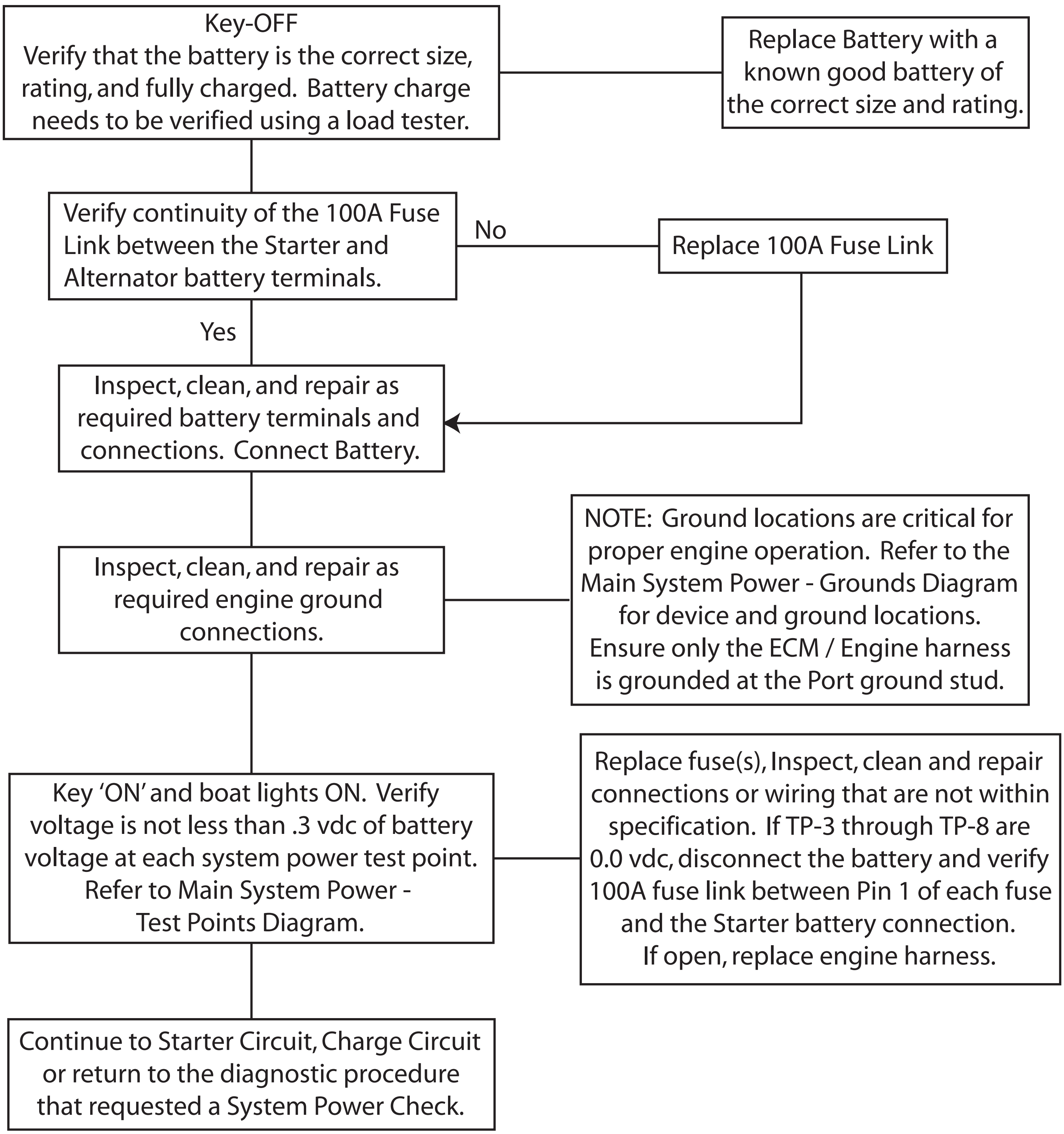


Figure 2-8 System Power Troubleshooting Tree

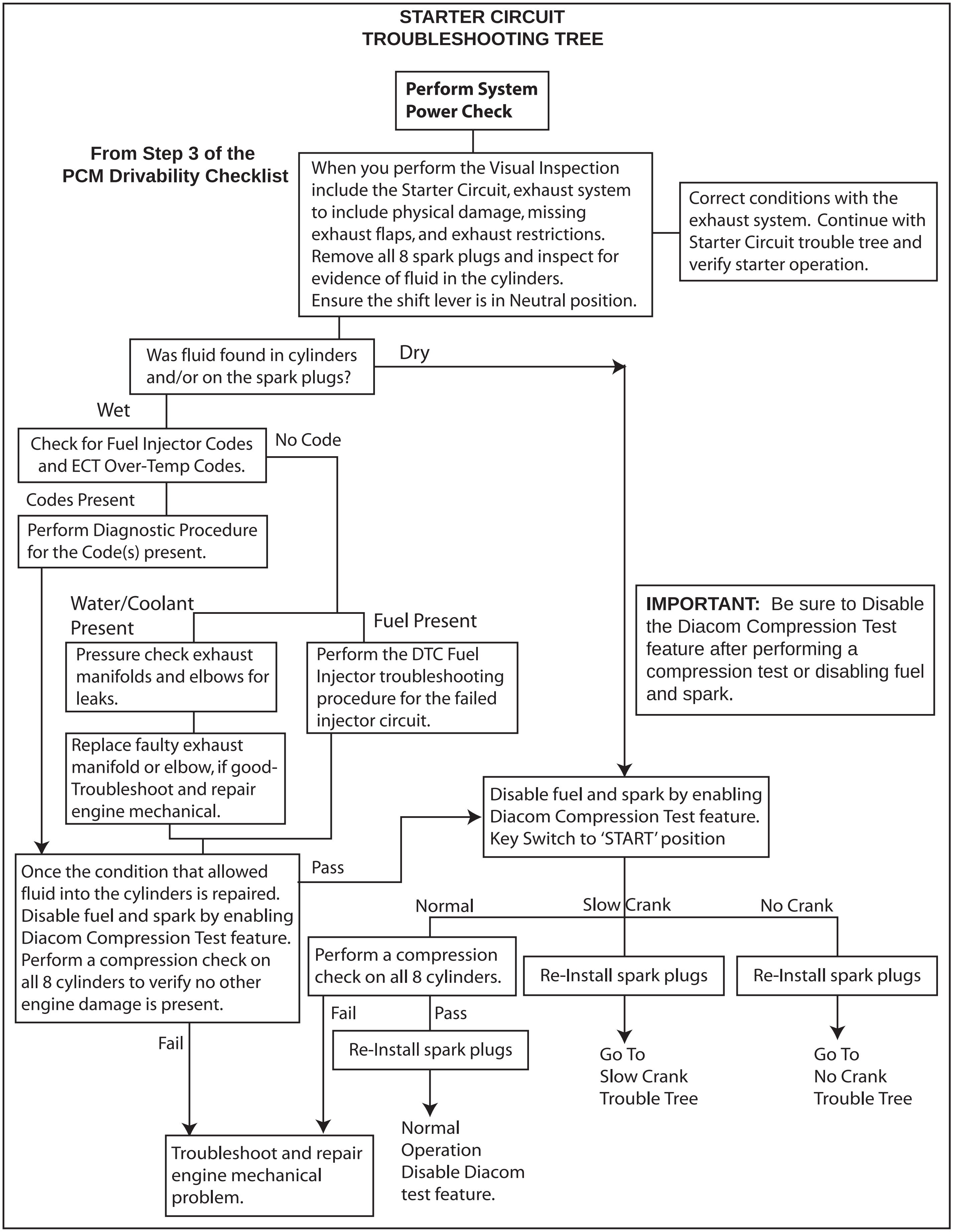
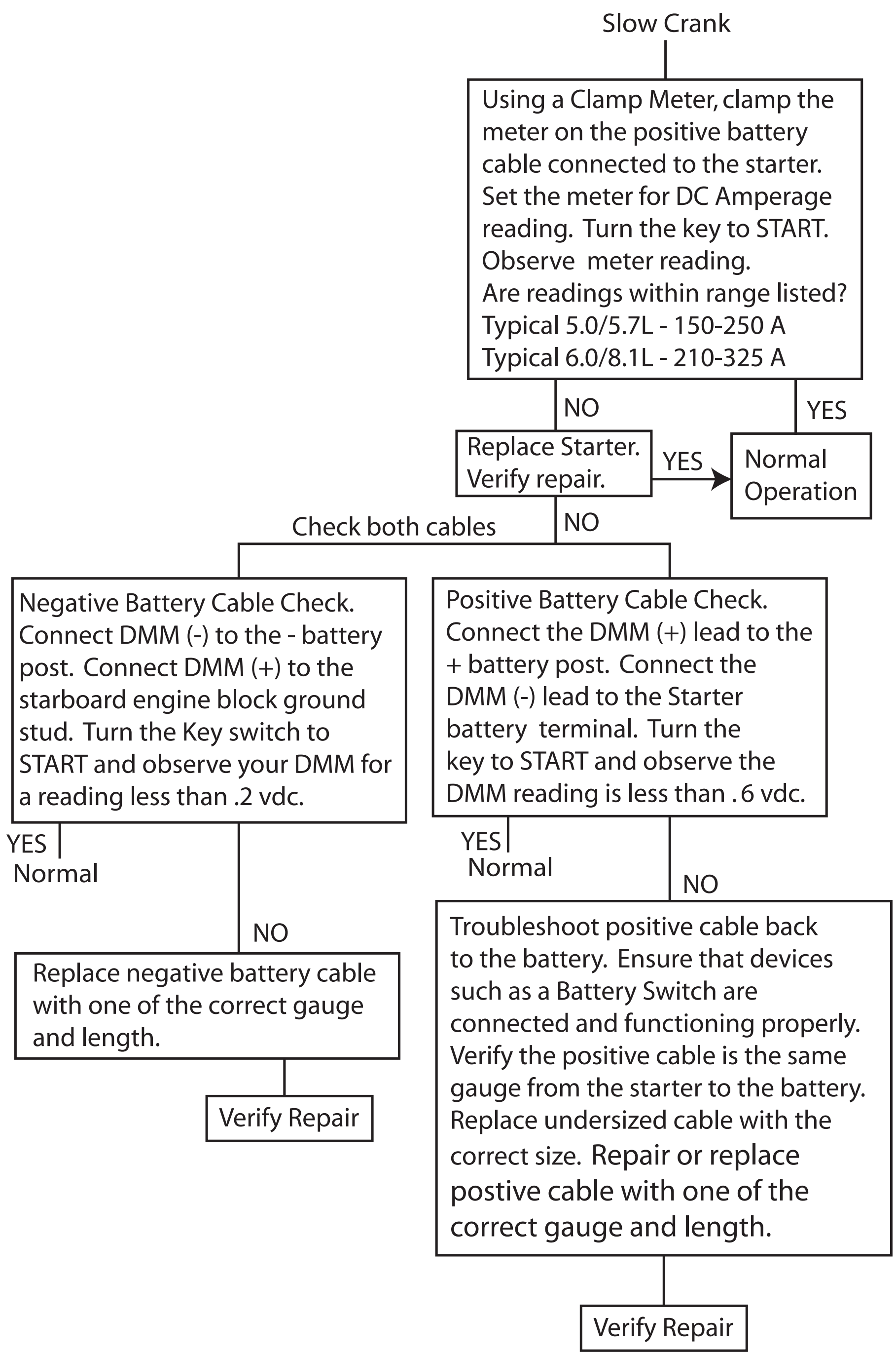


Figure 2-9 Starter Circuit Troubleshooting Tree

ECM0708

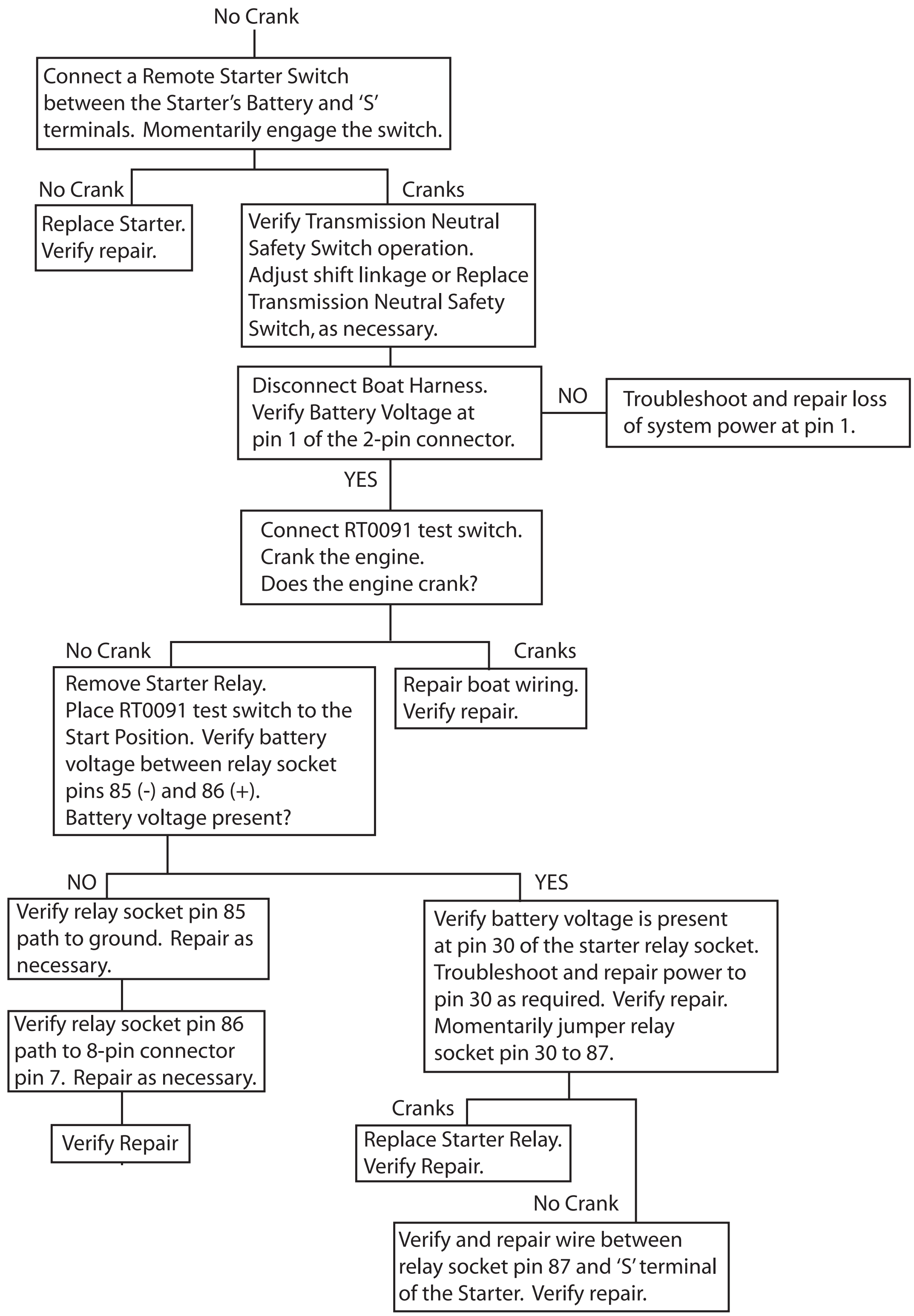
STARTER CIRCUIT
TROUBLESHOOTING TREE
SLOW CRANK CONDITION



******** 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

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

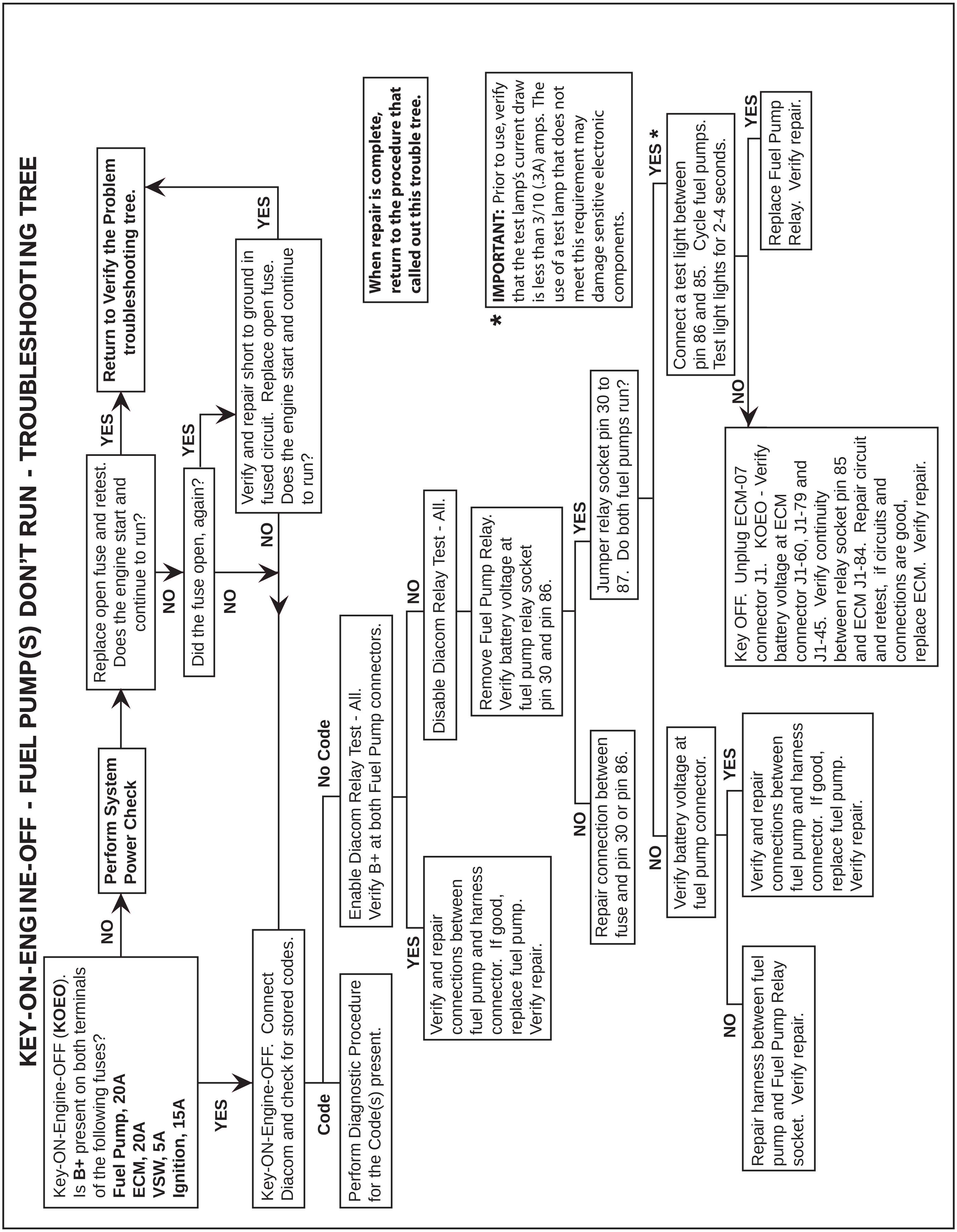


Figure 2-12 Fuel System - Fuel Pump(s) Do Not Run

ECM0708

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

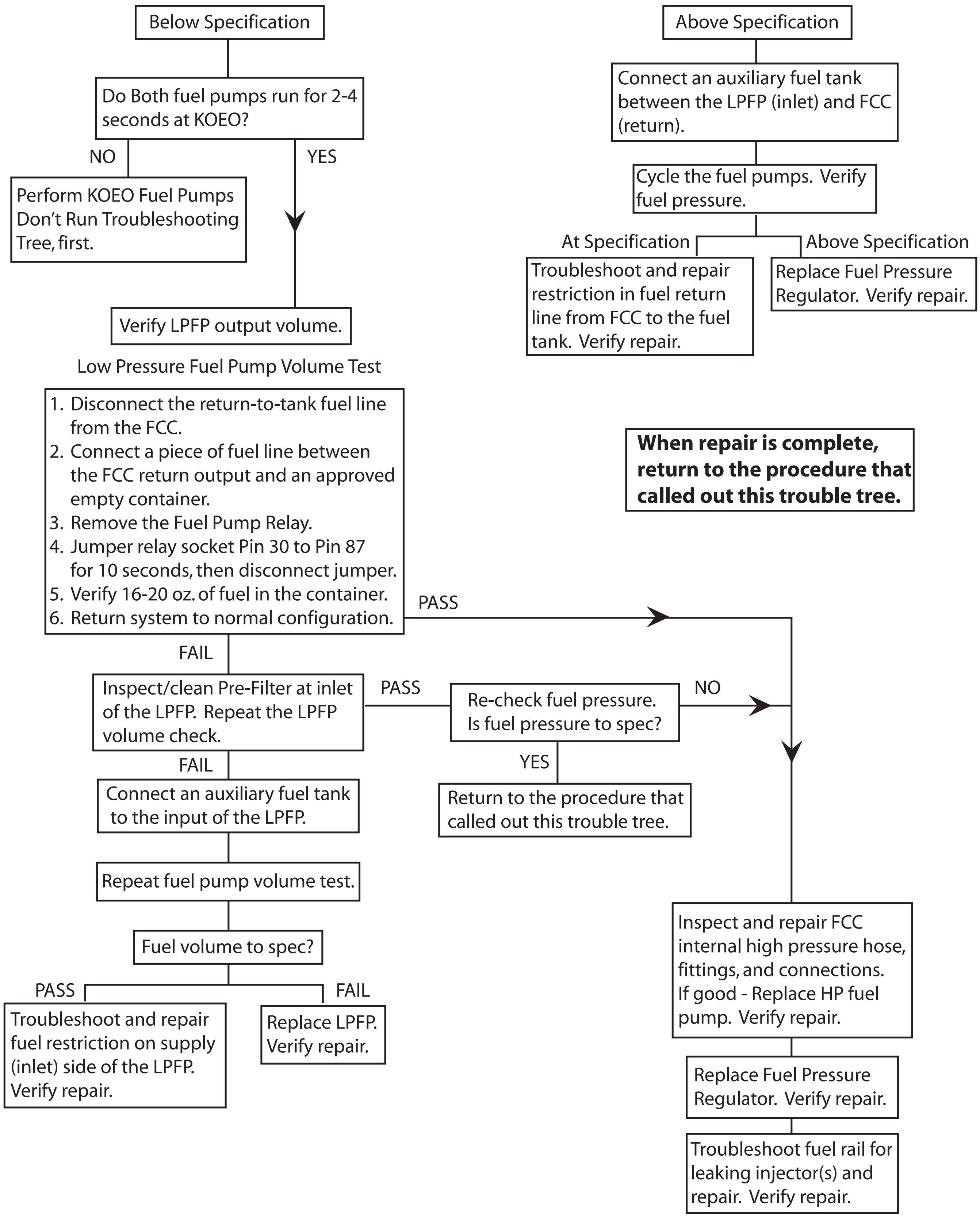


Figure 2-13 Fuel System - Fuel Pressure Out-Of-Range

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 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 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 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 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 171	4237	0	Adaptive-learn gasoline bank1 high
DTC 172	4237	1	Adaptive-learn gasoline bank1 low
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 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
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 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)
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 524	100	1	Oil pressure sender low pressure
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

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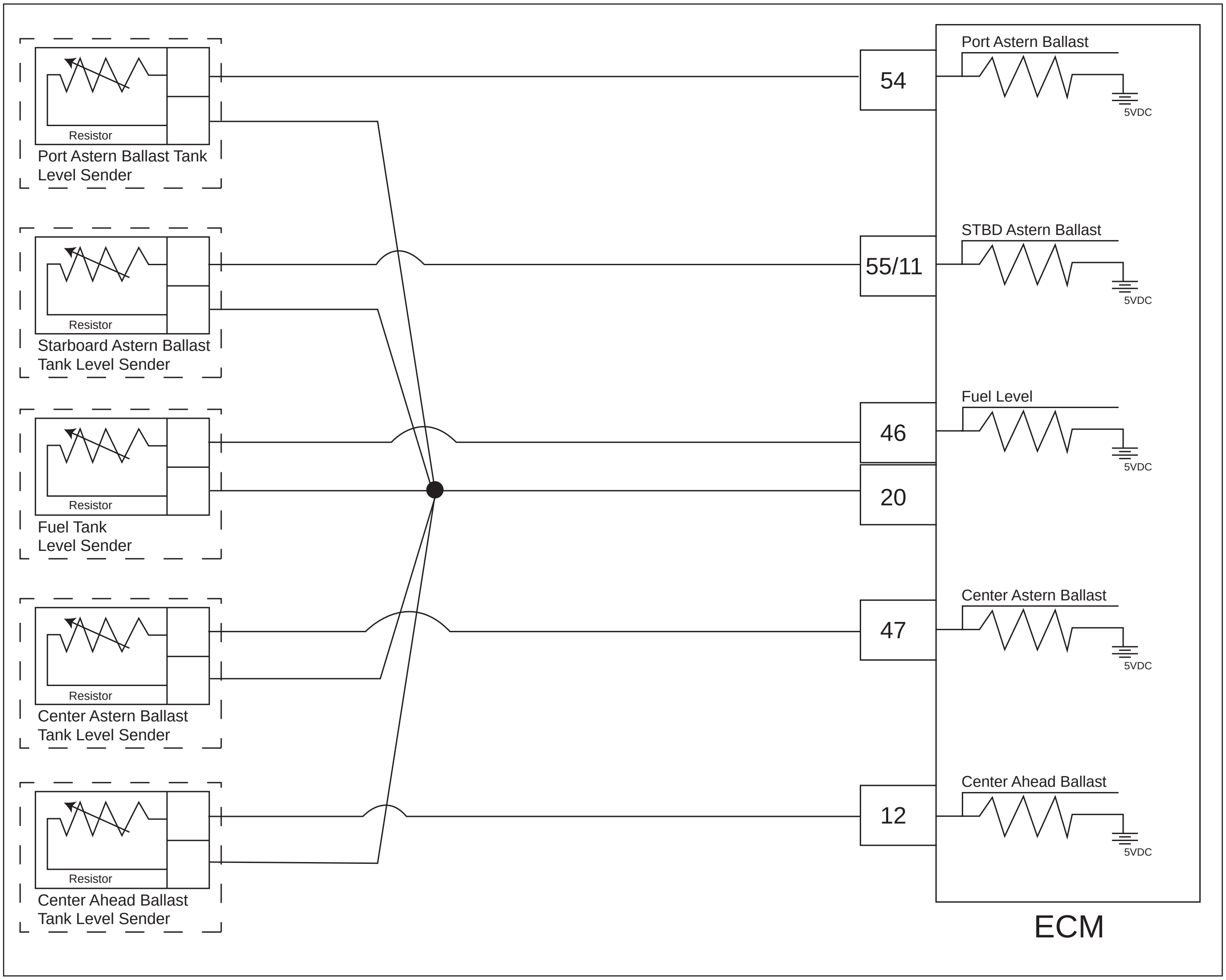
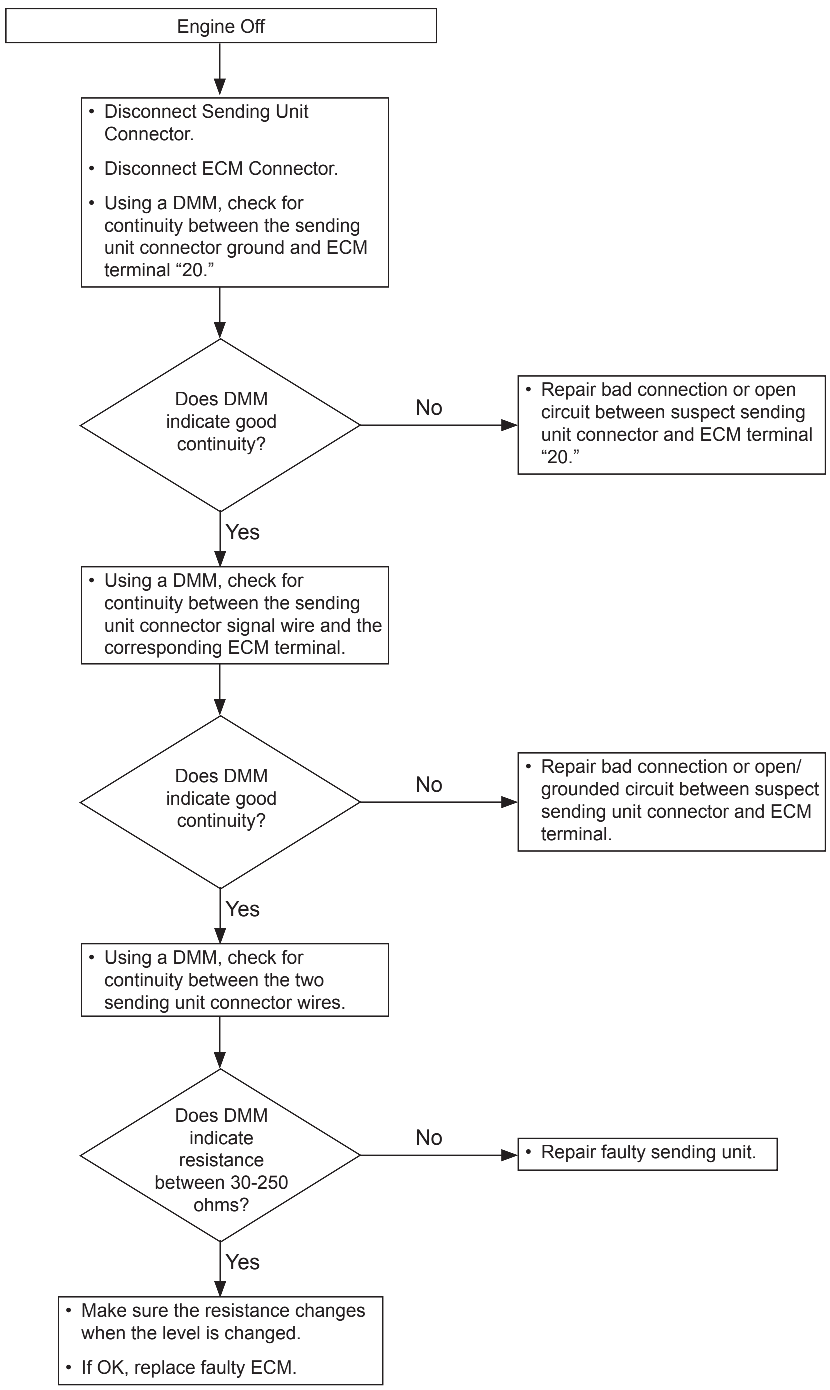
Ballast Tank Level / Fuel Level Diagnostics



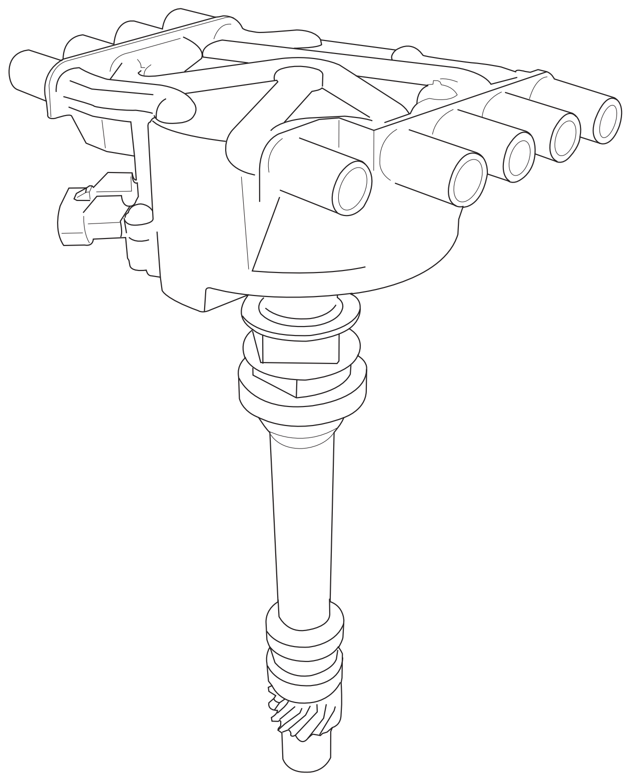
- Ballast Level / Fuel Level - LINC System
- *Check Condition* - None
- *Fault Condition* - None

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



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

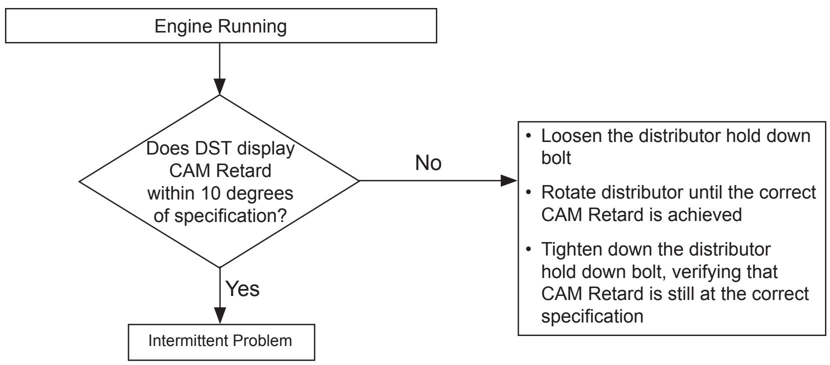


- Distributor Alignment (Position)
- *Check Condition* - Engine Running
- *Fault Condition* - Engine distributor position is greater than 10 degrees from specification
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning
- Emissions related fault

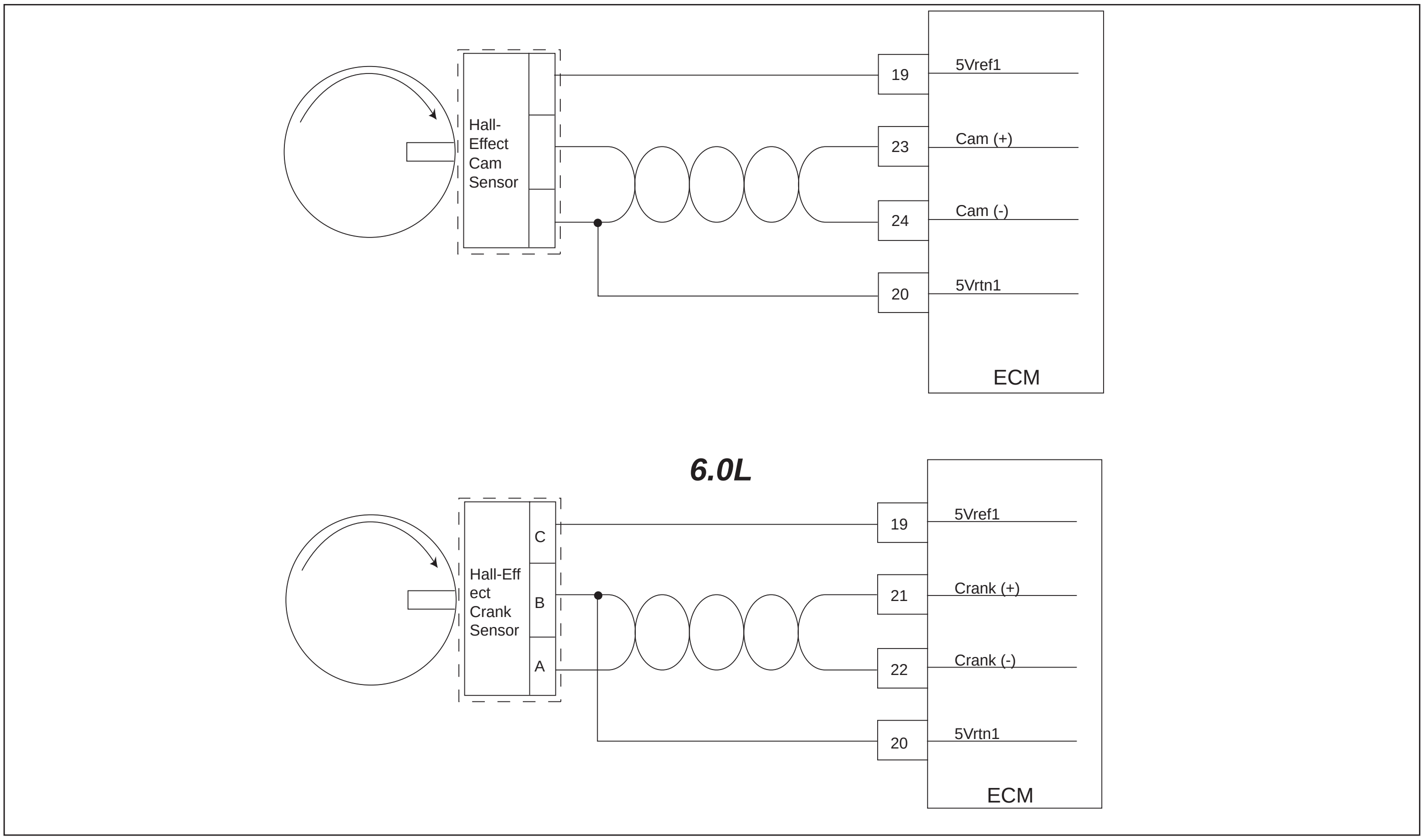
The camshaft position sensor is a magnetic sensor installed in the distributor on 5.0/5.7L engines adjacent to a “coded” trigger wheel. The sensor-trigger wheel combination is used to determine cam position (with respect to TDC cylinder #1 compression).

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
SPN - 520800; FMI - 7



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.

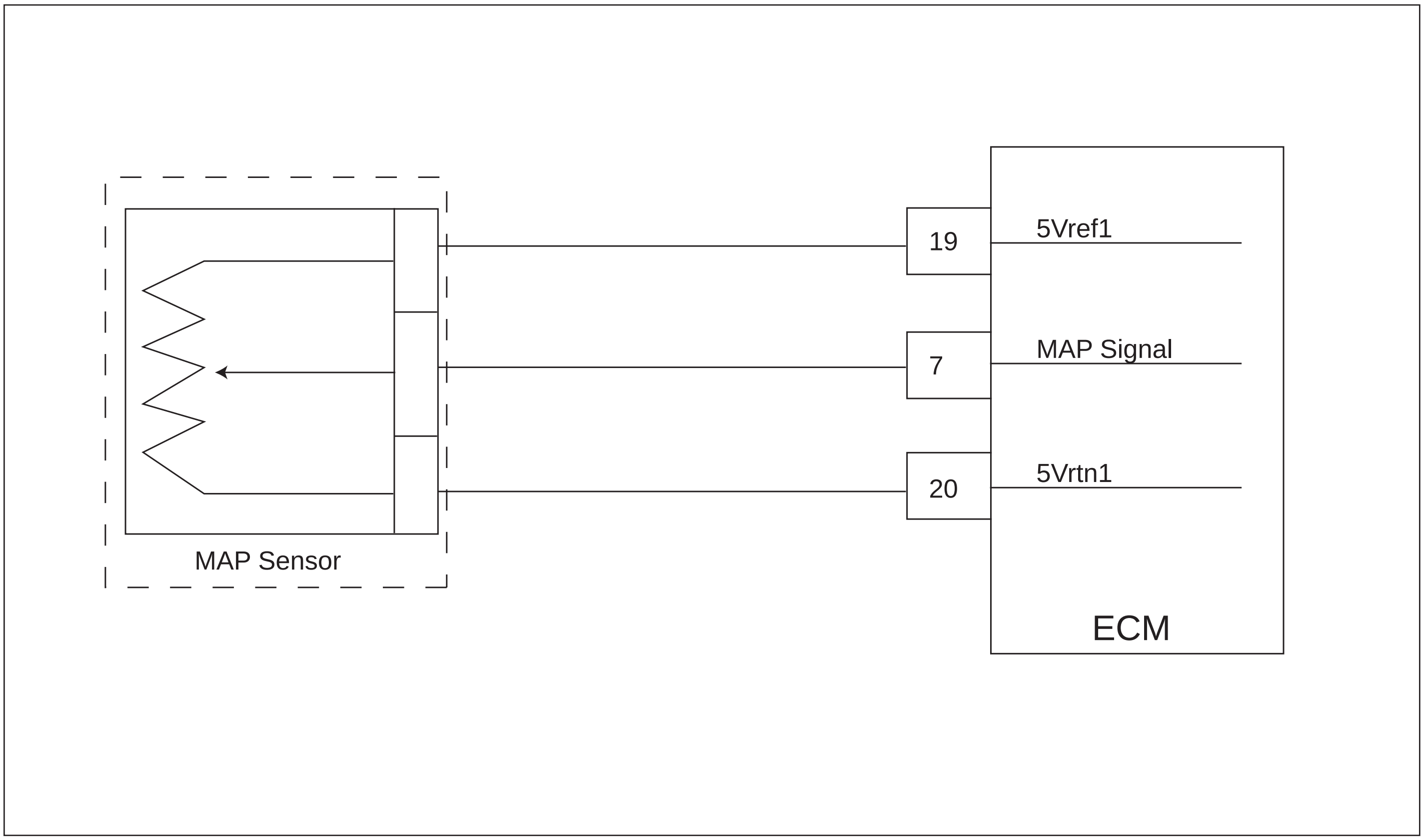
The ECM must see a valid crankshaft position and camshaft position signal properly aligned during cranking before it can synchronize the injection and ignition systems to initiate starting. If engine speed > 90 RPM and the crank and cam can not synchronize within 4.0 cranking revs, this fault will set.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

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



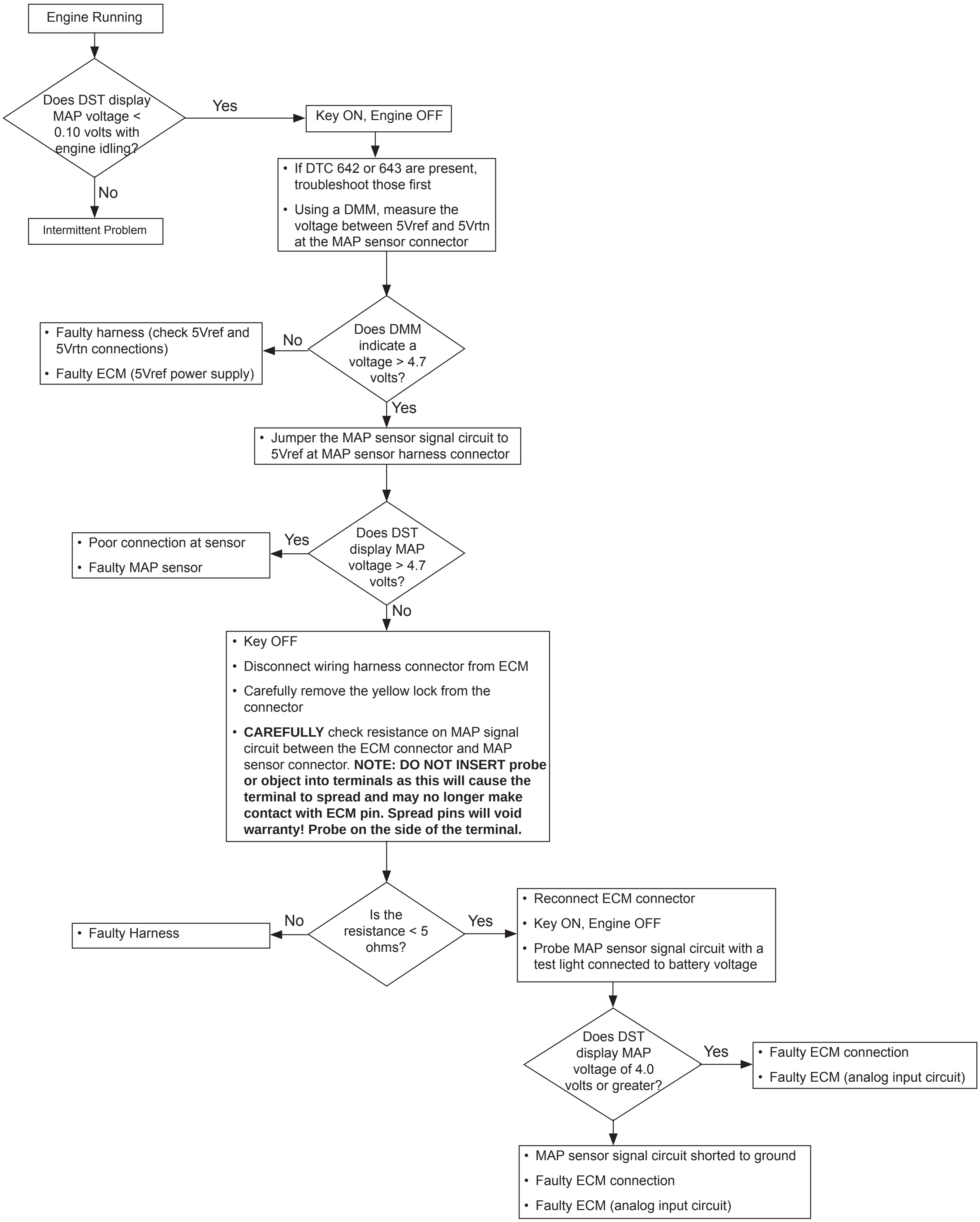
- Manifold Absolute Pressure Sensor
- *Check Condition* - Engine Cranking or Running
- *Fault Condition* - MAP sensor voltage feedback less than 0.10 volts when throttle position is greater than 2.0% and engine speed is less than 7000 RPM.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible 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.

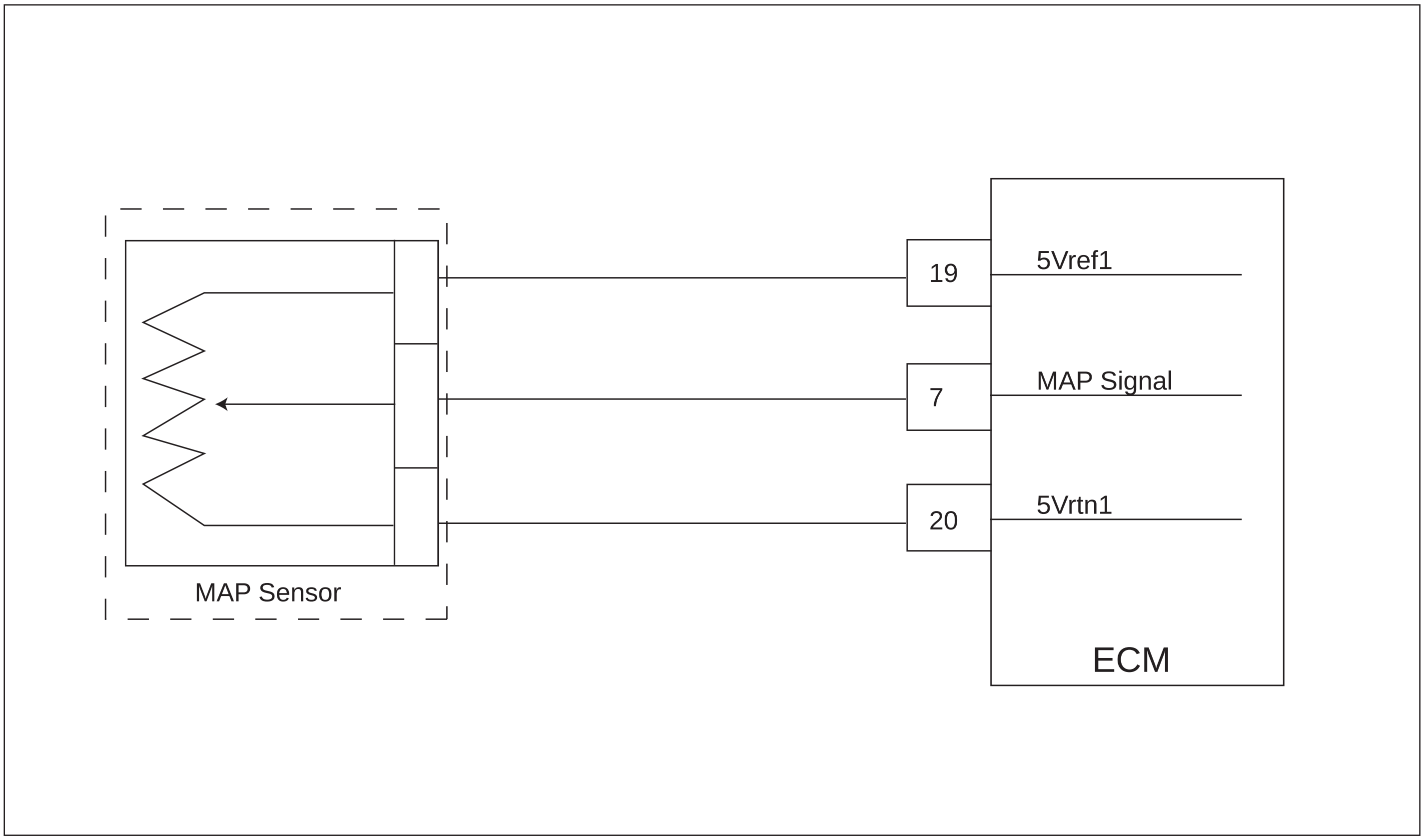
This fault will set when the MAP sensor voltage feedback is sensed as lower than 0.10 volts. In many cases, this condition is caused by the MAP sensor being disconnected from the engine harness, an open-circuit or short-to-ground of the MAP circuit in the wire harness, a loss of sensor reference voltage, 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



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

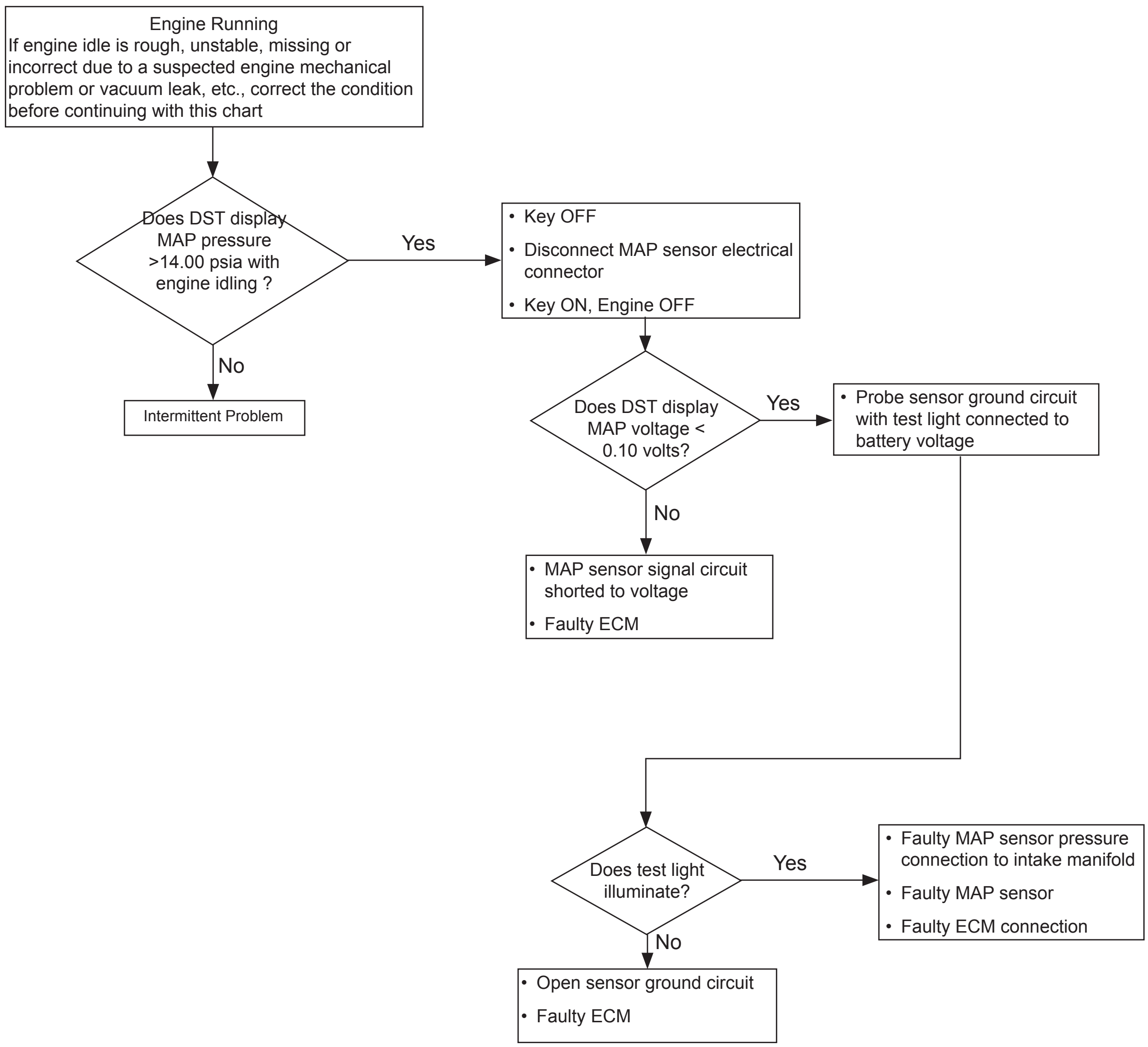


- Manifold Absolute Pressure Sensor
- *Check Condition* - Engine Cranking or Running
- *Fault Condition* -MAP is higher than 14.00 psia when throttle position is less than 10% and engine speed is greater than 1800 RPM.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate 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

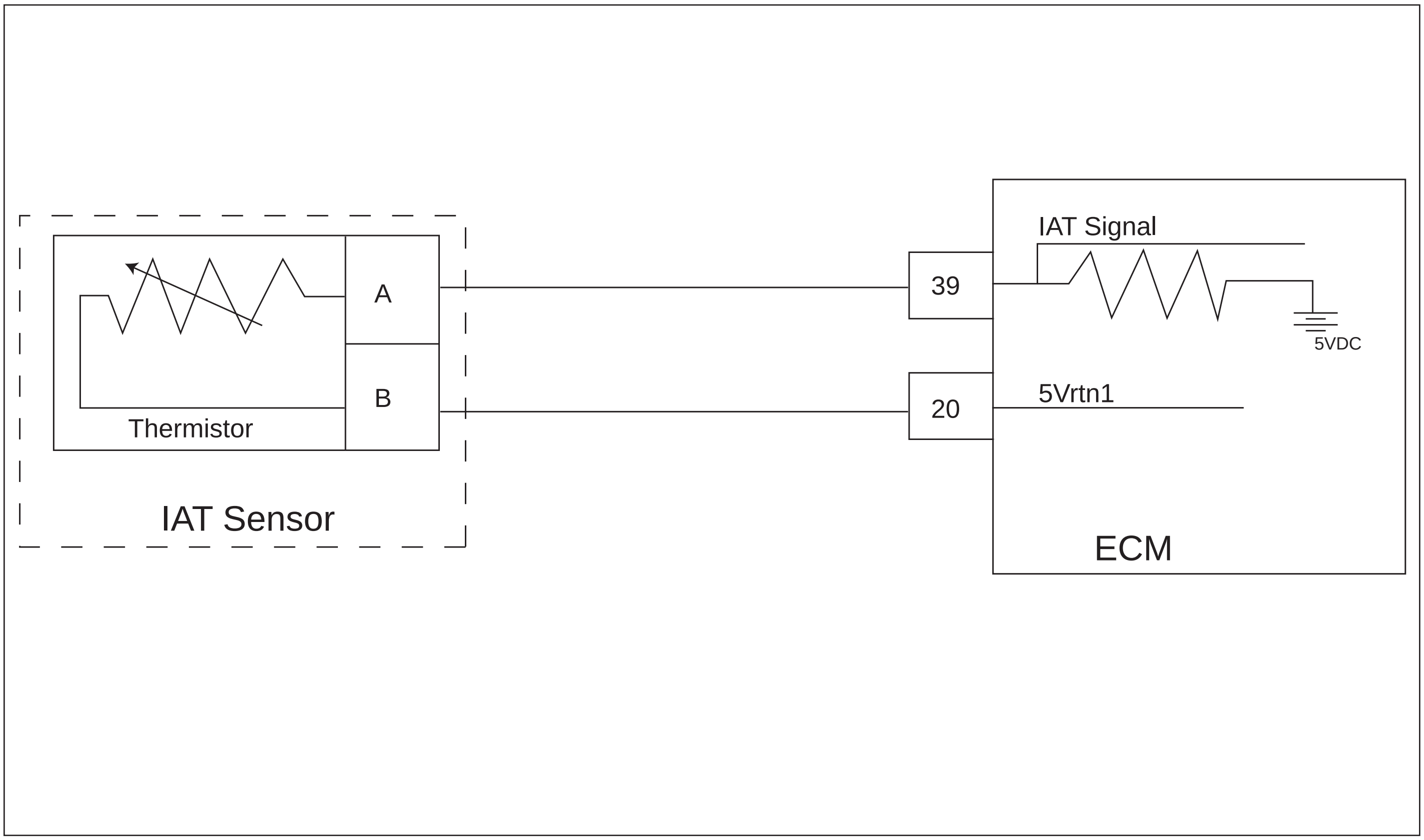
The Manifold Absolute Pressure sensor is a pressure transducer connected to the intake manifold. It is used to measure the pressure of air in the manifold prior to induction into the engine. The pressure reading is used as an index for spark, fuel, base fuel, etc. and is used in conjunction with other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



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.

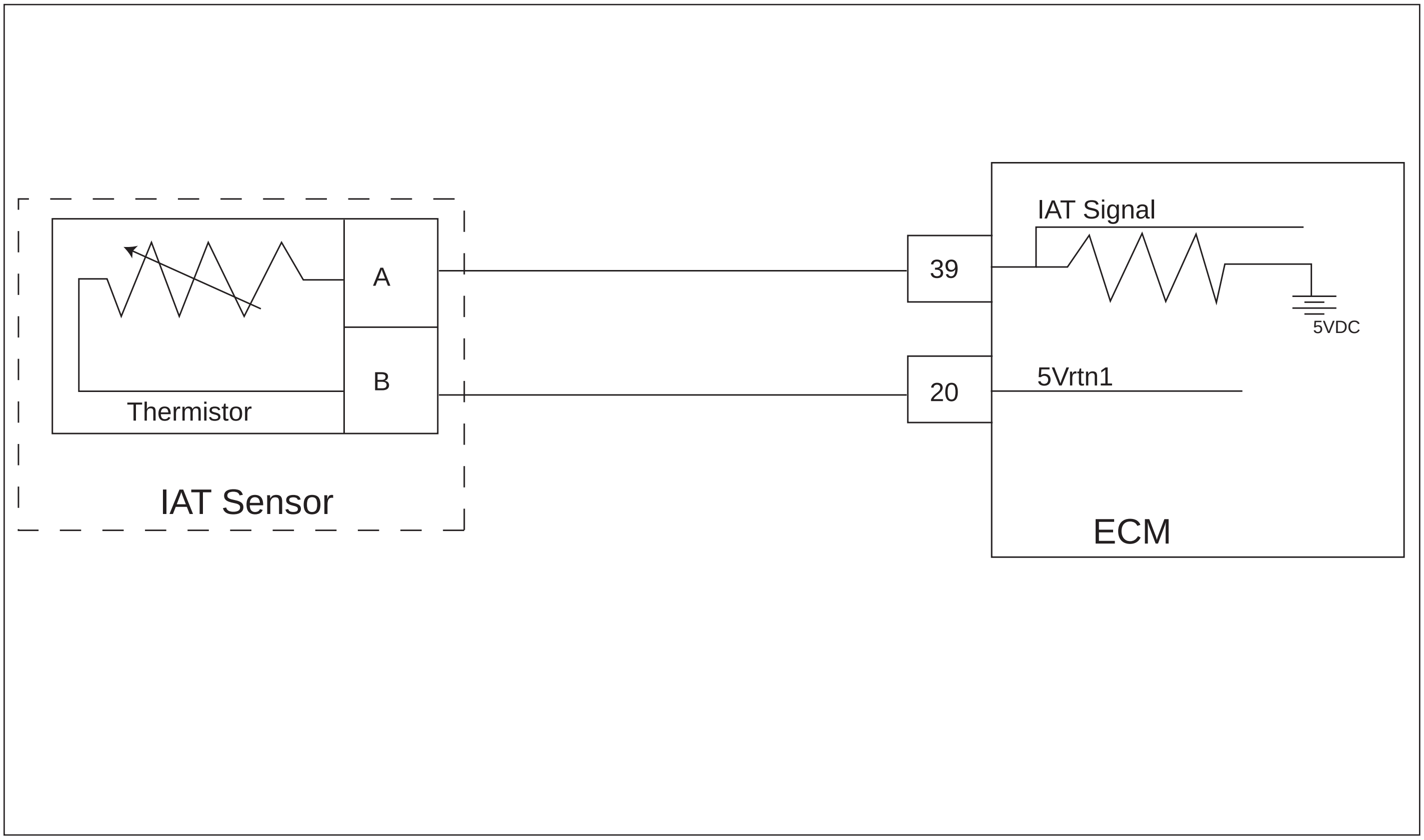
This fault will set if the Intake Air Temperature is greater than 200 degrees F and the operating condition is at a speed greater than 1500 RPM.

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.

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



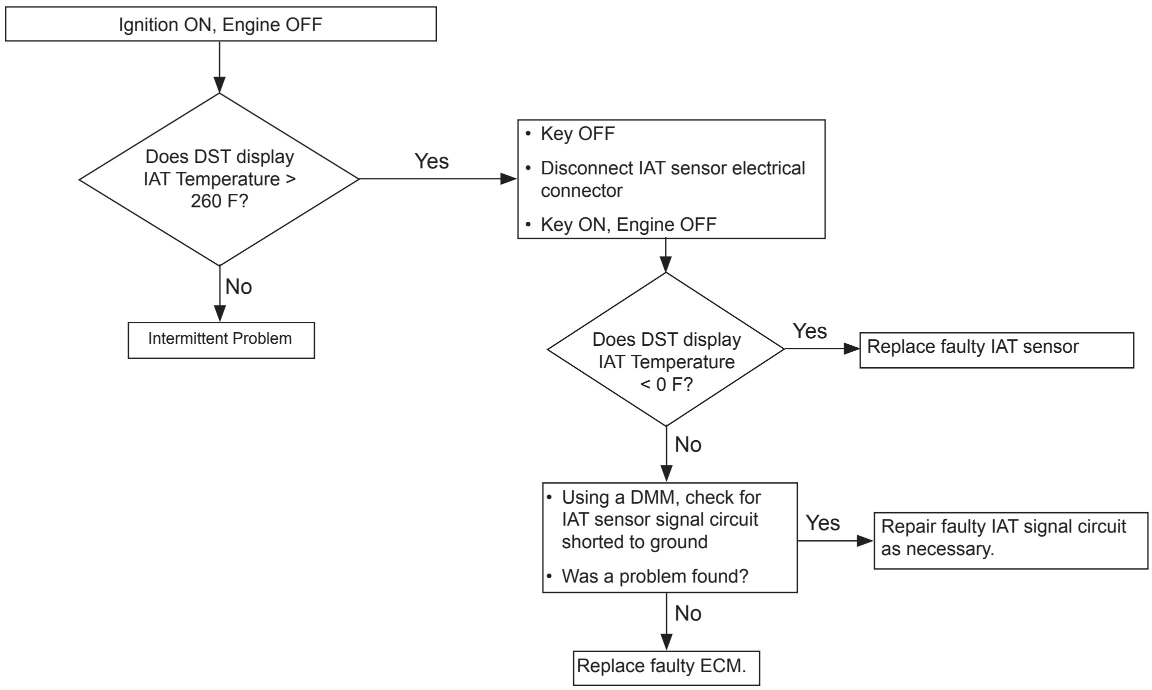
- Intake Air Temperature Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - IAT sensor voltage less than 0.050 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination 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.

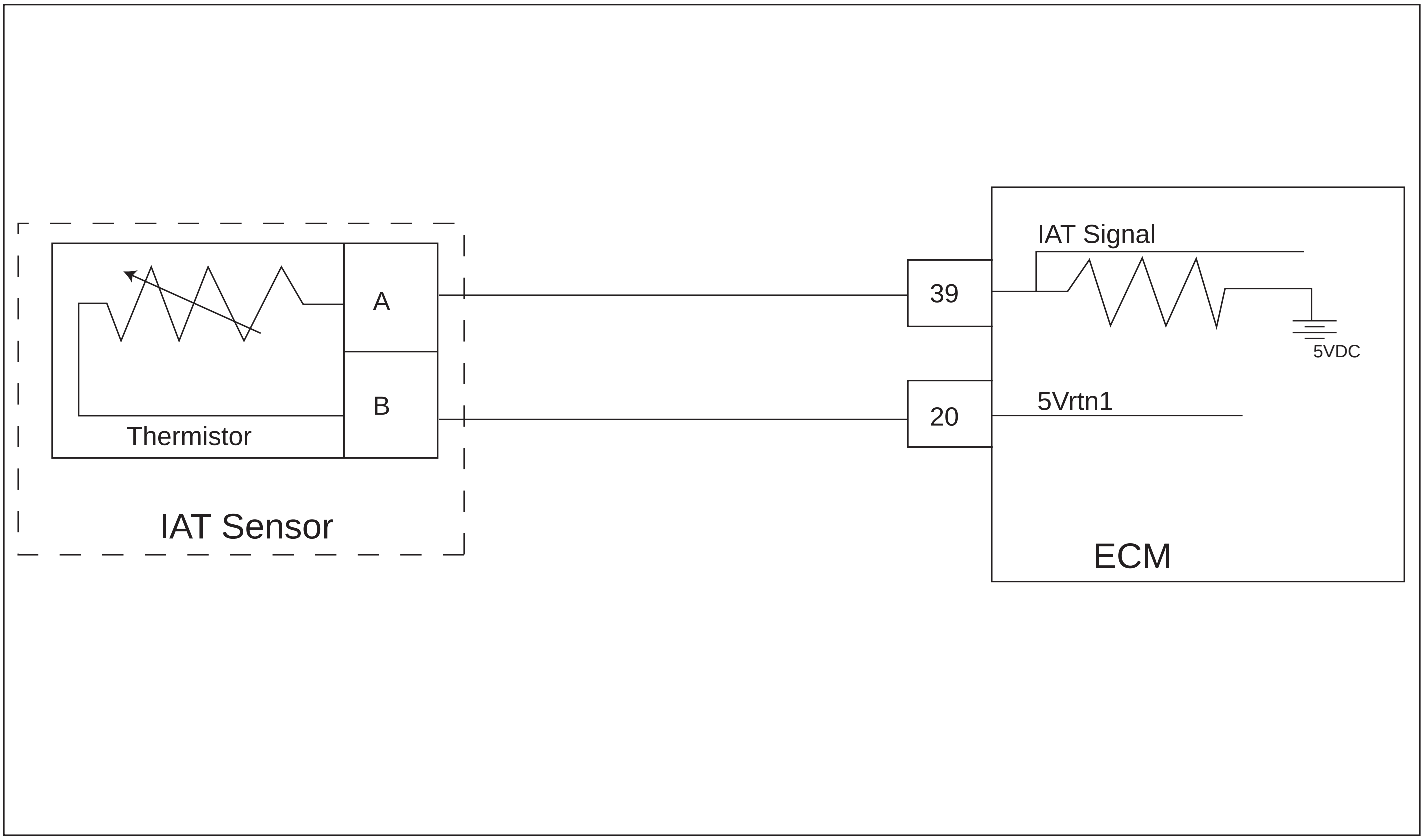
The Manifold Air Temperature is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT at low airflow. It is used to monitor incoming air and the output, in conjunction with other sensors, is used to determine the airflow to the engine.

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



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



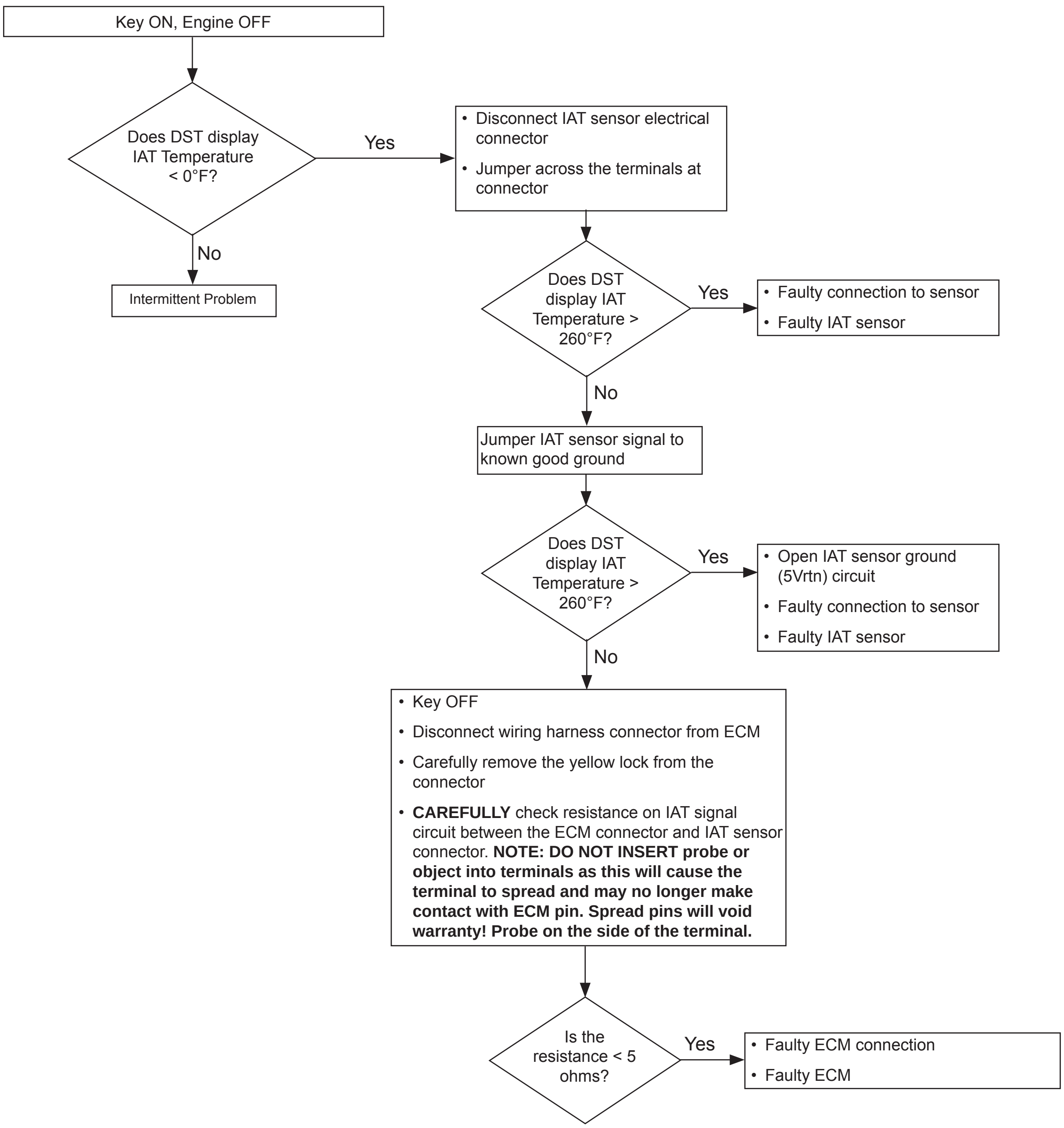
- Intake Air Temperature Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - IAT sensor voltage greater than 4.95 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn and closed-loop fueling correction during active fault, or 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.

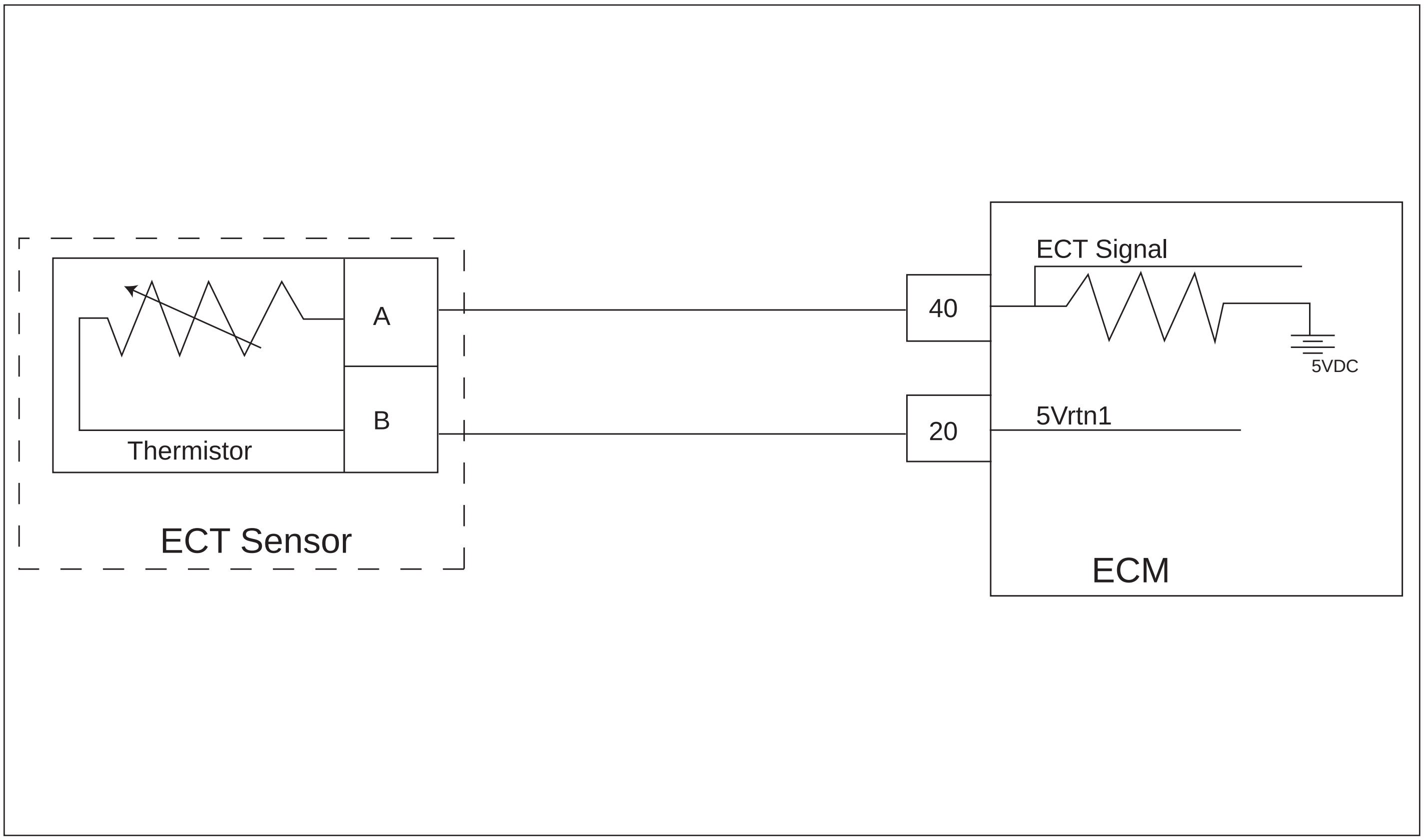
The Manifold Air Temperature is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT at low airflow. It is used to monitor incoming air and the output, in conjunction with other sensors, is used to determine the airflow to the engine.

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



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.

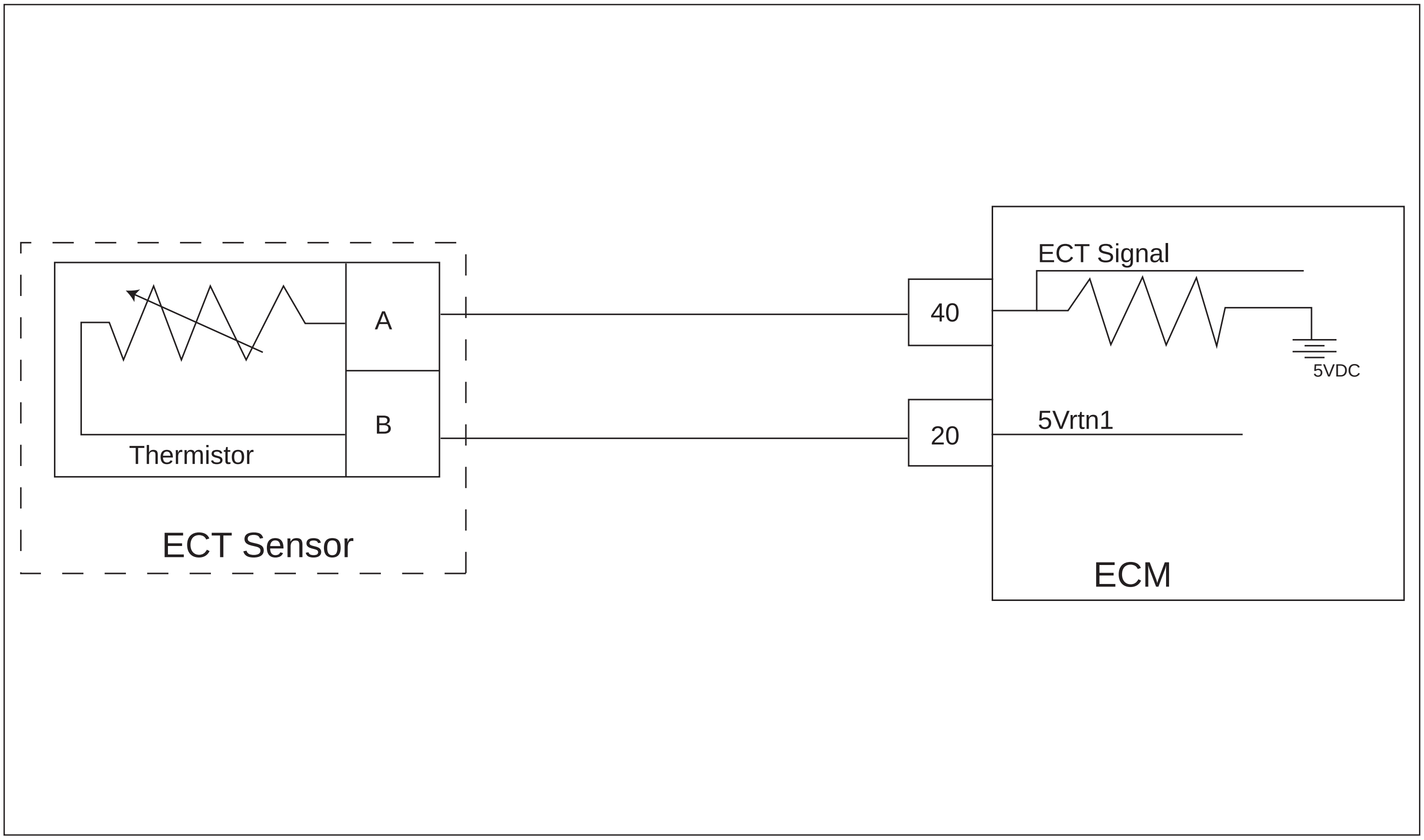
This fault will help protect the engine in the event of over temperature. When the coolant exceeds 200 deg. F and engine RPM exceeds 600 RPM for 60 seconds this fault will set.

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

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

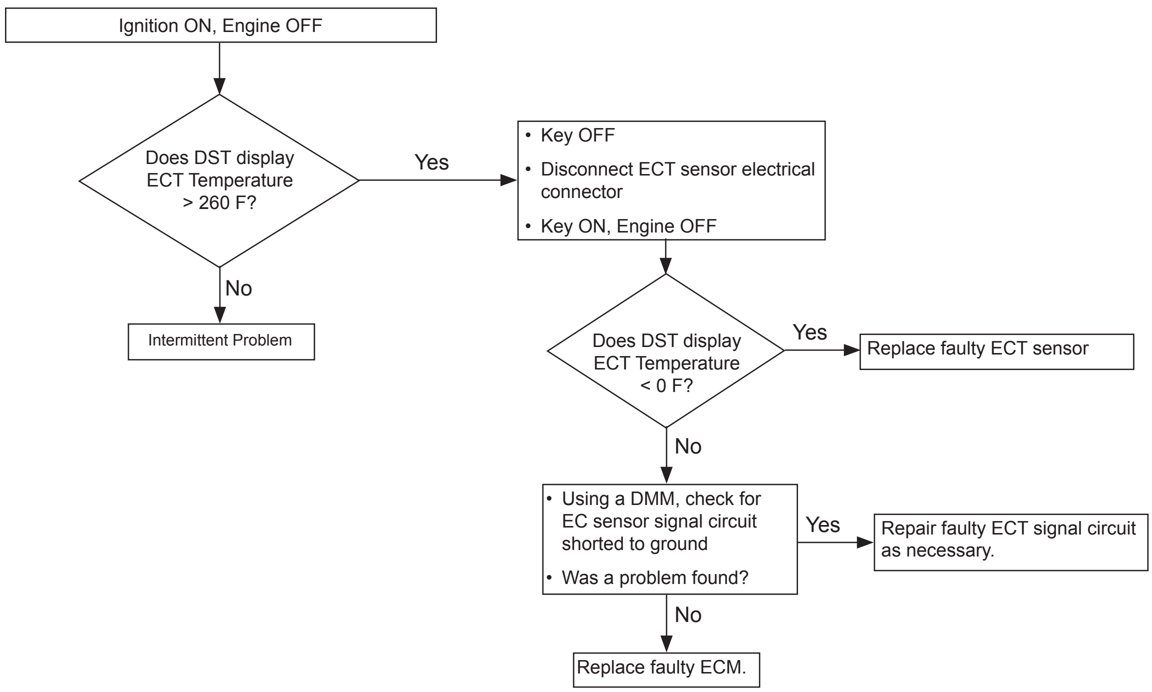


- Engine Coolant Temperature Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - ECT sensor voltage less than 0.050 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination 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

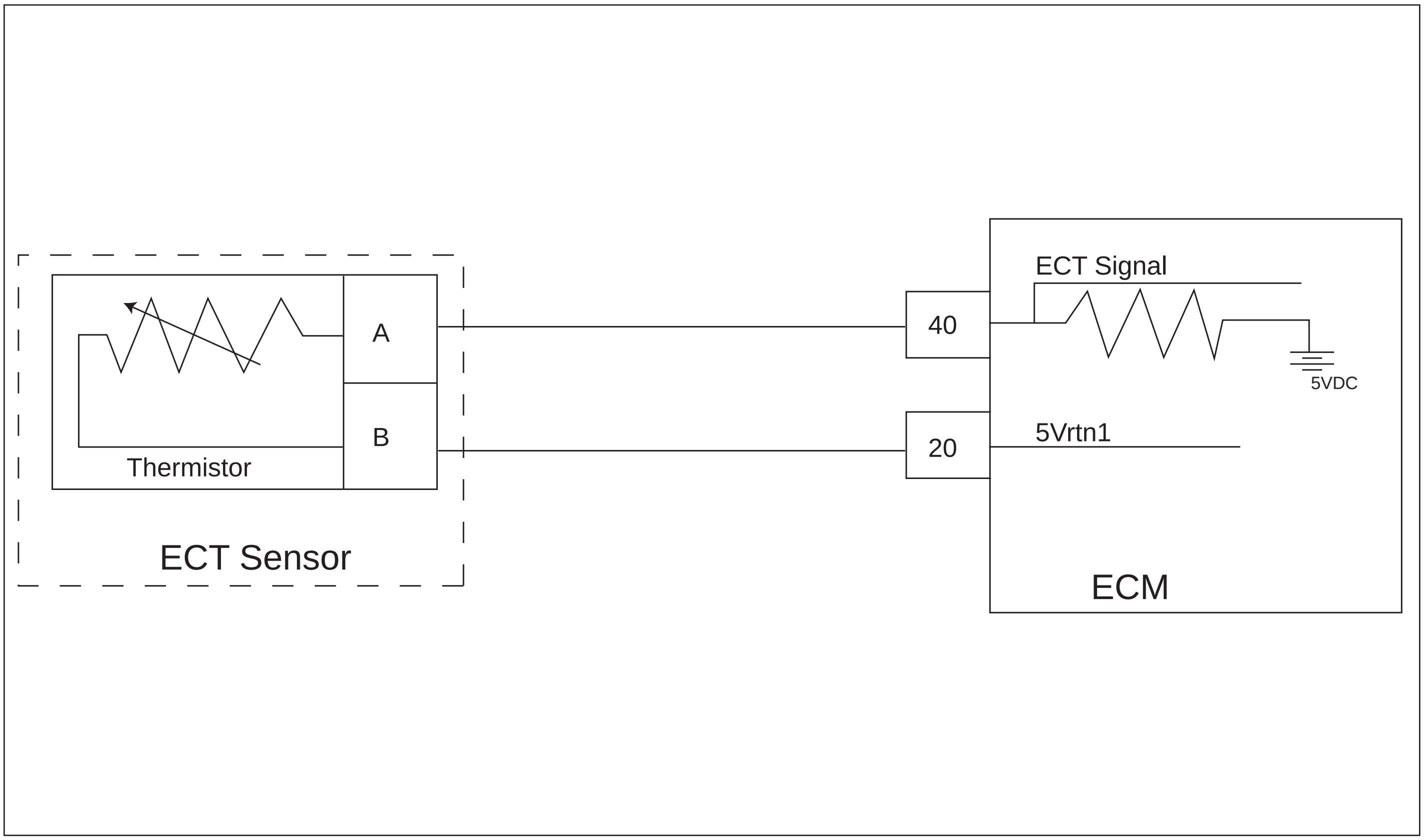
The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. This is used for engine airflow calculation, ignition timing control, to enable certain features, and for engine protection. The ECM provides a voltage divider circuit so when the sensor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



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

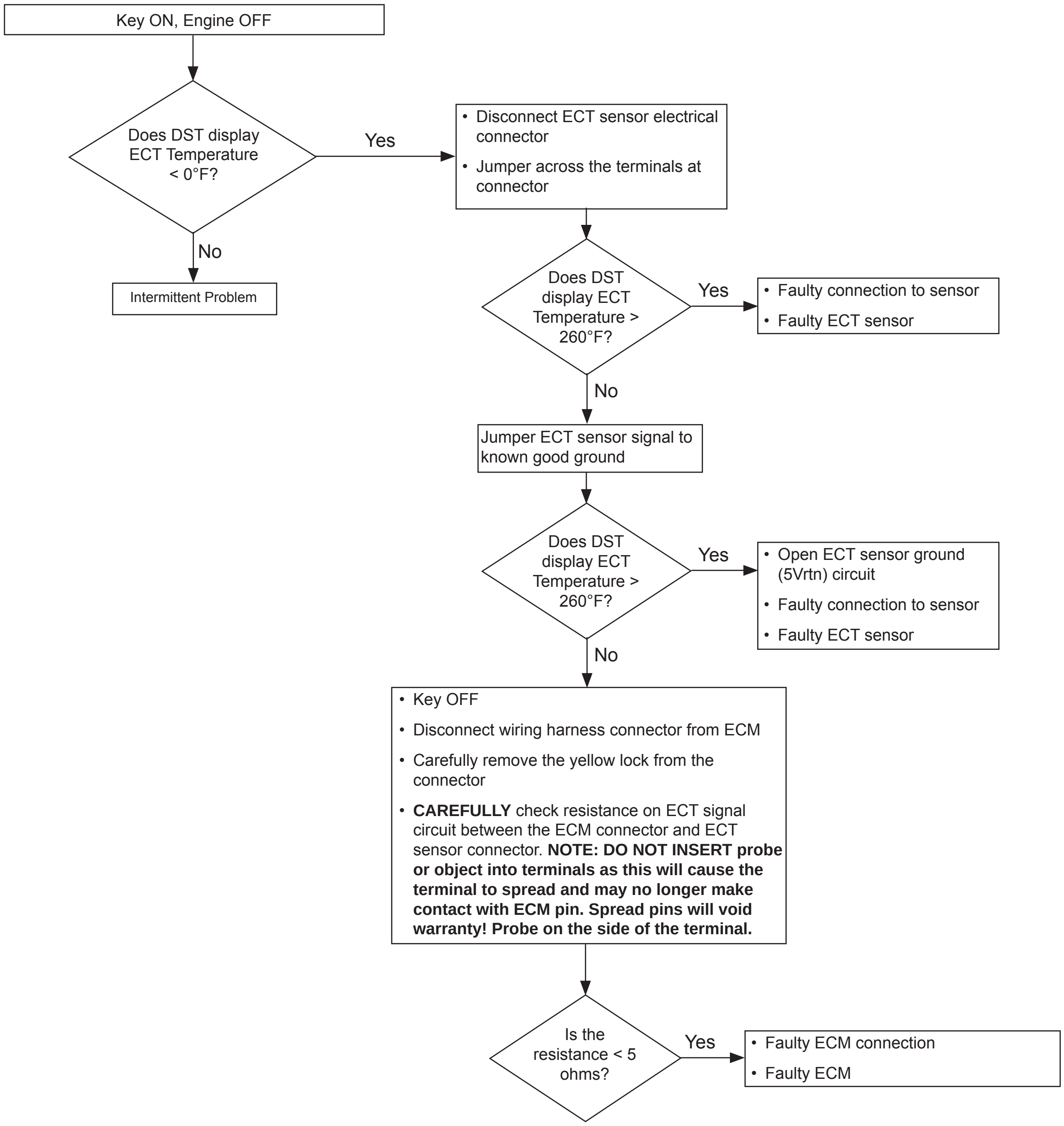


- Engine Coolant Temperature Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - ECT sensor voltage higher than 4.95 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination 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

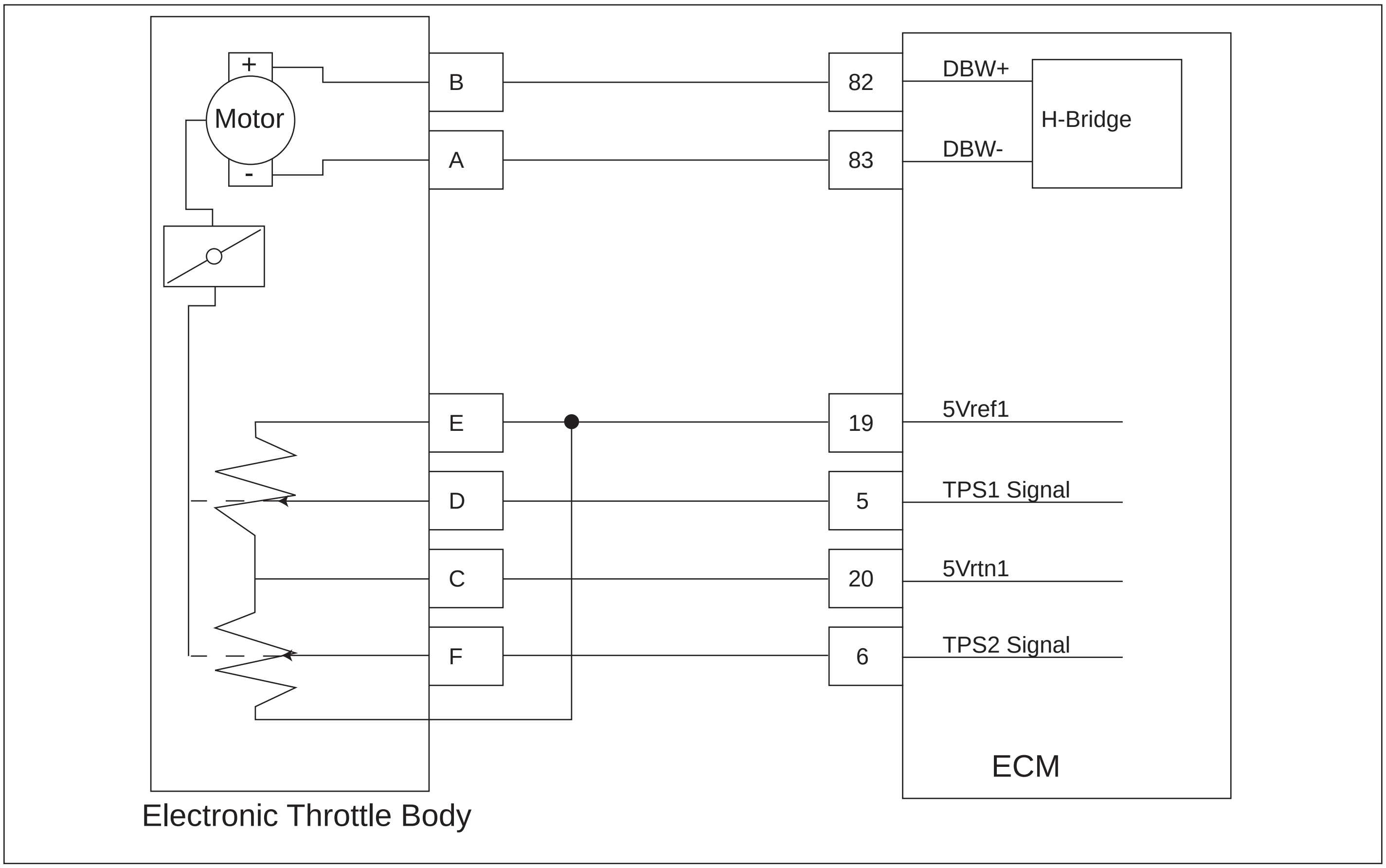
The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. This is used for engine airflow calculation, ignition timing control, to enable certain features, and for engine protection. The ECM provides a voltage divider circuit so when the sensor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



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



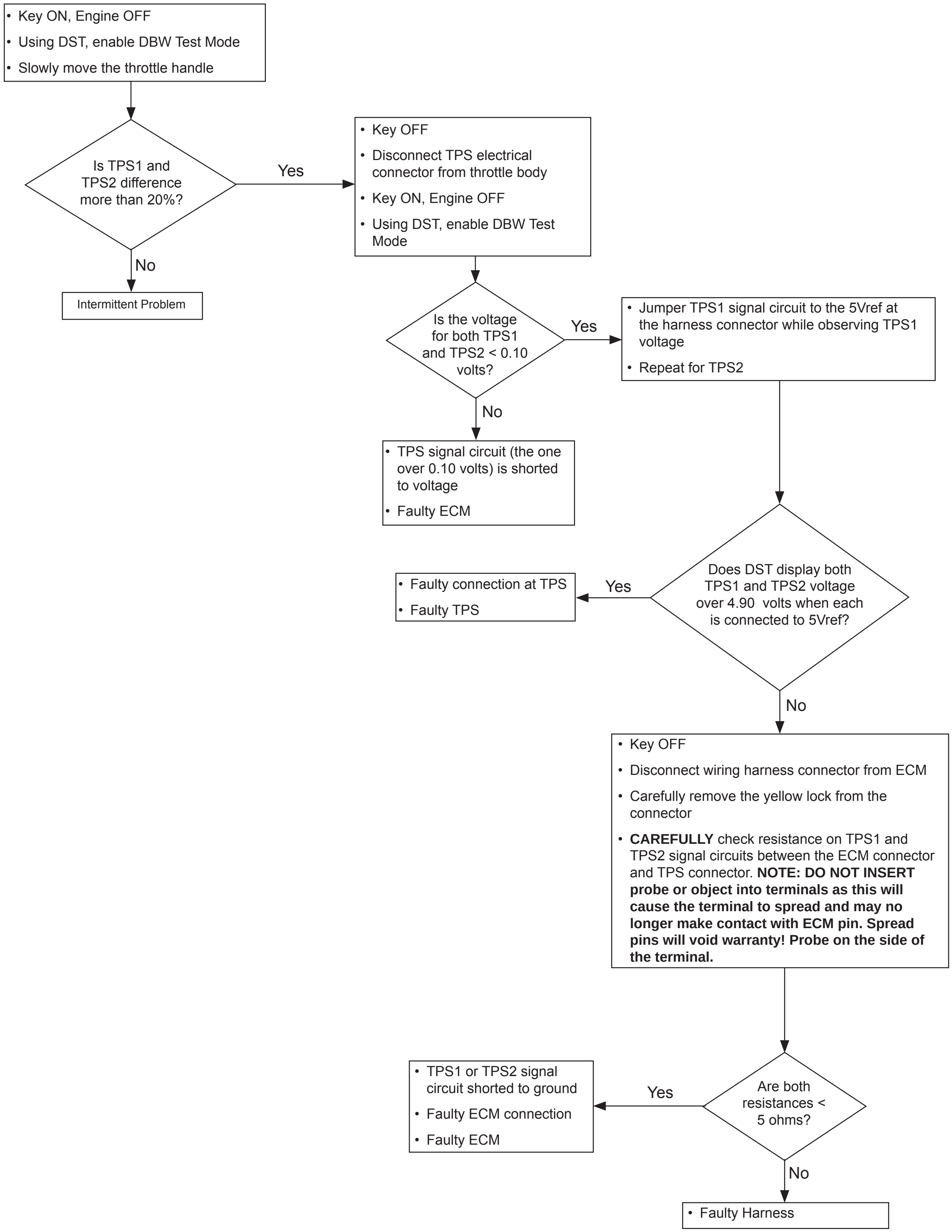
- Throttle Body - Throttle Position Sensor 1 & 2 (electronic throttle body only)
- *Check Condition* - Key-On, Engine Cranking, or Running
- *Fault Condition* - TPS1 lower than TPS2 by 20%
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions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

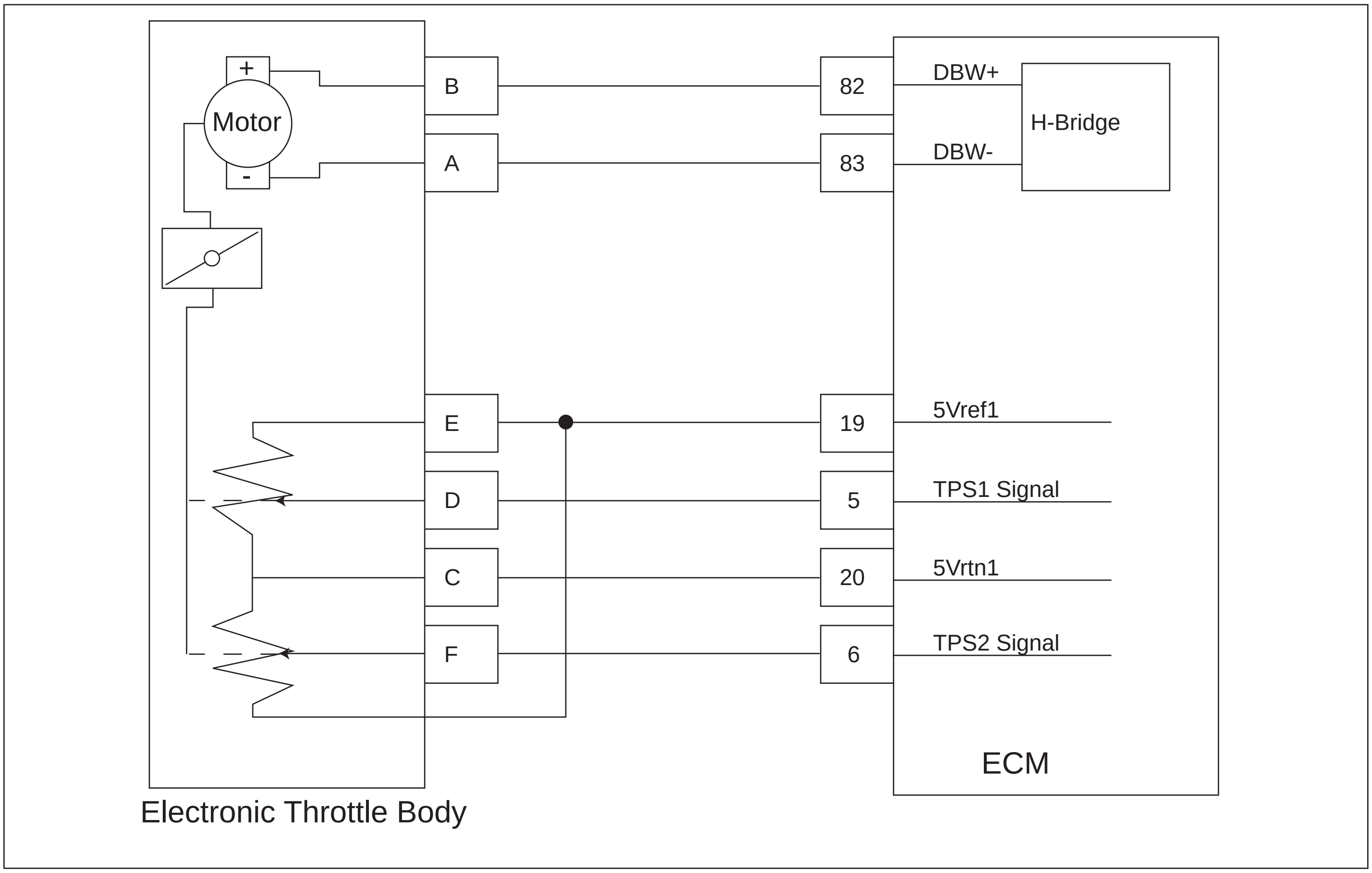
The Throttle Position Sensor uses a variable resistor and voltage divider circuitr to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In an Electronic 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 is 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



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



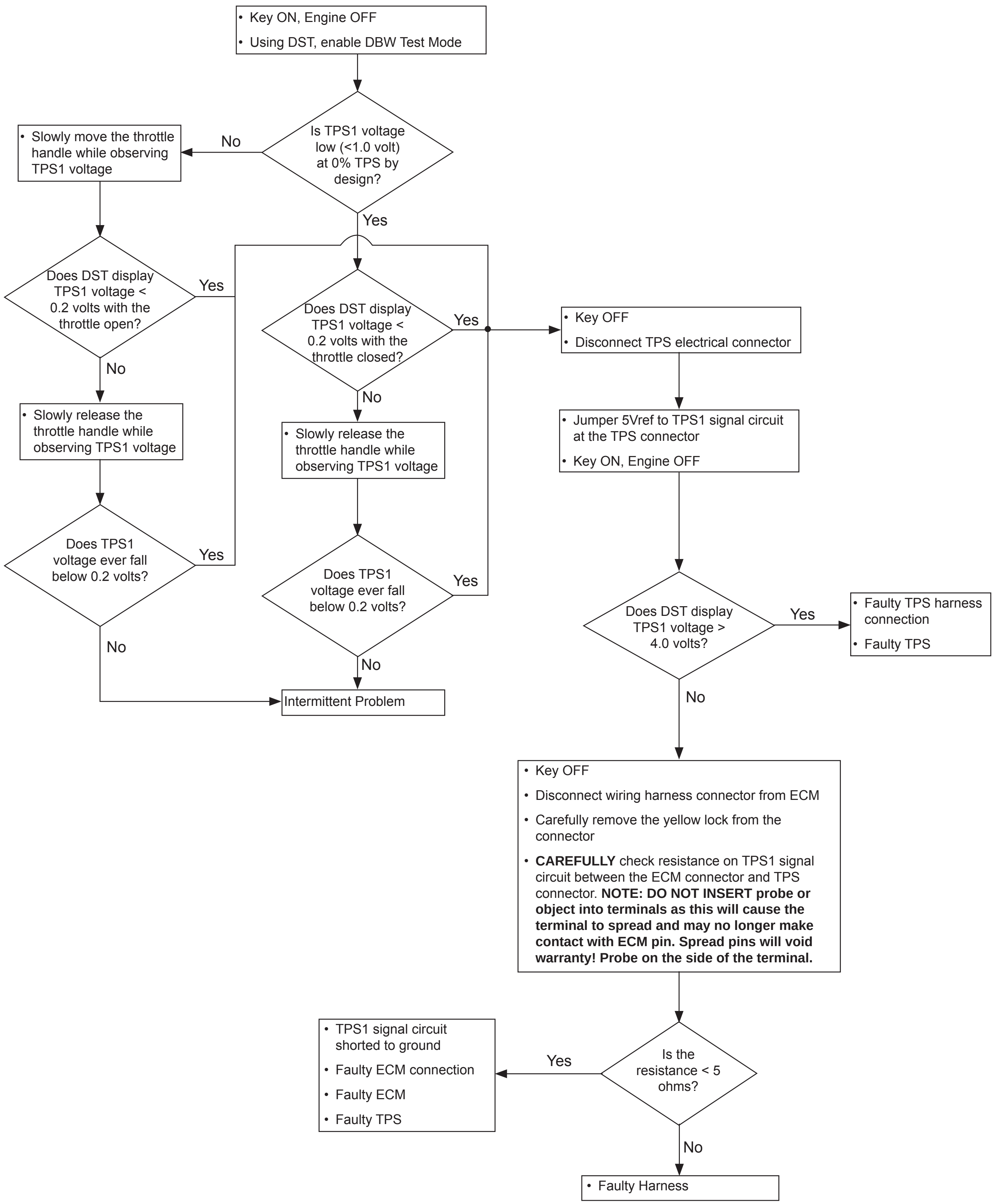
- Throttle Body - Throttle Position Sensor 1
- *Check Condition* - Key On, Engine Cranking or Running
- *Fault Condition* - TPS1 sensor voltage lower than 0.20 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions related fault

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.

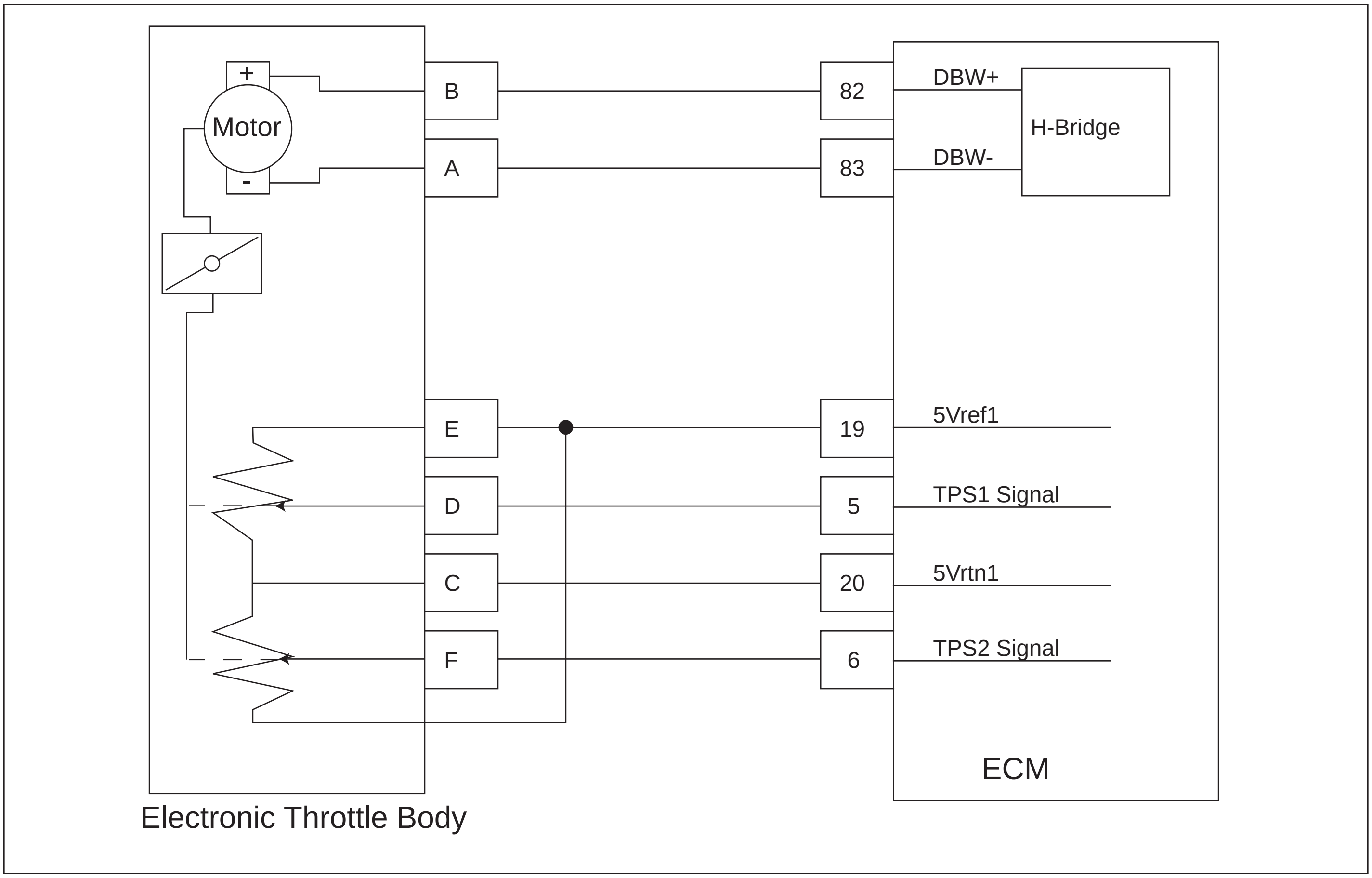
The Throttle Position Sensor uses a variable resistor and voltage divider circuitr to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In an Electronic 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



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



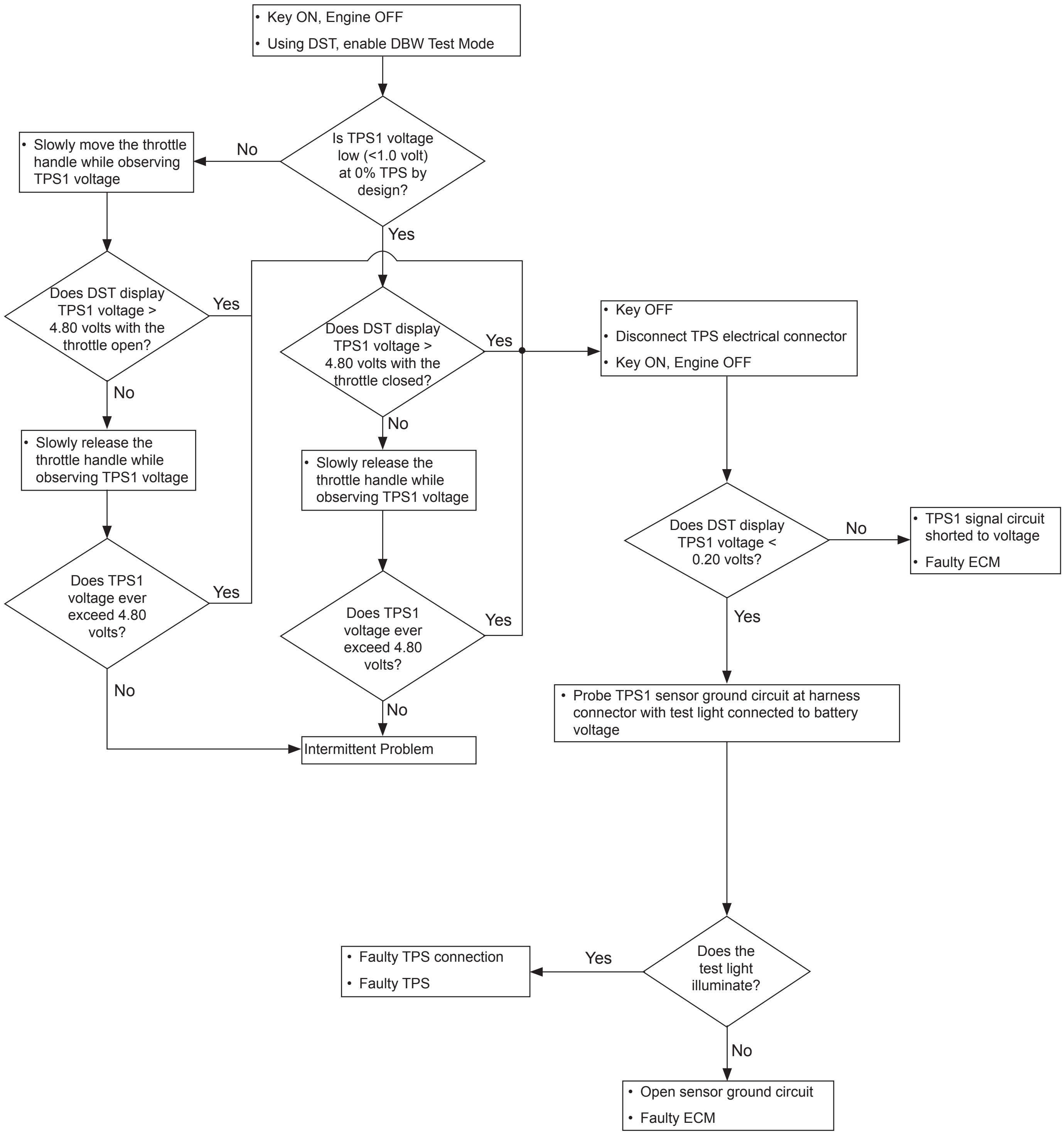
- Throttle Body - Throttle Position Sensor 1
- *Check Condition* - Key On, Engine Cranking or Running
- *Fault Condition* - TPS1 sensor voltage higher than 4.80 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions related fault

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.

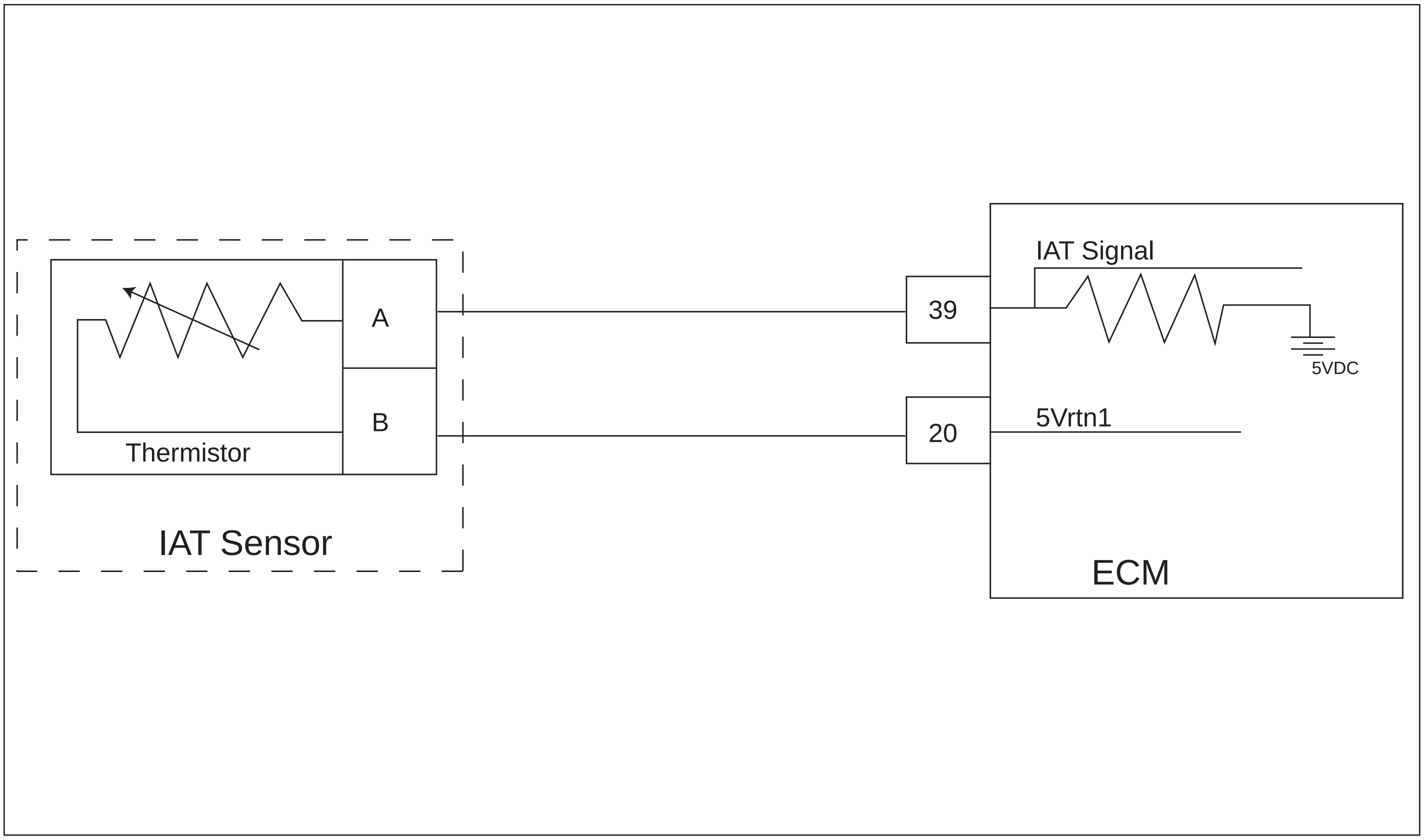
The Throttle Position Sensor uses a variable resistor and voltage divider circuitr to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In an Electronic 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



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.

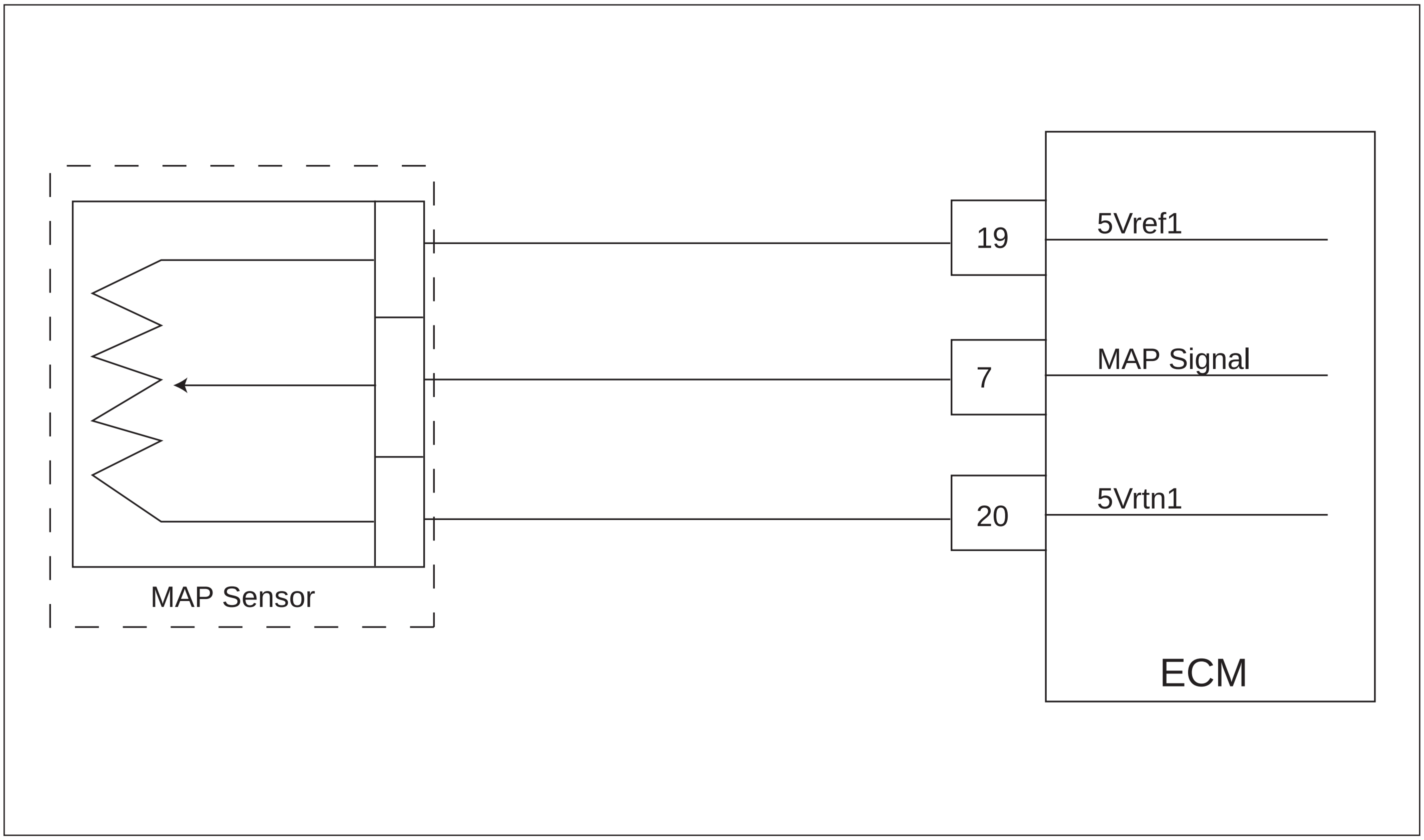
This fault will set if the Intake Air Temperature is greater than 210 degrees F and the operating condition is at a speed greater than 1500 RPM.

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.

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

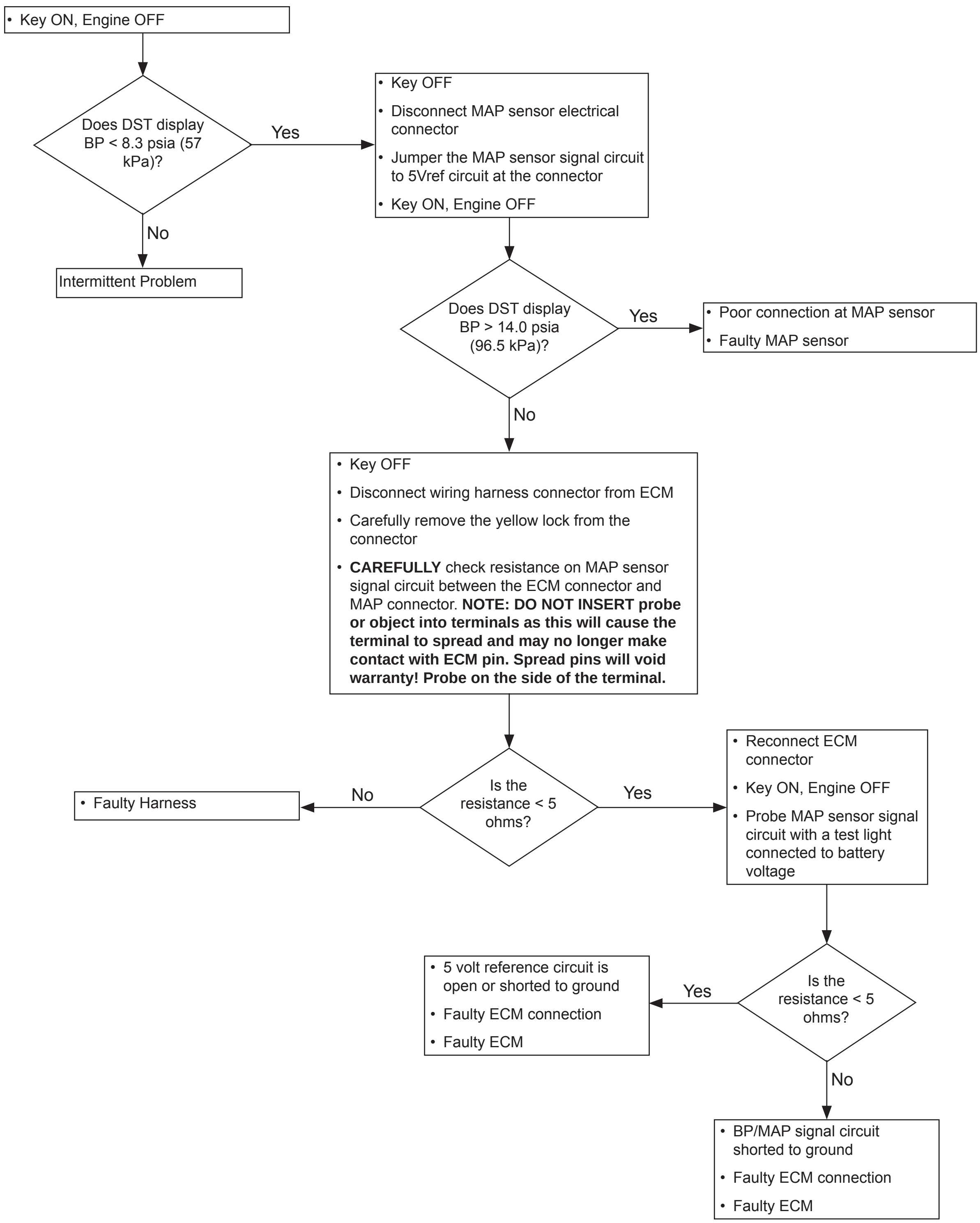


- Barometric Pressure
- *Check Condition* - Key On, Engine Off or after BP estimate during low-speed/high load operation
- *Fault Condition* - Barometric Pressure is less than 8.30 psia
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable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

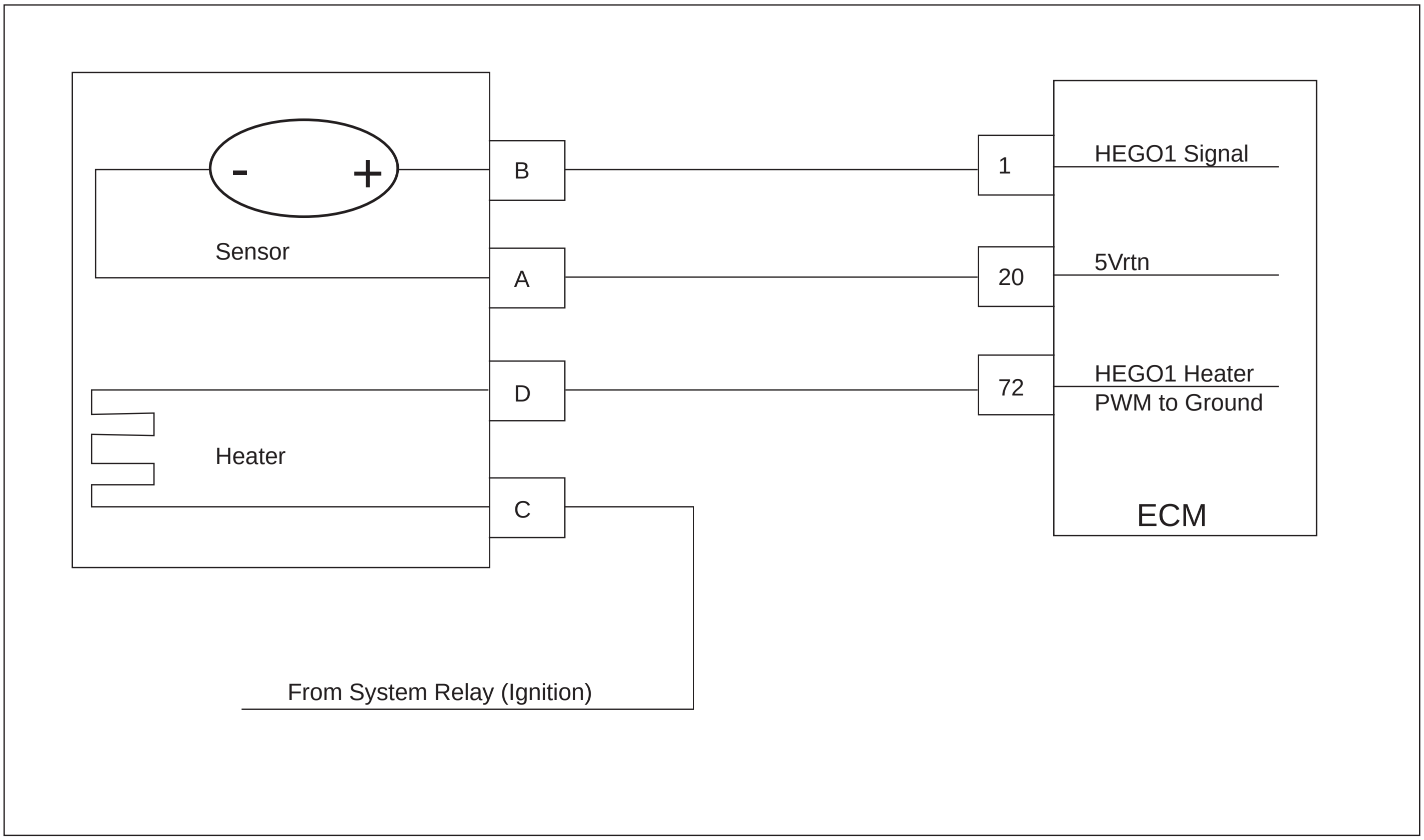
Barometric Pressure is estimated from the MAP sensor at key-on and in some calibrations during low speed/high load operation as defined in the engine's calibration. The barometric pressure value is used for fuel and airflow calculations and equivalence ratio targets based on altitude.

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



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

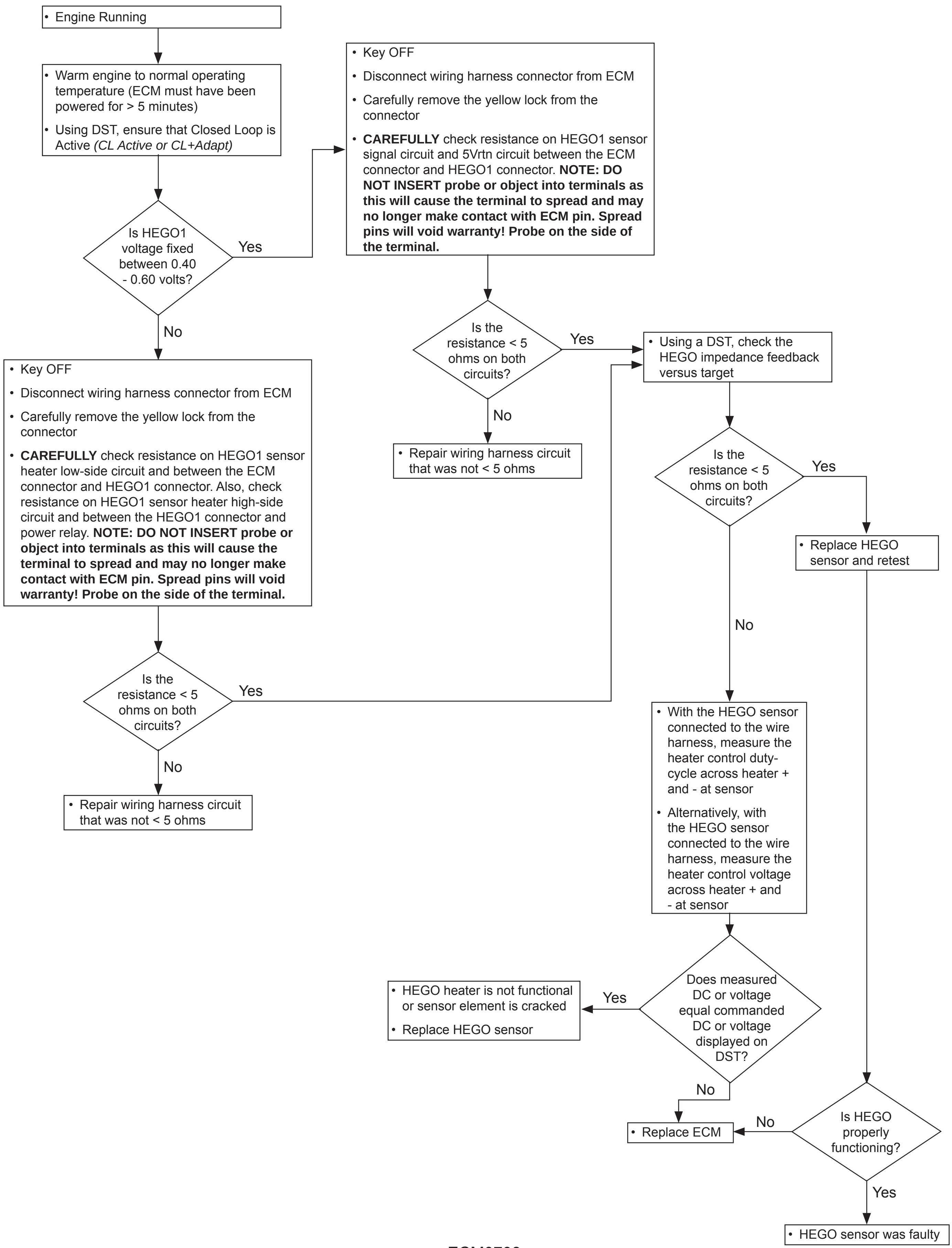


- Heated Exhaust Gas Oxygen Sensor (Bank 1-Sensor 1/Bank 1-Before Catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - HEGO cold longer than 120 seconds
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn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

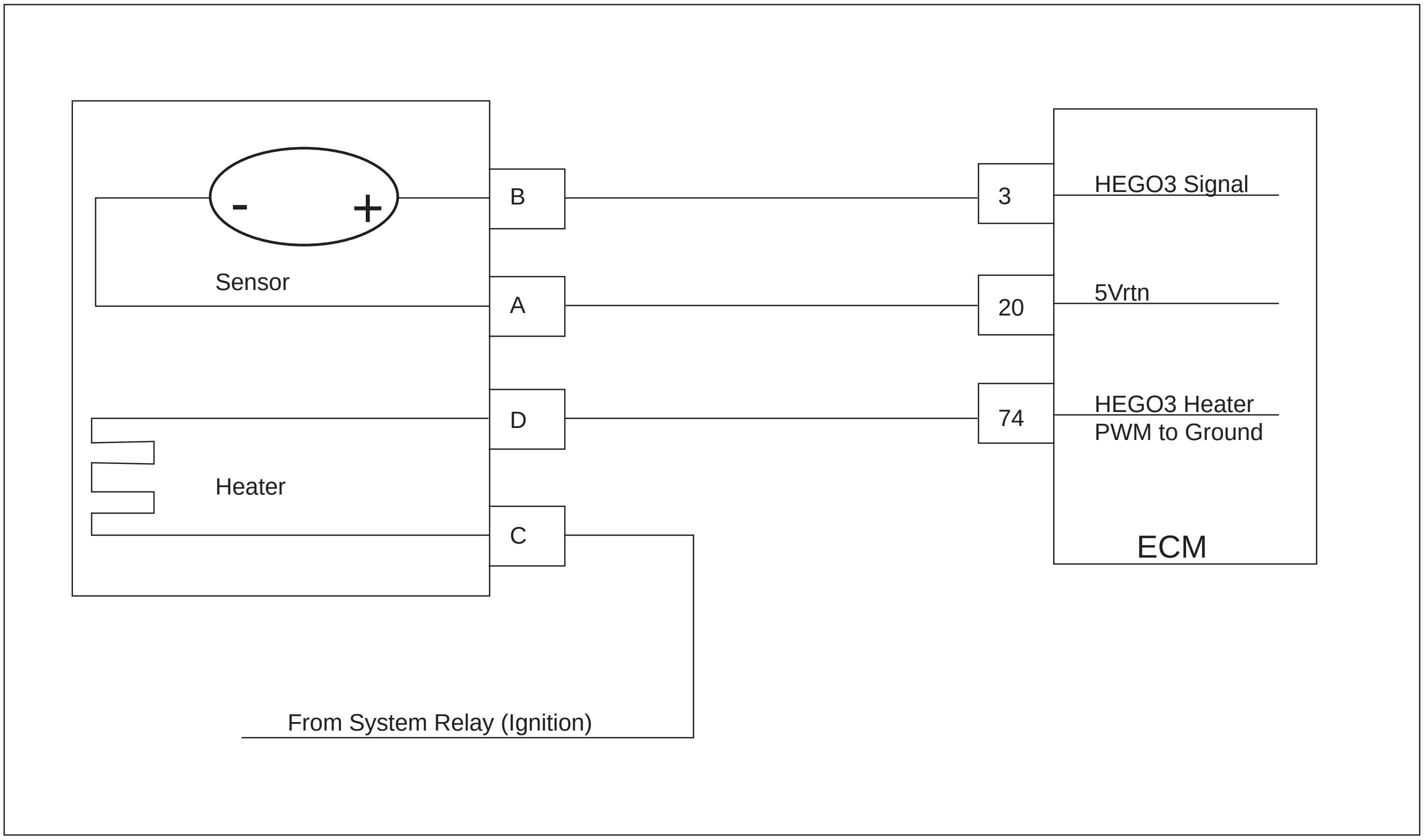
The HEGO sensor is a switching-type sensor about stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted using the Closed 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



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

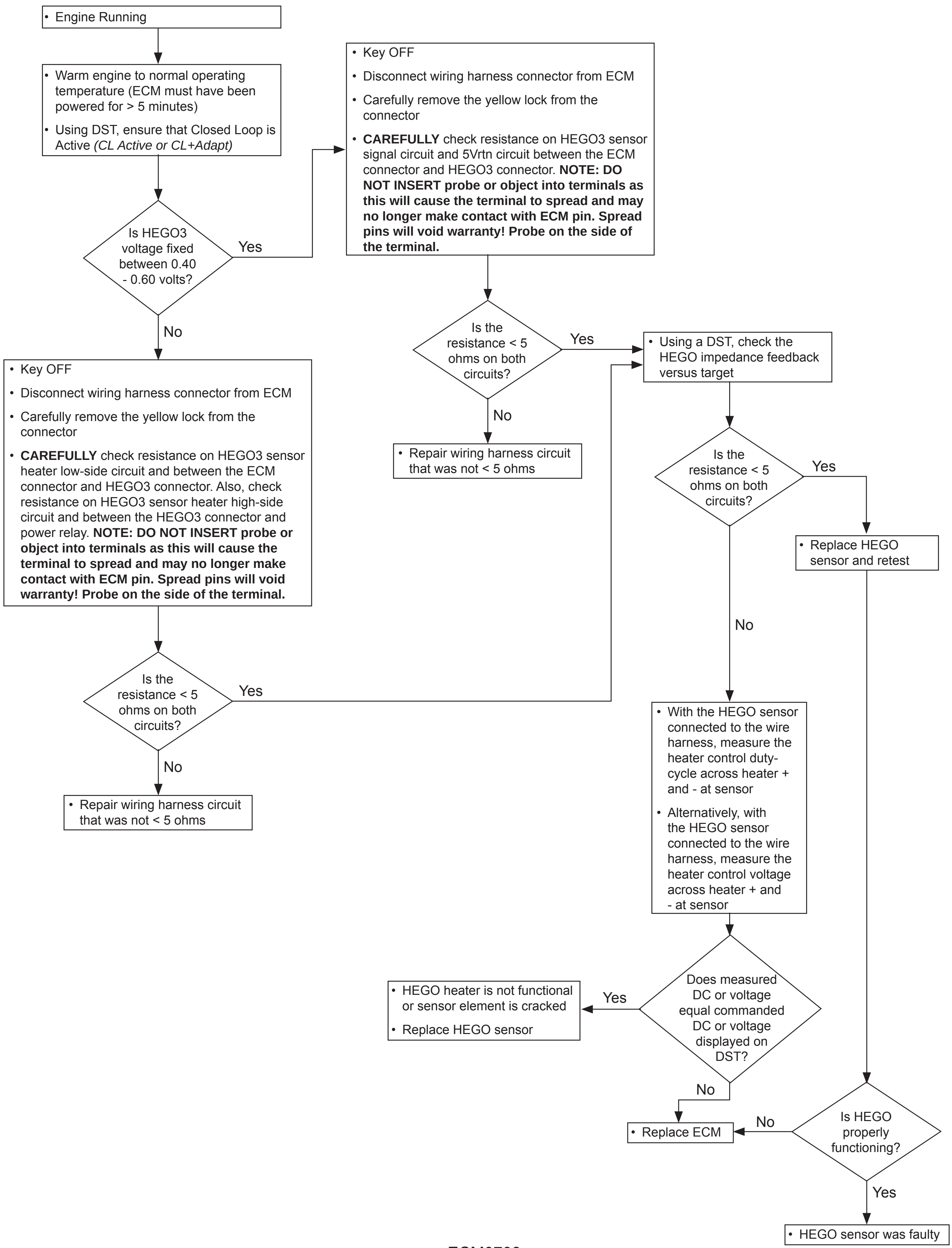


- Heated Exhaust Gas Oxygen Sensor (Bank 1-Sensor 3/Bank 1-After Catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - HEGO cold longer than 120 seconds
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling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

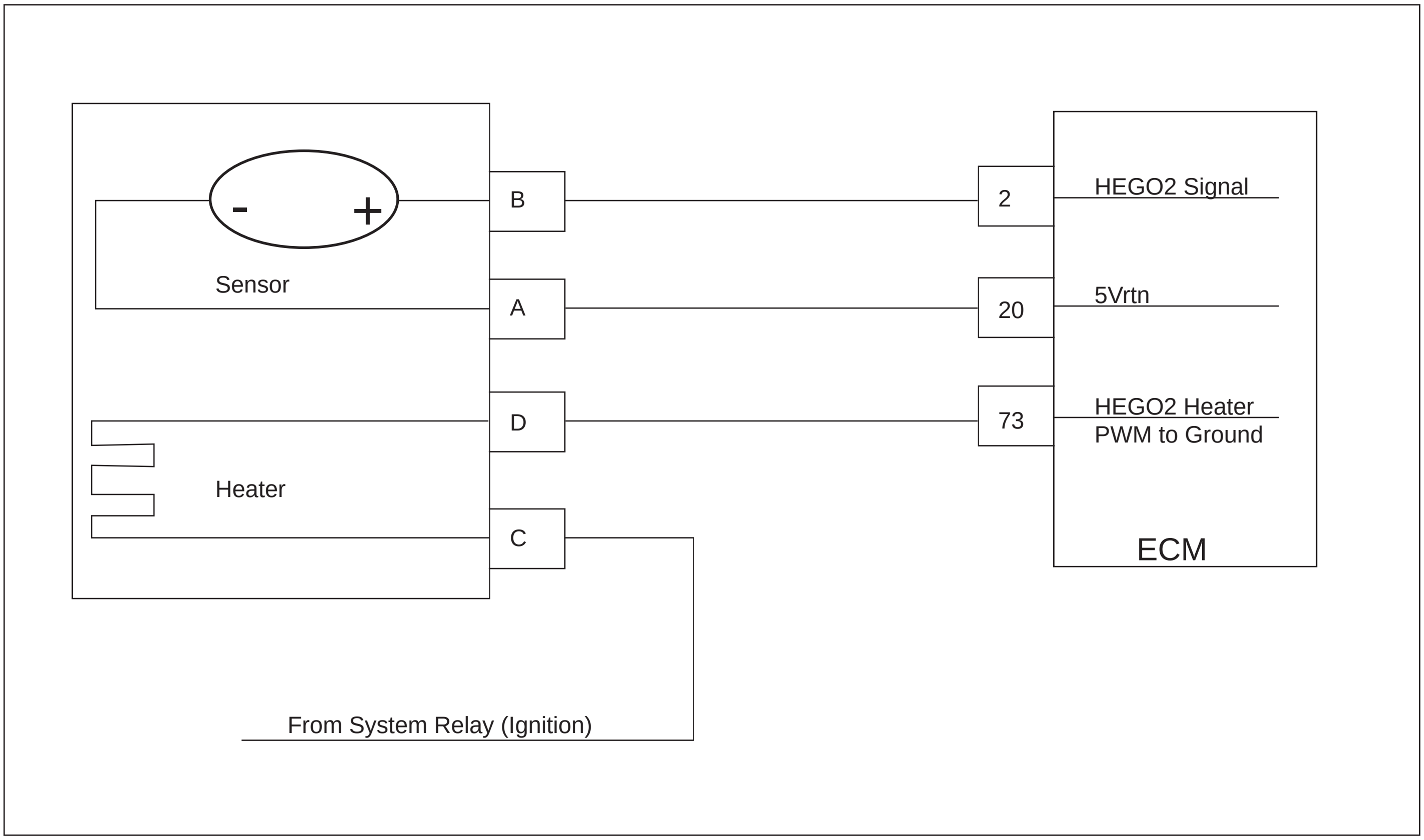
The HEGO sensor is a switching-type sensor about stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted using the Closed 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



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

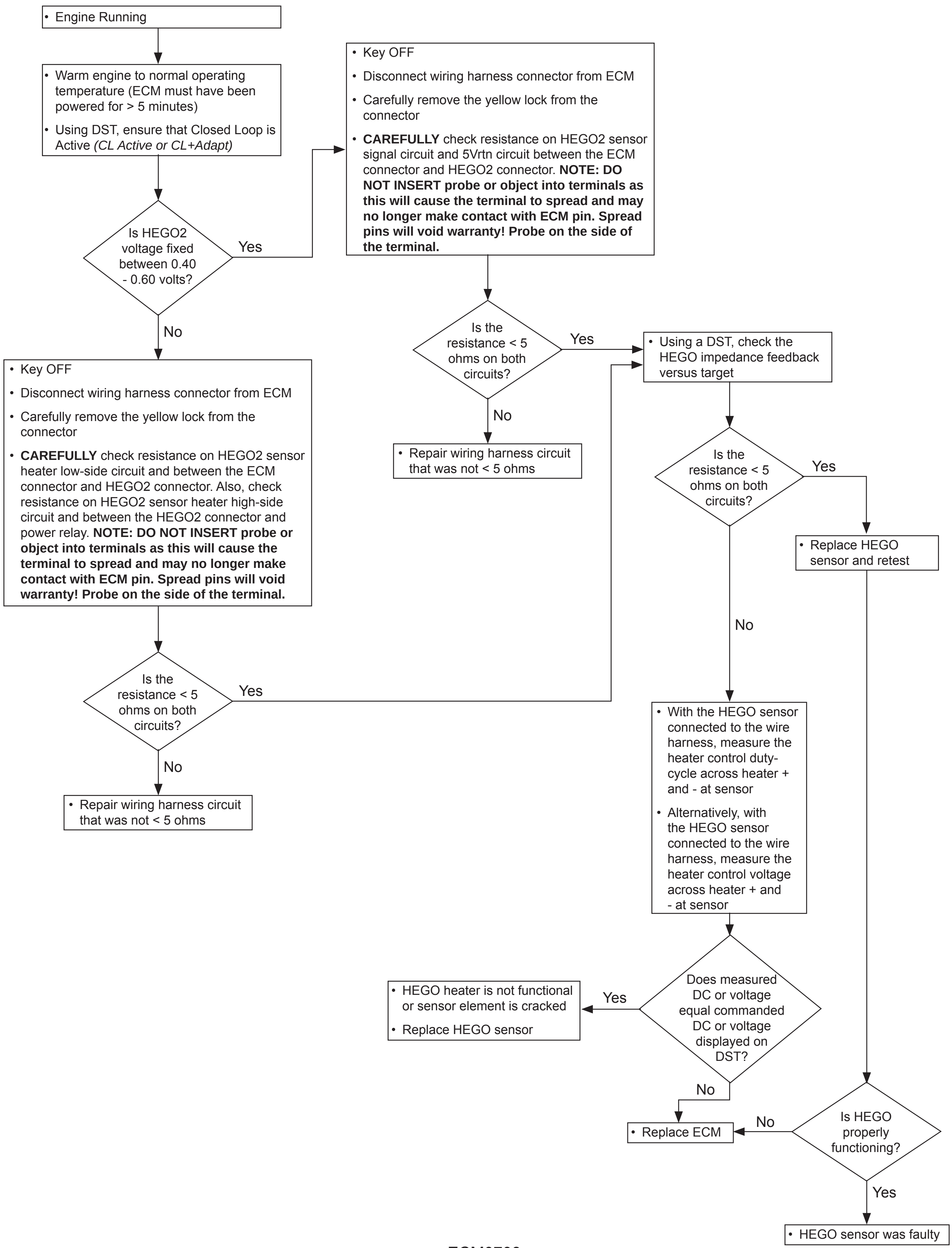


- Heated Exhaust Gas Oxygen Sensor (Bank 2-Sensor 2/Bank 2-Before Catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - HEGO cold longer than 120 seconds
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn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

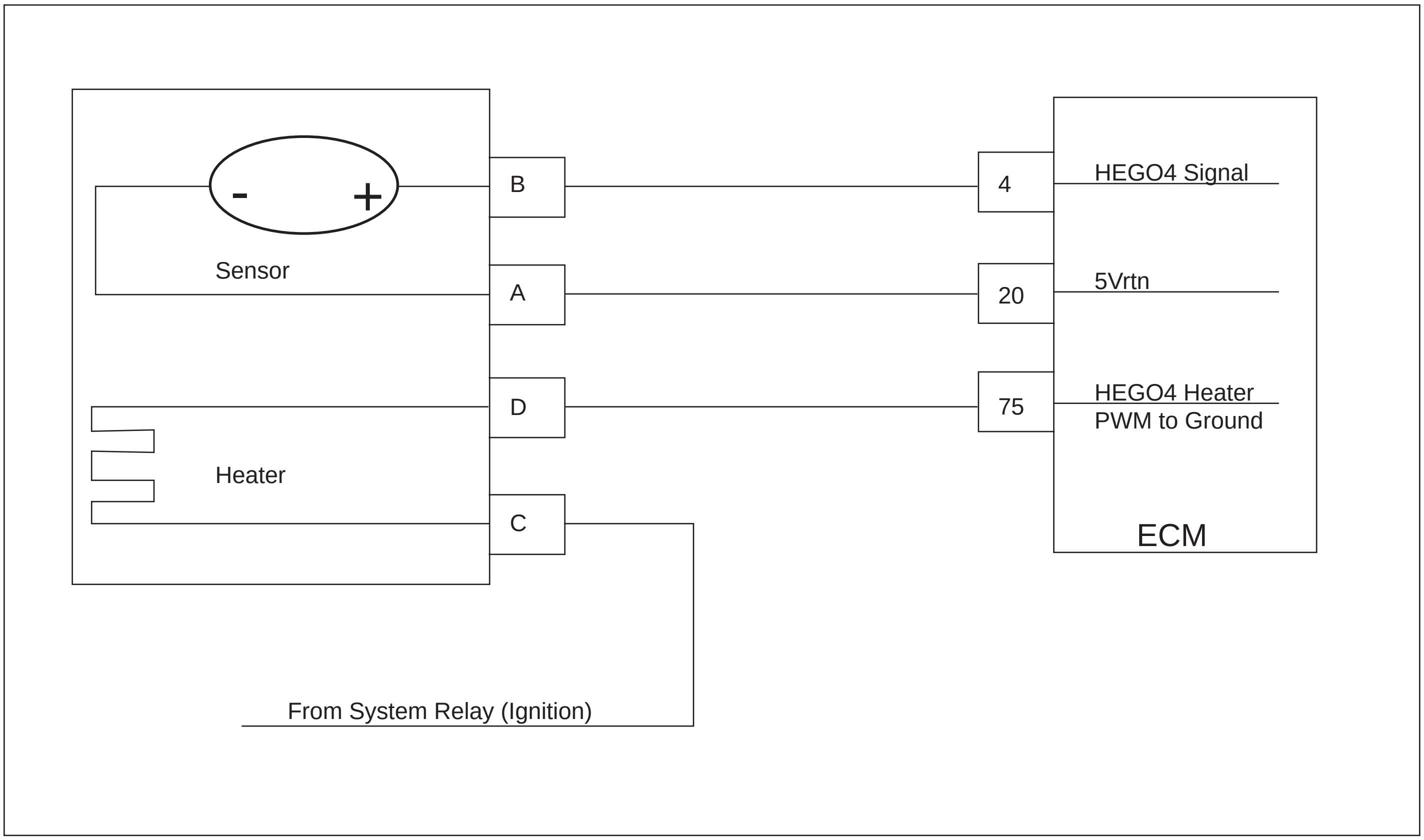
The HEGO sensor is a switching-type sensor about stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted using the Closed 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



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

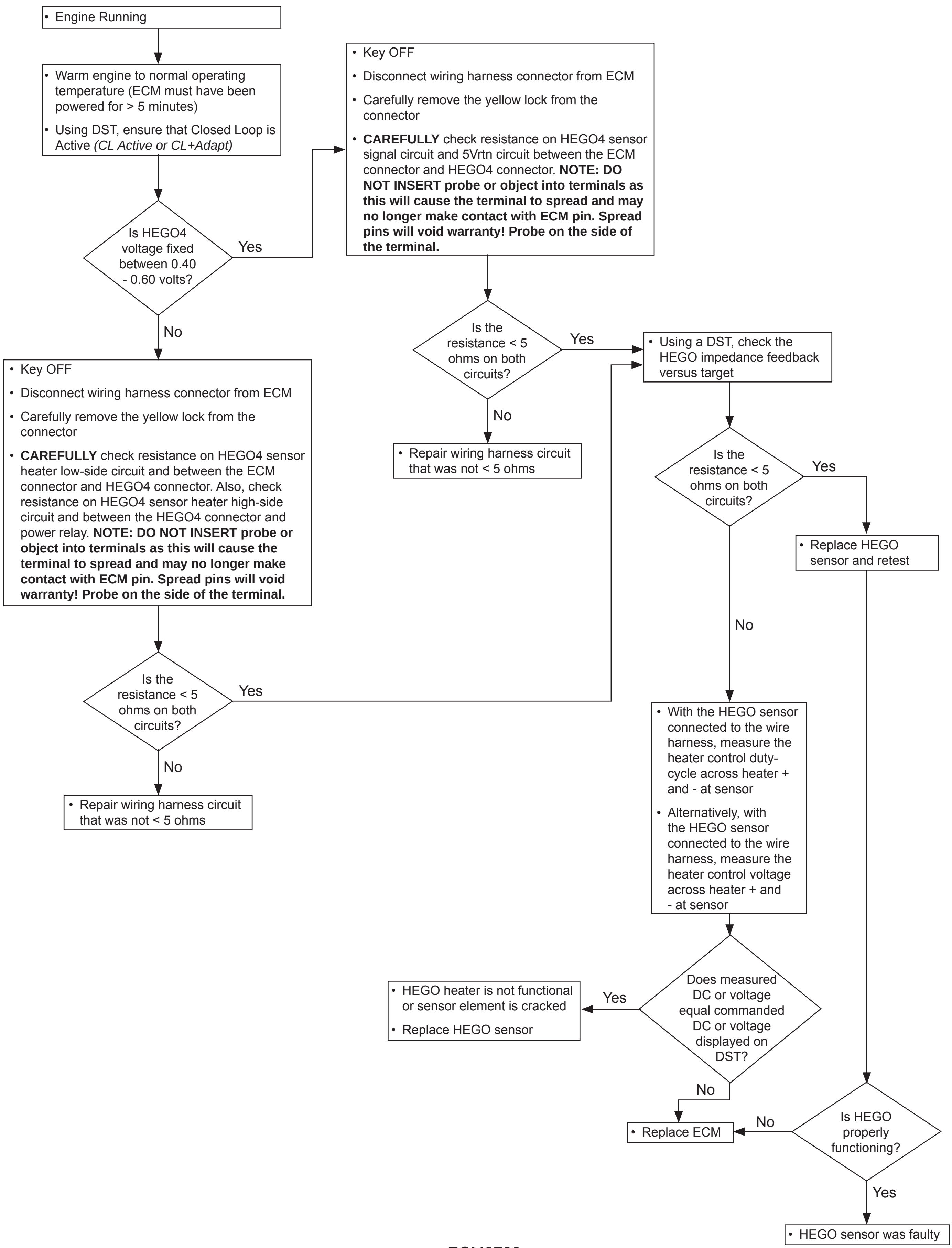


- Heated Exhaust Gas Oxygen Sensor (Bank 2-Sensor 4/Bank 2-After Catalyst)
- *Check Condition* - Engine Running
- *Fault Condition* - HEGO cold longer than 120 seconds
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling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

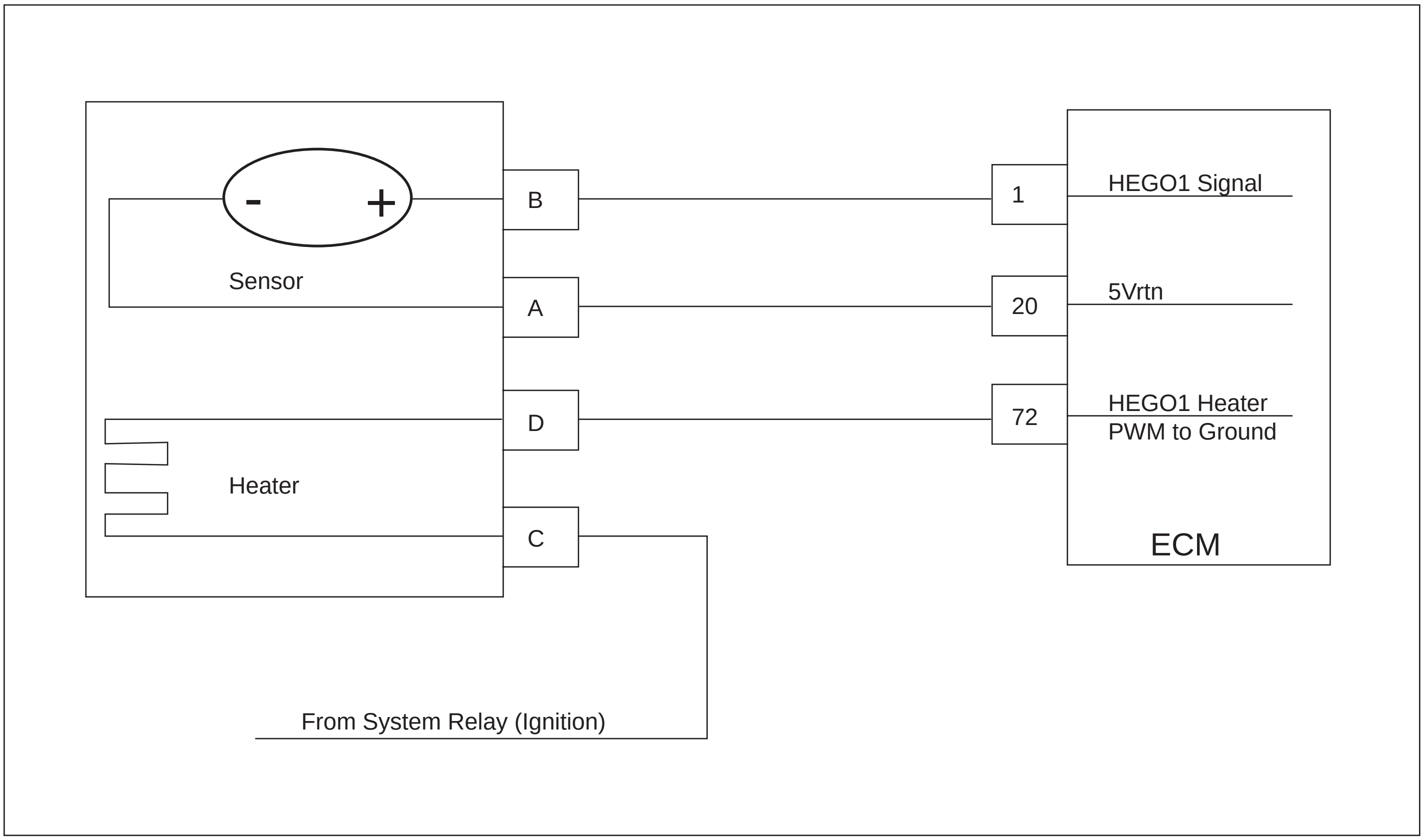
The HEGO sensor is a switching-type sensor about stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted using the Closed 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



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.

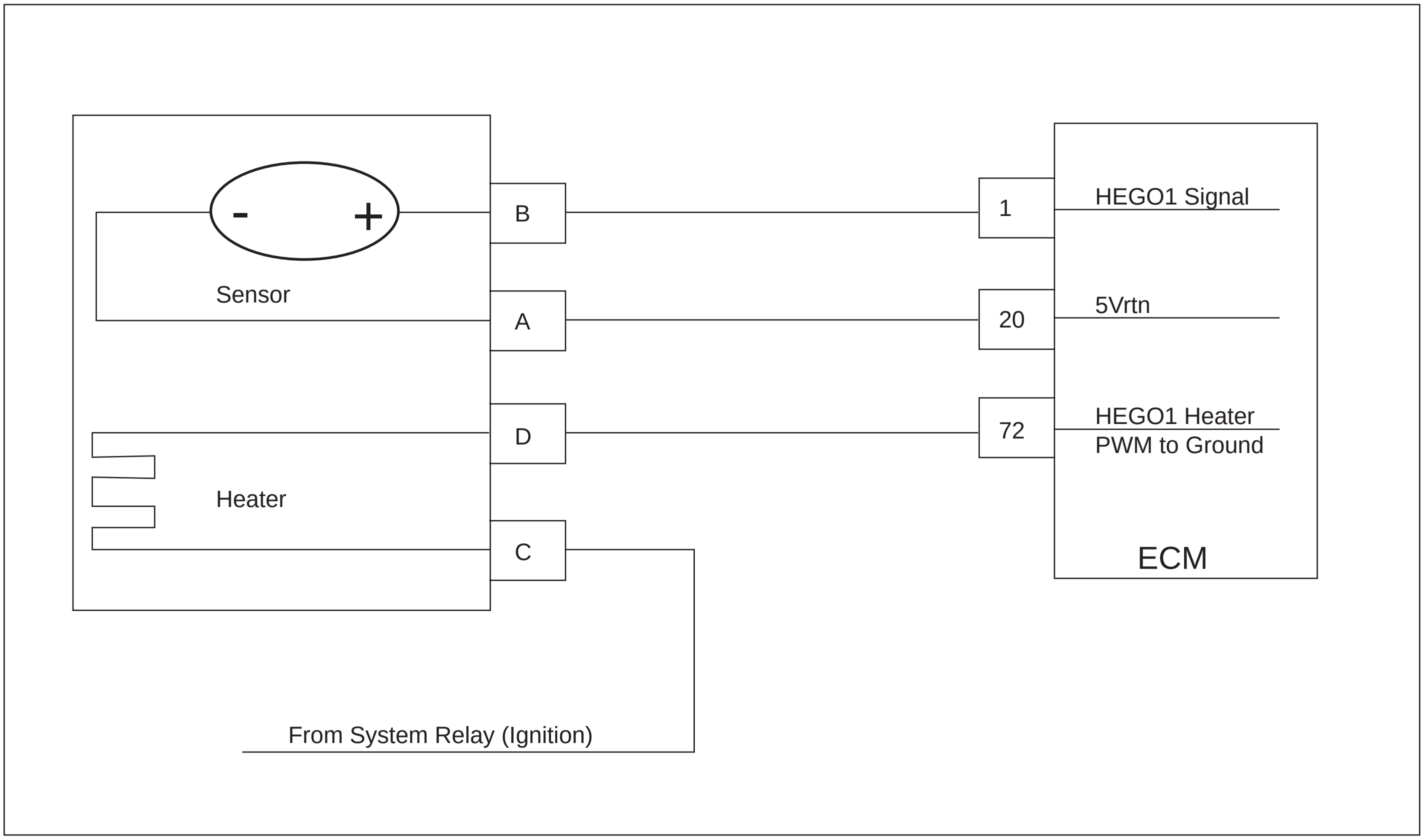
This fault sets if the Adaptive multiplier exceeds 30%, indicating that the engine is operating lean (excess oxygen) and requires more fuel than allowed by corrections. Often high positive fueling corrections are a function of one or more of the following conditions: 1) exhaust leaks upstream or near 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.

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.

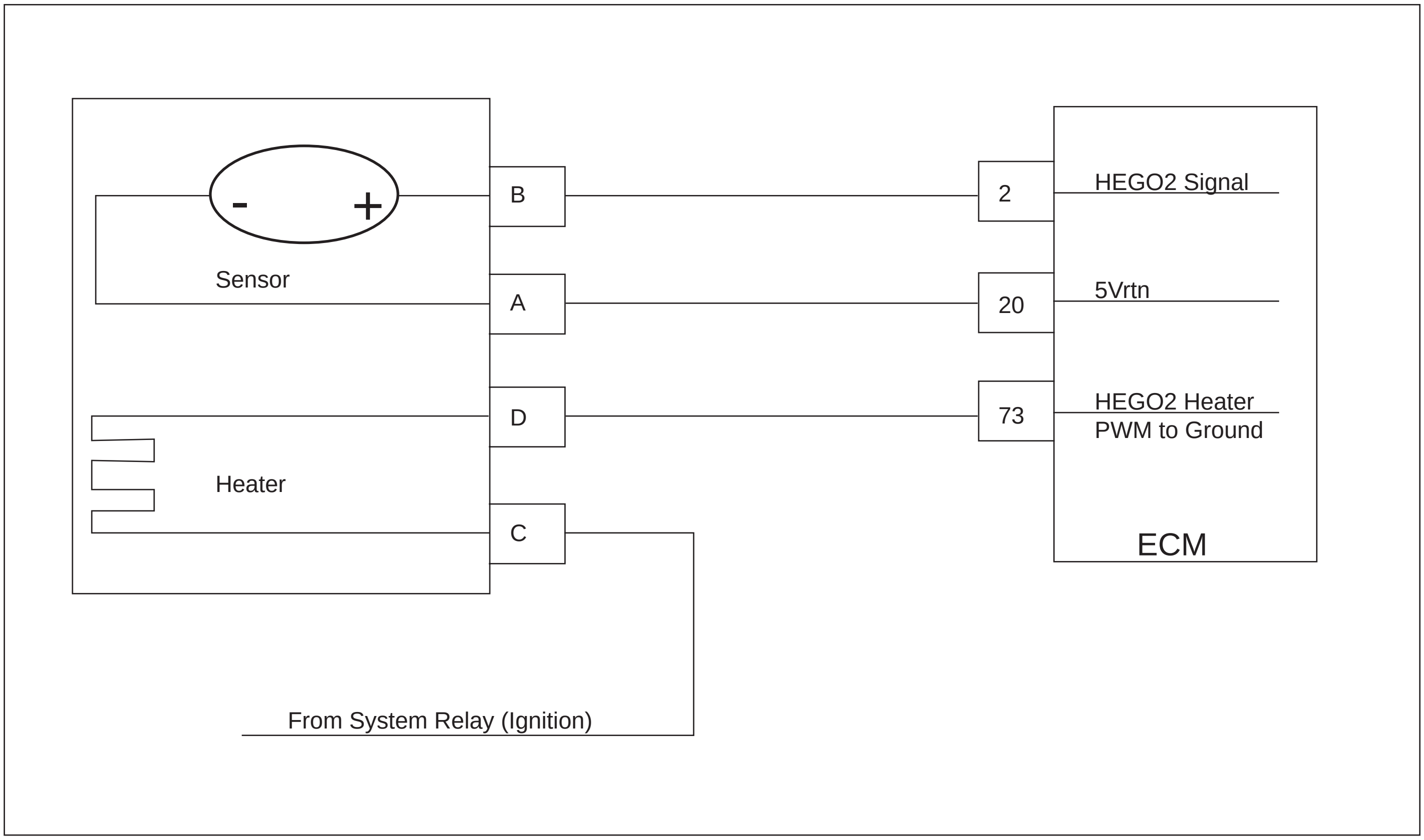
DTC 0172 - Adaptive-Learn Bank 1 Low
SPN - 4237; FMI - 1

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

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.

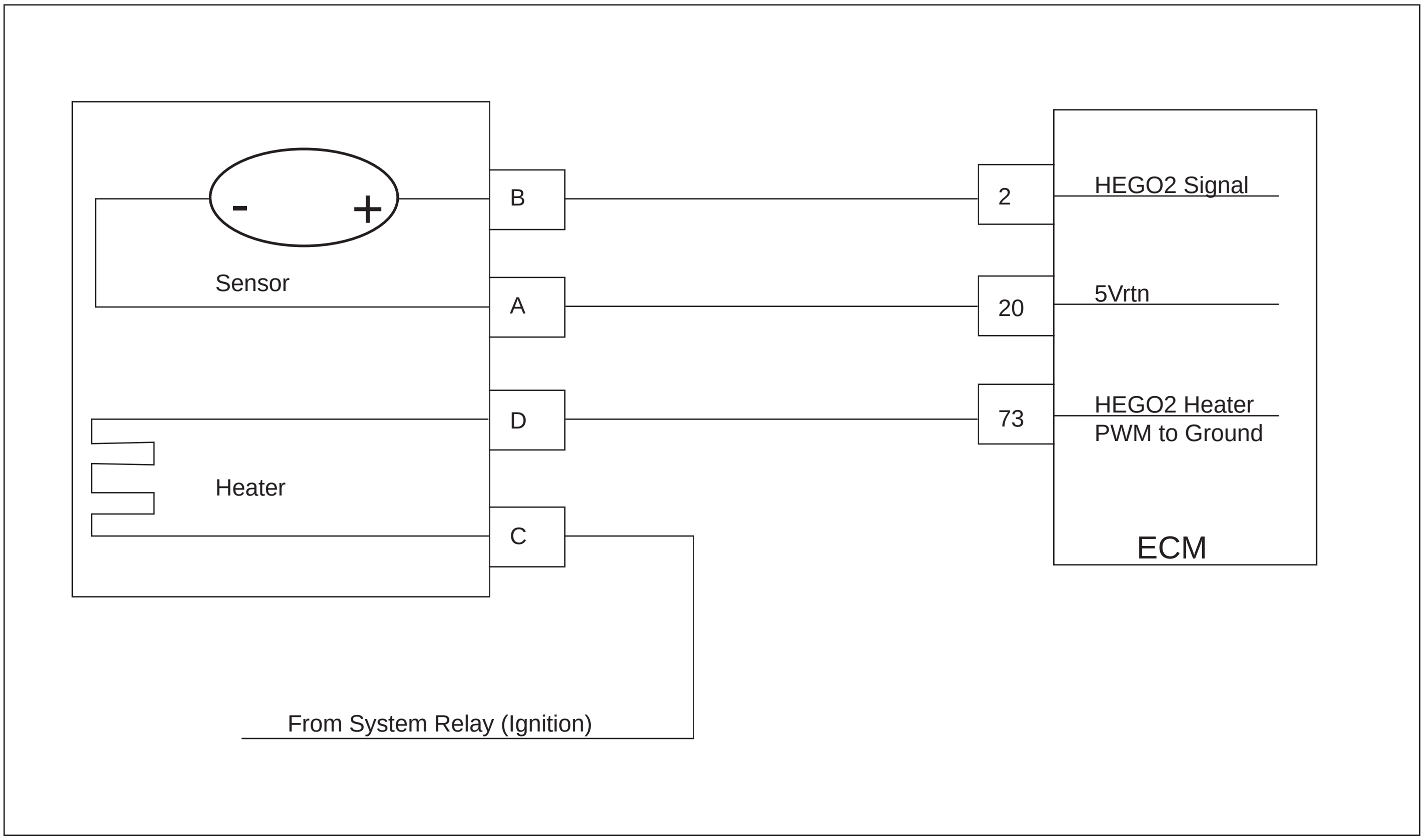
This fault sets if the Adaptive multiplier exceeds 30%, indicating that the engine is operating lean (excess oxygen) and requires more fuel than allowed by corrections. Often high positive fueling corrections are a function of one or more of the following conditions: 1) exhaust leaks upstream or near 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.

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.

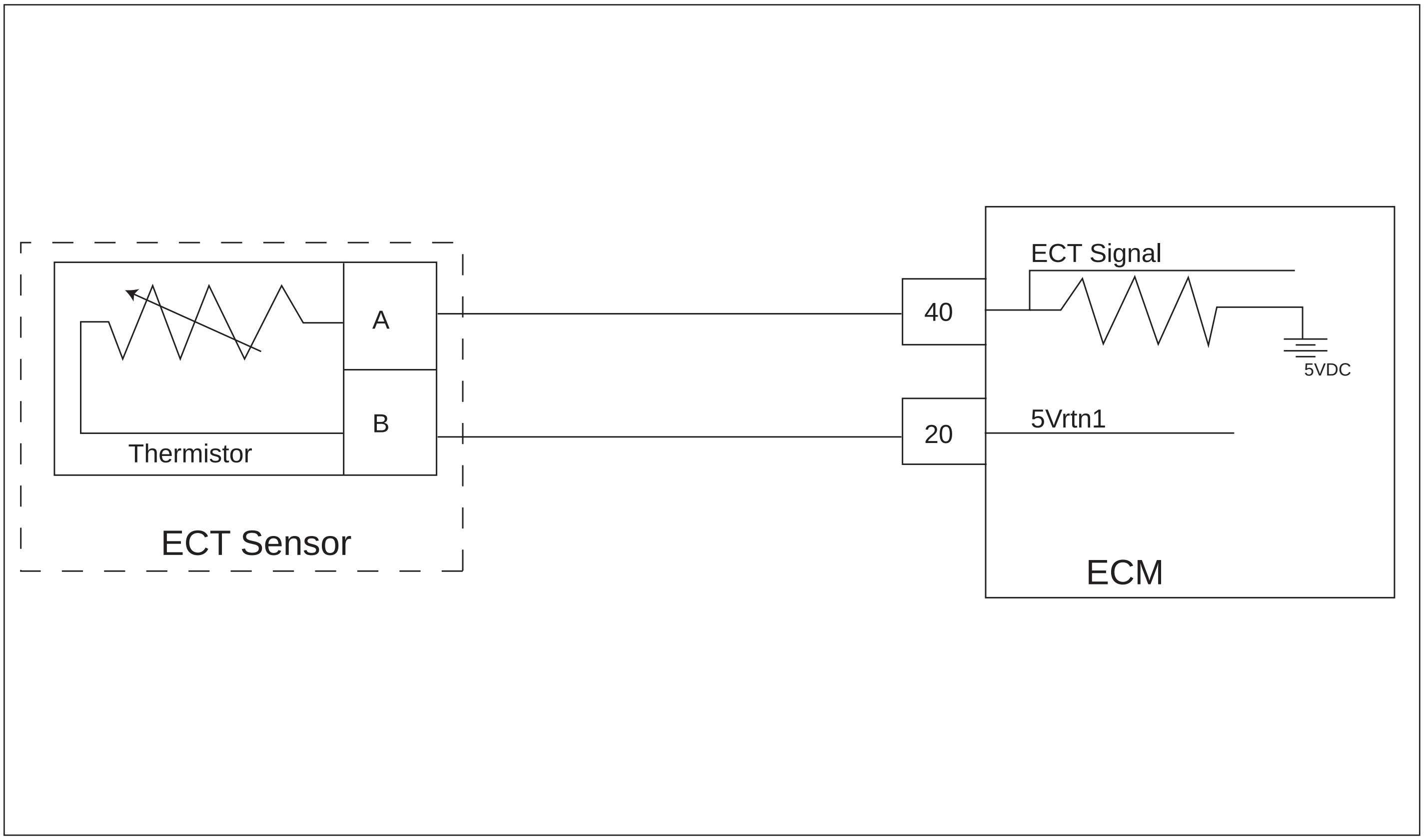
DTC 0175 - Adaptive-Learn Bank 2 Low
SPN - 4239; FMI - 1

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

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.

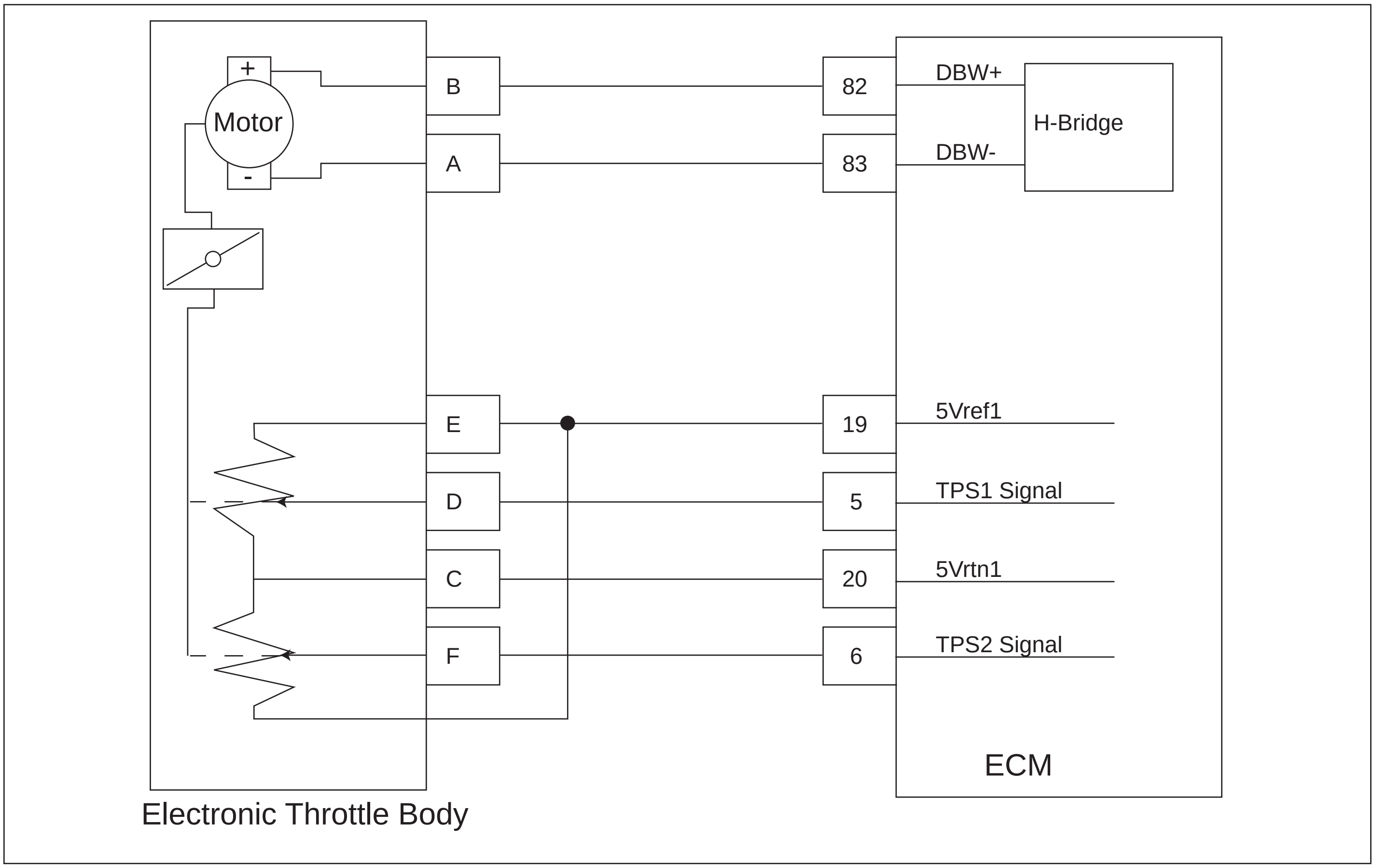
This fault will help protect the engine in the event of over temperature. When the coolant exceeds 210 deg. F and engine RPM exceeds 600 RPM for the latch time this fault will set.

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

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.

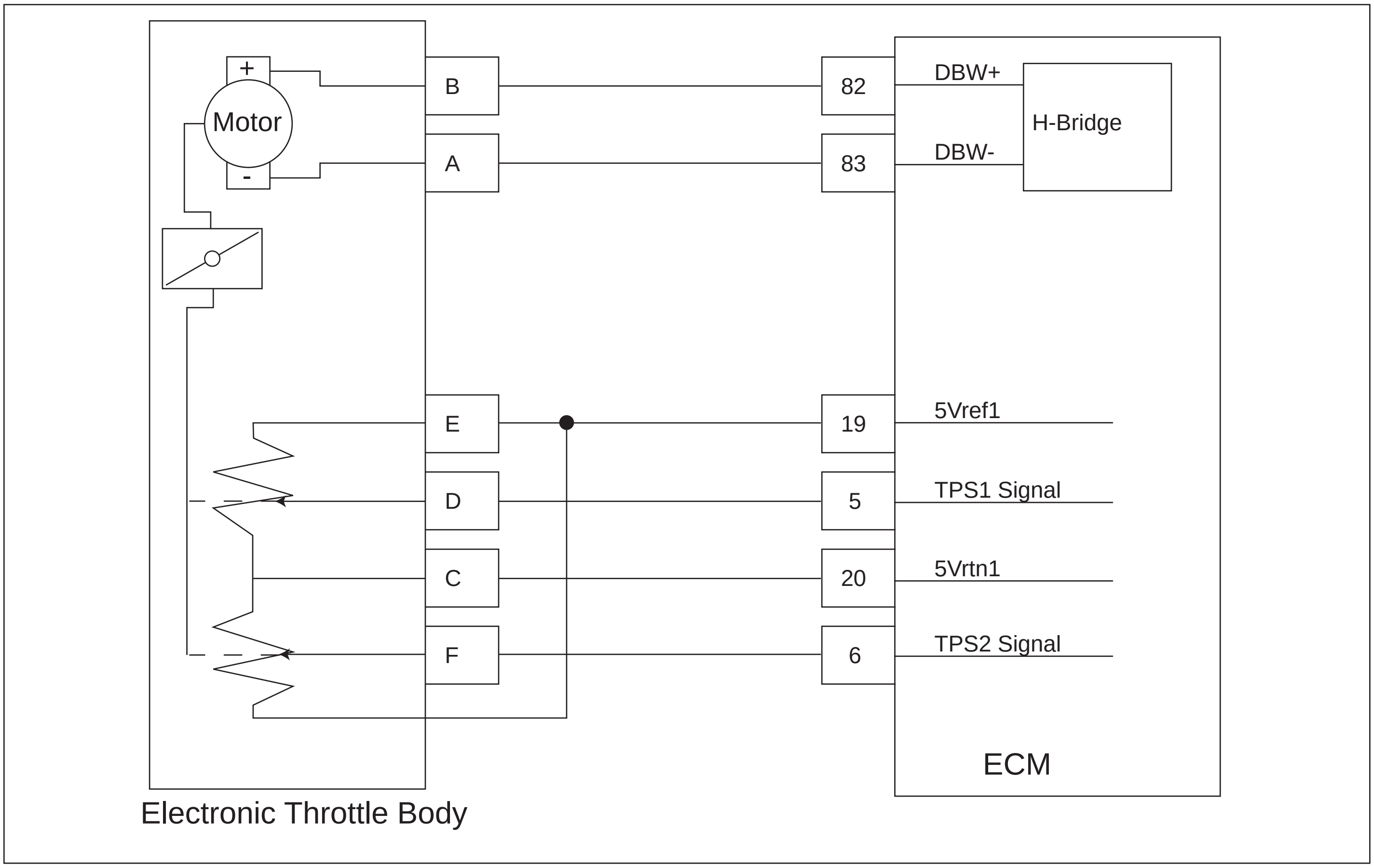
DTC 0219 - RPM Higher Than Max Allowed Governed Speed
SPN - 515; FMI - 15

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

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



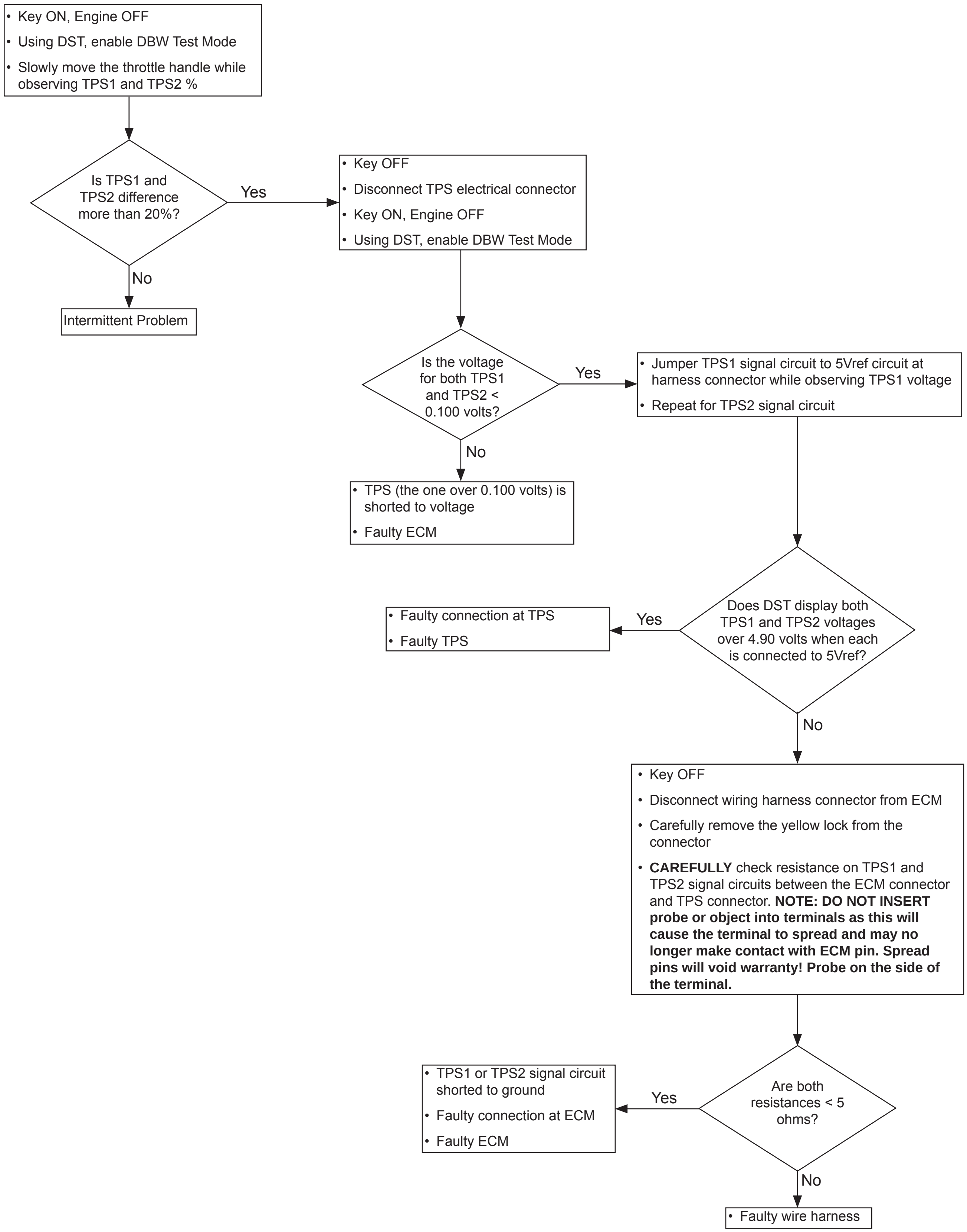
- Throttle Body-Throttle Position Sensor 1 & 2 (electronic throttle body only)
- *Check Condition* - Key-On, Engine Cranking, or Running
- *Fault Condition* - TPS1 higher than TPS2 by 20%
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions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

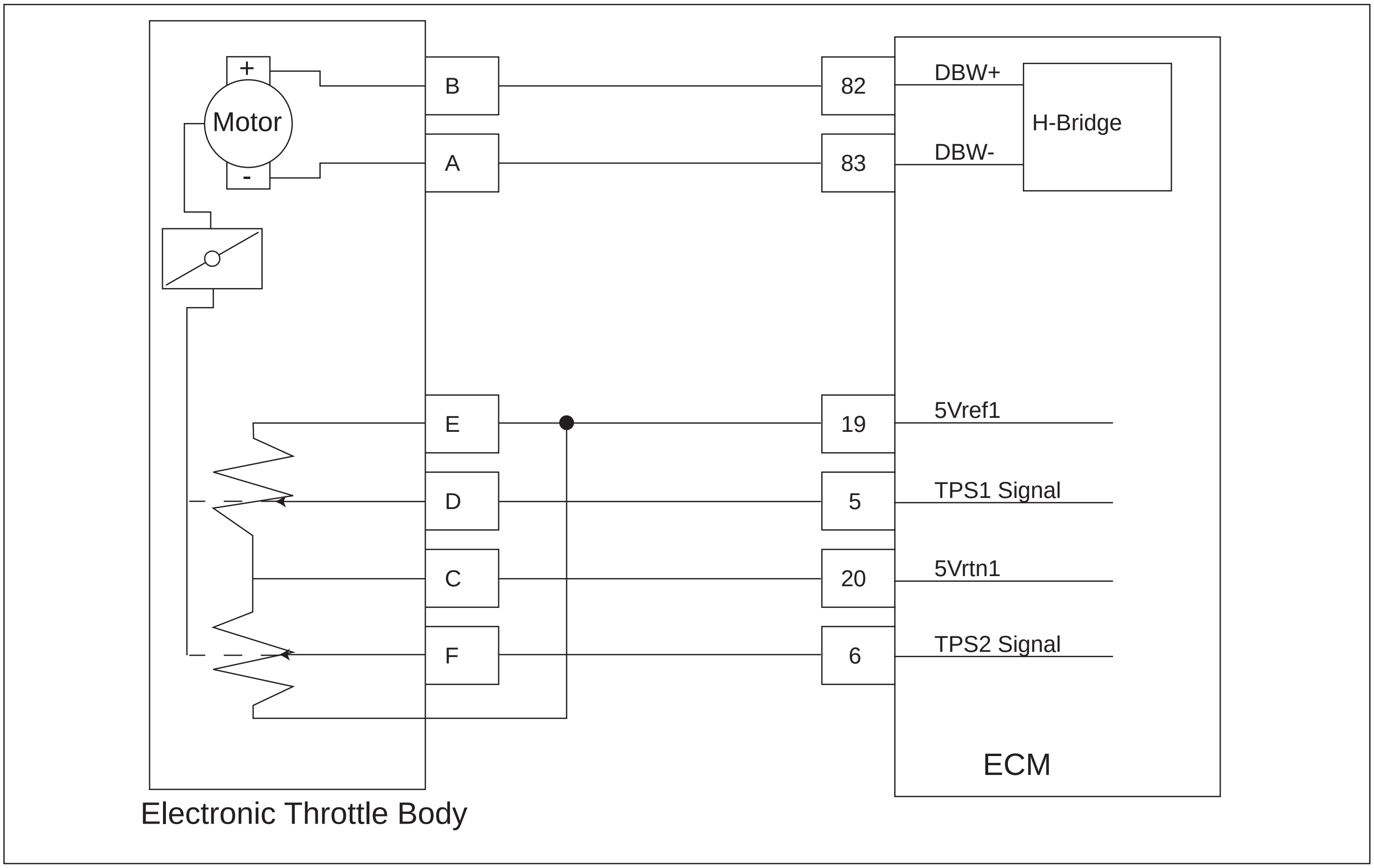
The Throttle Position Sensor uses a variable resistor and voltage divider circuitr to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In an Electronic 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 is 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



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



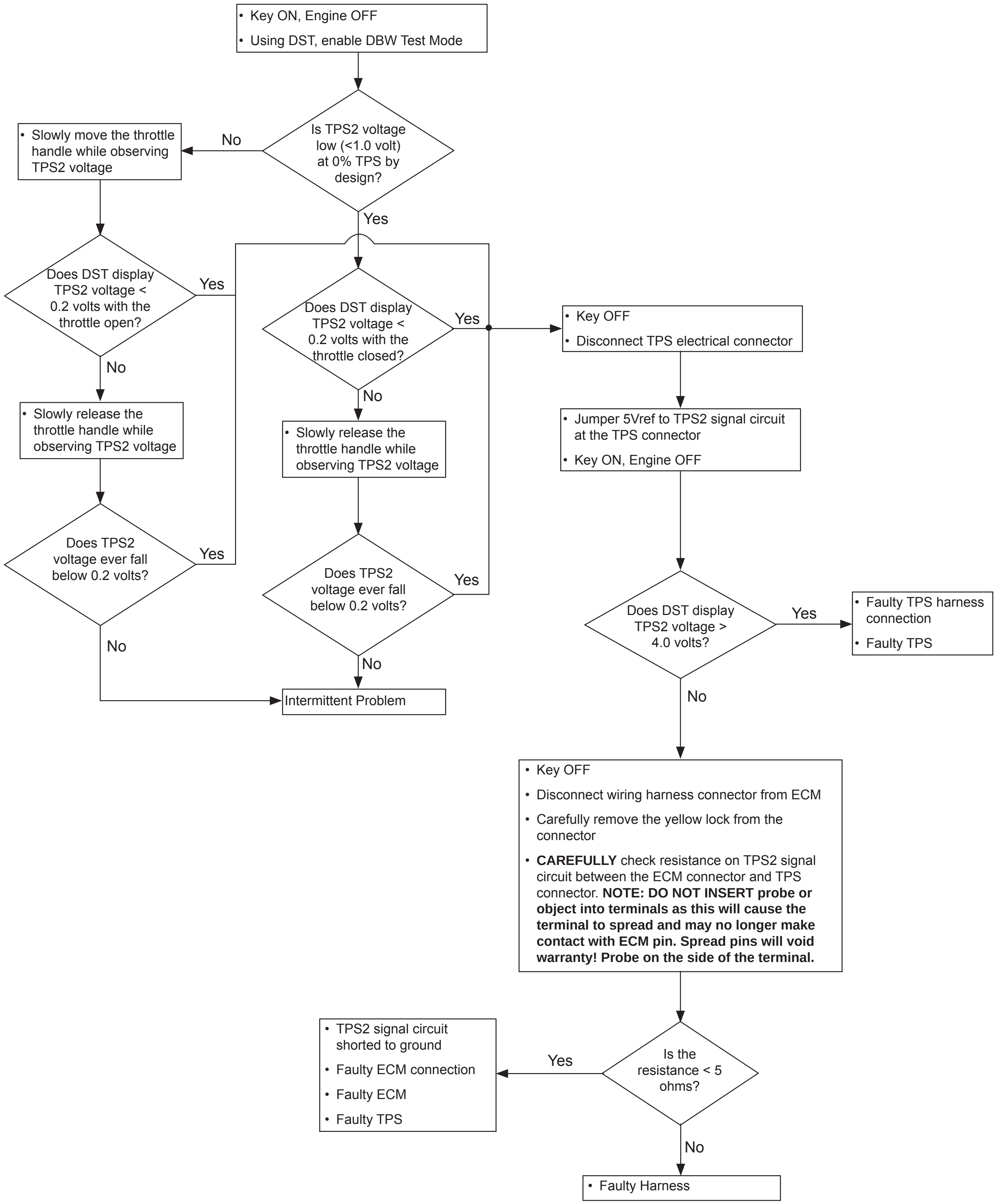
- Throttle Body - Throttle Position Sensor 2
- *Check Condition* - Key On, Engine Cranking or Running
- *Fault Condition* - TPS2 sensor voltage lower than 0.20 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions related fault

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.

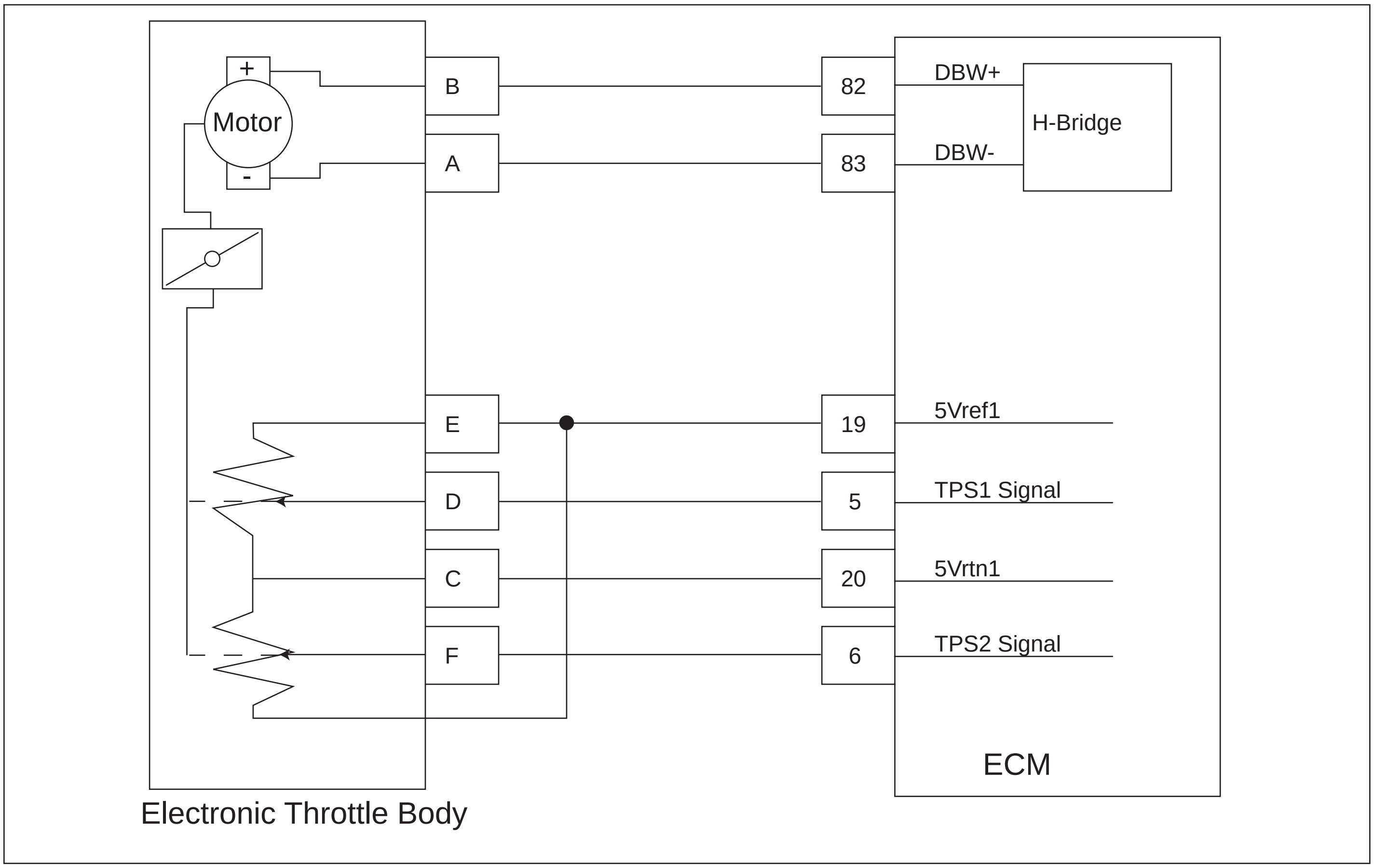
The Throttle Position Sensor uses a variable resistor and voltage divider circuitr to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In an Electronic 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



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



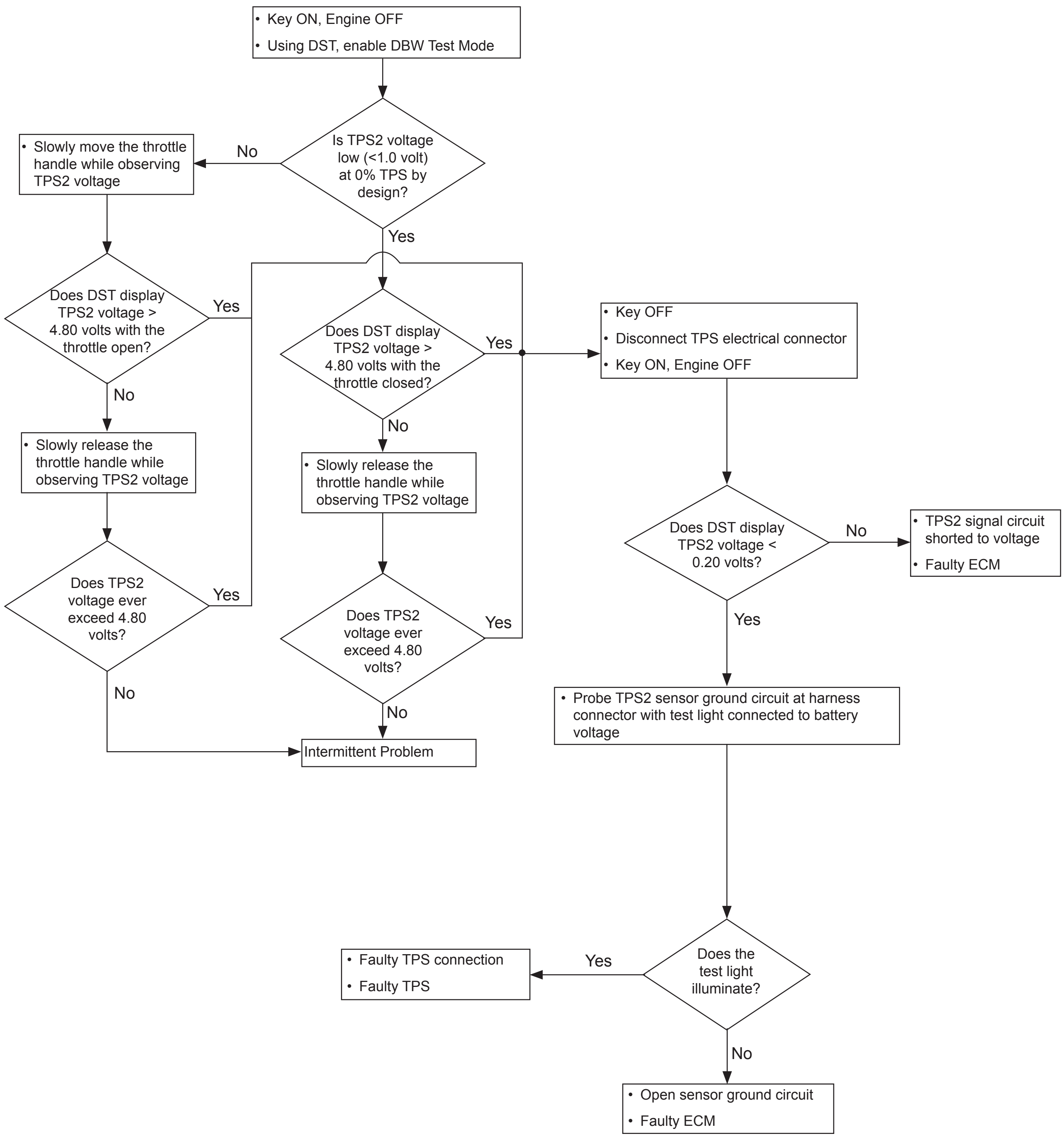
- Throttle Body - Throttle Position Sensor 2
- *Check Condition* - Key On, Engine Cranking or Running
- *Fault Condition* - TPS2 sensor voltage higher than 4.80 volts
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, shutdown engine
- Non-emissions related fault

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.

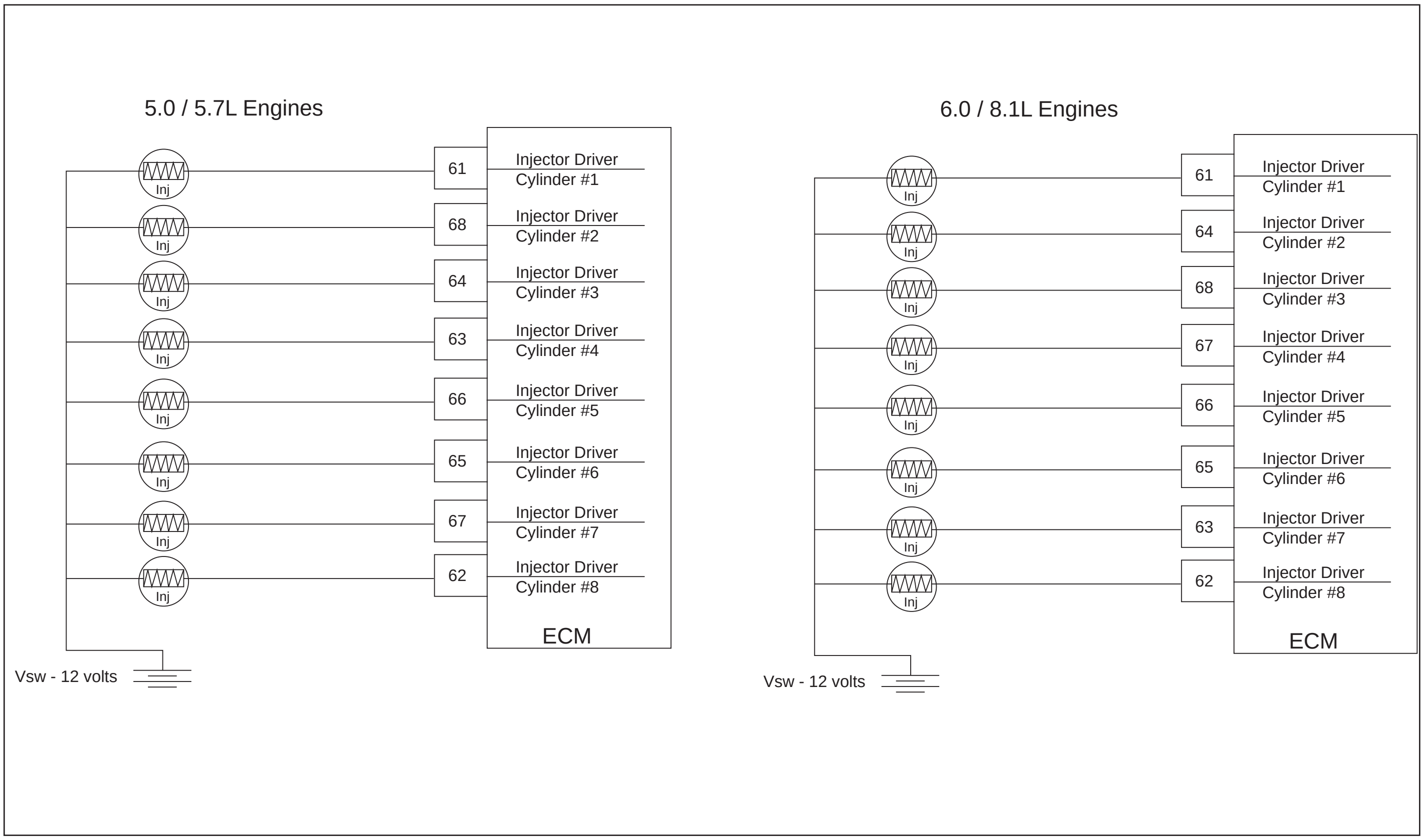
The Throttle Position Sensor uses a variable resistor and voltage divider circuitr to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In an Electronic 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



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

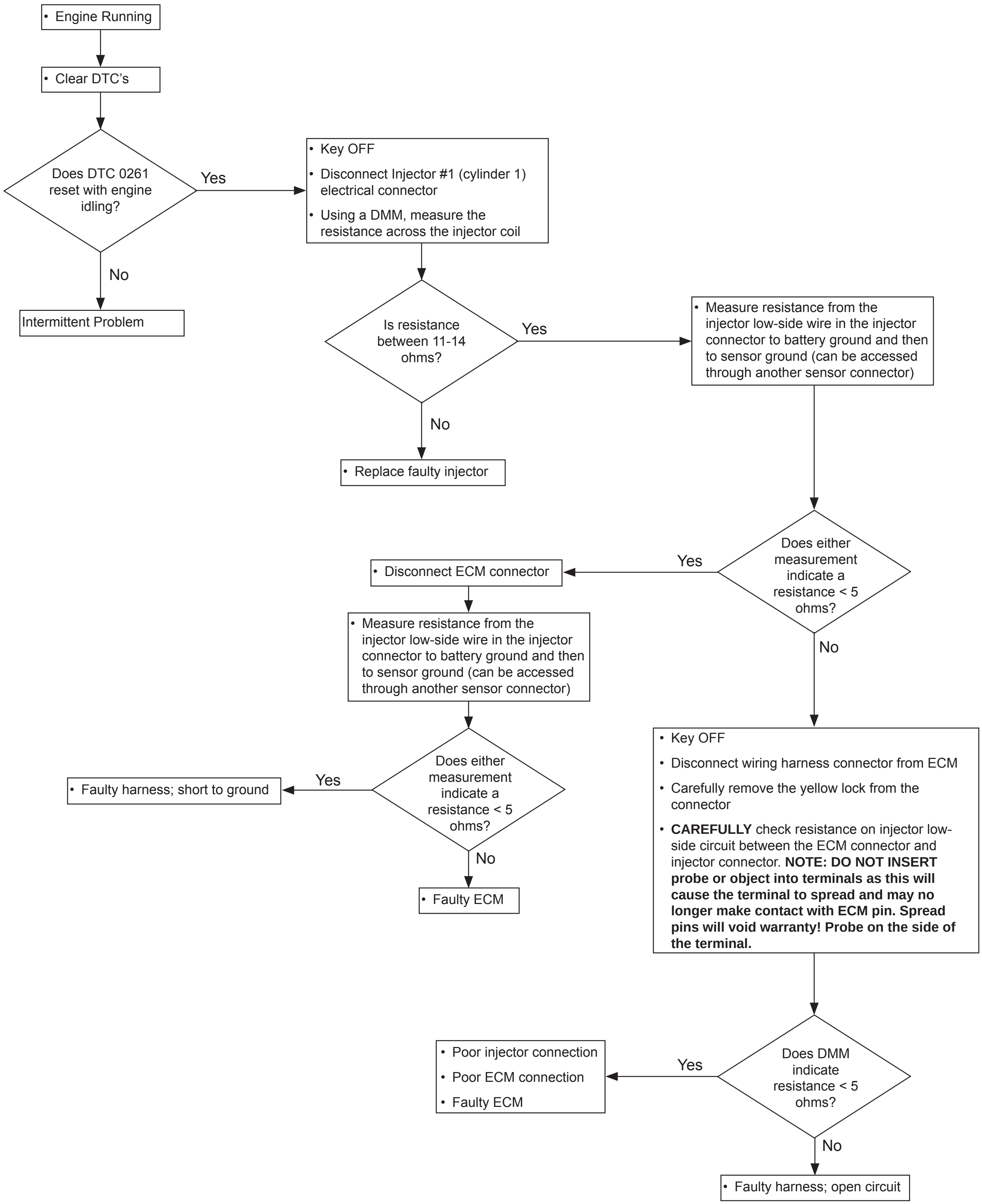


- Injector #1 Coil or Driver Open Circuit or Short-to-Ground
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM greater than 9.0 volts and injector low-side less than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible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

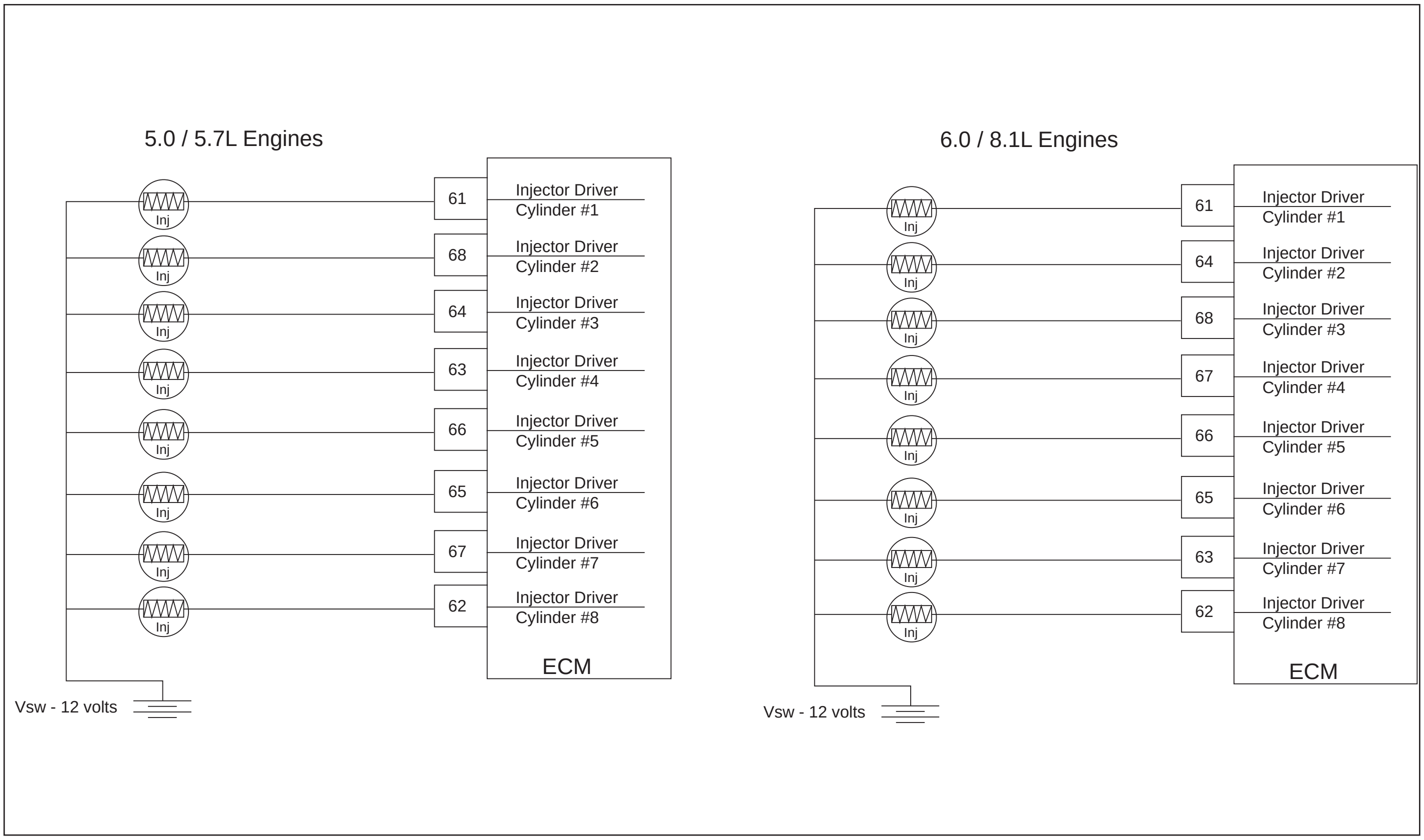
The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #1.

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



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

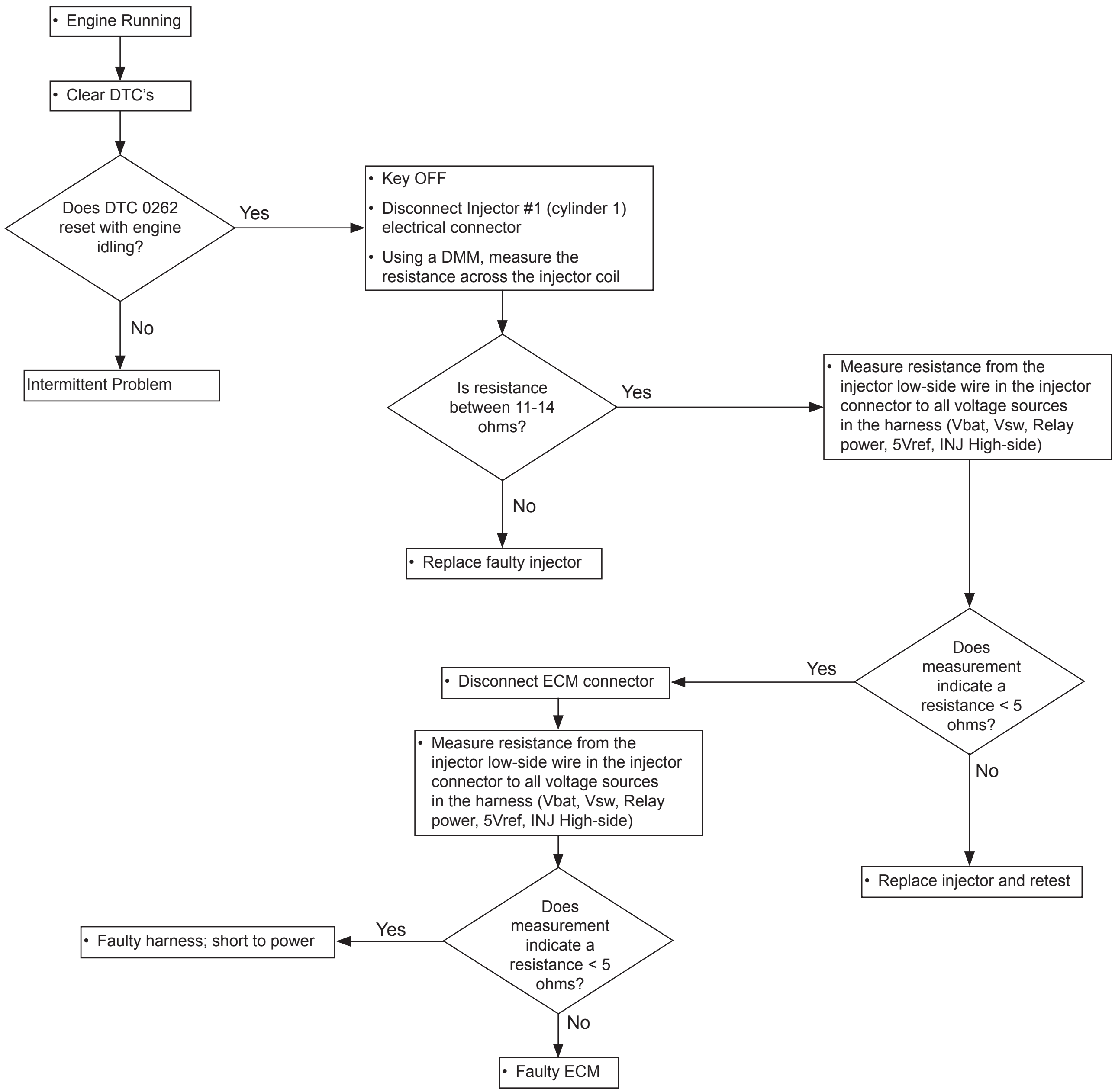


- Injector #1 Coil or Driver Short-to-Power
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM less than 16.0 volts and injector low-side greater than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable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

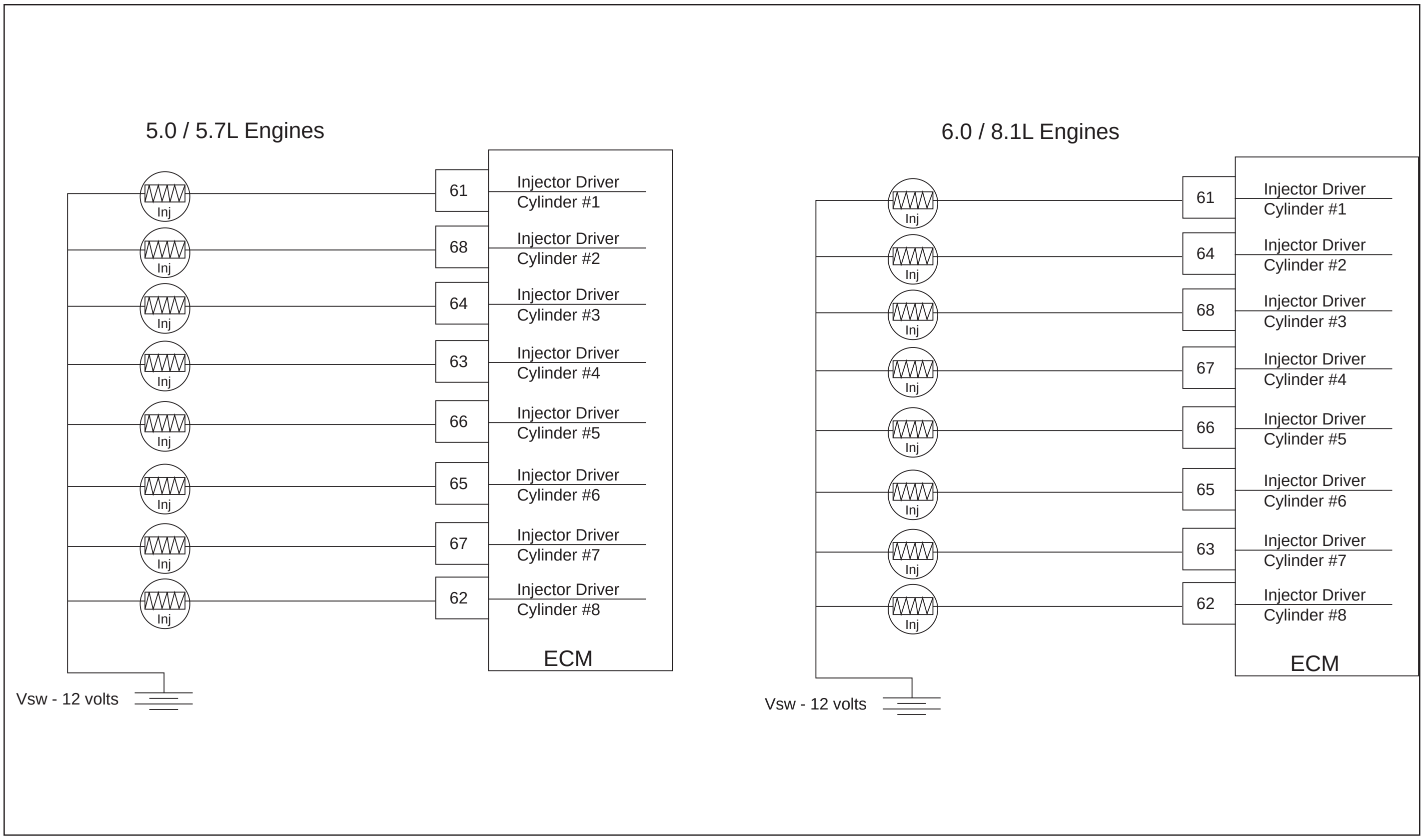
The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #1.

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



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

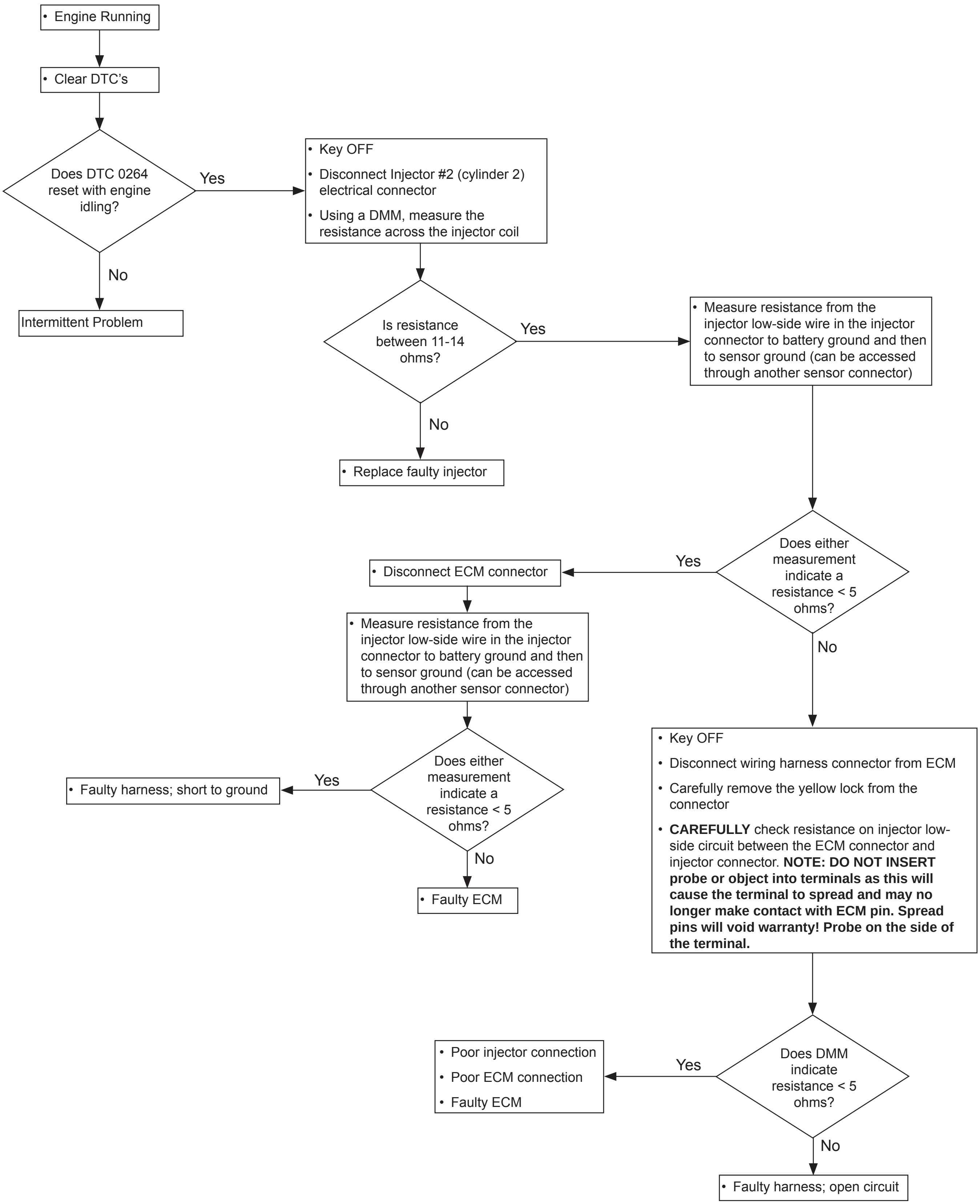


- Injector #2 Coil or Driver Open Circuit or Short-to-Ground
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM greater than 9.0 volts and injector low-side less than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible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

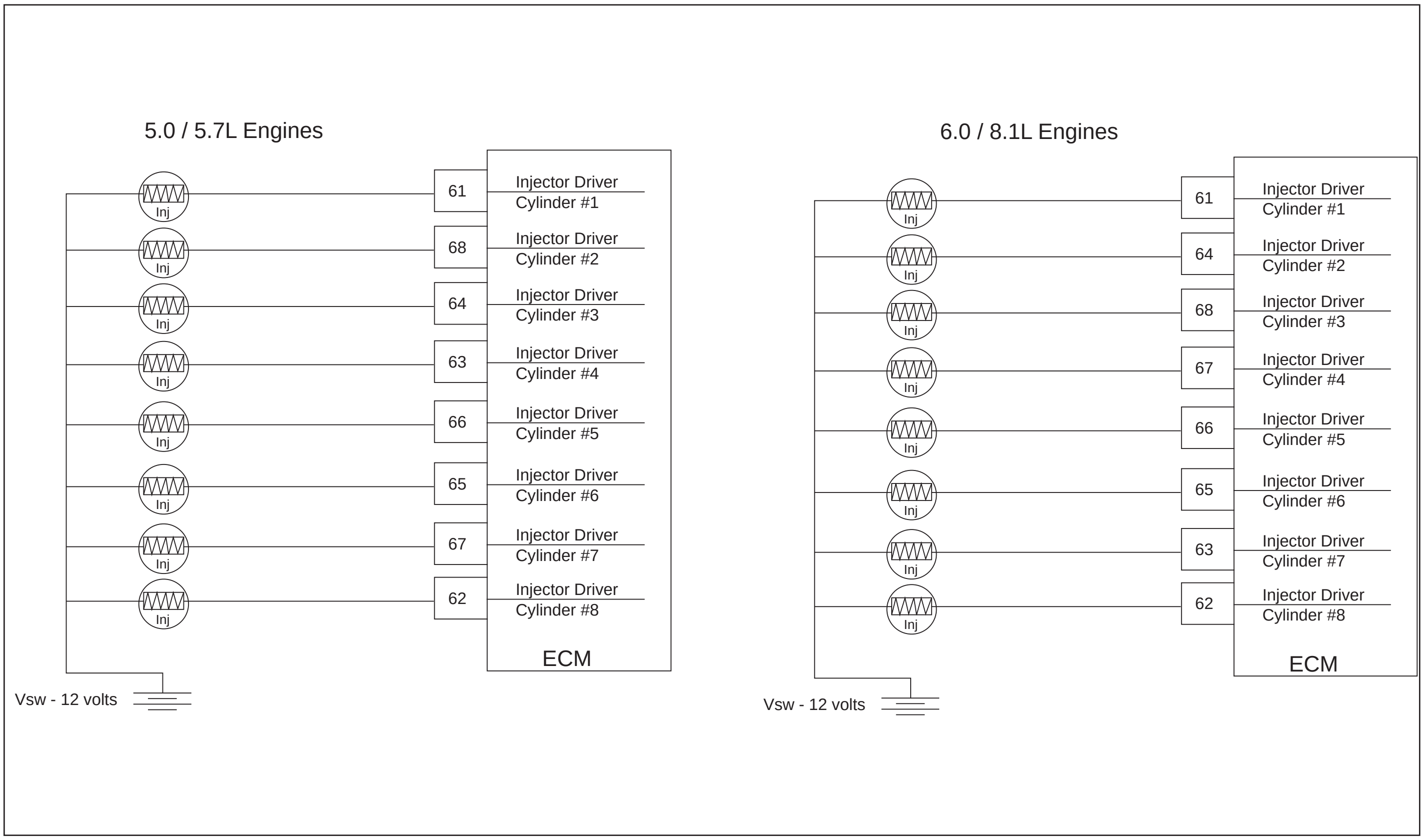
The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #2.

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



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

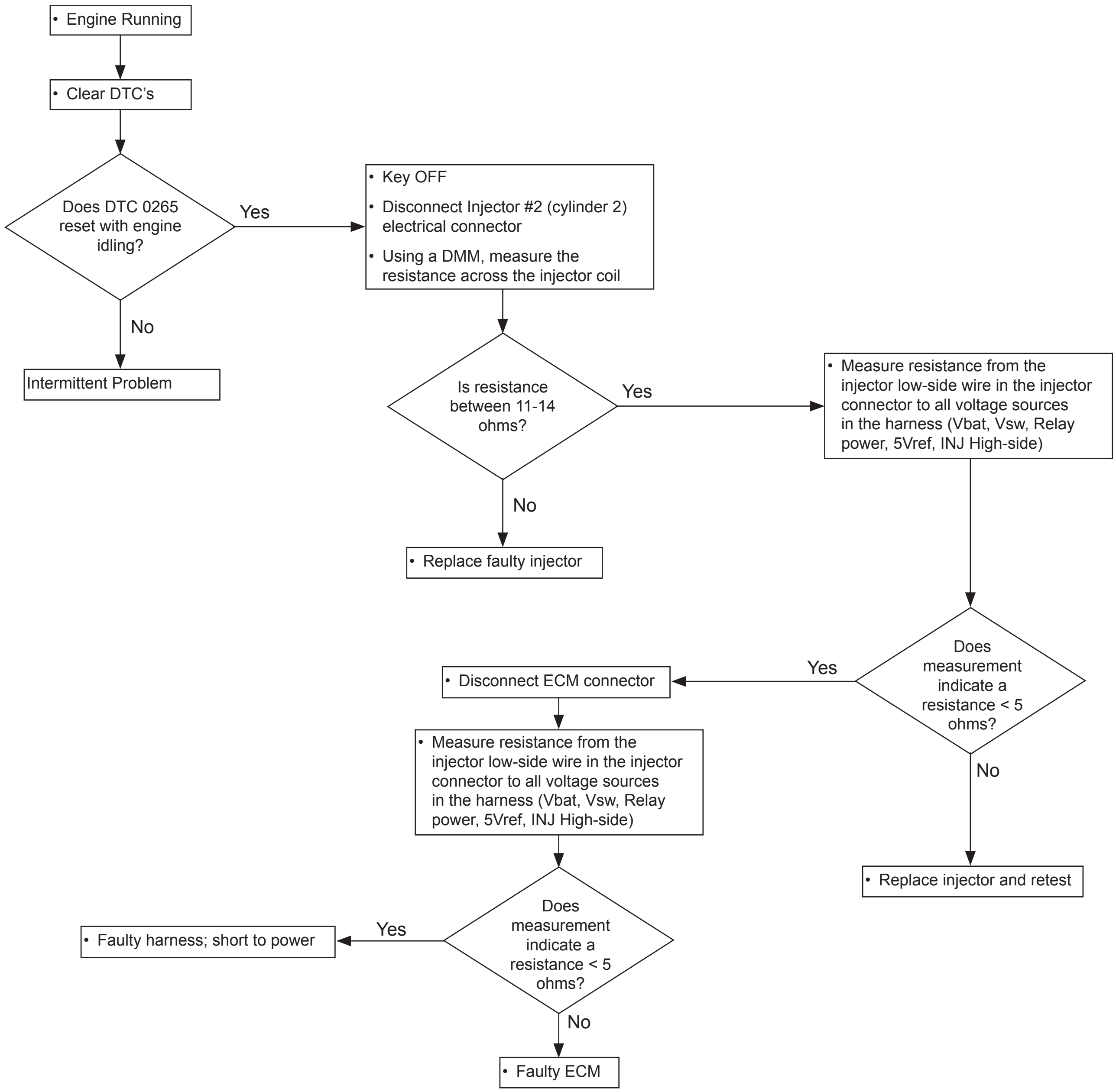


- Injector #2 Coil or Driver Short-to-Power
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM less than 16.0 volts and injector low-side greater than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable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

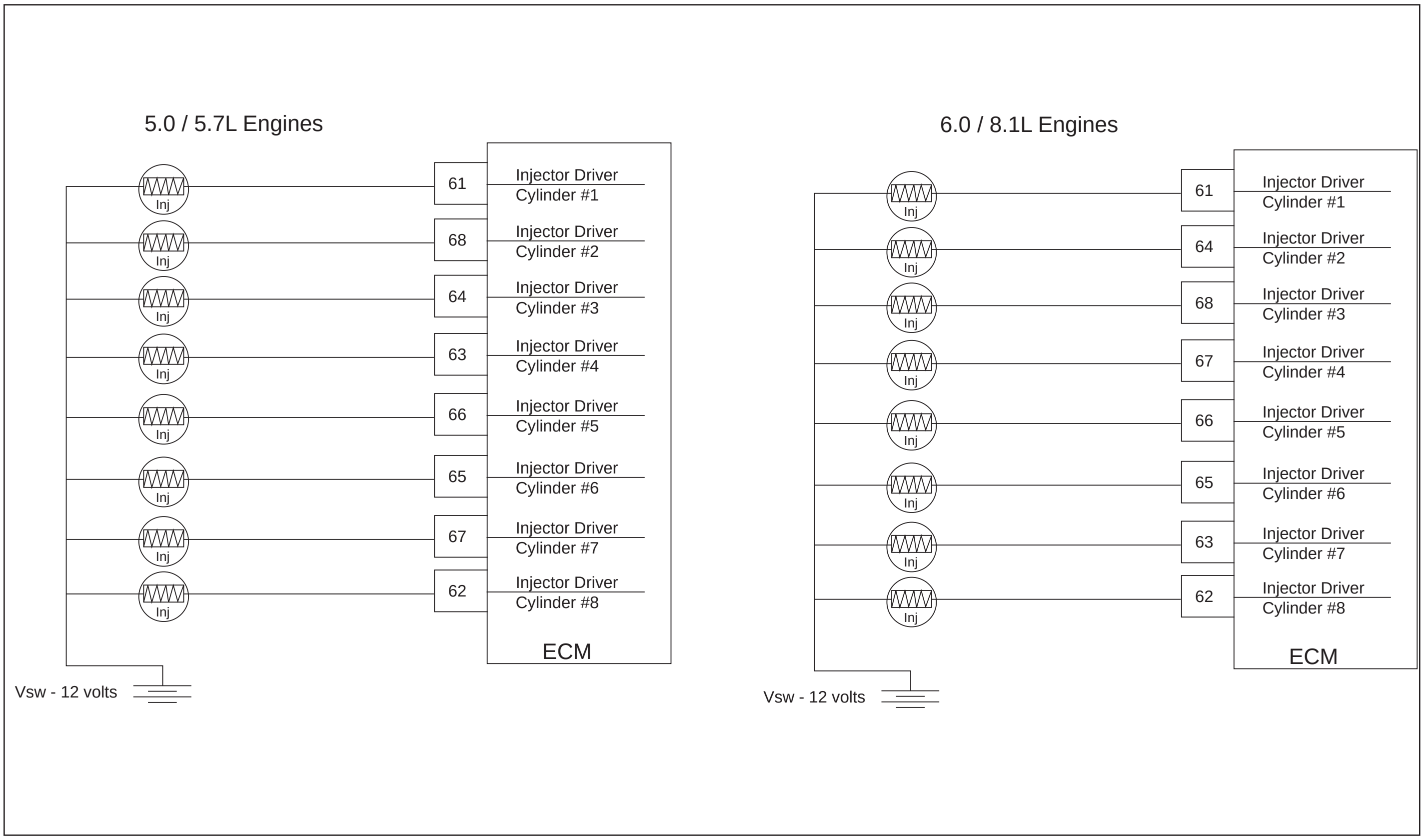
The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #2.

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



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

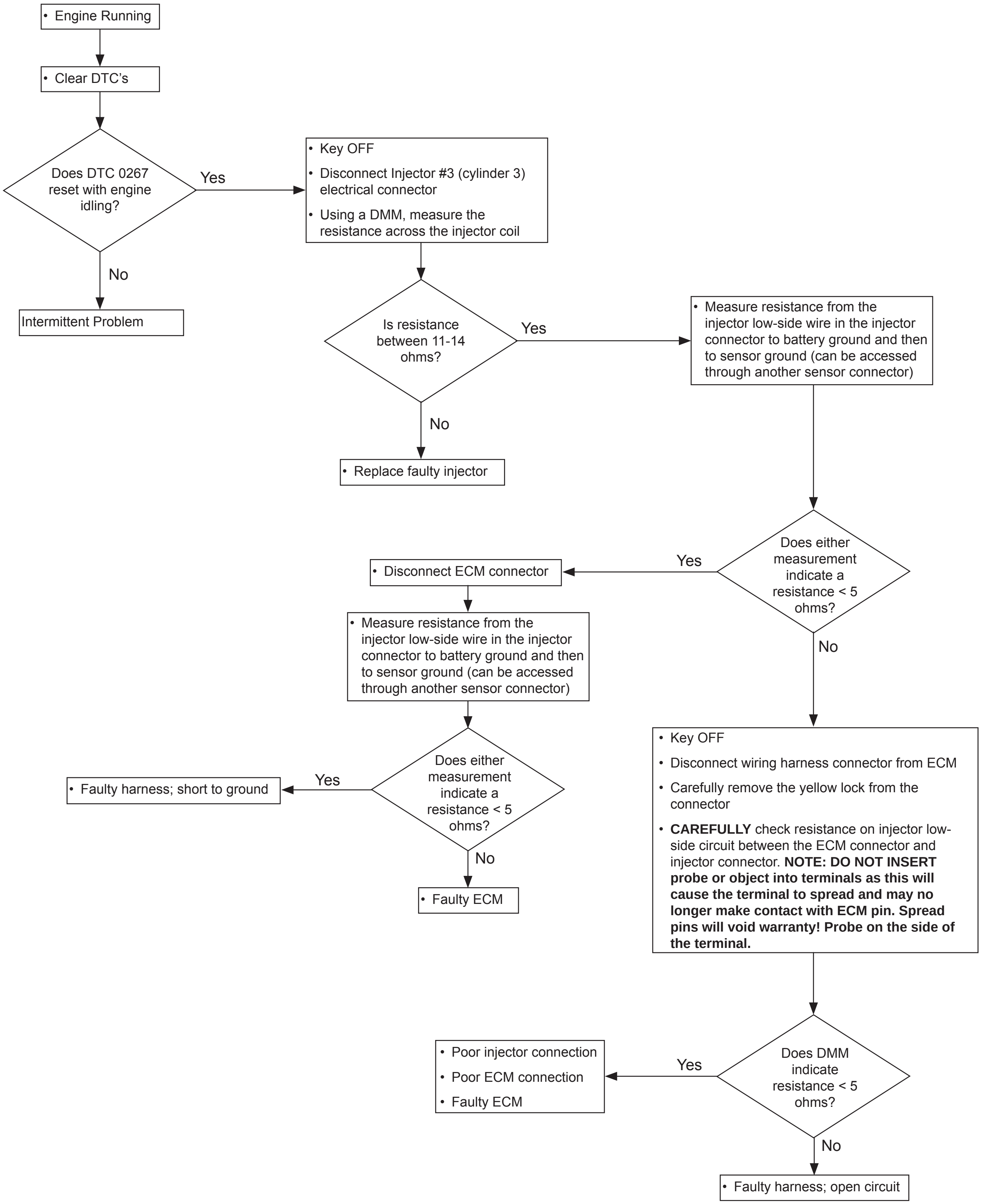


- Injector #3 Coil or Driver Open Circuit or Short-to-Ground
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM greater than 9.0 volts and injector low-side less than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible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

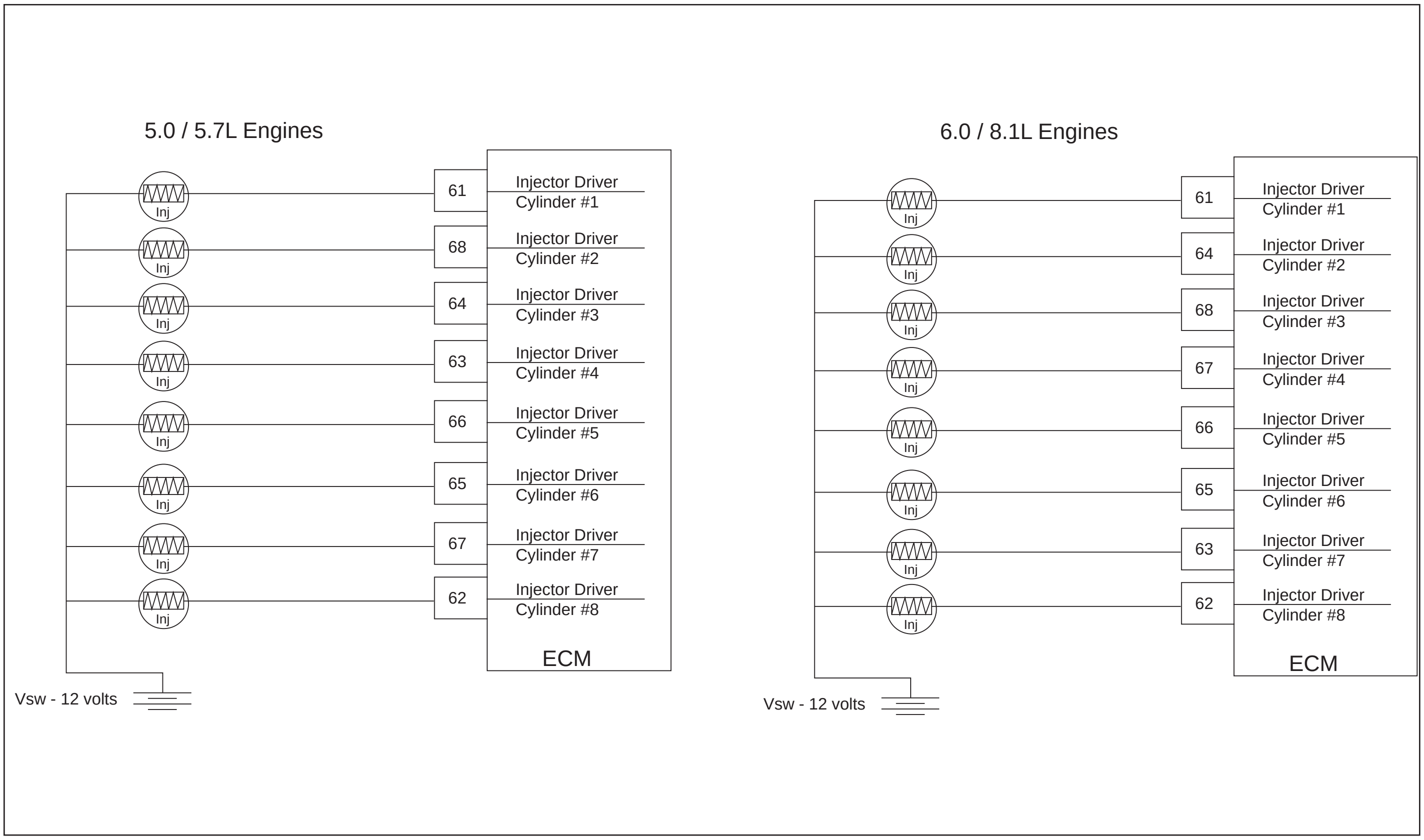
The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #3.

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



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

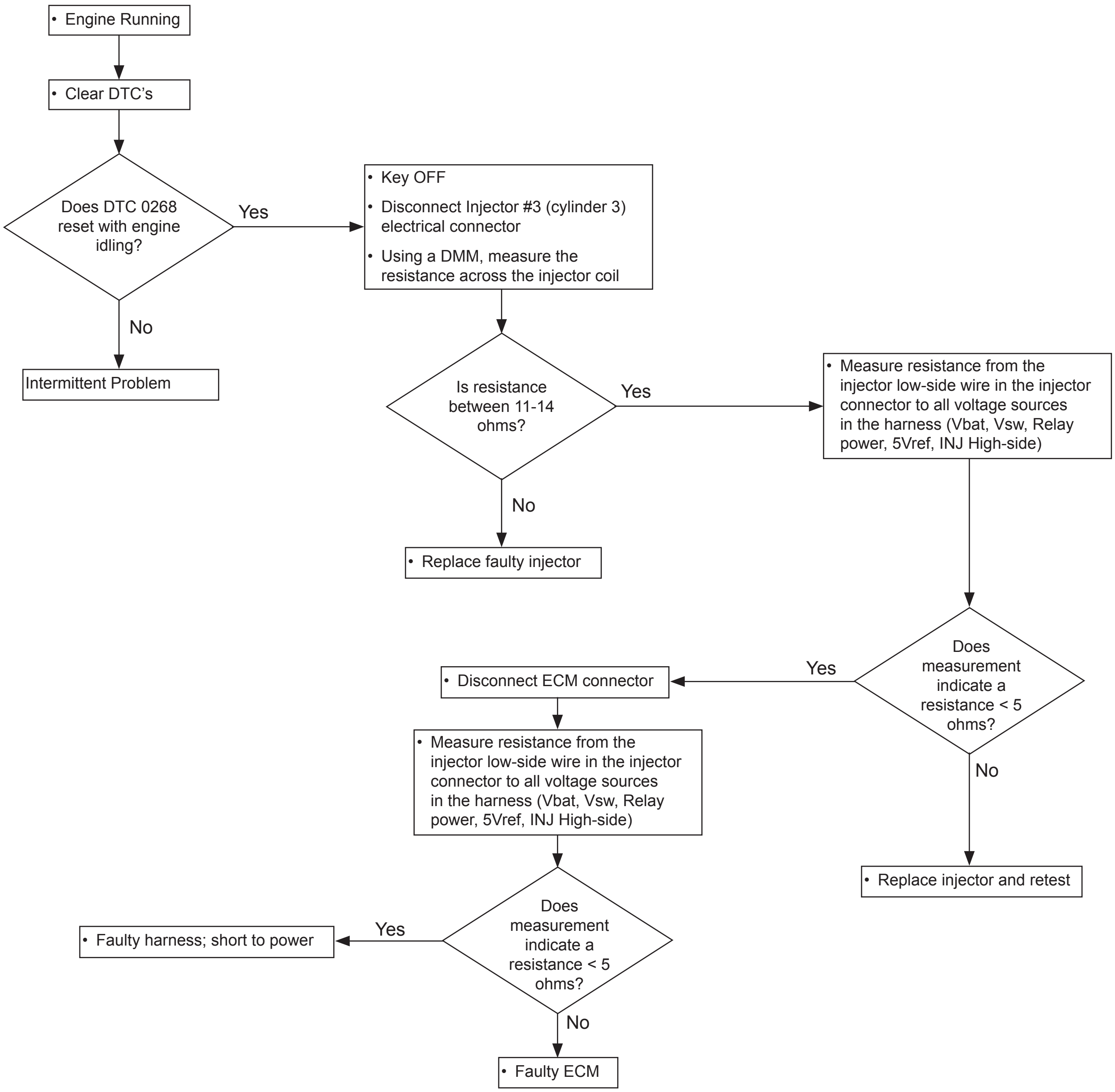


- Injector #3 Coil or Driver Short-to-Power
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM less than 16.0 volts and injector low-side greater than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable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

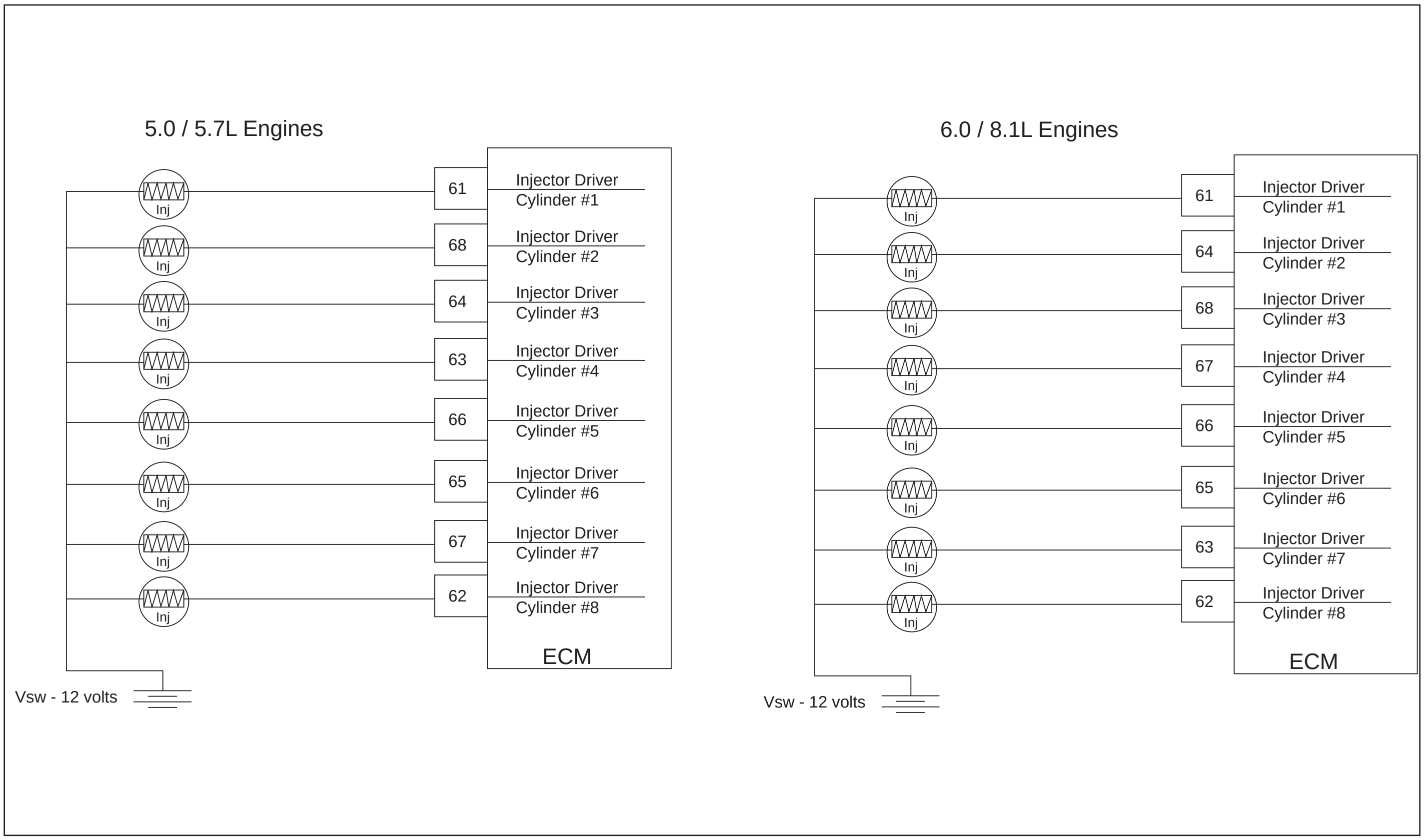
The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #3.

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



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

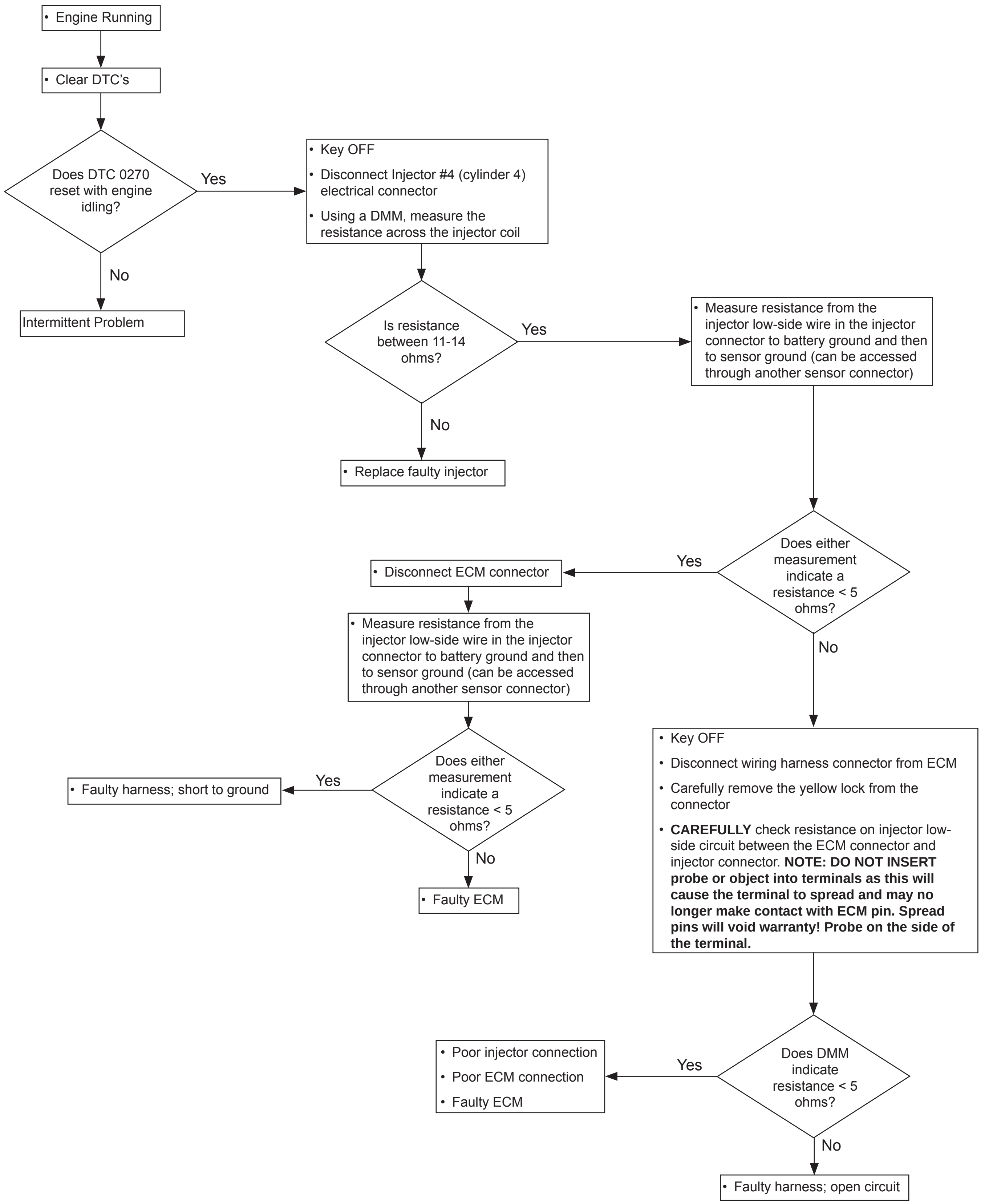


- Injector #4 Coil or Driver Open Circuit or Short-to-Ground
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM greater than 9.0 volts and injector low-side less than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible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

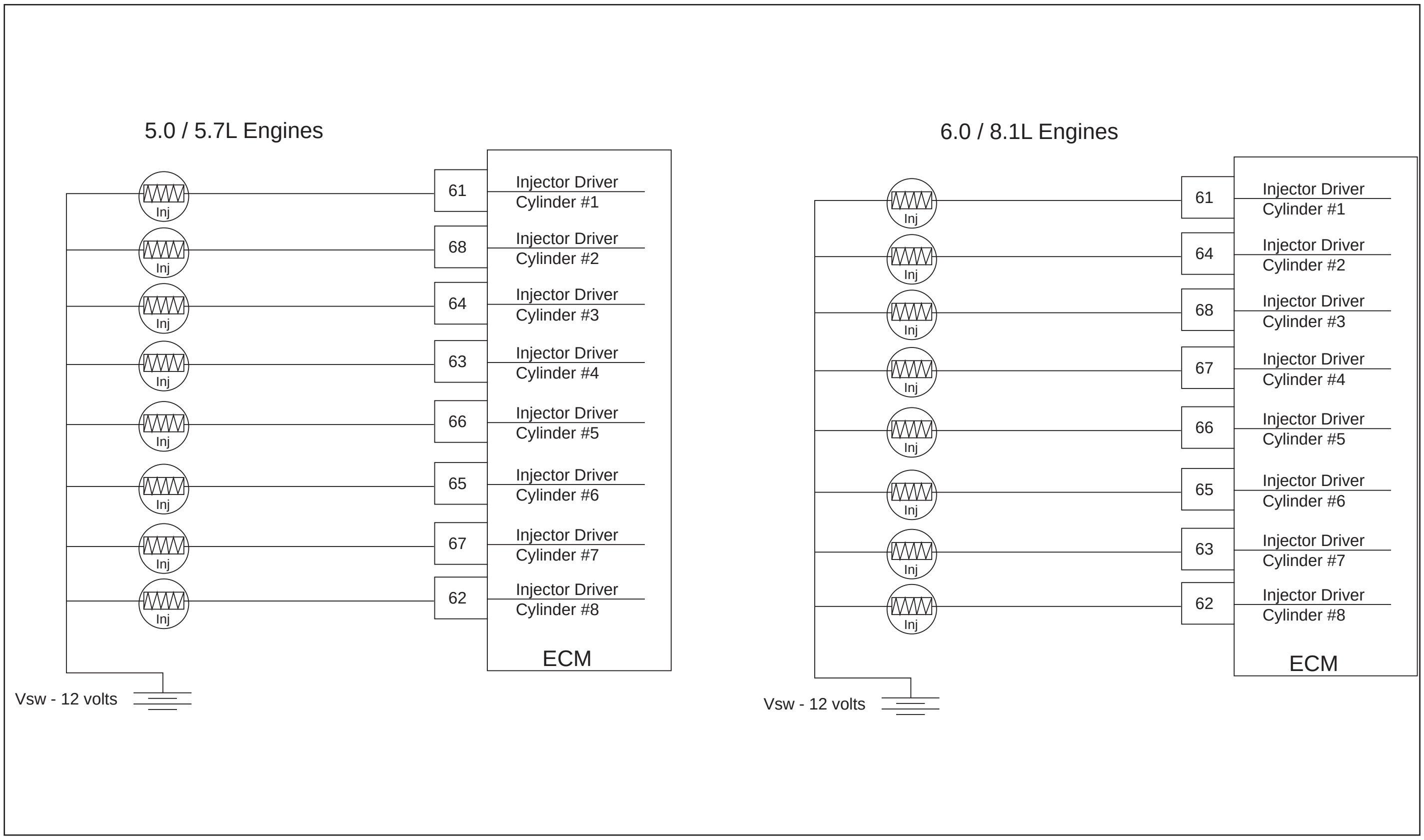
The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #4.

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



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

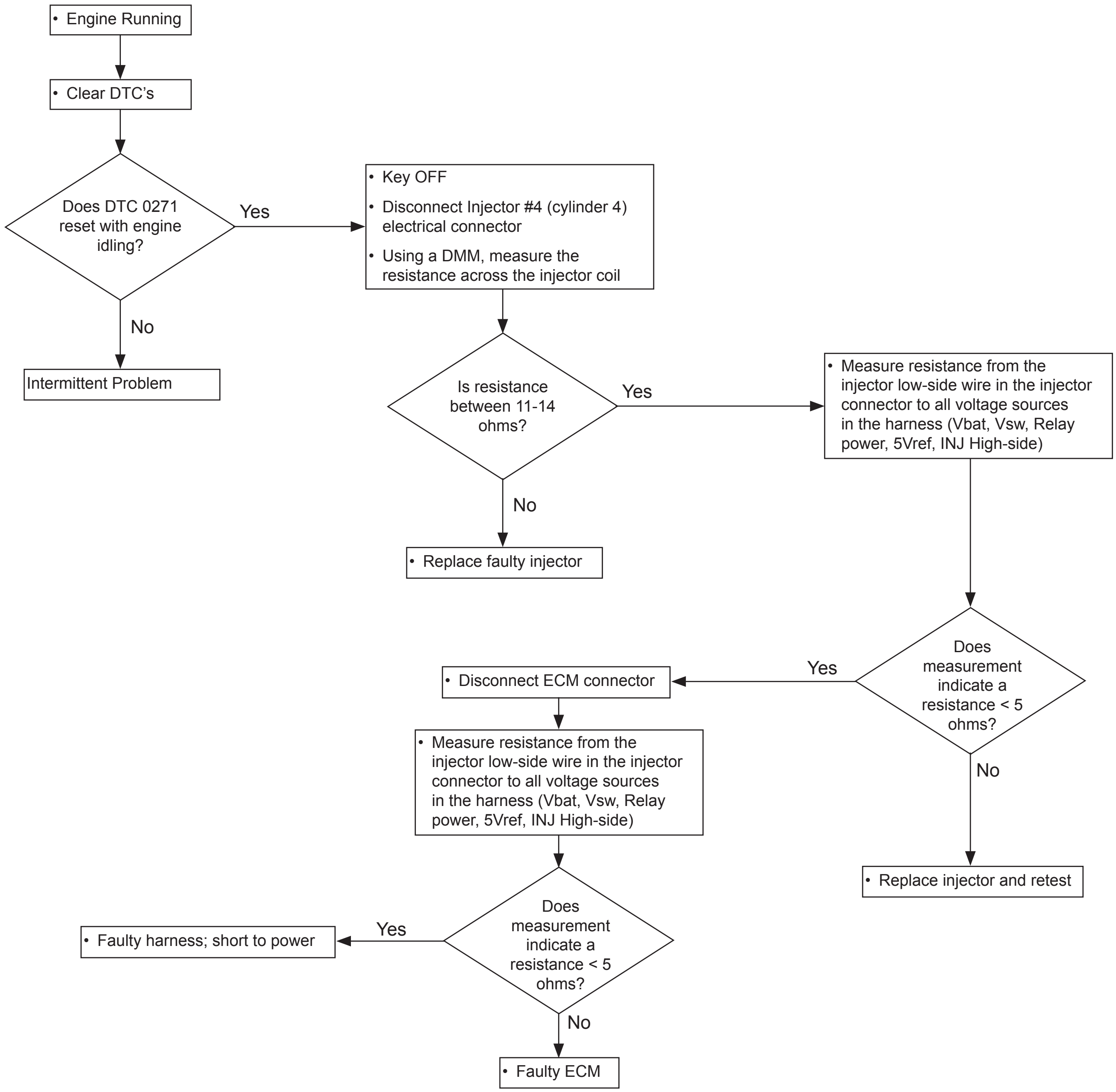


- Injector #4 Coil or Driver Short-to-Power
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM less than 16.0 volts and injector low-side greater than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable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

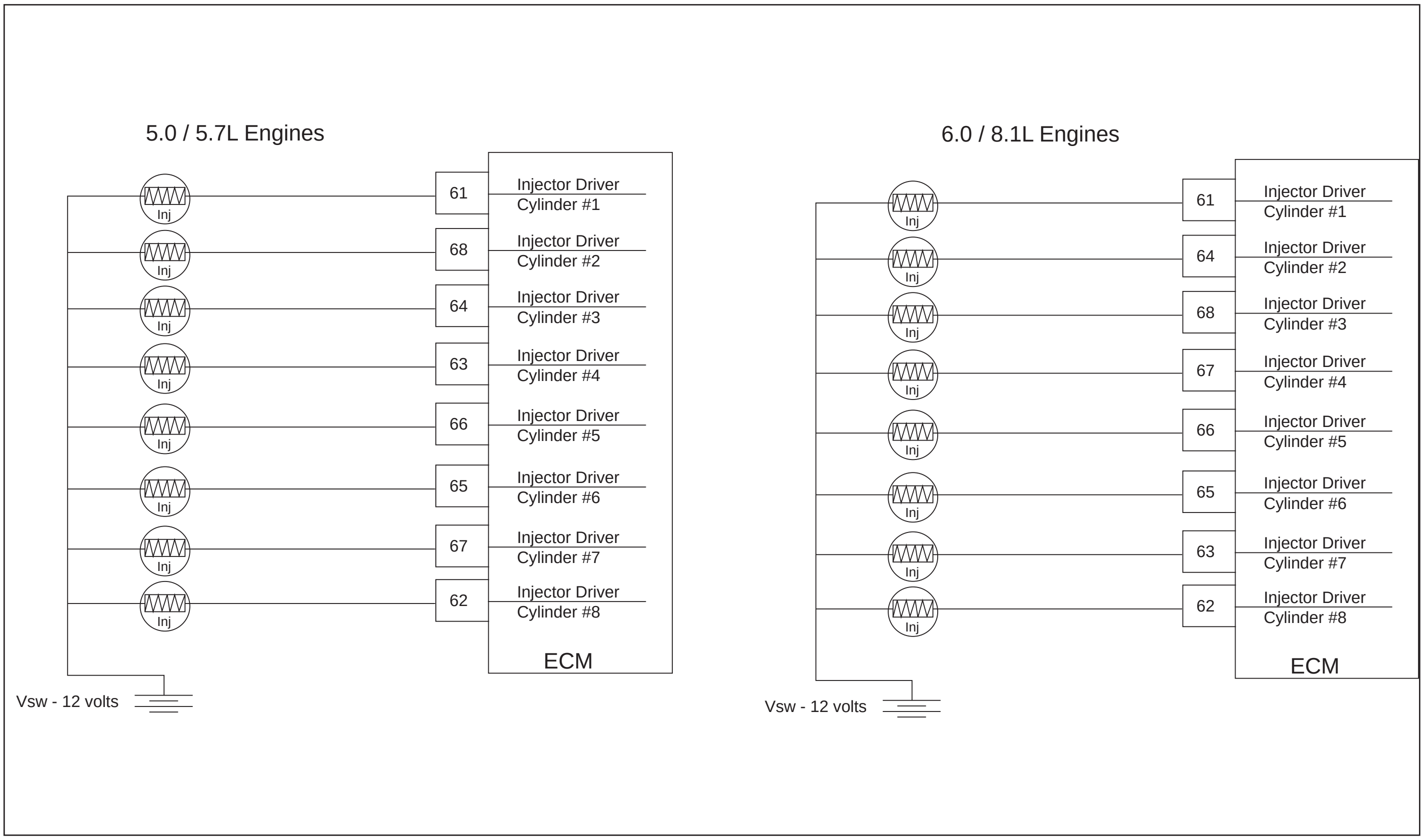
The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #4.

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



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

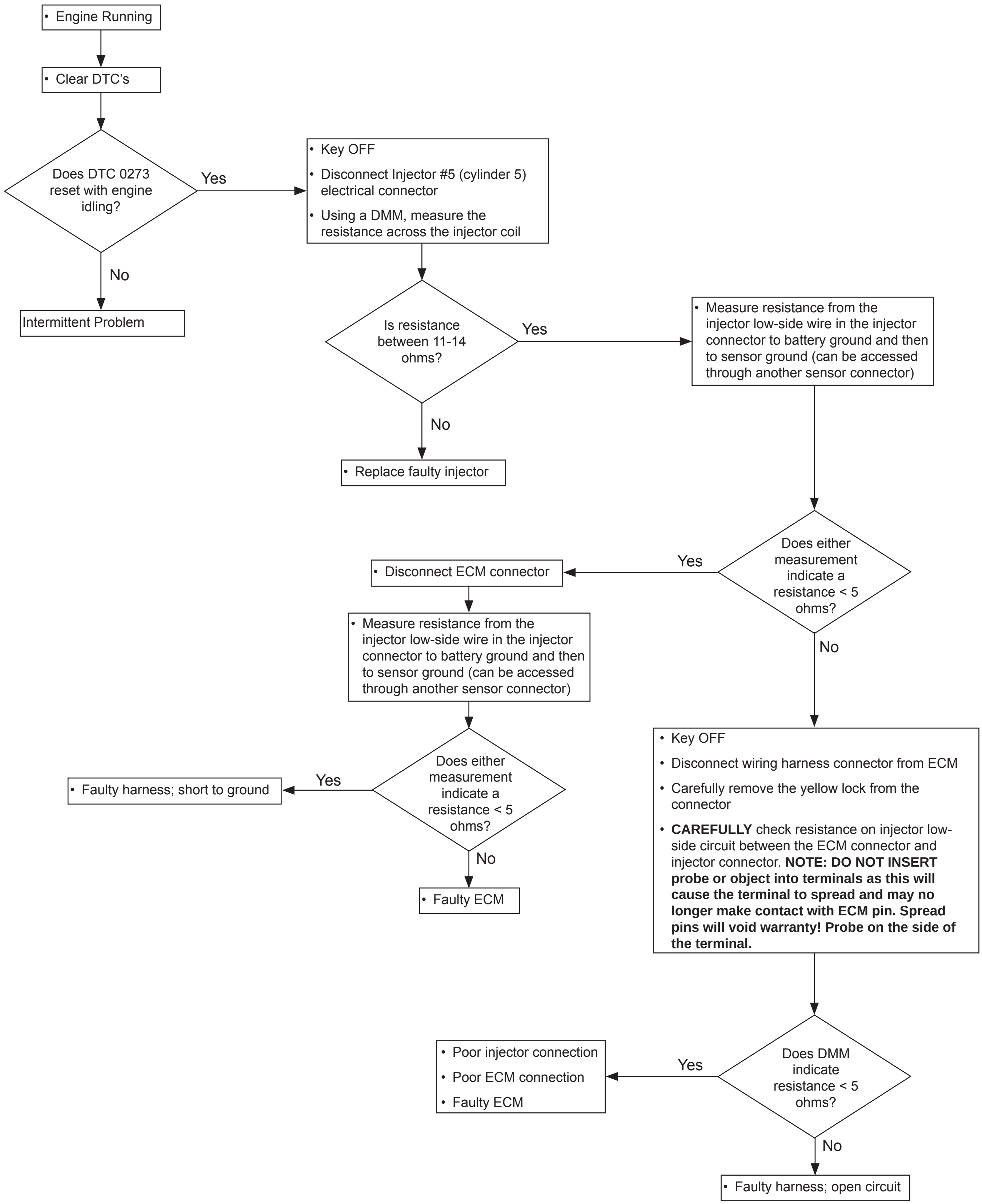


- Injector #5 Coil or Driver Open Circuit or Short-to-Ground
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM greater than 9.0 volts and injector low-side less than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible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

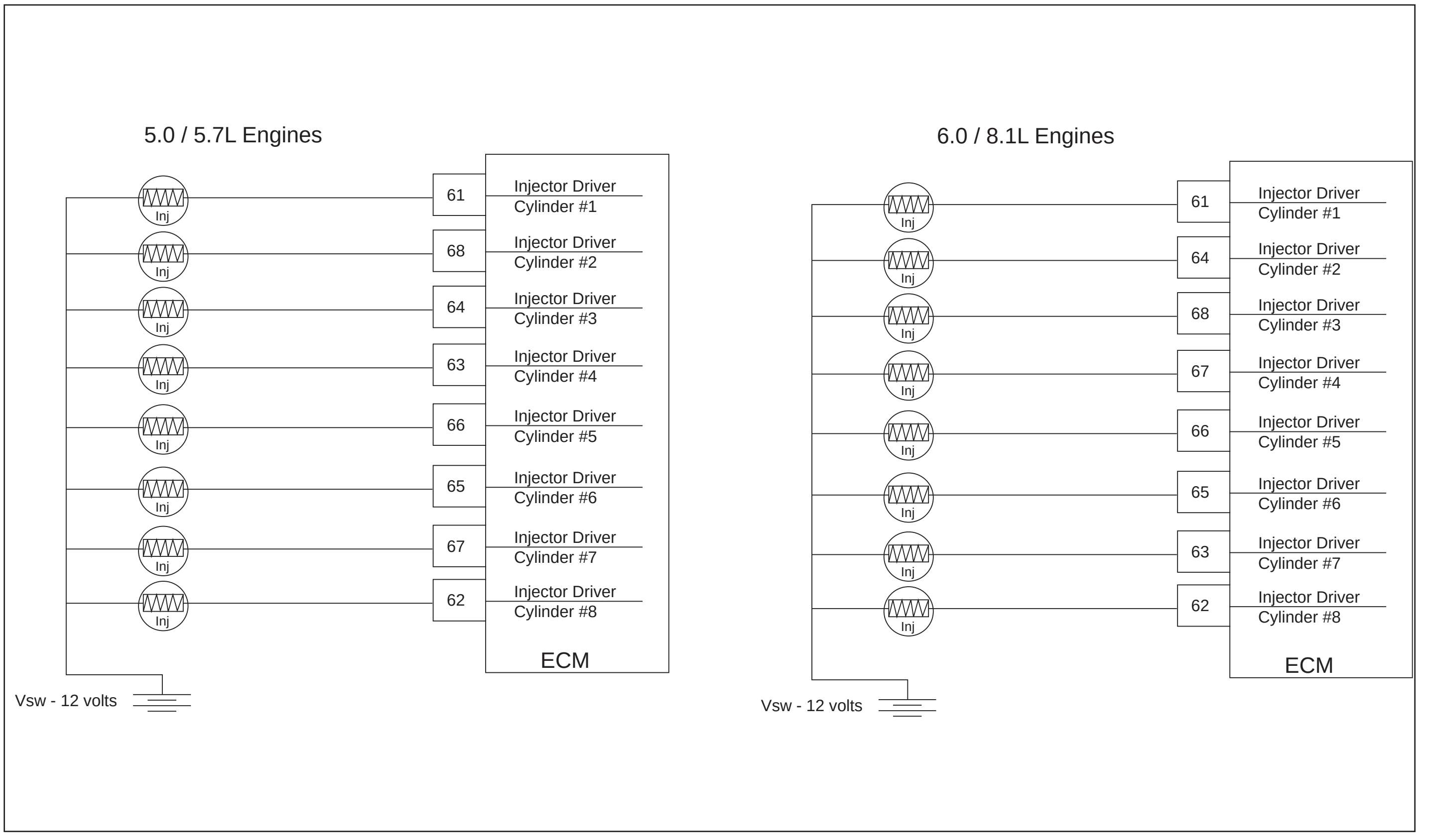
The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #5.

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



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

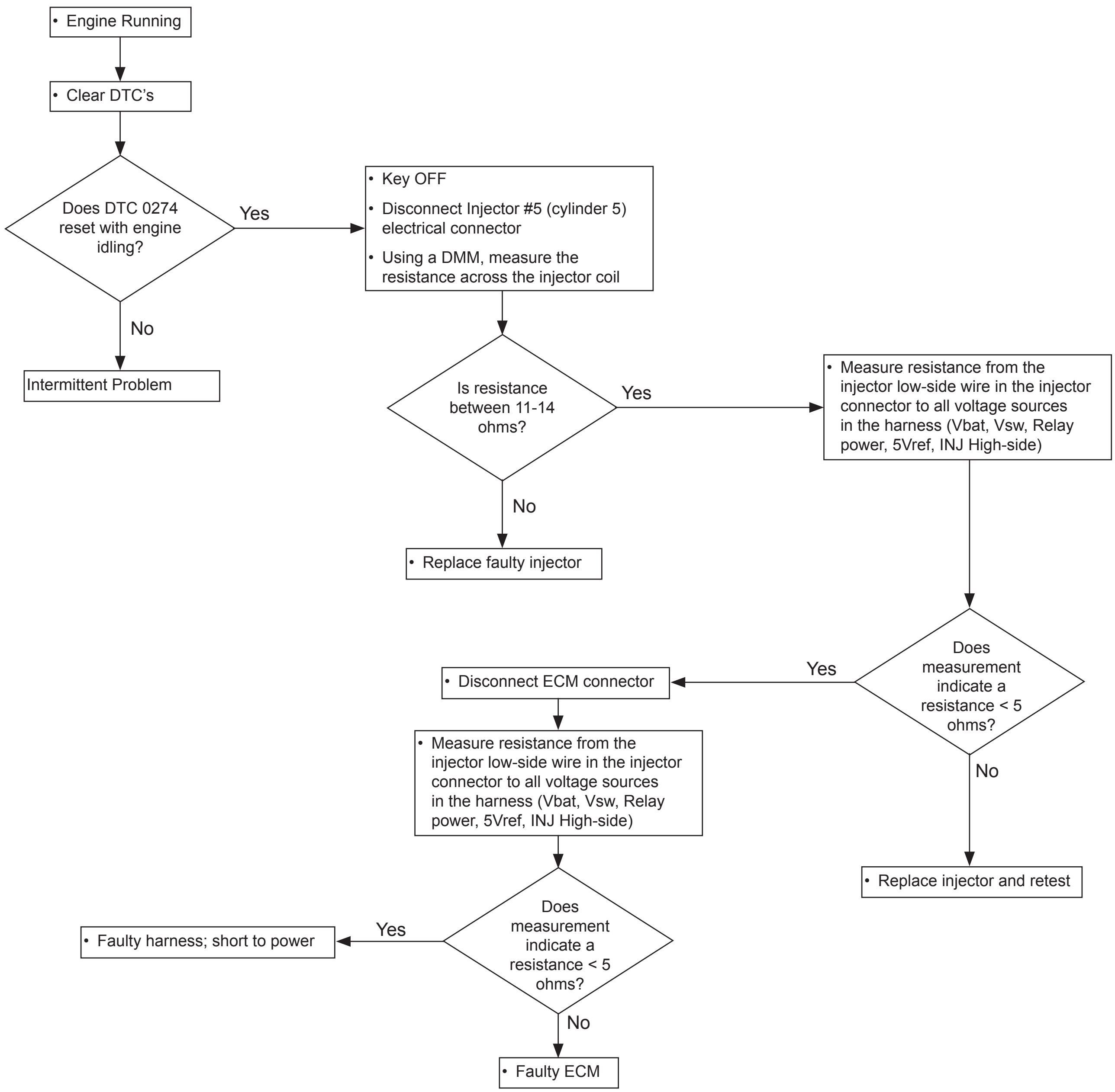


- Injector #5 Coil or Driver Short-to-Power
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM less than 16.0 volts and injector low-side greater than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable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

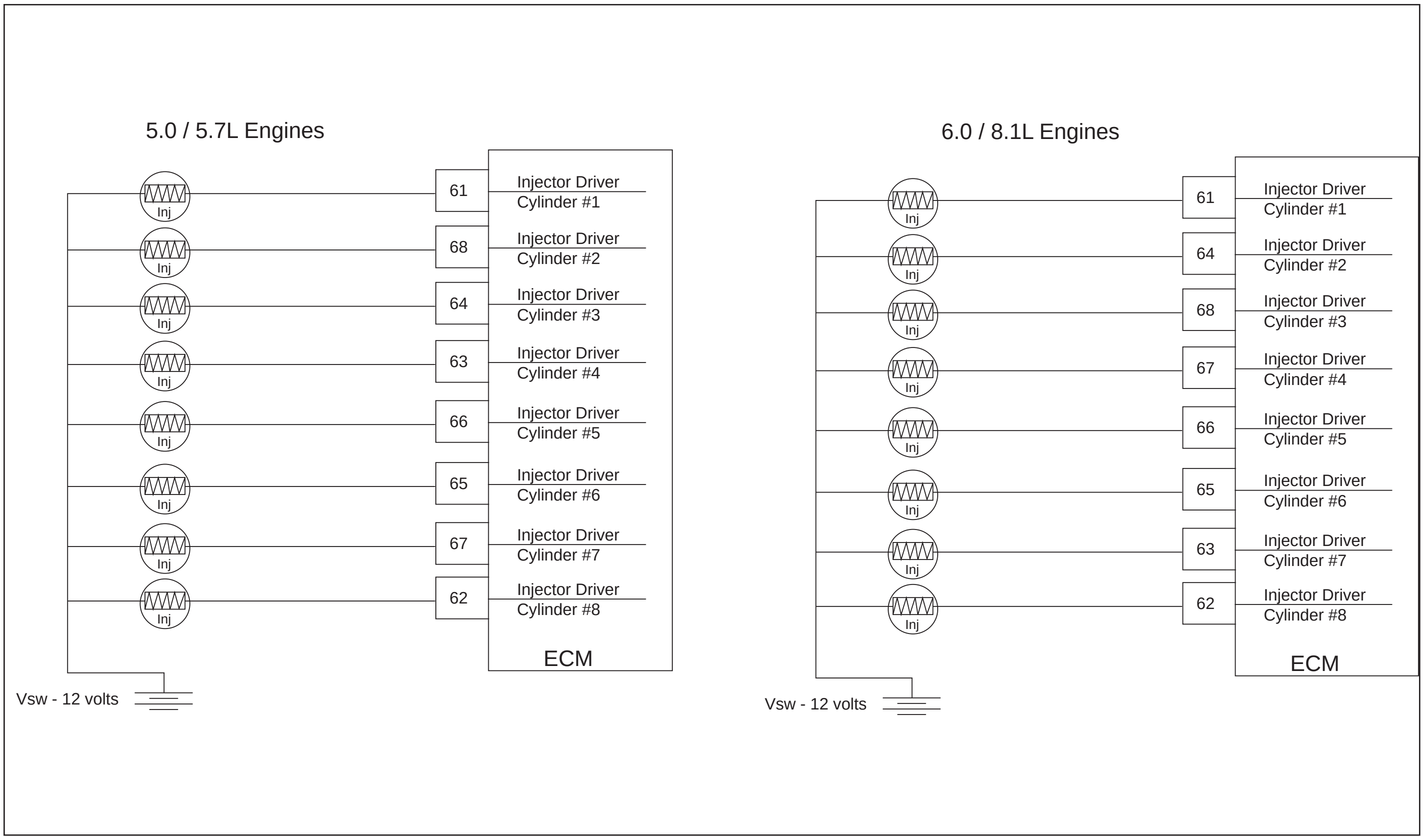
The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #5.

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



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

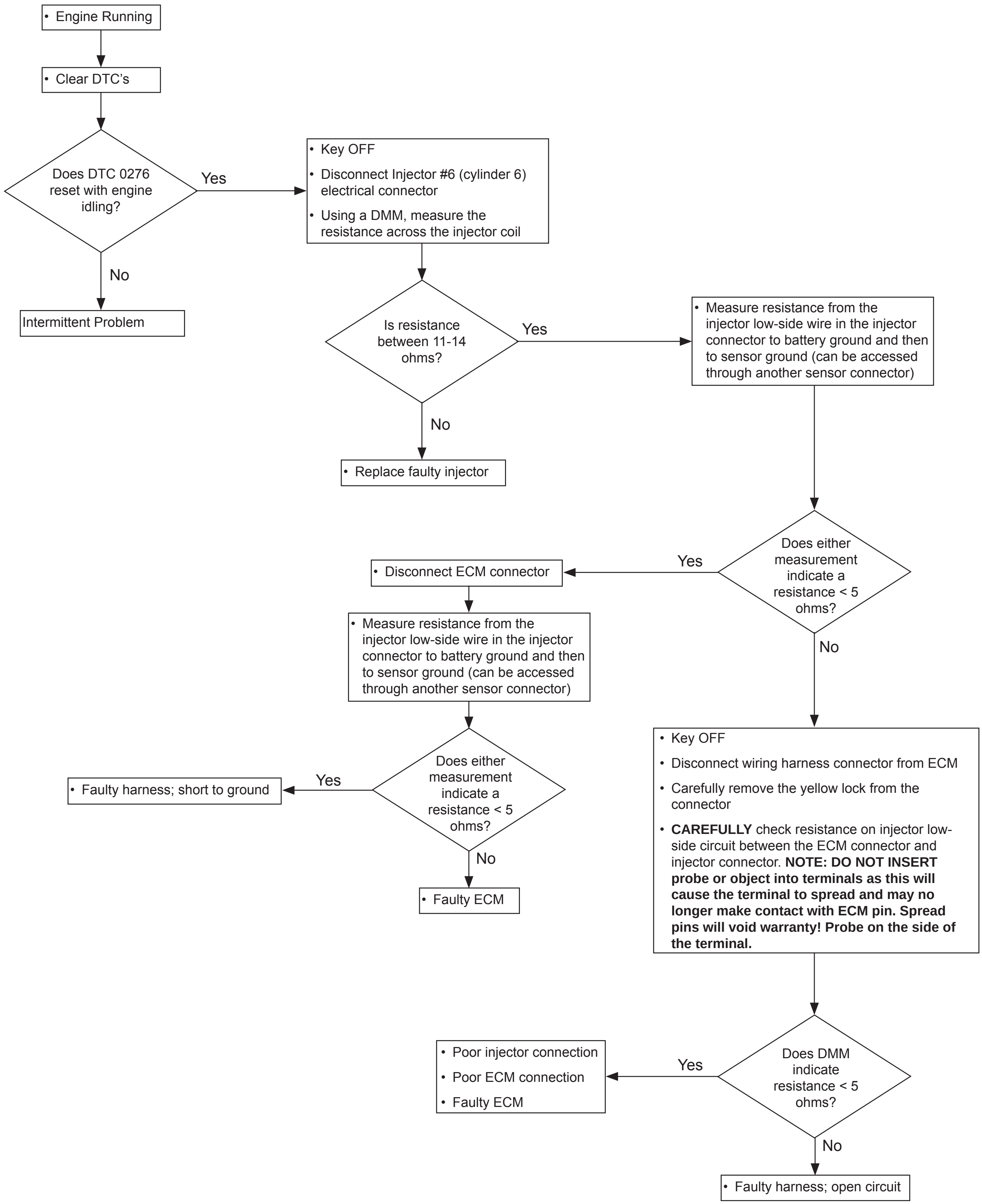


- Injector #6 Coil or Driver Open Circuit or Short-to-Ground
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM greater than 9.0 volts and injector low-side less than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible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

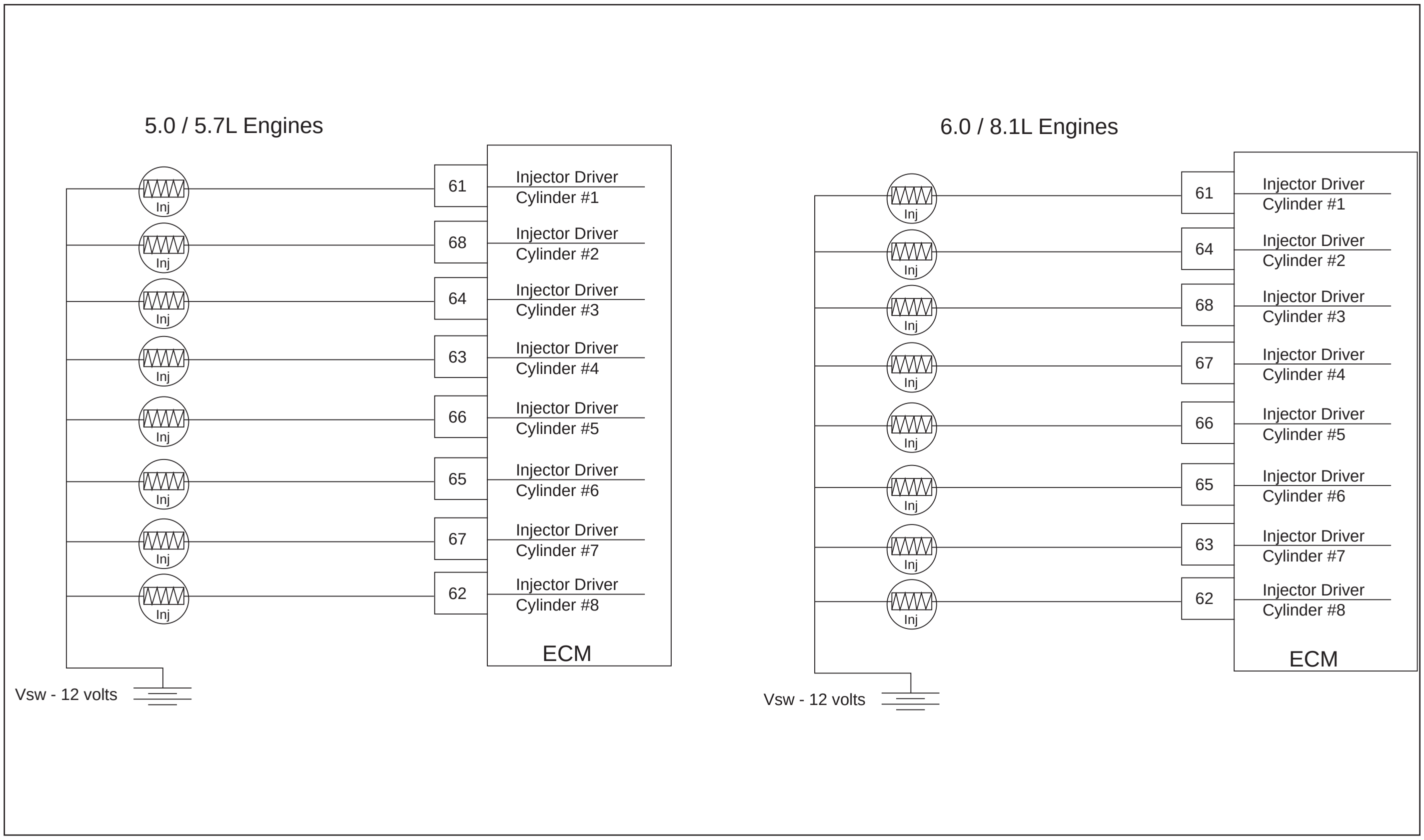
The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #6.

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



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

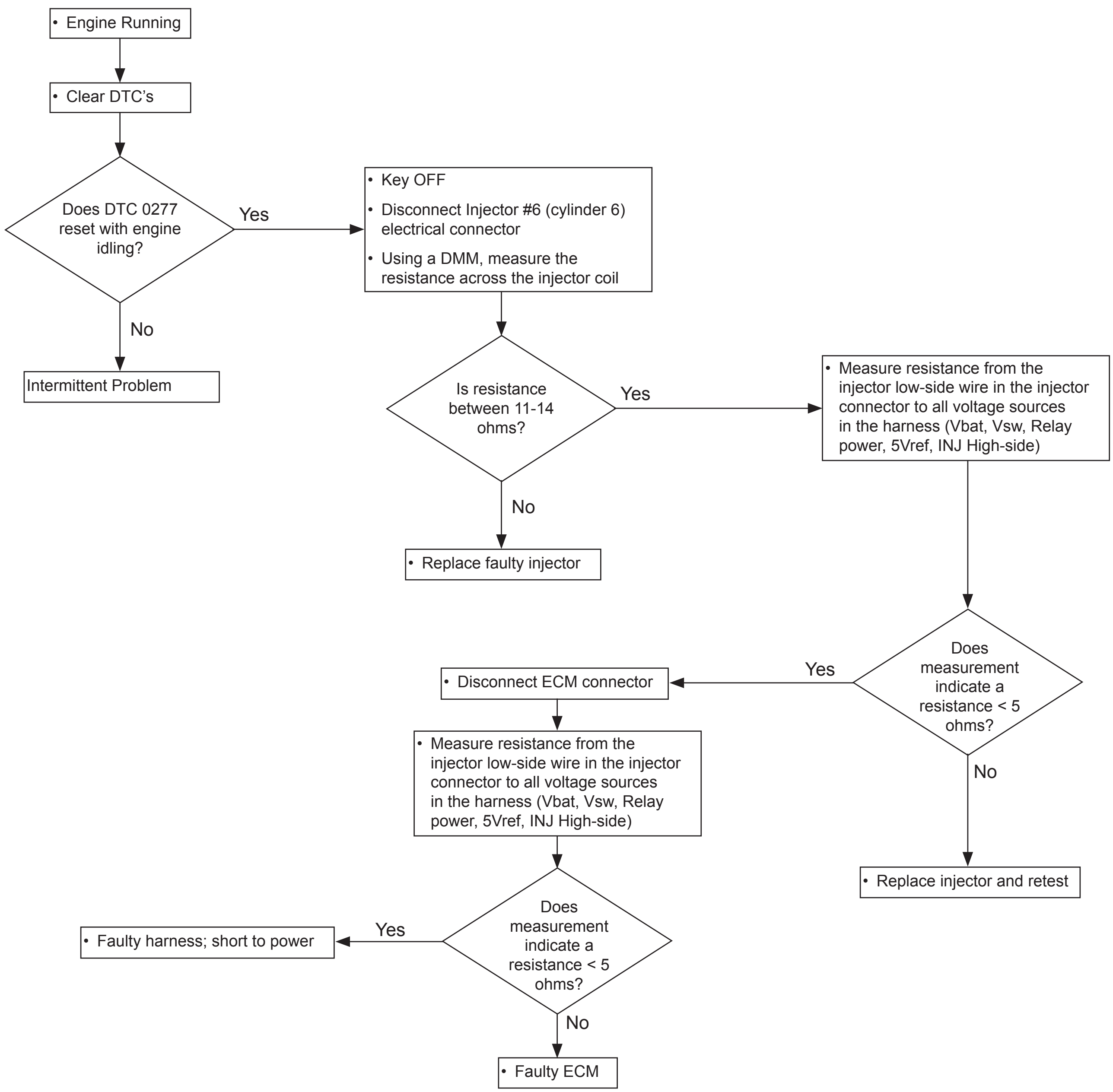


- Injector #6 Coil or Driver Short-to-Power
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM less than 16.0 volts and injector low-side greater than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable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

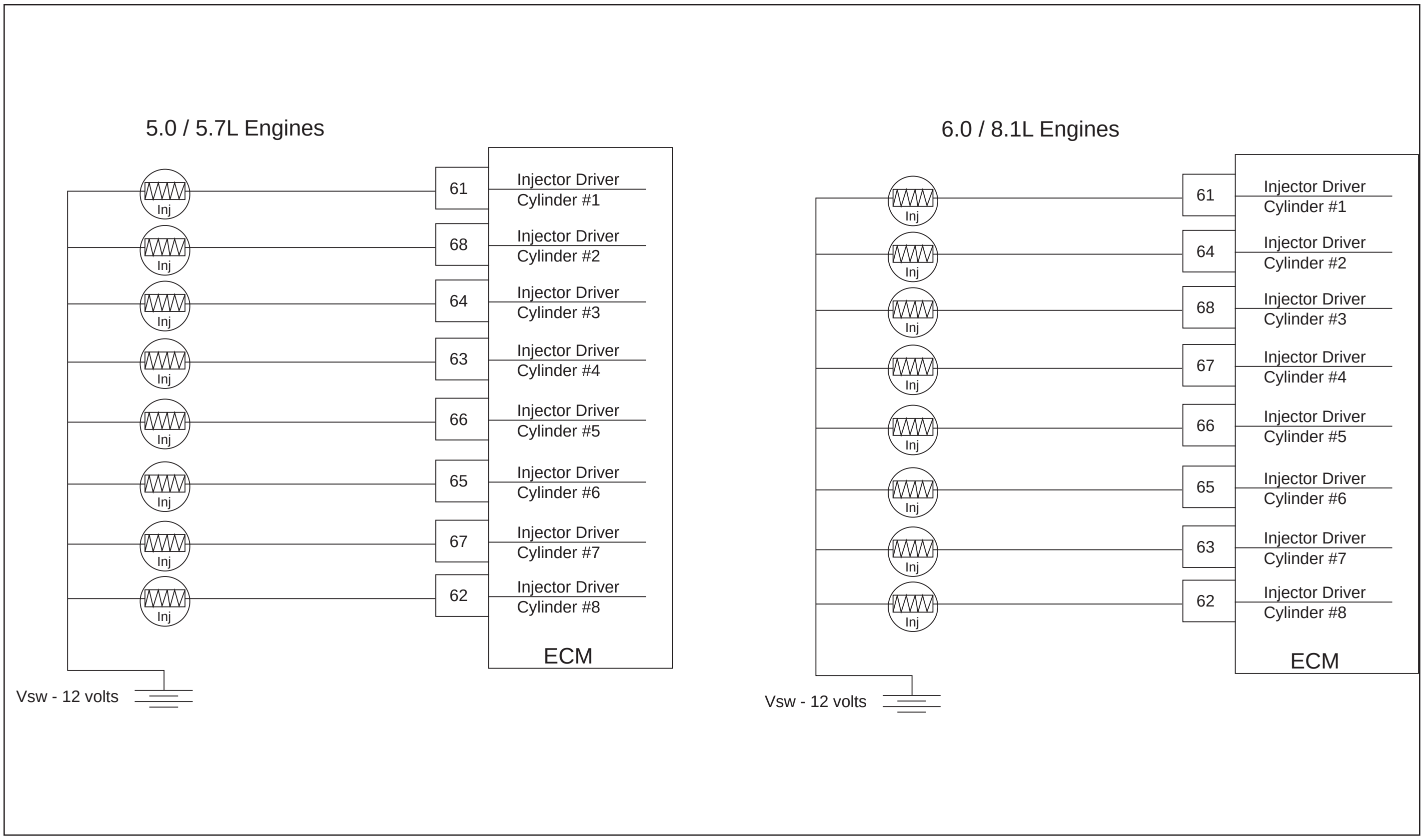
The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #6.

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



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

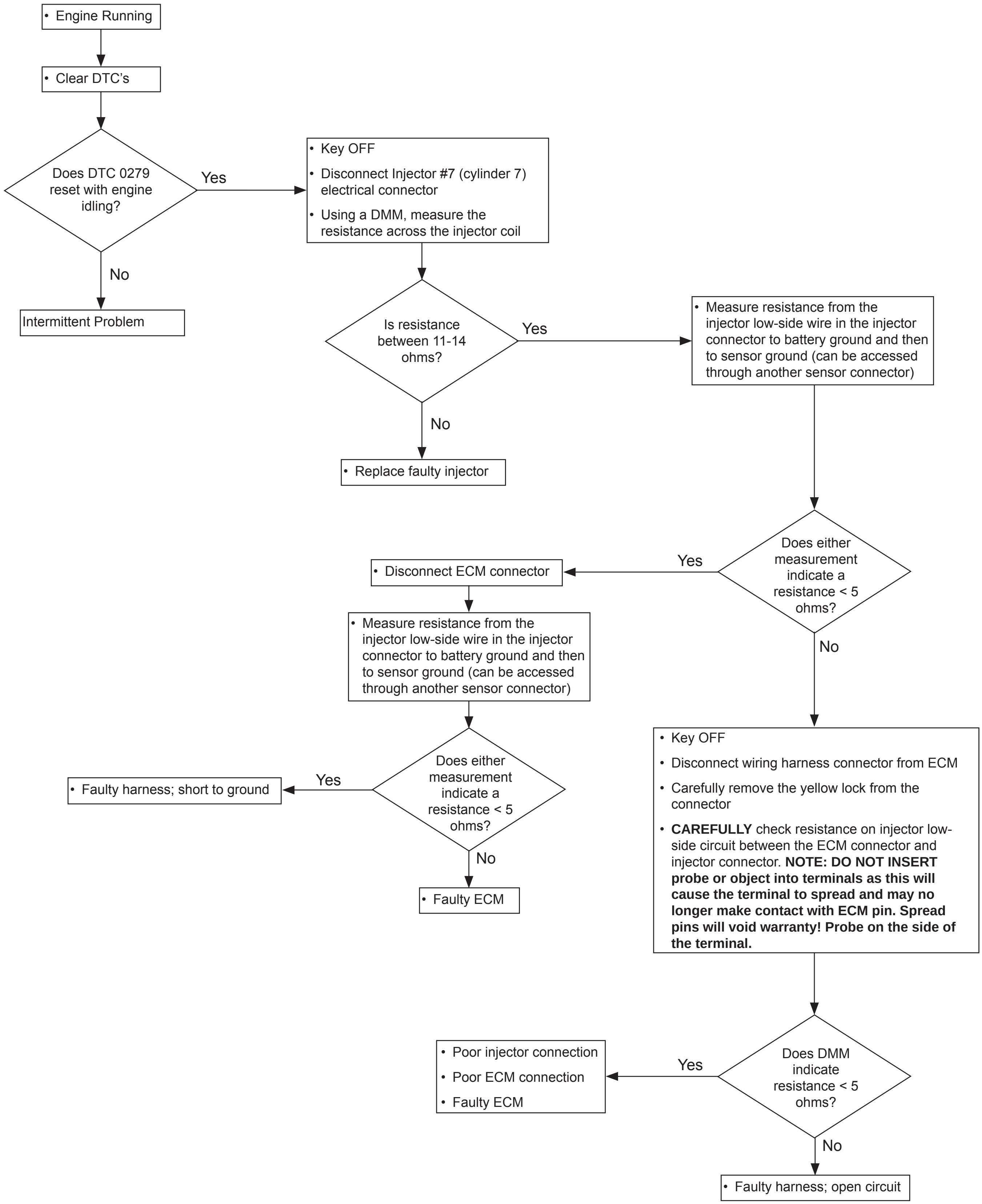


- Injector #7 Coil or Driver Open Circuit or Short-to-Ground
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM greater than 9.0 volts and injector low-side less than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible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

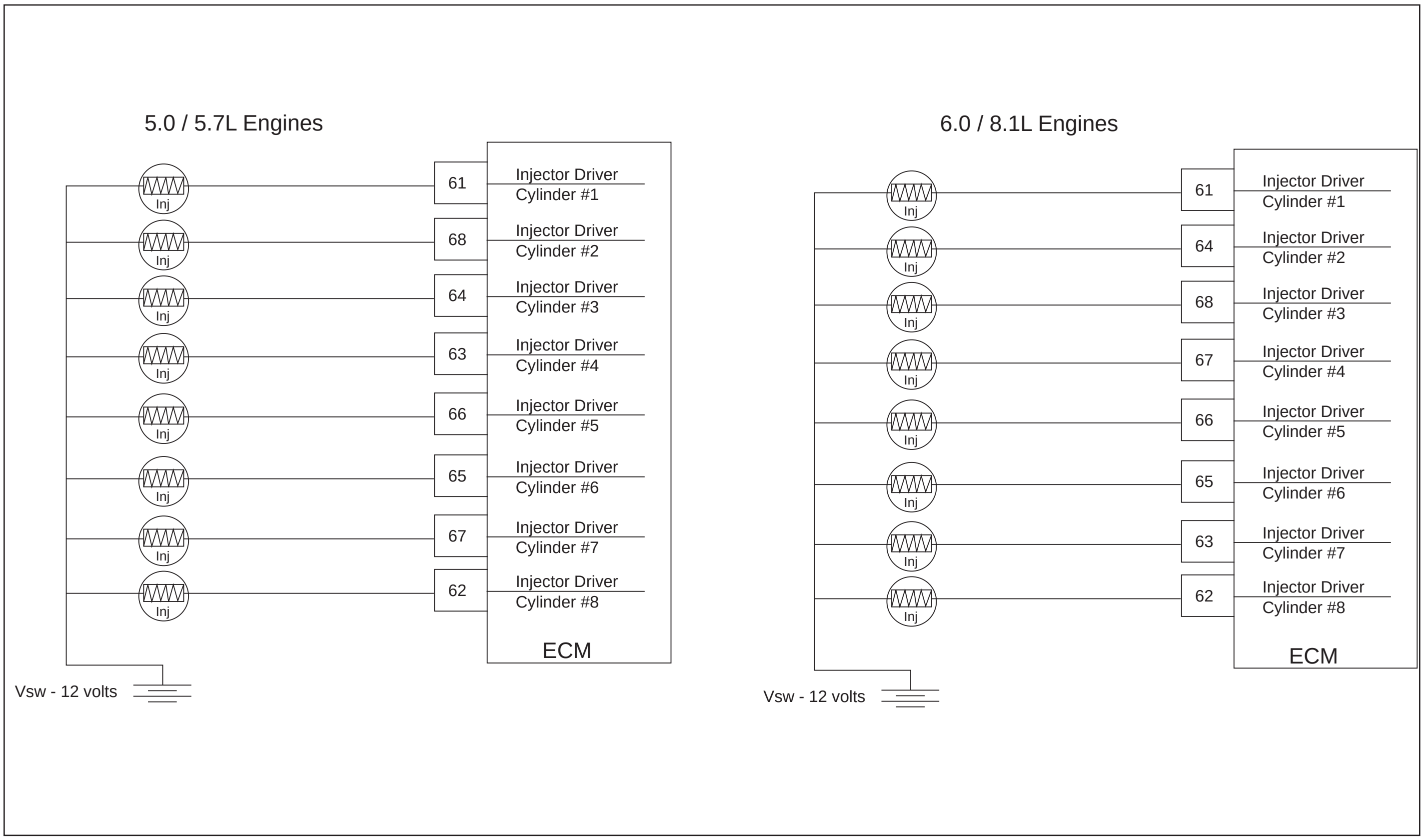
The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #7.

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



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

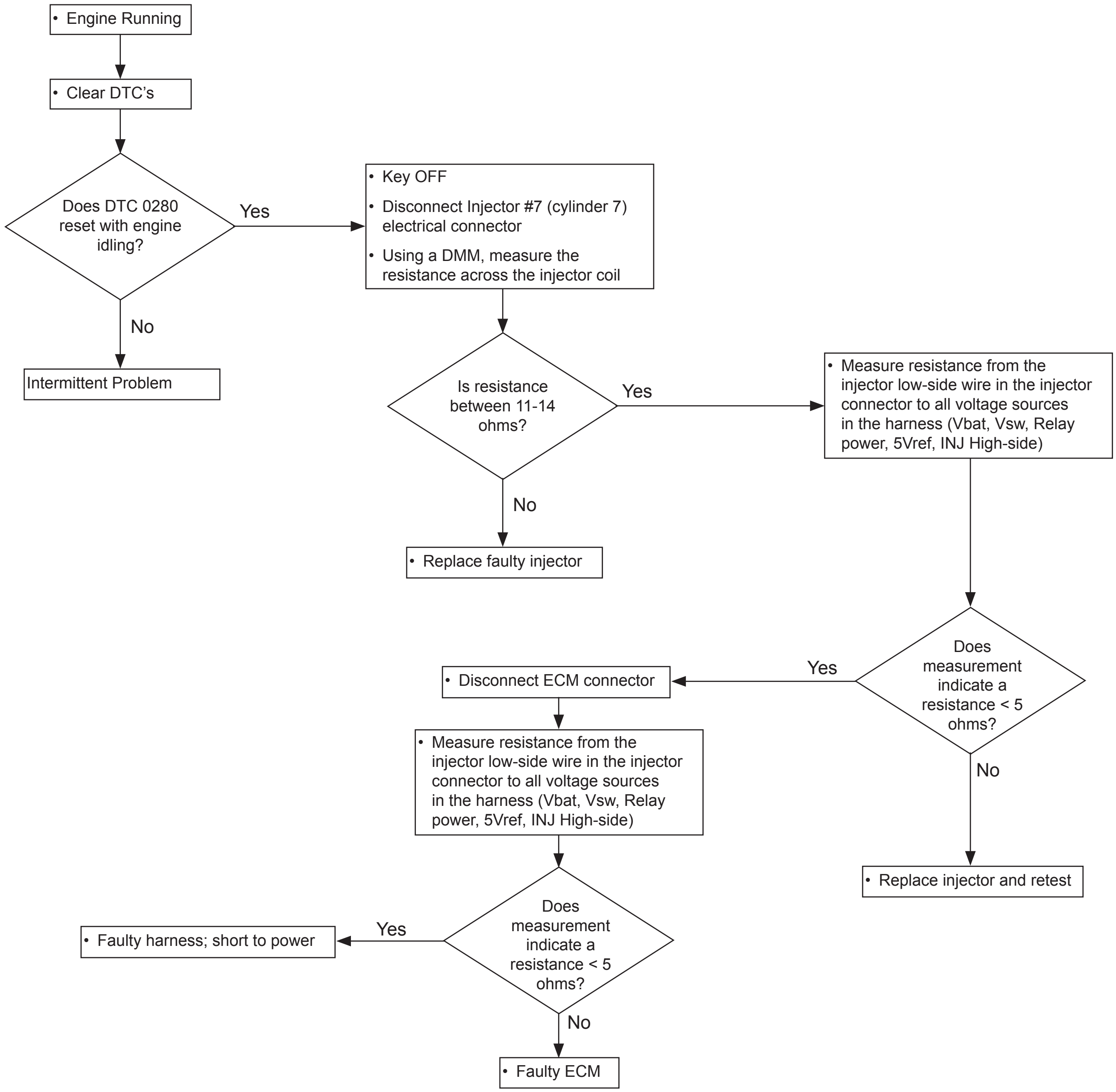


- Injector #7 Coil or Driver Short-to-Power
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM less than 16.0 volts and injector low-side greater than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable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

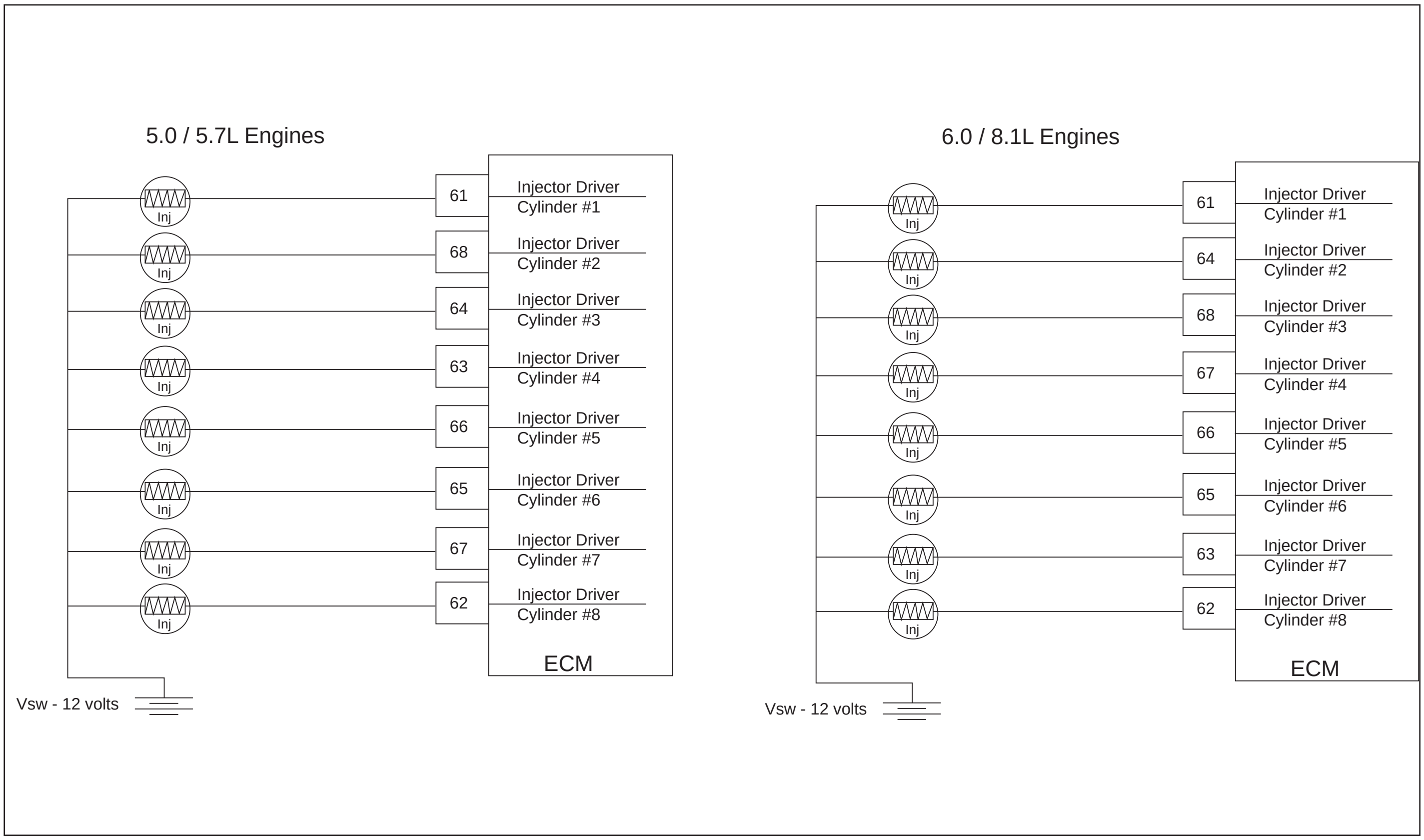
The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #7.

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



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

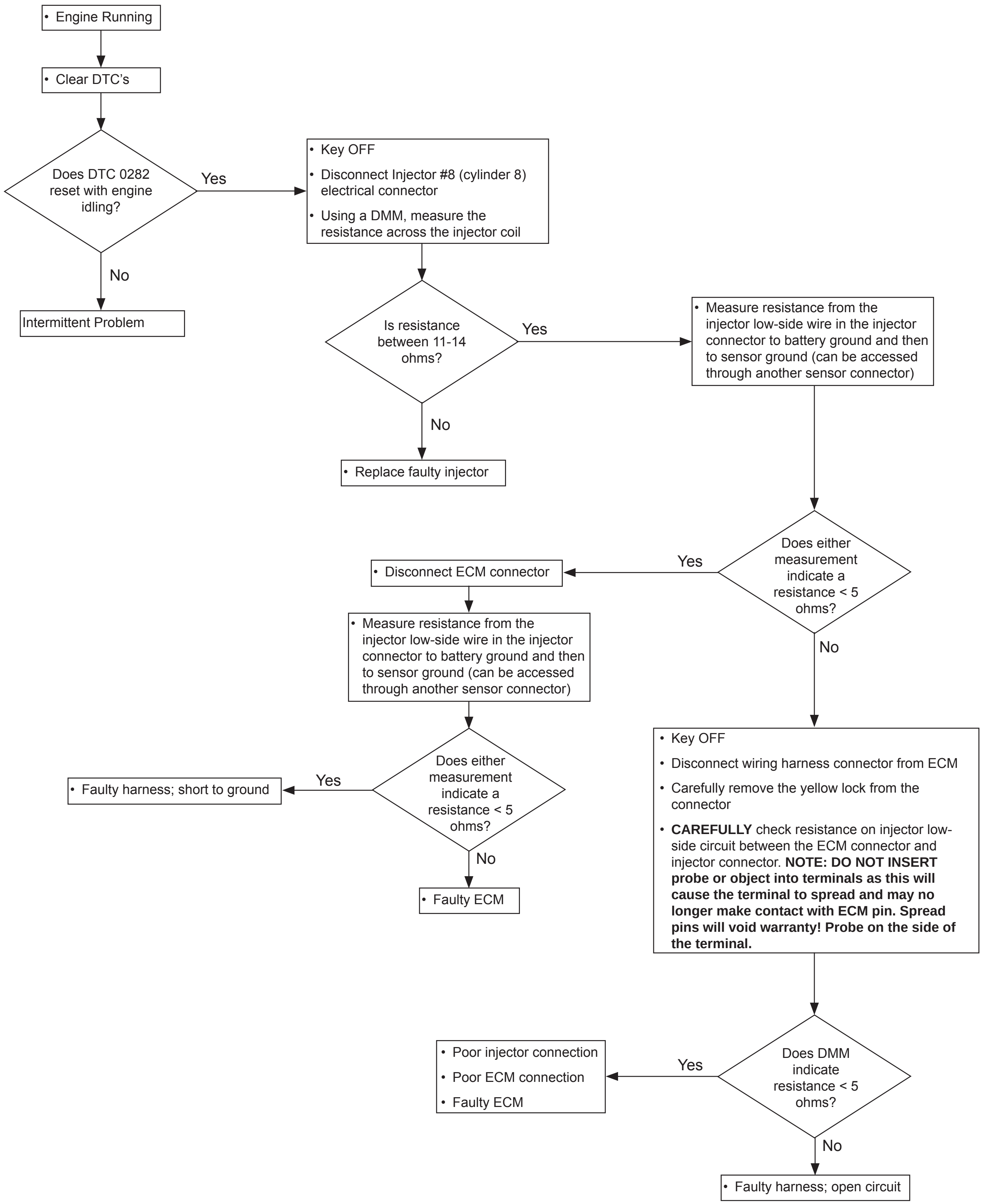


- Injector #8 Coil or Driver Open Circuit or Short-to-Ground
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM greater than 9.0 volts and injector low-side less than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible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

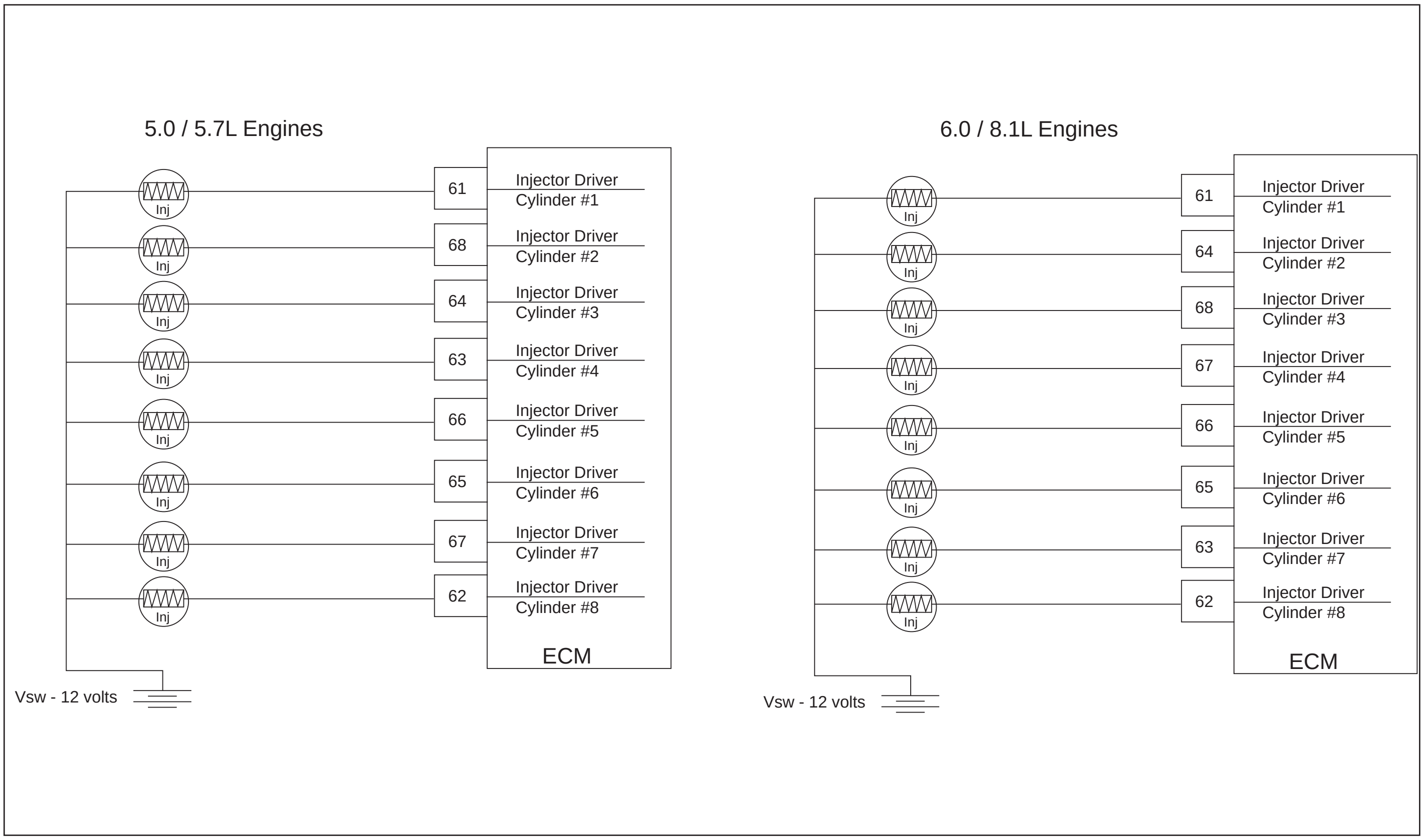
The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #8.

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



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

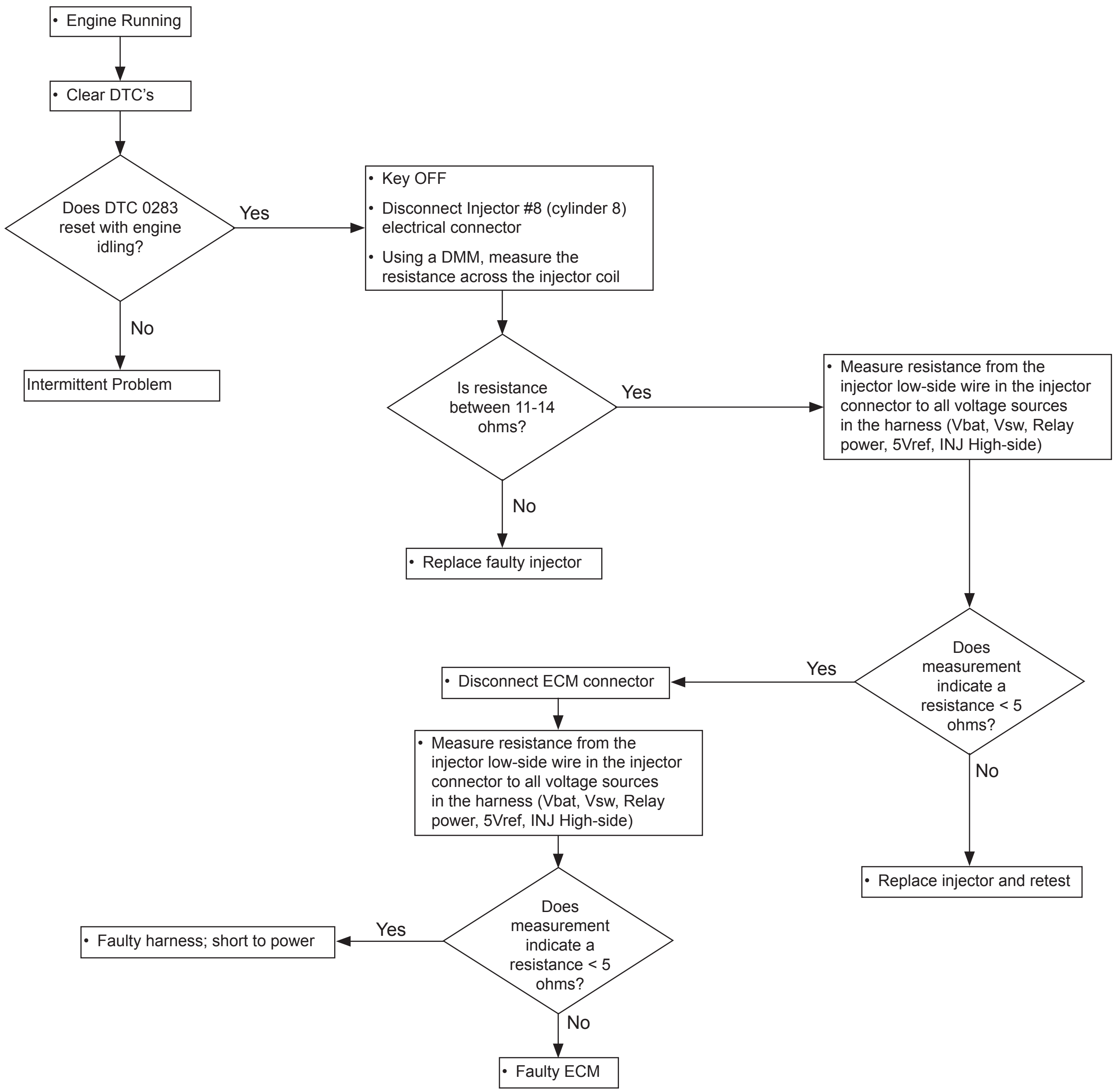


- Injector #8 Coil or Driver Short-to-Power
- *Check Condition* - Key-On, Engine Running
- *Fault Condition* - Battery voltage at ECM less than 16.0 volts and injector low-side greater than 4.0 volts for 10 injector firings.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning, disable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

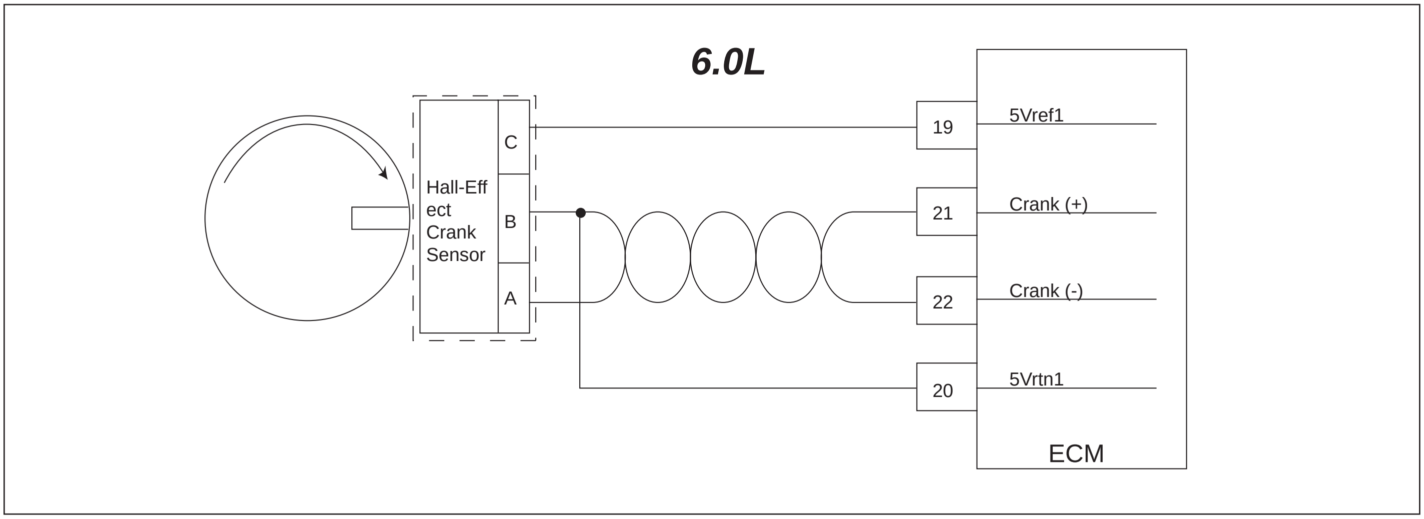
The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder (Sequential Port Fuel Injection). This fault sets for the injector on cylinder #8.

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



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 banks 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 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.

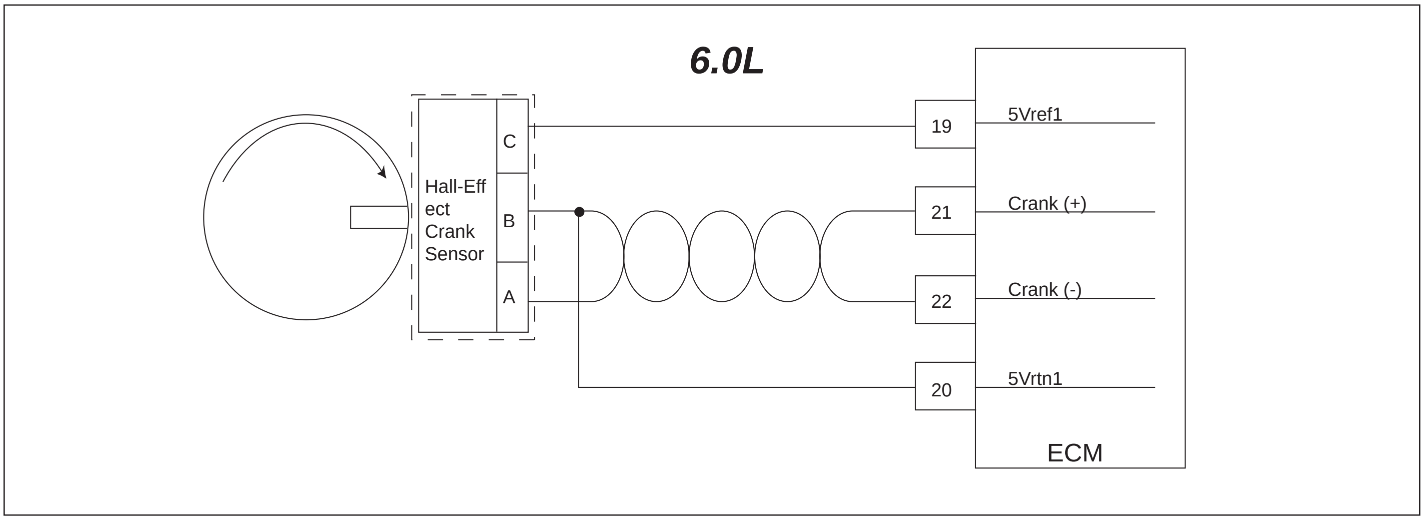
This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

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).

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 banks 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.

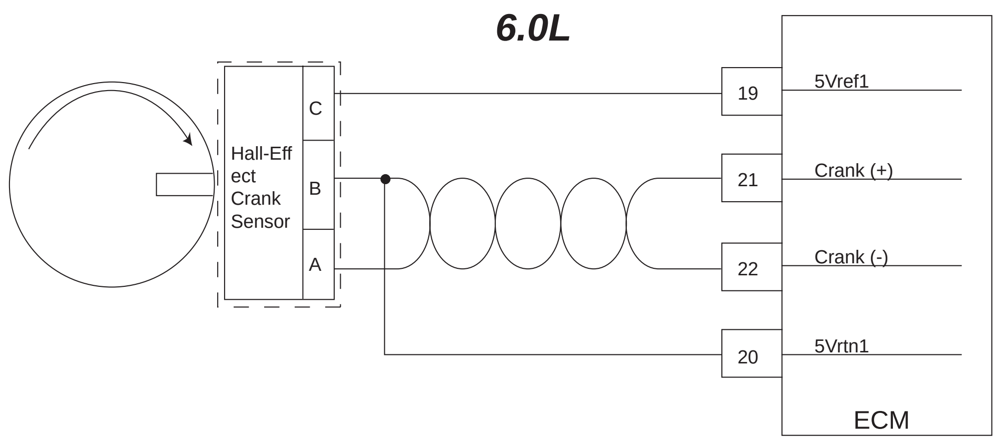
This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

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).

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 banks 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.

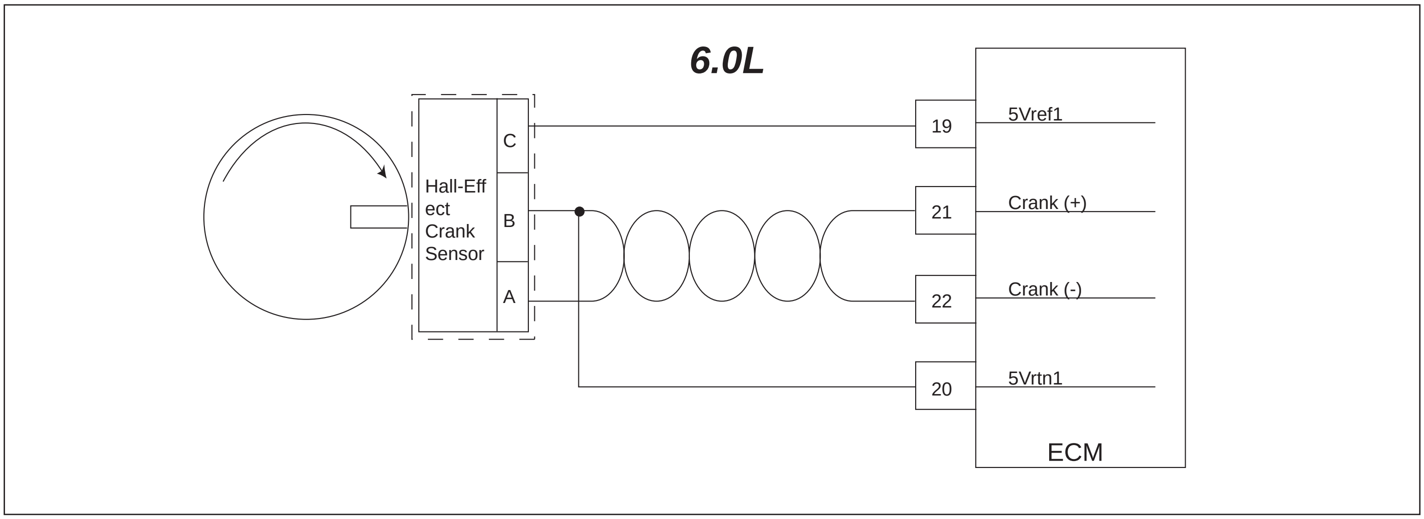
This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

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).

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 banks 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 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.

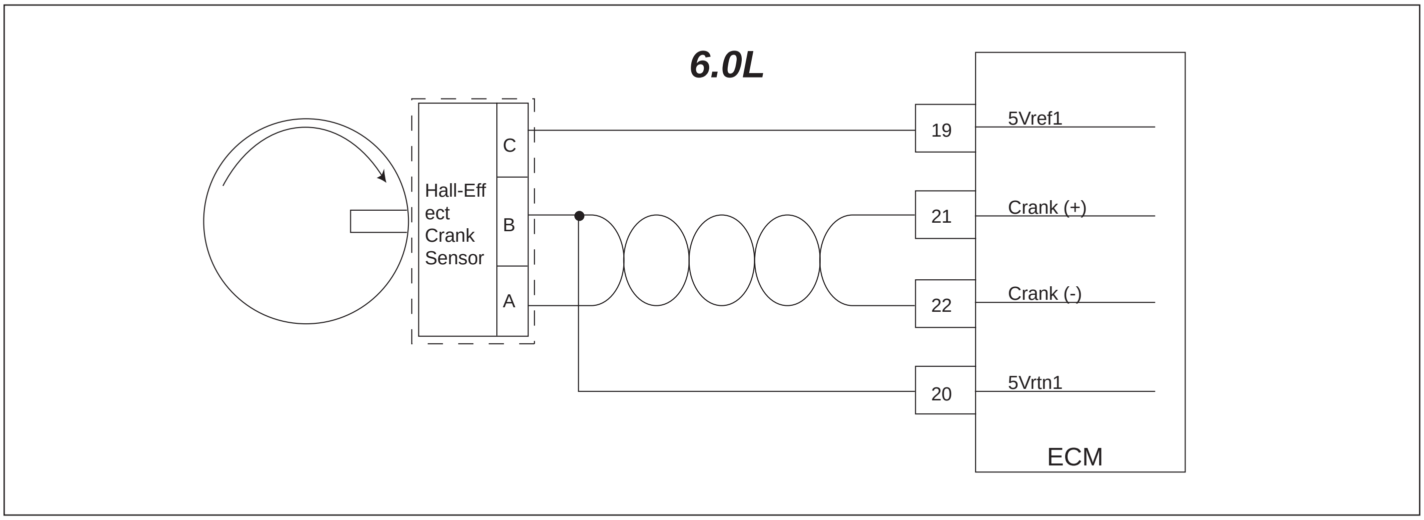
This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

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).

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 banks 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 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.

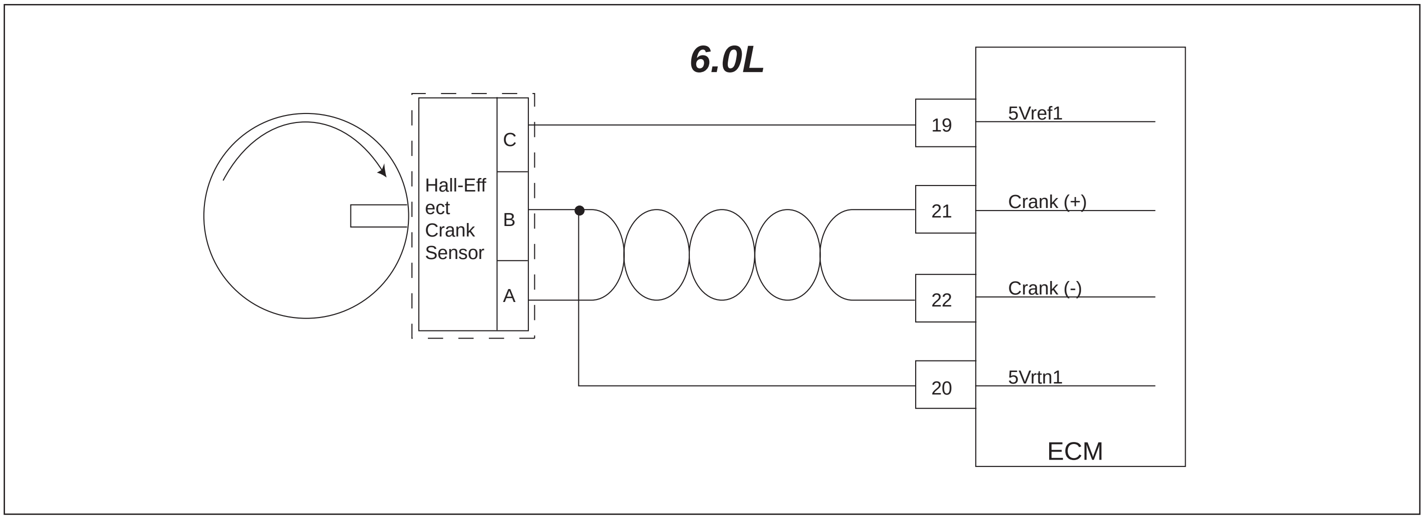
This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

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).

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 banks 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.

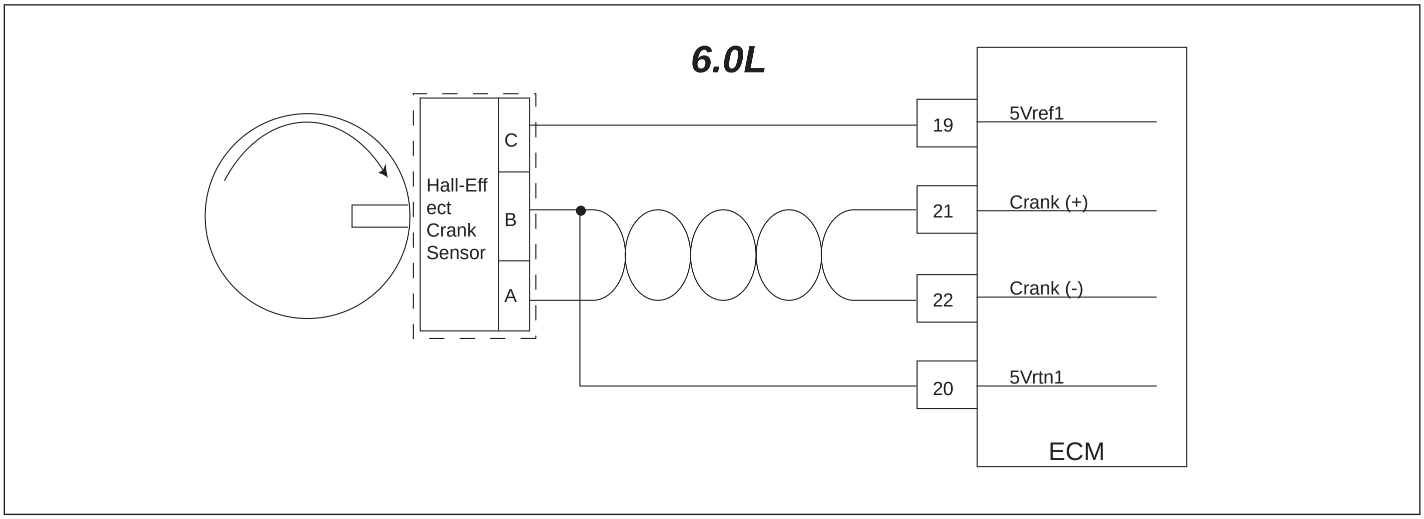
This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

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).

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 banks 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.

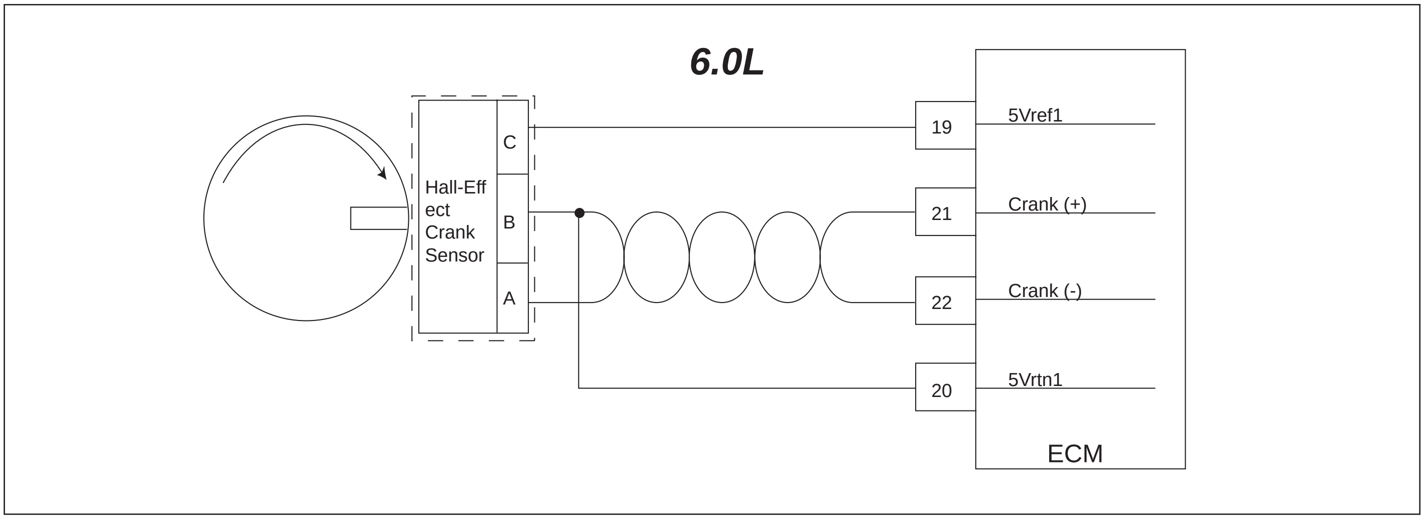
This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

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).

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 banks 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.

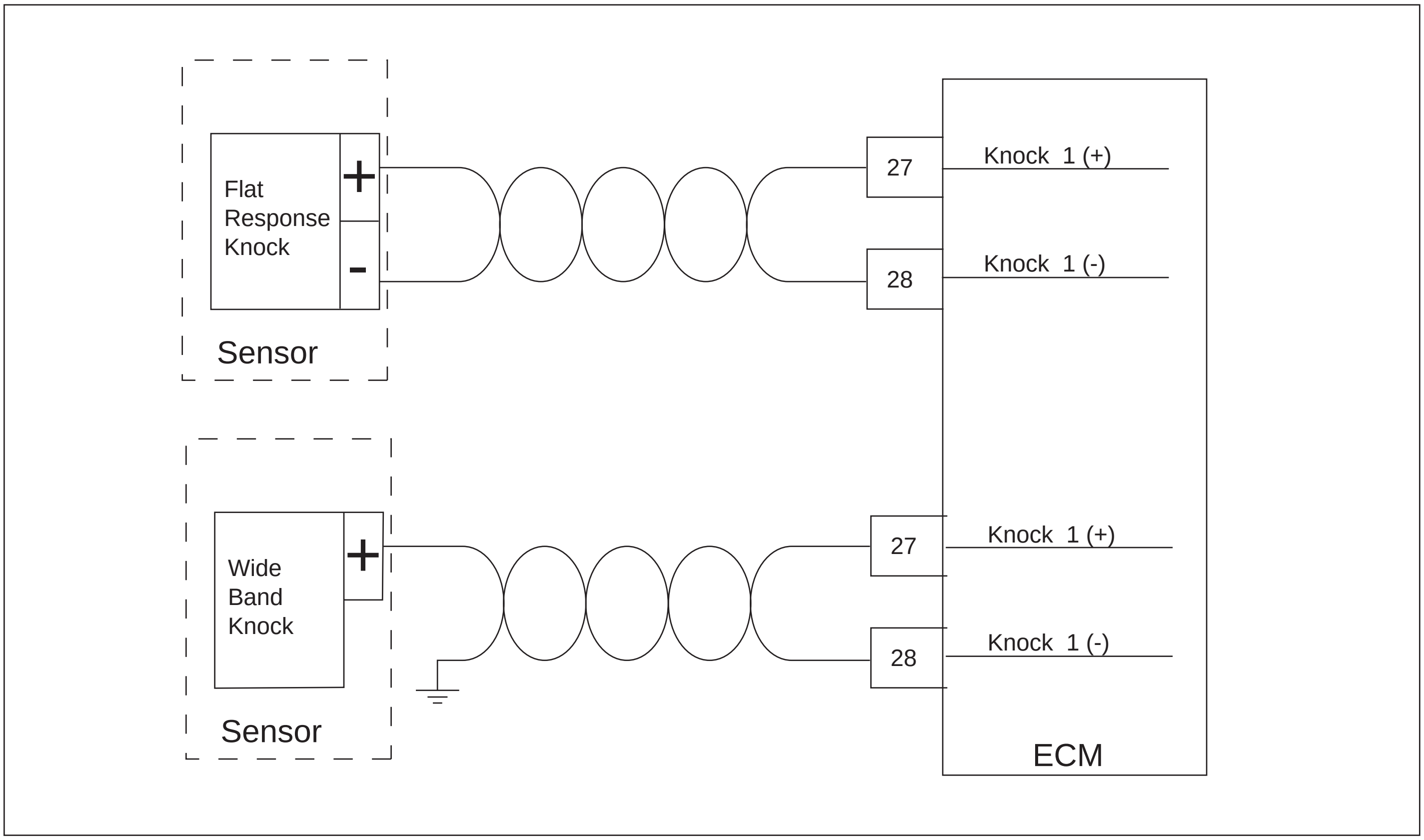
This fault sets if the misfire counter for cylinder #1 exceeds the emissions/catalyst misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

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).

DTC 0326 - Knock 1 Excessive or Erratic Signal
SPN - 731; FMI - 2

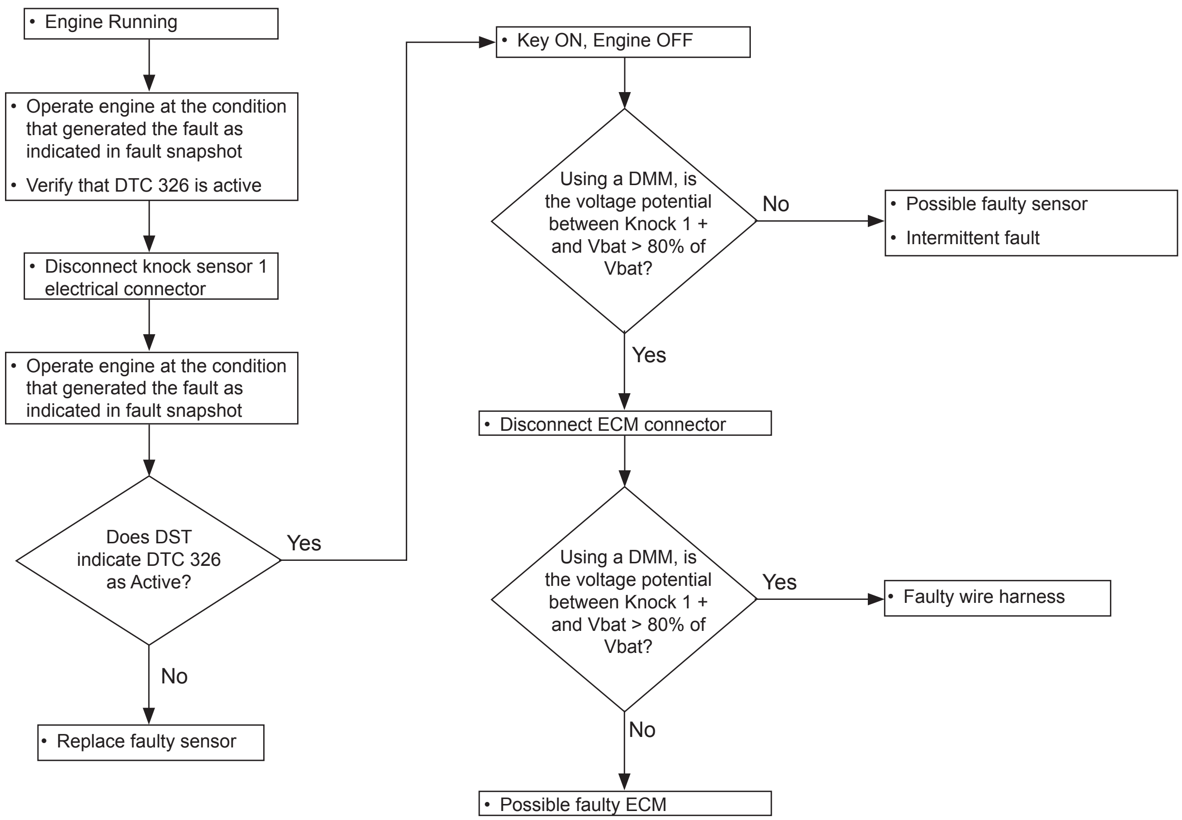


- Knock sensor #1
- *Check Condition* - Key On, Engine On
- *Fault Condition* - Knock sensor 1 indicates an excessive signal level
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, possibly power derate the engine, and retard spark to Faulted KNK Retard level to protect engine from possible damage due to unsensed detonation
- Emissions related fault

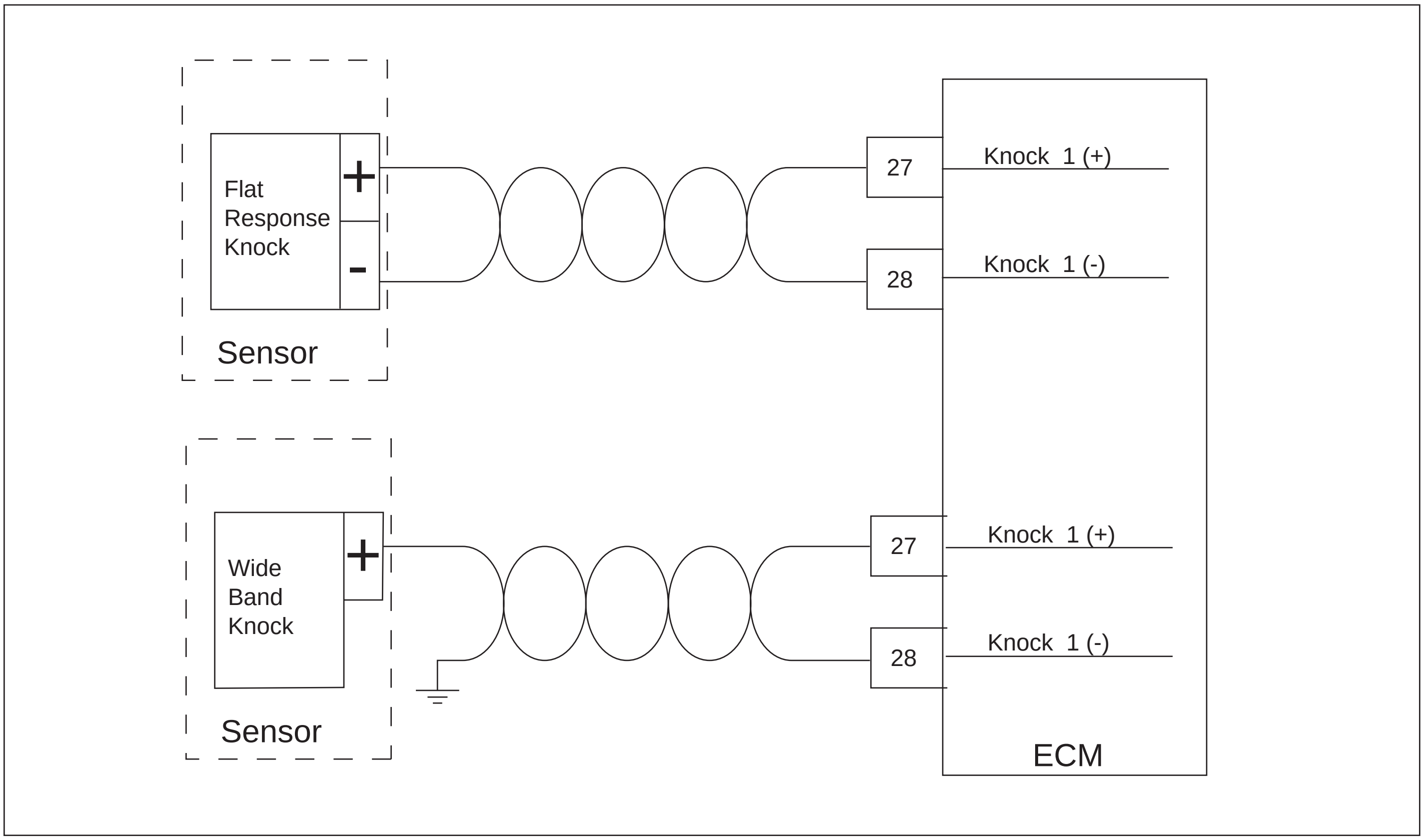
The knock sensor is used to detect detonation through mechanical vibration in the engine block and/or cylinder heads and provide feedback for the ignition system to retard spark to reduce knock intensity. In most applications the knock sensor is used to protect the engine from damage that can be caused 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



DTC 0327 - Knock 1 Sensor Circuit Open
SPN - 731; FMI - 4

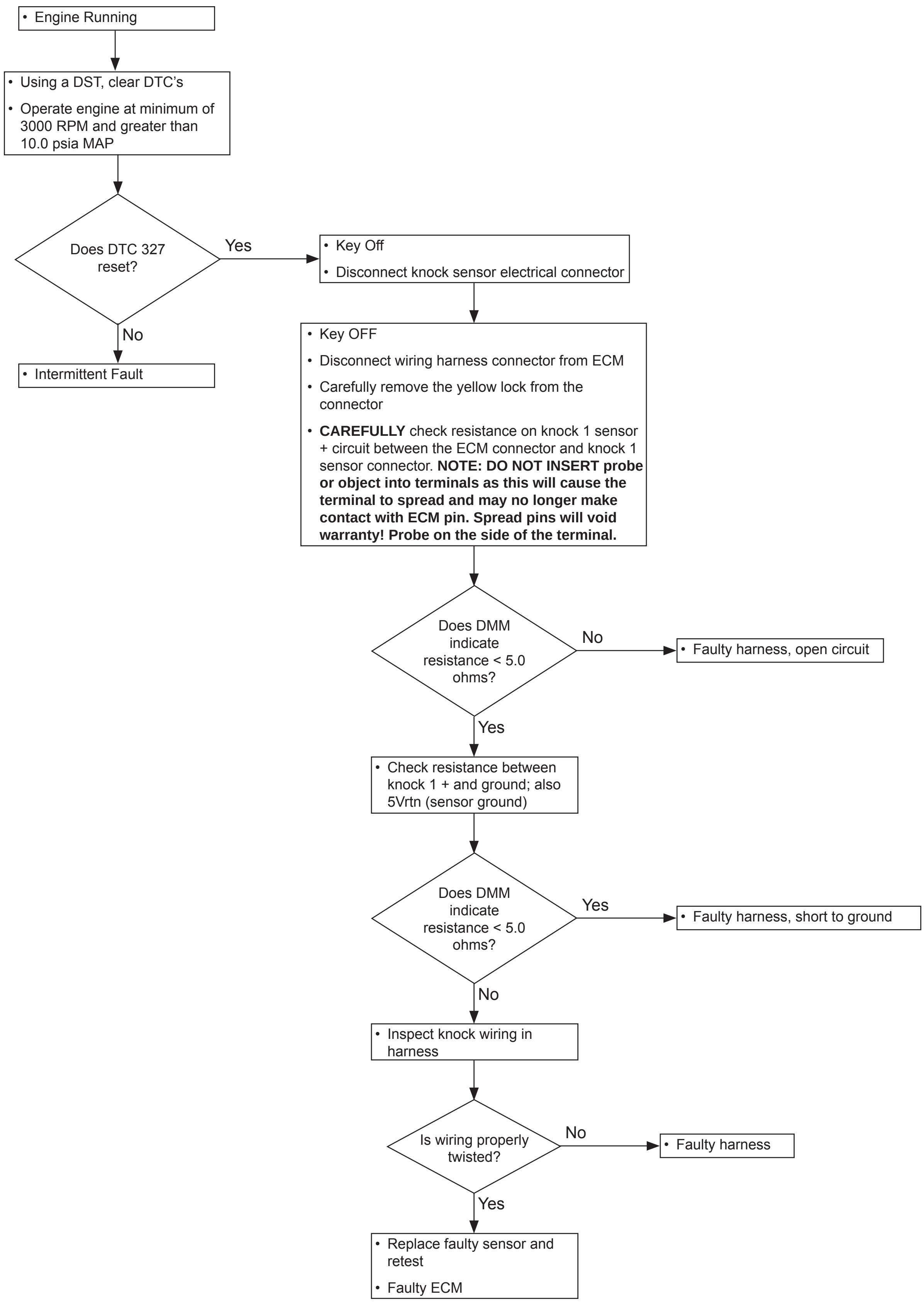


- Knock sensor #1
- *Check Condition* - Key On, Engine On
- *Fault Condition* - Knock sensor 1 signal low while engine speed is greater than 3000 RPM and MAP is greater than 10.00 psia as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate 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

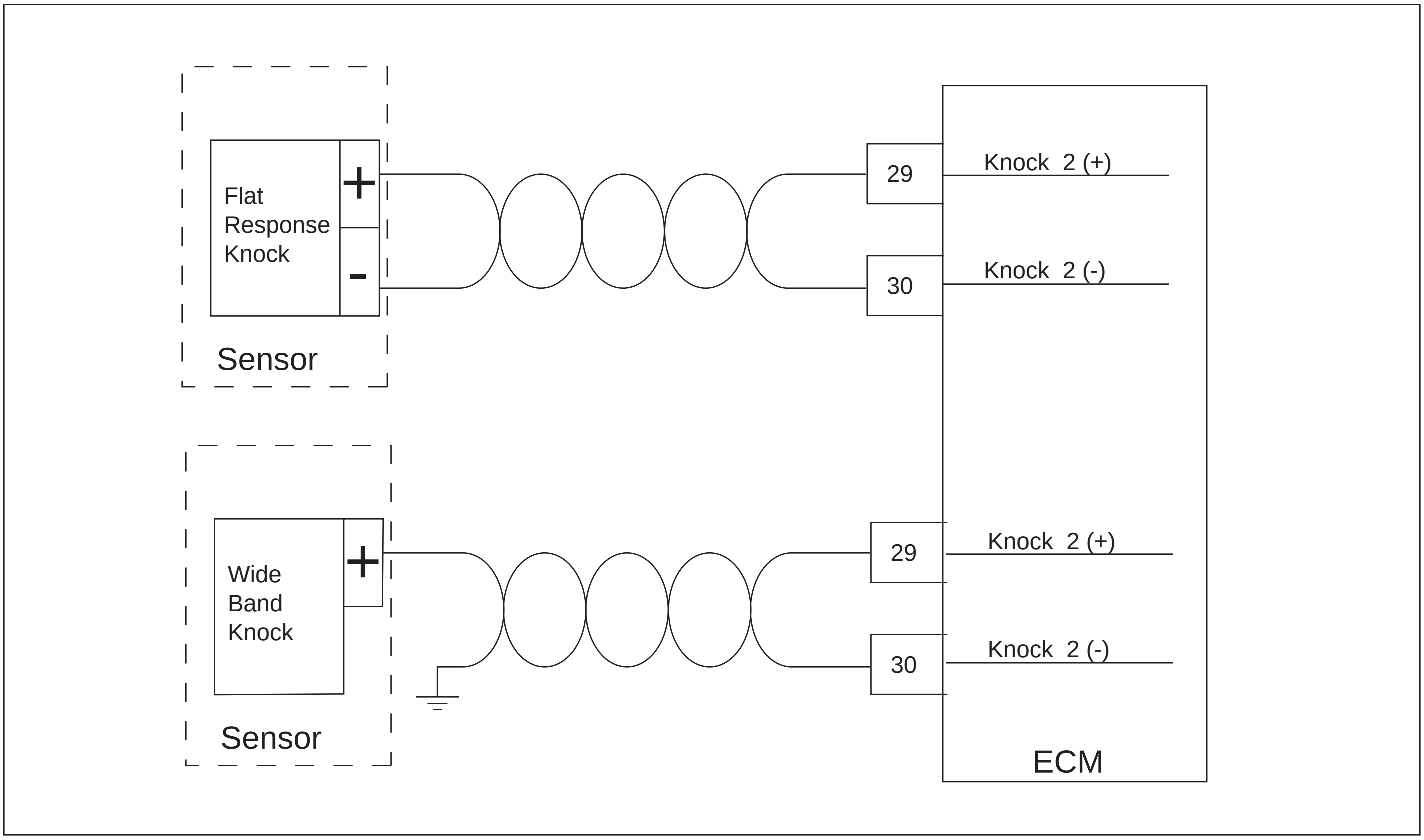
The knock sensor is used to detect detonation through mechanical vibration in the engine block and/or cylinder heads and provide feedback for the ignition system to retard spark to reduce knock intensity. In most applications the knock sensor is used to protect the engine from damage that can be caused 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



DTC 0331 - Knock 2 Excessive or Erratic Signal
SPN - 520197; FMI - 2

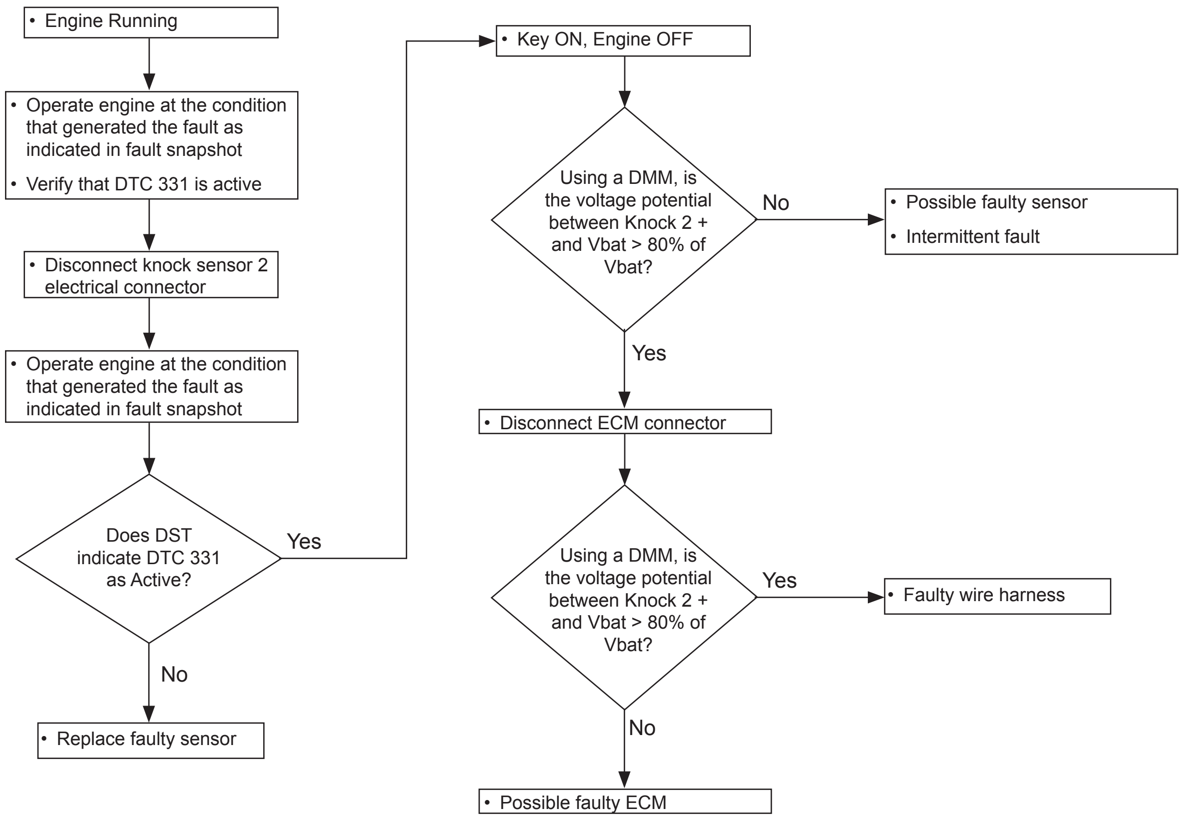


- Knock sensor #2
- *Check Condition* - Key On, Engine On
- *Fault Condition* - Knock sensor 2 indicates an excessive signal level
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, possibly power derate the engine, and retard spark to Faulted KNK Retard level to protect engine from possible damage due to unsensed detonation
- Emissions related fault

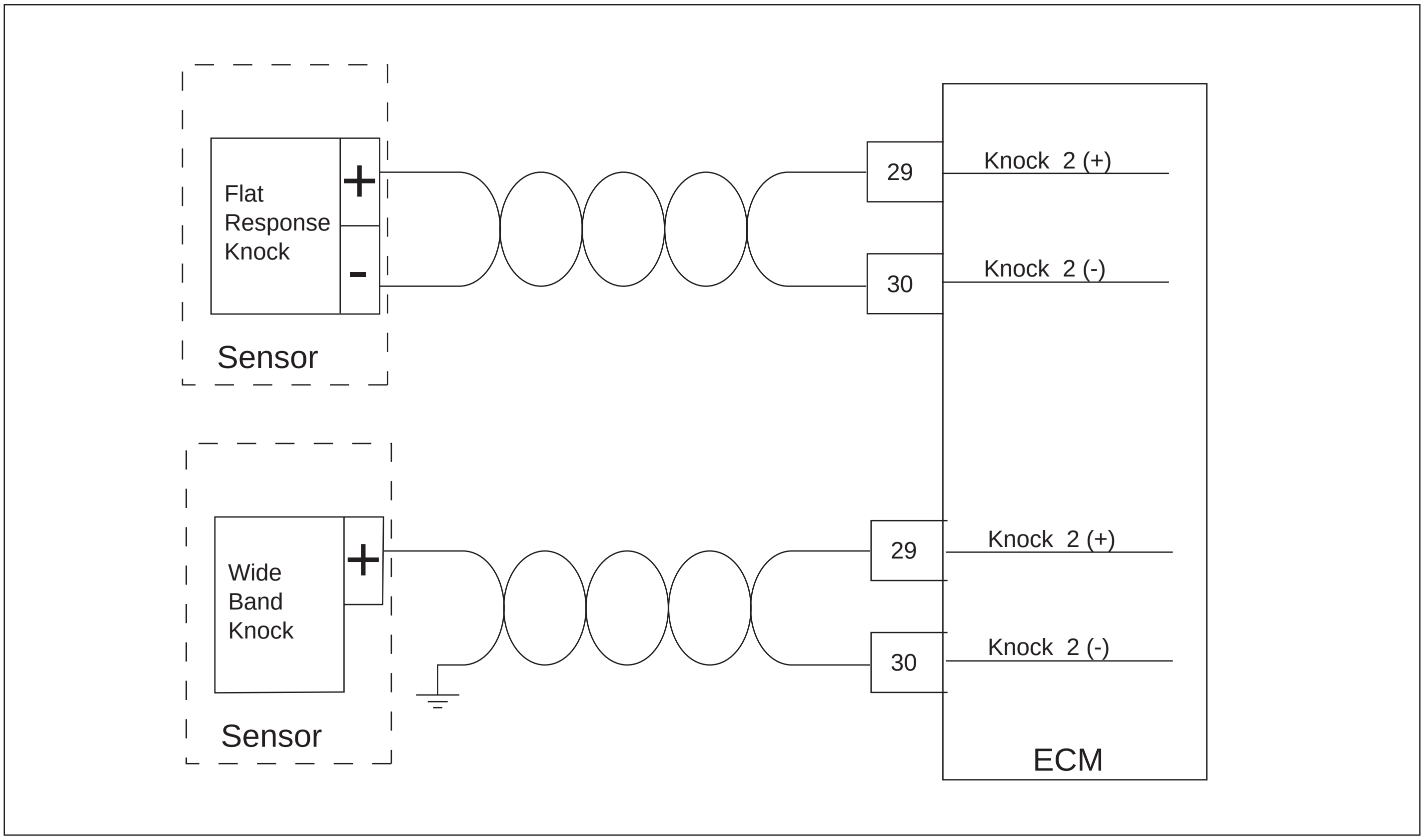
The knock sensor is used to detect detonation through mechanical vibration in the engine block and/or cylinder heads and provide feedback for the ignition system to retard spark to reduce knock intensity. In most applications the knock sensor is used to protect the engine from damage that can be caused 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



DTC 0332 - Knock 2 Sensor Circuit Open
SPN - 520197; FMI - 4

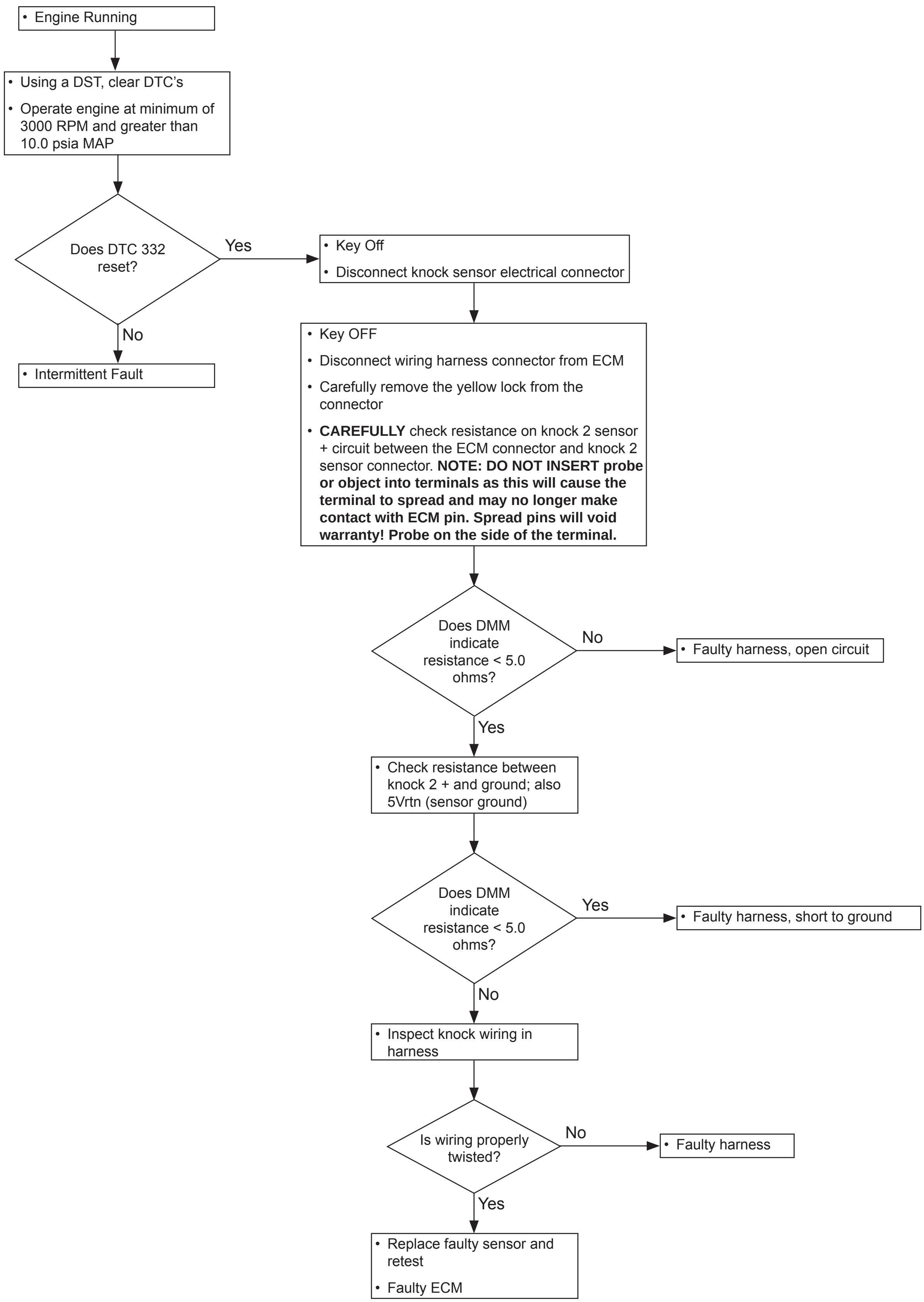


- Knock sensor #2
- *Check Condition* - Key On, Engine On
- *Fault Condition* - Knock sensor 2 signal low while engine speed is greater than 3000 RPM and MAP is greater than 10.00 psia as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate 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

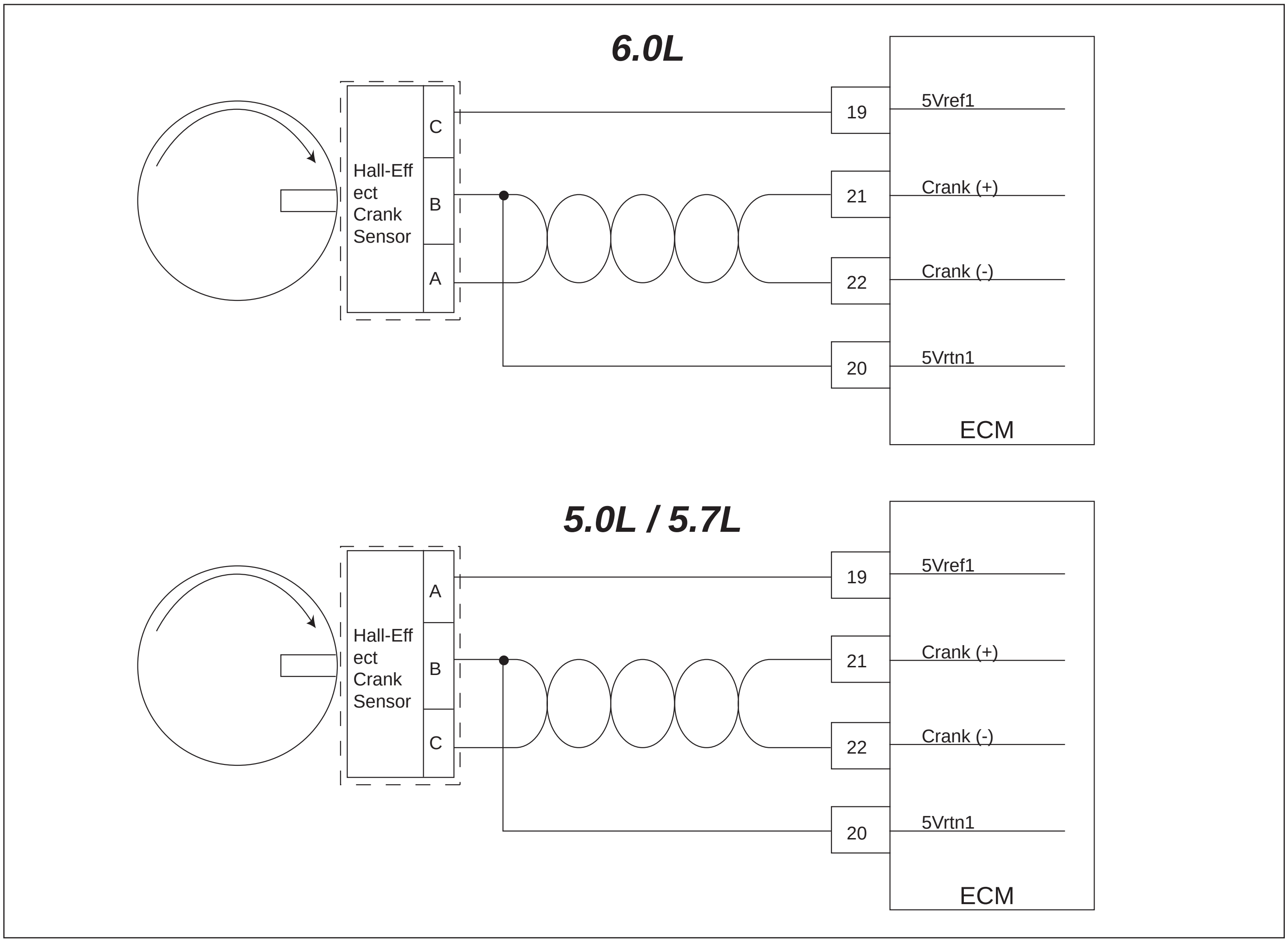
The knock sensor is used to detect detonation through mechanical vibration in the engine block and/or cylinder heads and provide feedback for the ignition system to retard spark to reduce knock intensity. In most applications the knock sensor is used to protect the engine from damage that can be caused 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



DTC 0336 - Crank Sensor Input Signal Noise
SPN - 636; FMI - 2

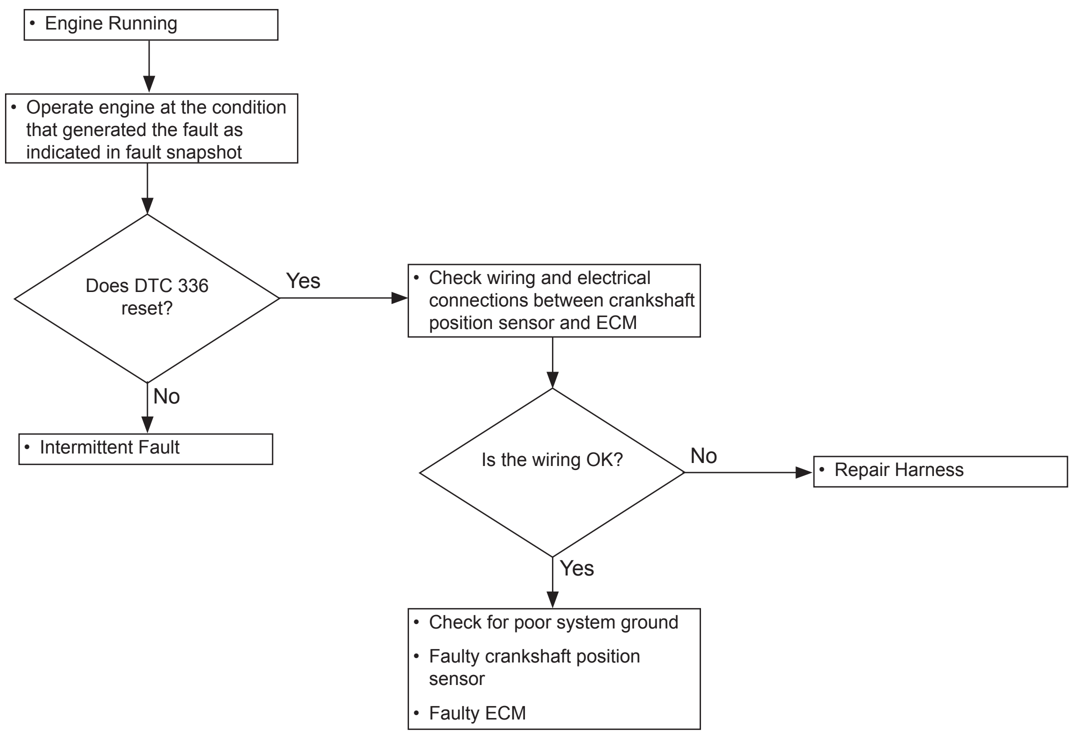


- Crankshaft Position sensor
- *Check Condition* - Key On, Engine On
- *Fault Condition* - Electrical noise or irregular crank pattern detected causing 1 number of crank re-synchronization events as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp and disable adaptive fueling correction for remainder of key-cycle.
- Emissions related fault

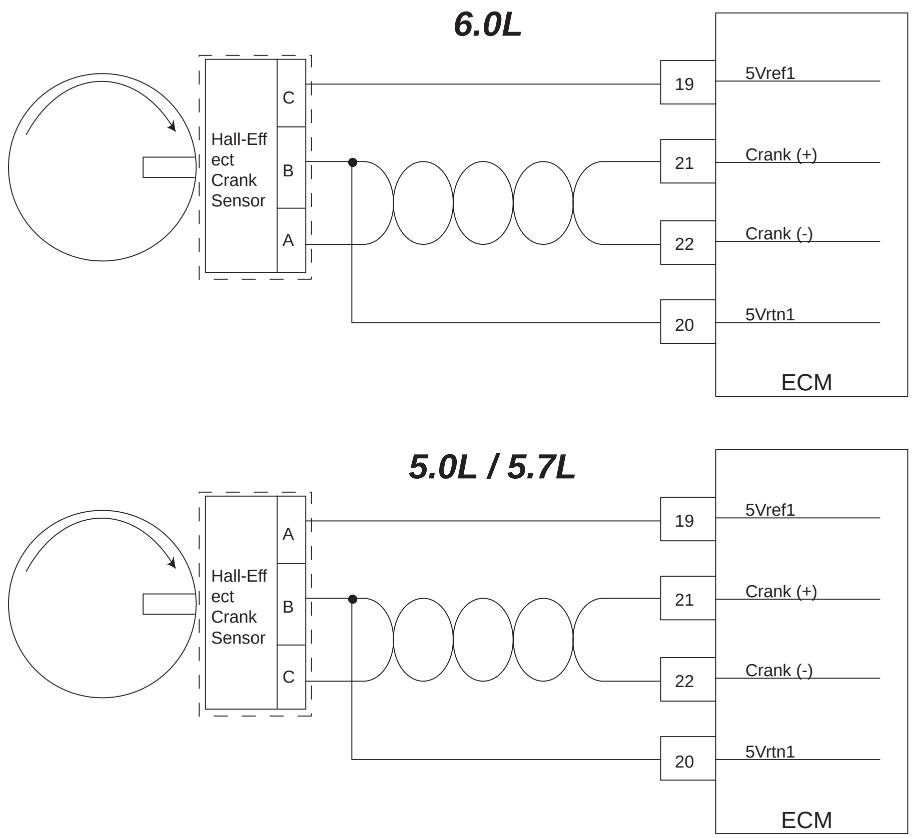
The crankshaft position sensor is a magnetic sensor installed in the engine block adjacent to a “coded” trigger wheel located on the crankshaft. The sensor-trigger wheel combination is used to determine crankshaft position (with respect to TDC cylinder #1 compression) and the rotational engine speed. 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



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

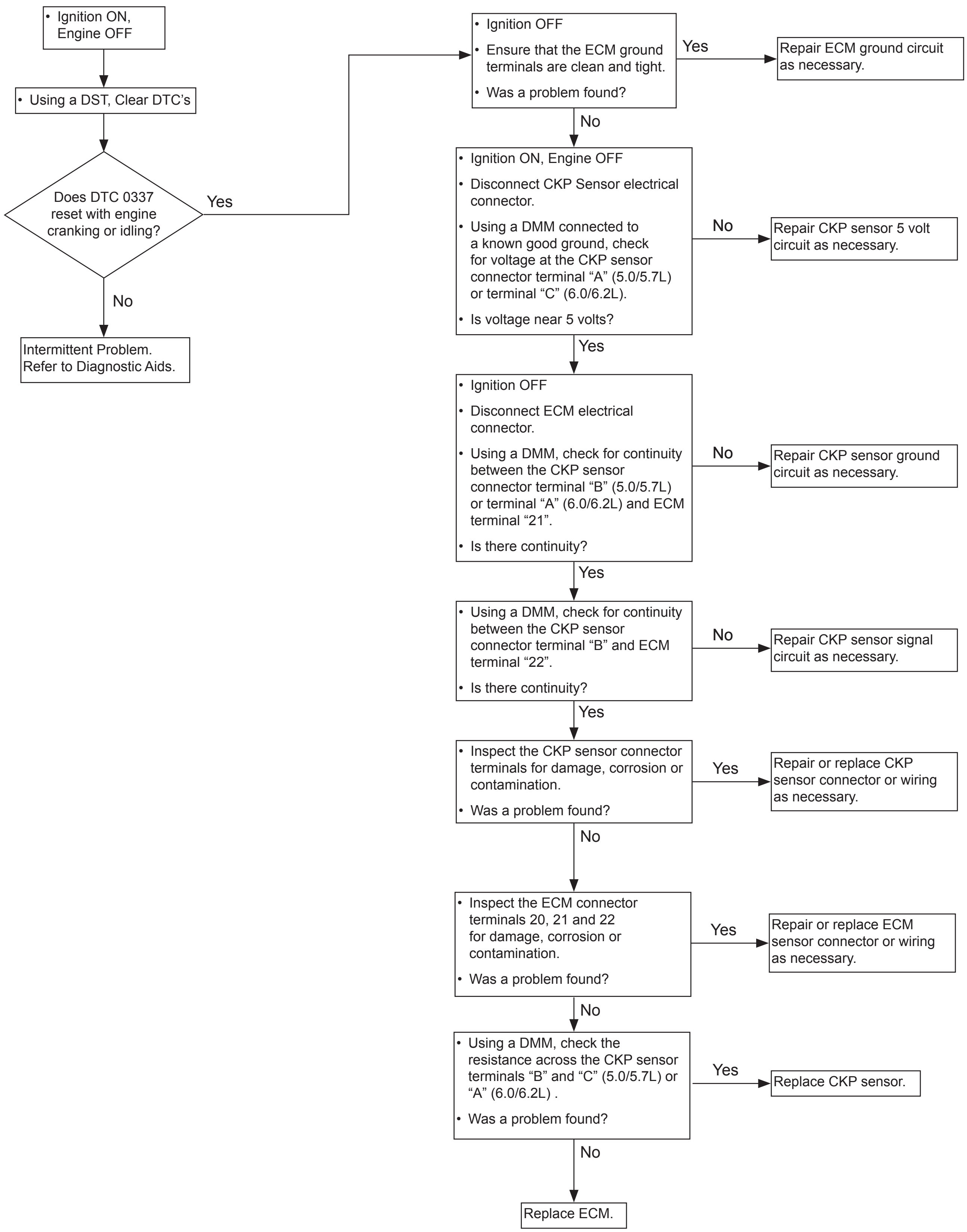
The crankshaft position sensor is a magnetic sensor installed in the engine block adjacent to a “coded” trigger wheel located on the crankshaft. The sensor-trigger wheel combination is used to determine crankshaft position (with respect to TDC cylinder #1 compression) and the rotational engine speed. 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.

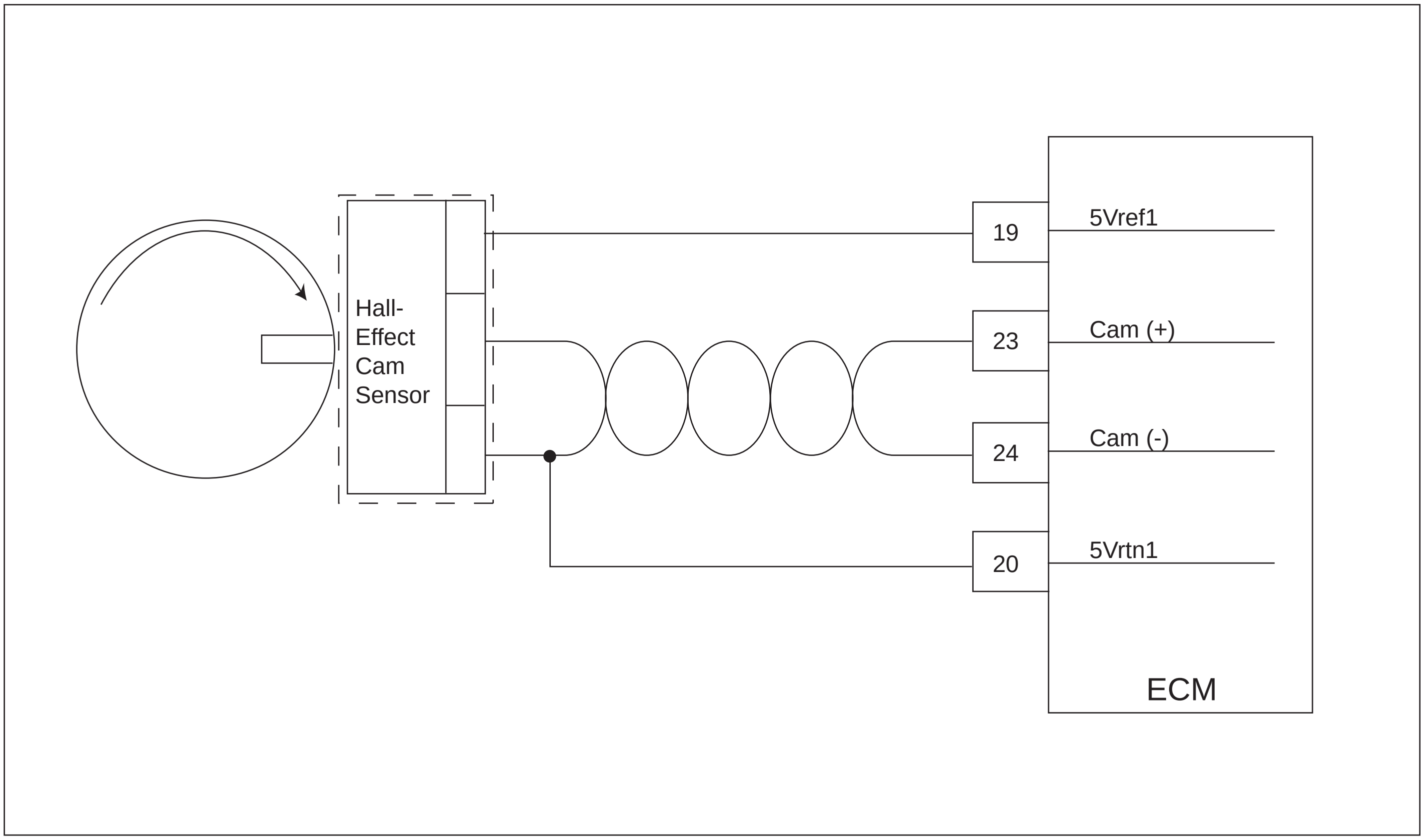
Diagnostic Aids

- □ 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



DTC 0341 - Camshaft Sensor Input Signal Noise
SPN - 723; FMI - 2

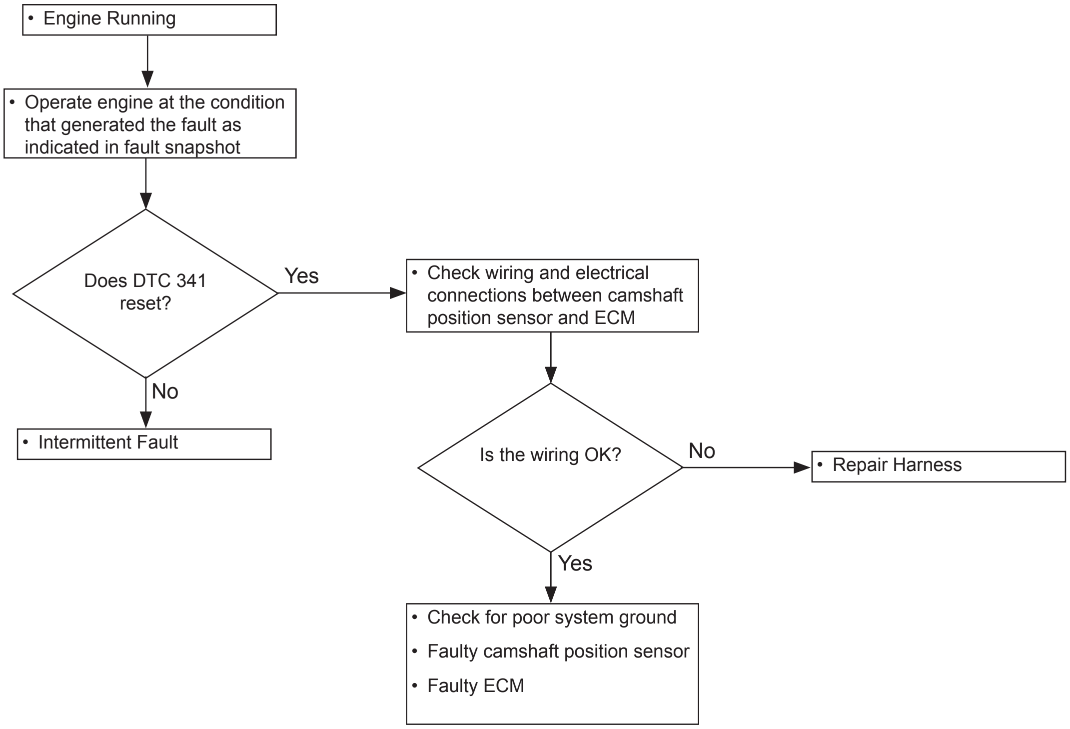


- Camshaft Position sensor
- *Check Condition* - Key On, Engine On
- *Fault Condition* - Electrical noise or irregular cam pattern detected causing 1 number of cam re-synchronization events as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp and disable adaptive fueling correction for remainder of key-cycle.
- Emissions related fault

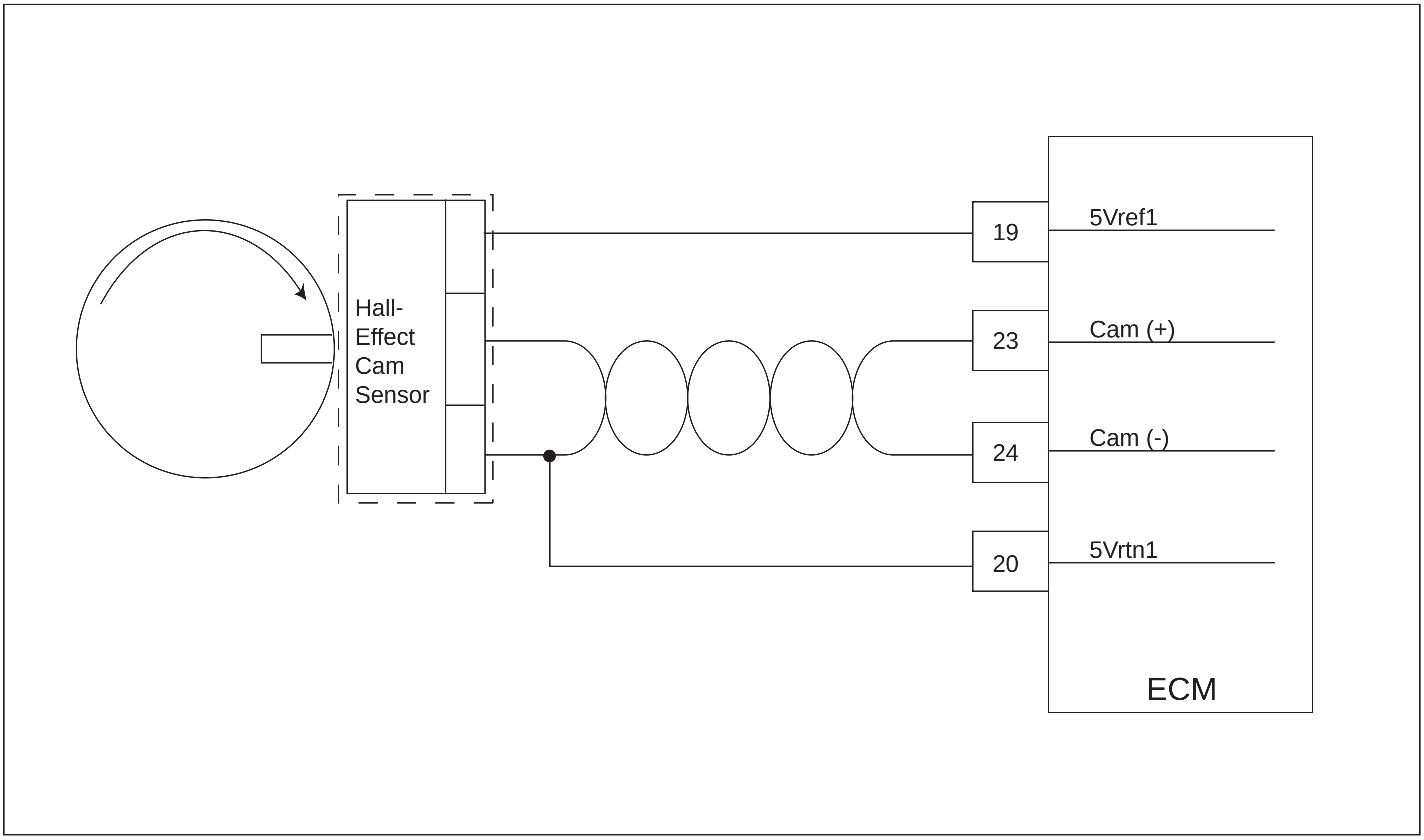
The camshaft position sensor is a magnetic sensor installed in the engine block or valve train adjacent to a “coded” trigger wheel located on or off of the camshaft. The sensor-trigger wheel combination is used to determine cam position (with respect to TDC cylinder #1 compression). Determination of 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



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 reluctant/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.

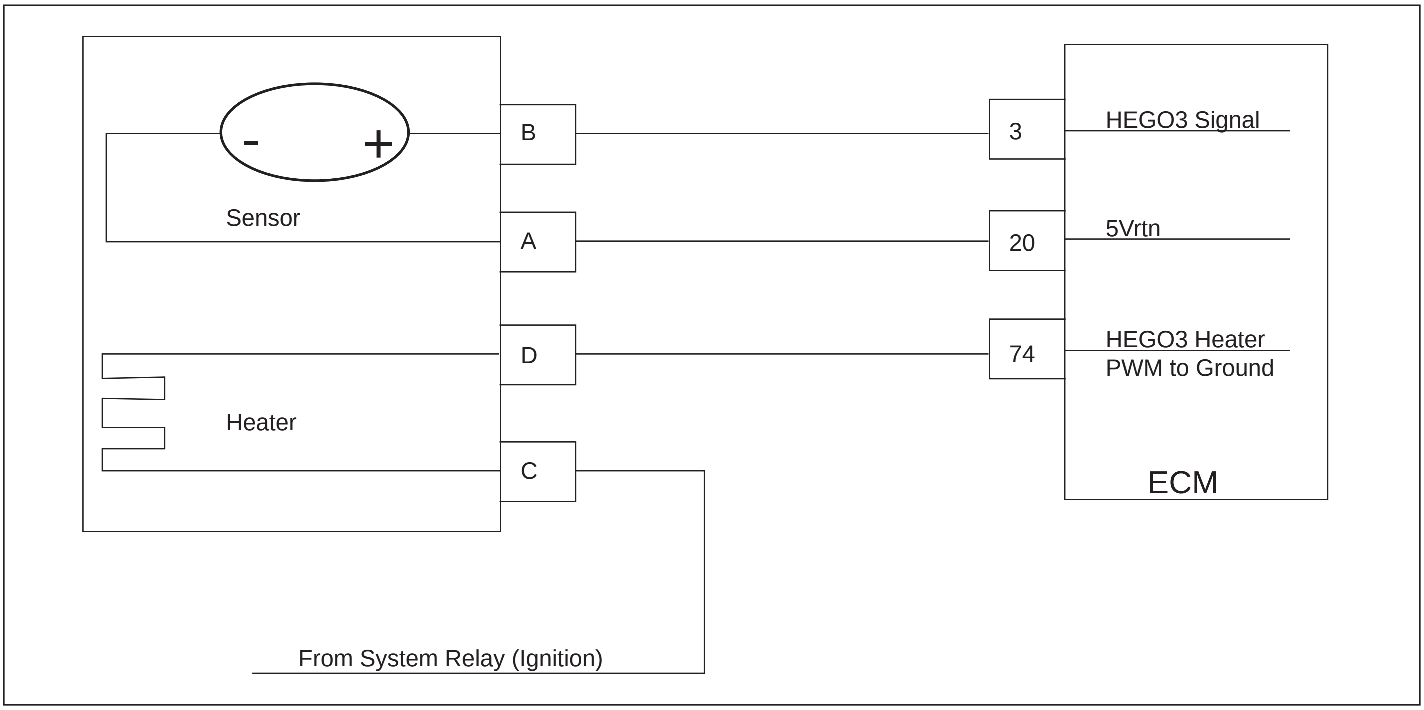
For a cam synchronized engine, the ECM must see a valid camshaft position signal while running. This fault will set if valid crankshaft position data is received for 2.0 number of engine cycles while engine speed is greater than 100 RPM and no camshaft signal is received. Normally the engine will continue 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

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.

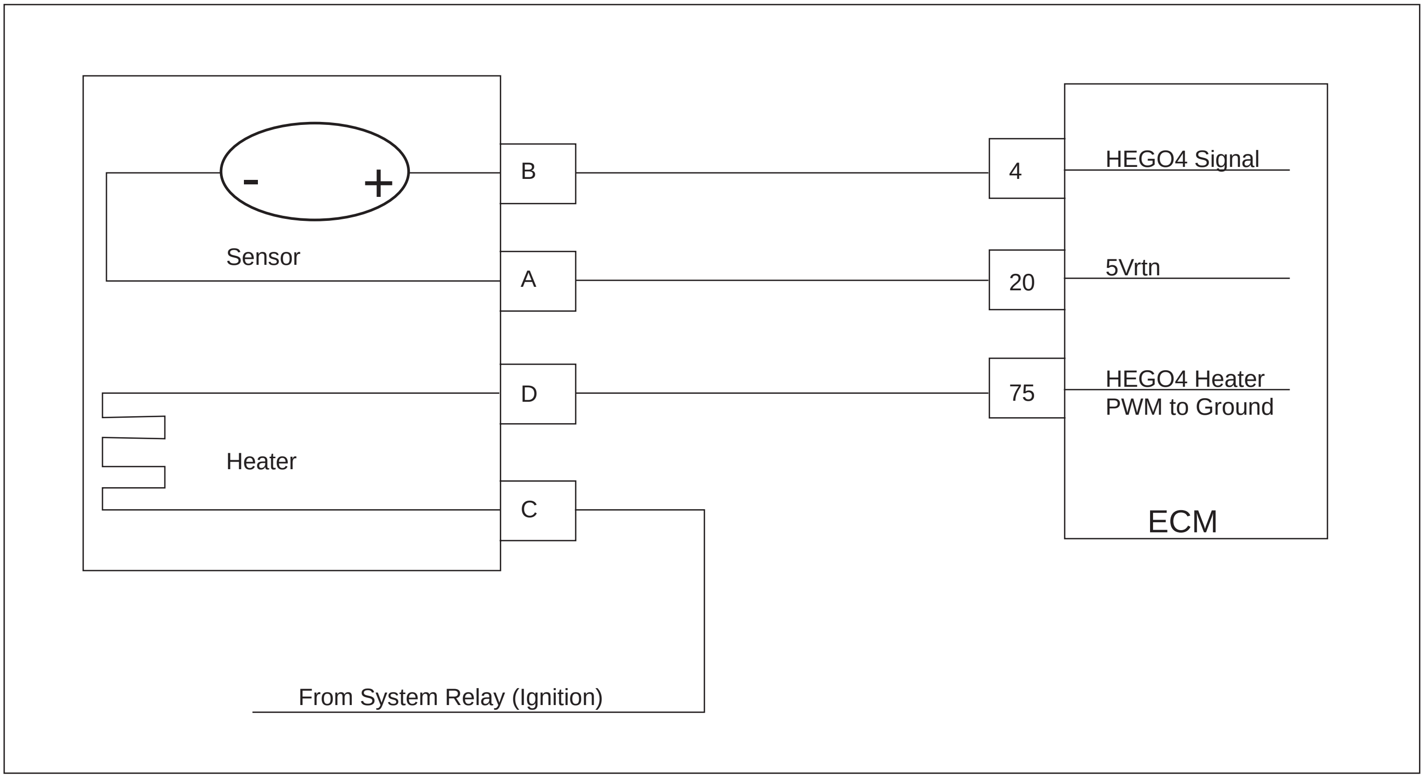
DTC 0420 - Catalyst Inactive on Bank 1
SPN - 3050; FMI - 11

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.

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.

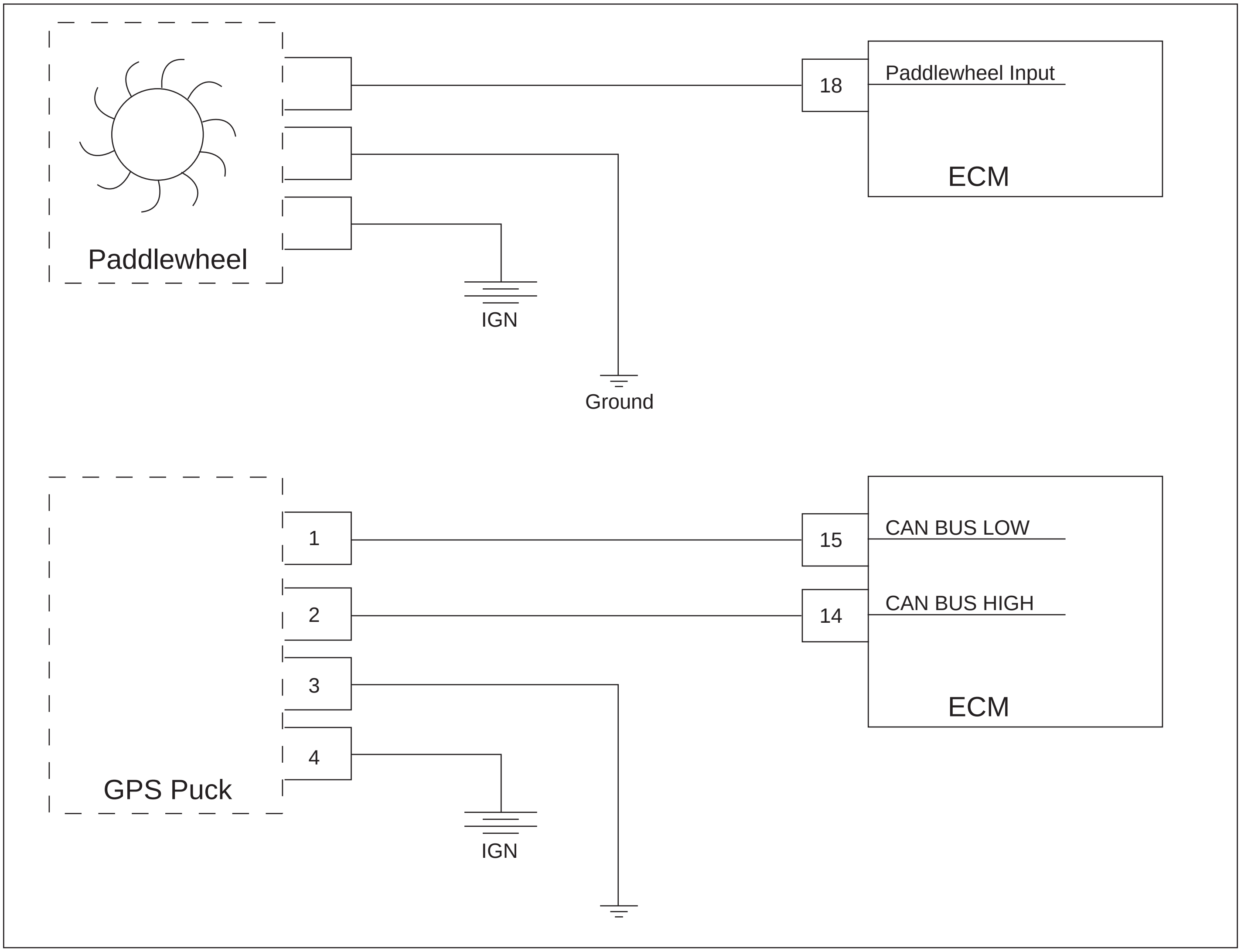
DTC 0430 - Catalyst Inactive on Bank 2
SPN - 3051; FMI - 11

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.

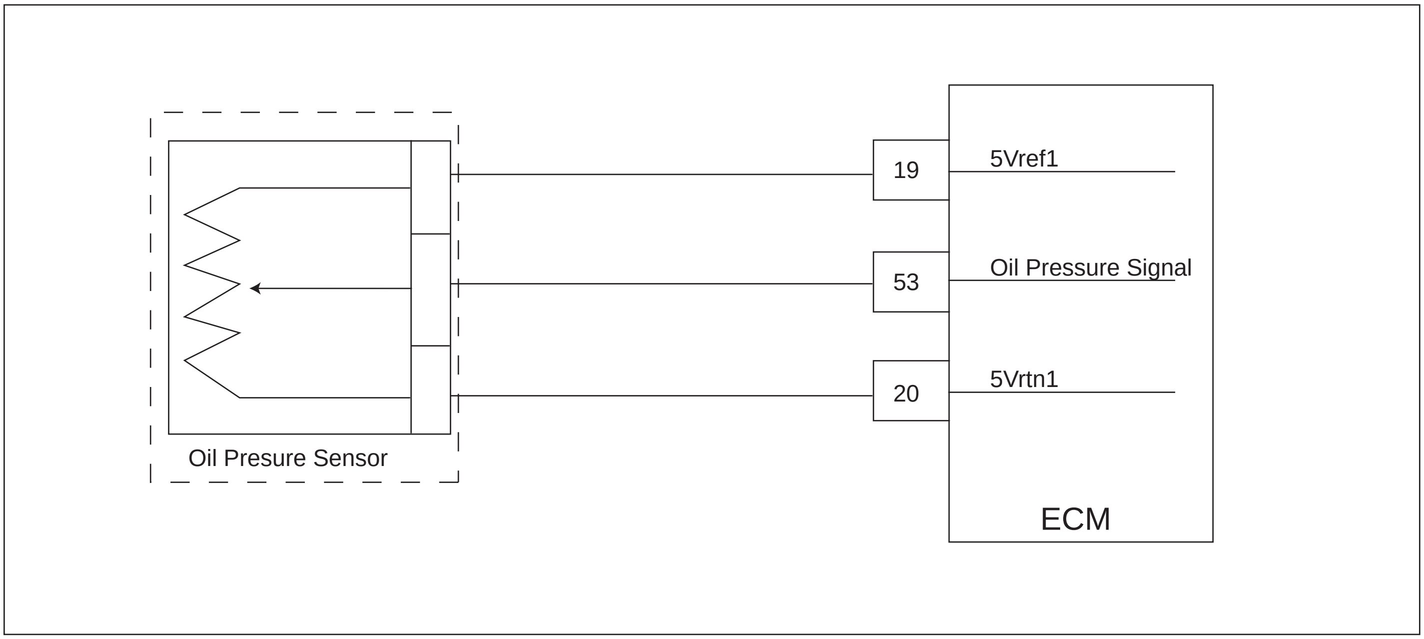
DTC 0502 - Boatspeed Input Loss of Signal
SPN - 84; FMI - 8



- 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 intial 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

DTC 0521 - Oil Pressure Sensor - High Pressure
SPN - 100; FMI - 0

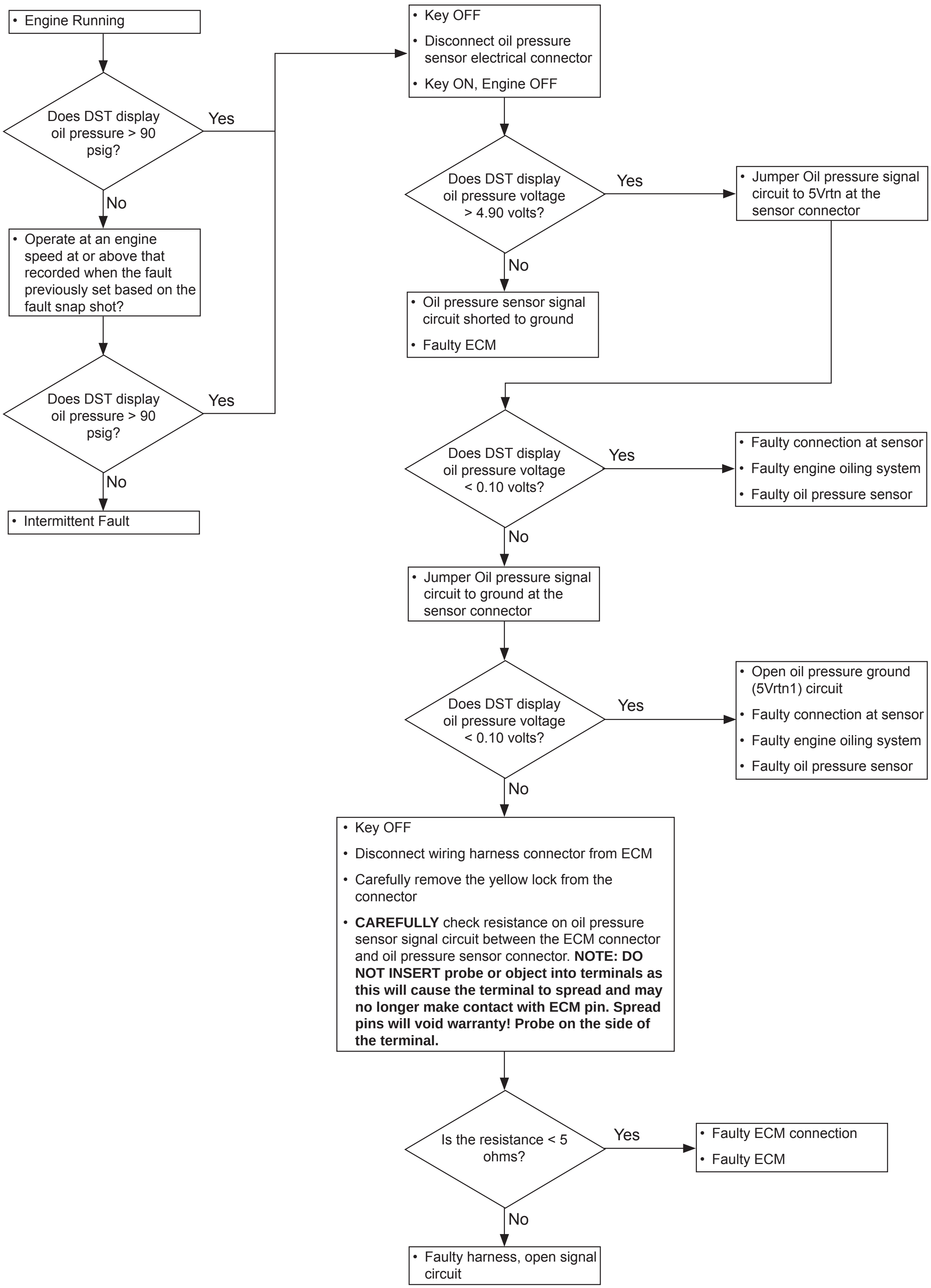


- Engine Oil Pressure
- *Check Condition* - Key on, Engine on
- *Fault Condition* - Oil pressure higher than 90.0 psia while engine speed is less than 3000 RPM.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

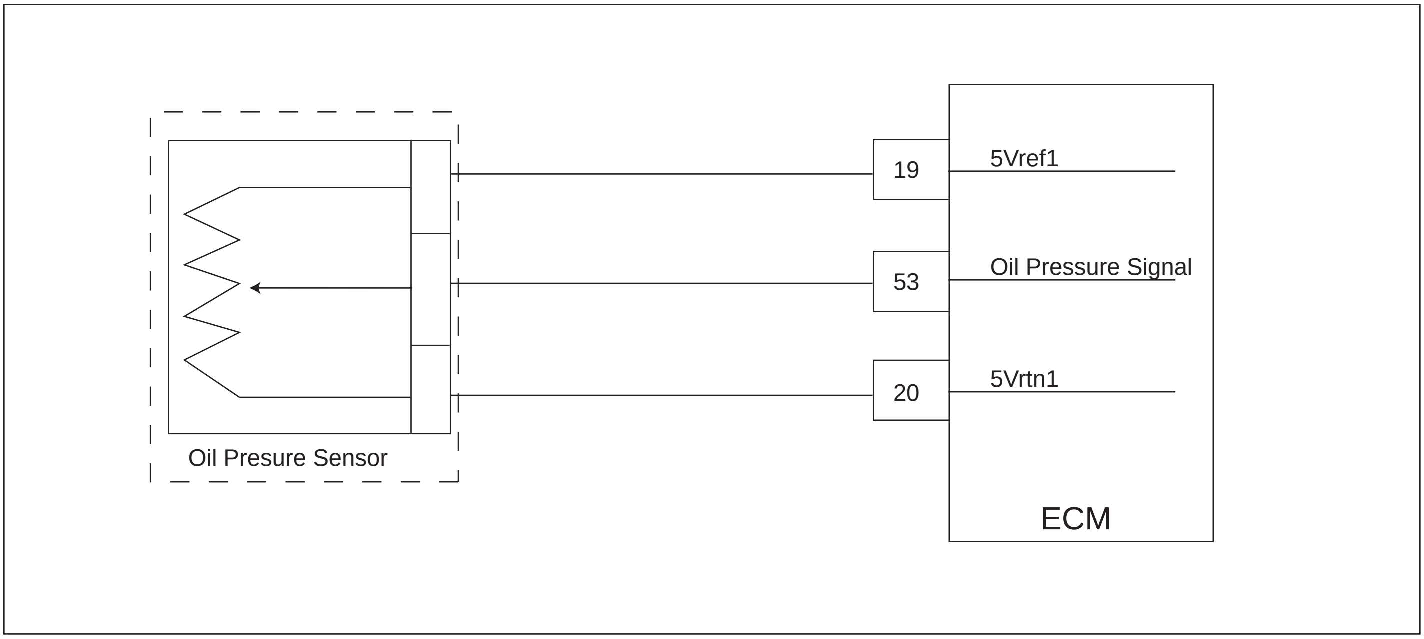
The ECM monitors oil pressure through a proportional transducer. Oil pressure monitoring is important to prevent engine damage due to low oil pressure resulting in higher friction and lack of lubrication. In addition, high oil pressure can be undesirable because it can cause oil to leak past seals and 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



DTC 0522 - Oil Pressure Sensor - Low Voltage
SPN - 100; FMI - 4

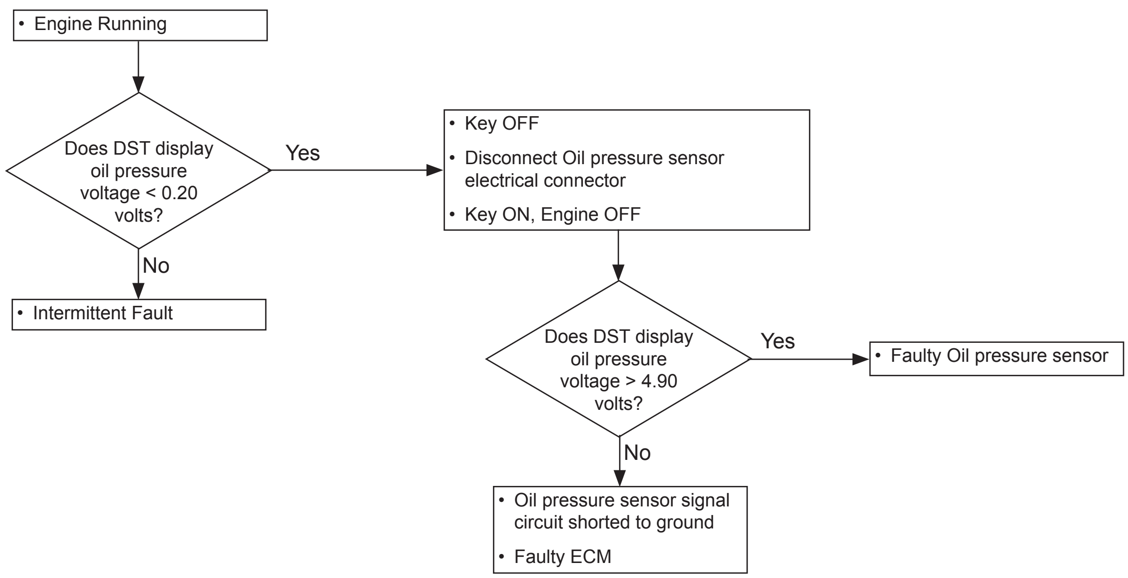


- Engine Oil Pressure
- *Check Condition* - Key on, Engine on
- *Fault Condition* - Oil pressure sensor voltage lower than 0.20 volts
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

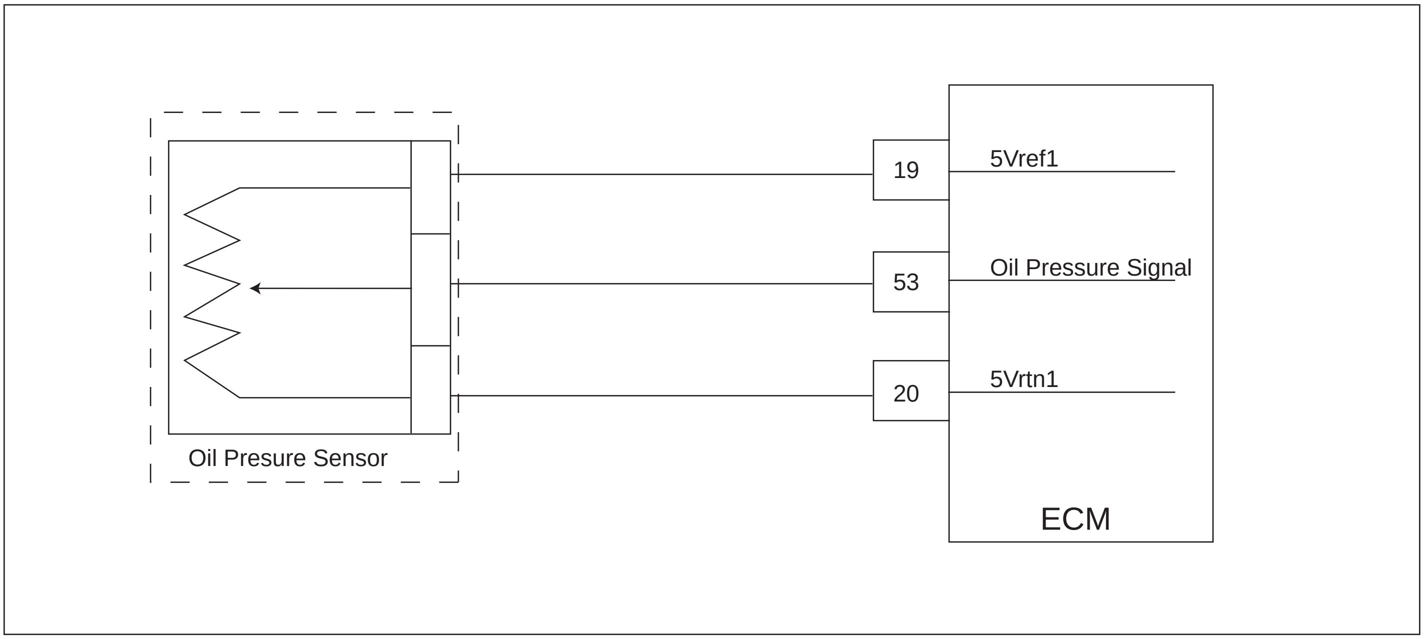
The ECM monitors oil pressure through a proportional transducer. Oil pressure monitoring is important to prevent engine damage due to low oil pressure resulting in higher friction and lack of lubrication. In addition, high oil pressure can be undesirable because it can cause oil to leak past seals and 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



DTC 0523 - Oil Pressure Sensor - High Voltage
SPN - 100; FMI - 3

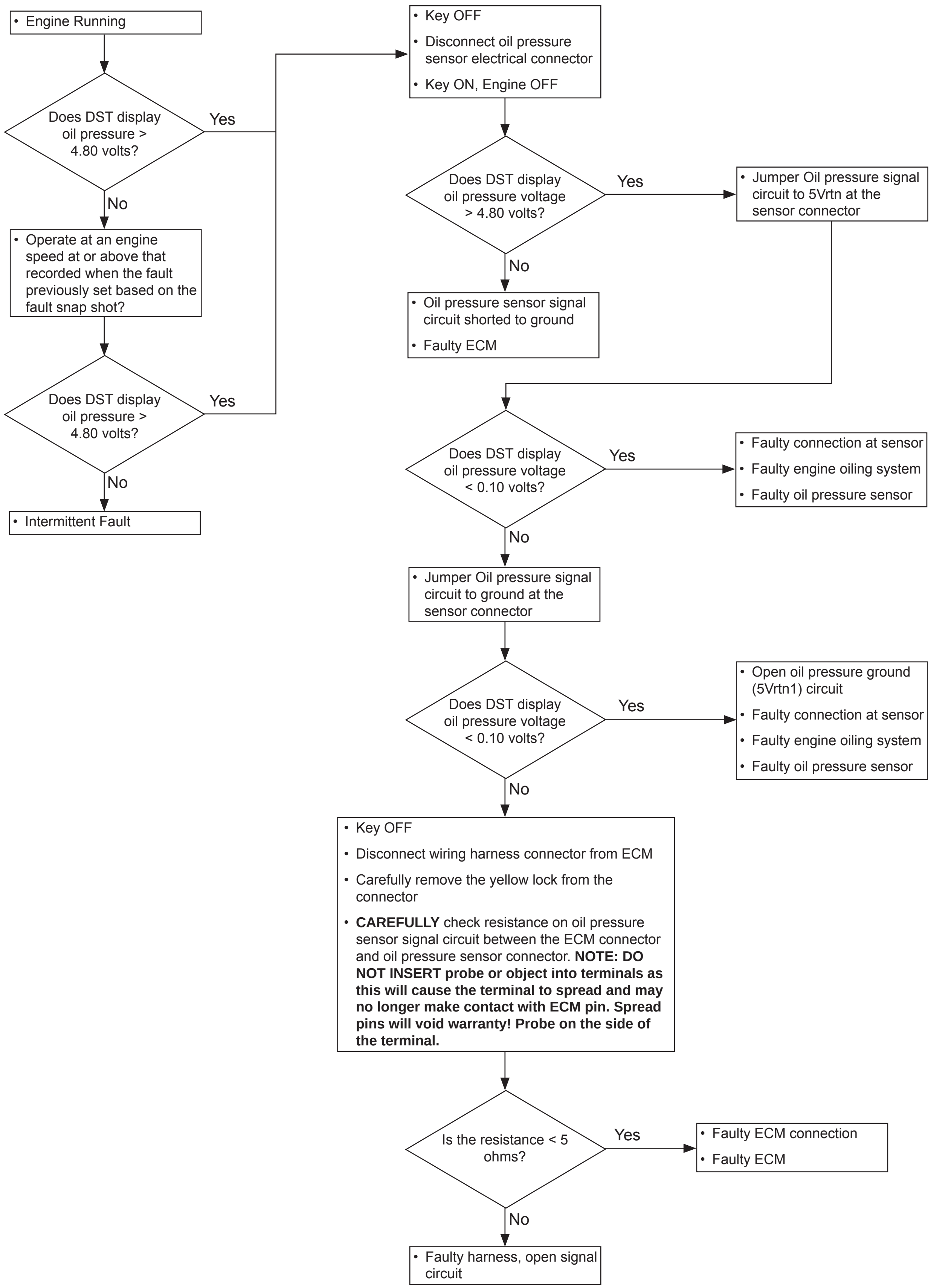


- Engine Oil Pressure
- *Check Condition* - Key on, Engine on
- *Fault Condition* - Oil pressure sensor voltage higher than 4.80 volts
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

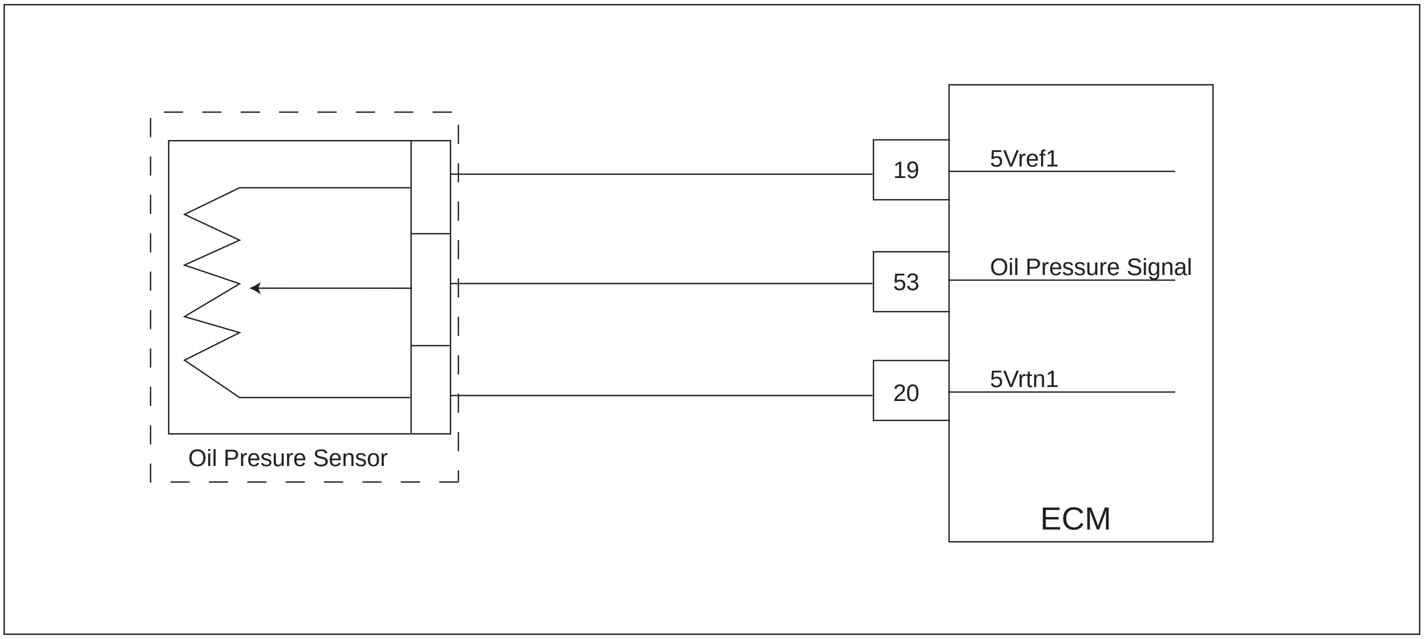
The ECM monitors oil pressure through a proportional transducer. Oil pressure monitoring is important to prevent engine damage due to low oil pressure resulting in higher friction and lack of lubrication. In addition, high oil pressure can be undesirable because it can cause oil to leak past seals and 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



DTC 0524 - Oil Pressure Sensor - Low Pressure
SPN - 100; FMI - 1

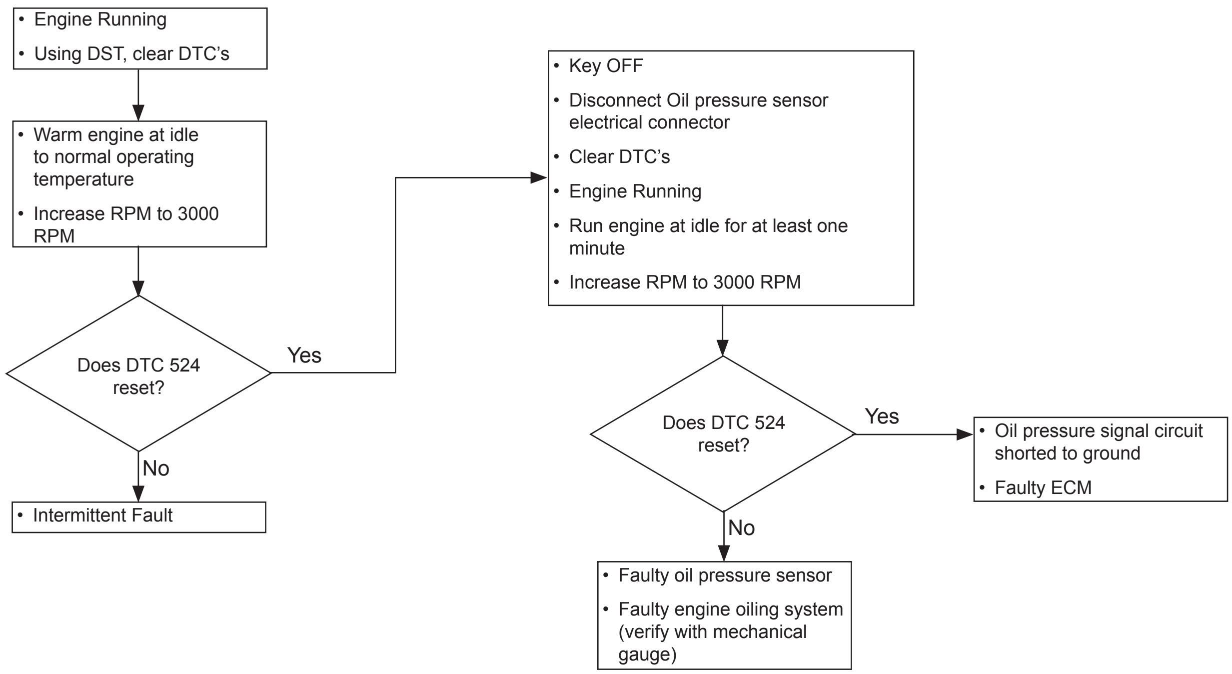


- Engine Oil Pressure
- *Check Condition* - Key on, Engine on
- *Fault Condition* - Engine oil pressure lower than expected while engine has been running for a minimum amount of time while engine speed is above some limit as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate 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

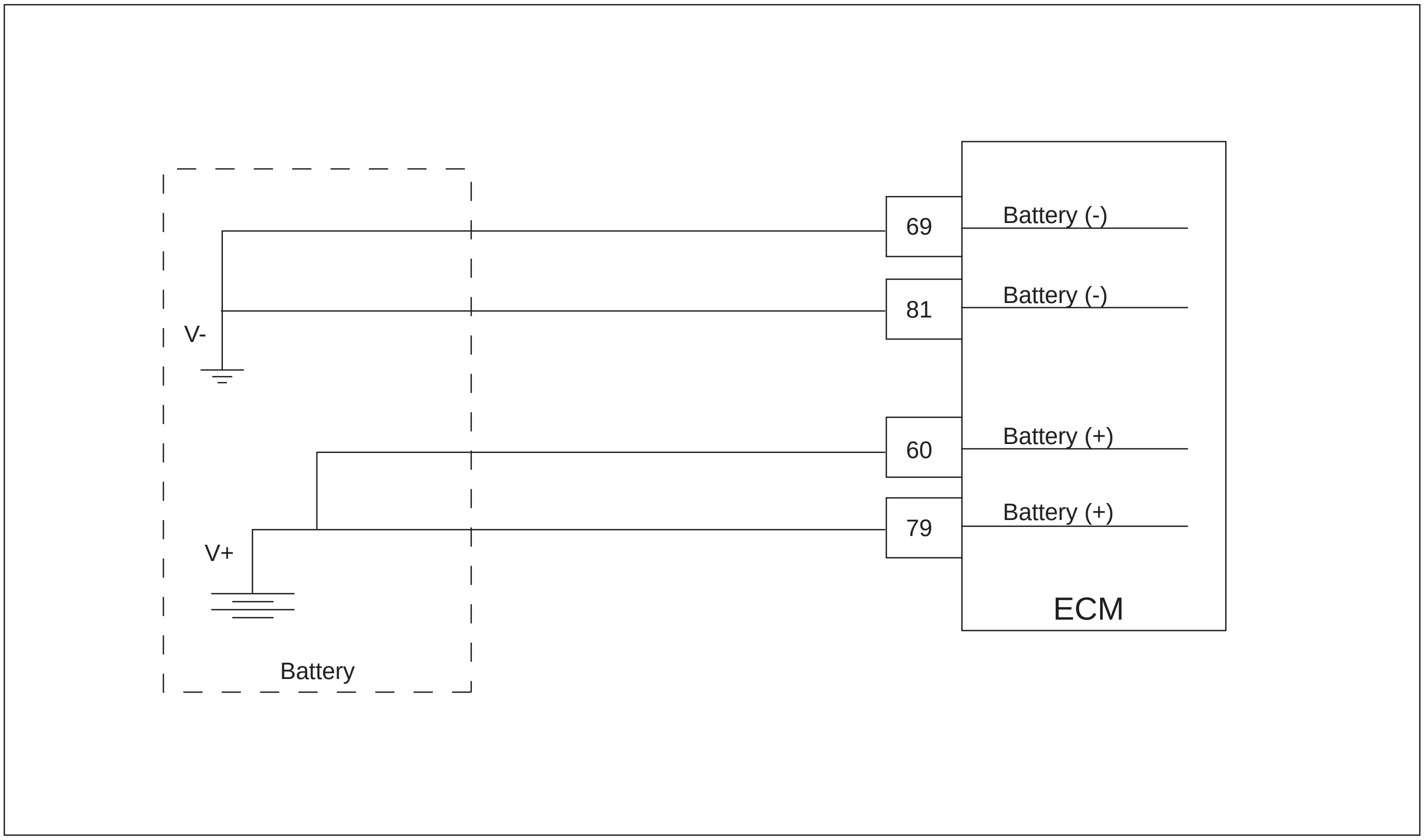
The ECM monitors oil pressure through a proportional transducer. Oil pressure monitoring is important to prevent engine damage due to low oil pressure resulting in higher friction and lack of lubrication. In addition, high oil pressure can be undesirable because it can cause oil to leak past seals and 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



DTC 0562 - Battery Voltage (Vbat) Low
SPN - 168; FMI - 17

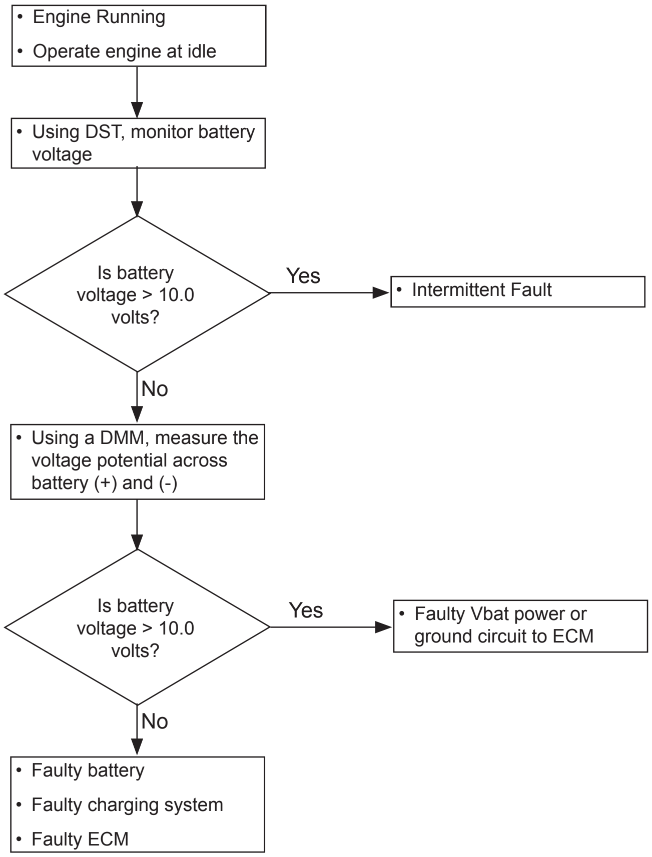


- System voltage to ECM
- *Check Condition* - Key on, Engine on
- *Fault Condition* - Battery voltage to ECM less than 10.0 volts while the engine is operating at 1500 RPM or greater as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle
- Non-emissions related fault

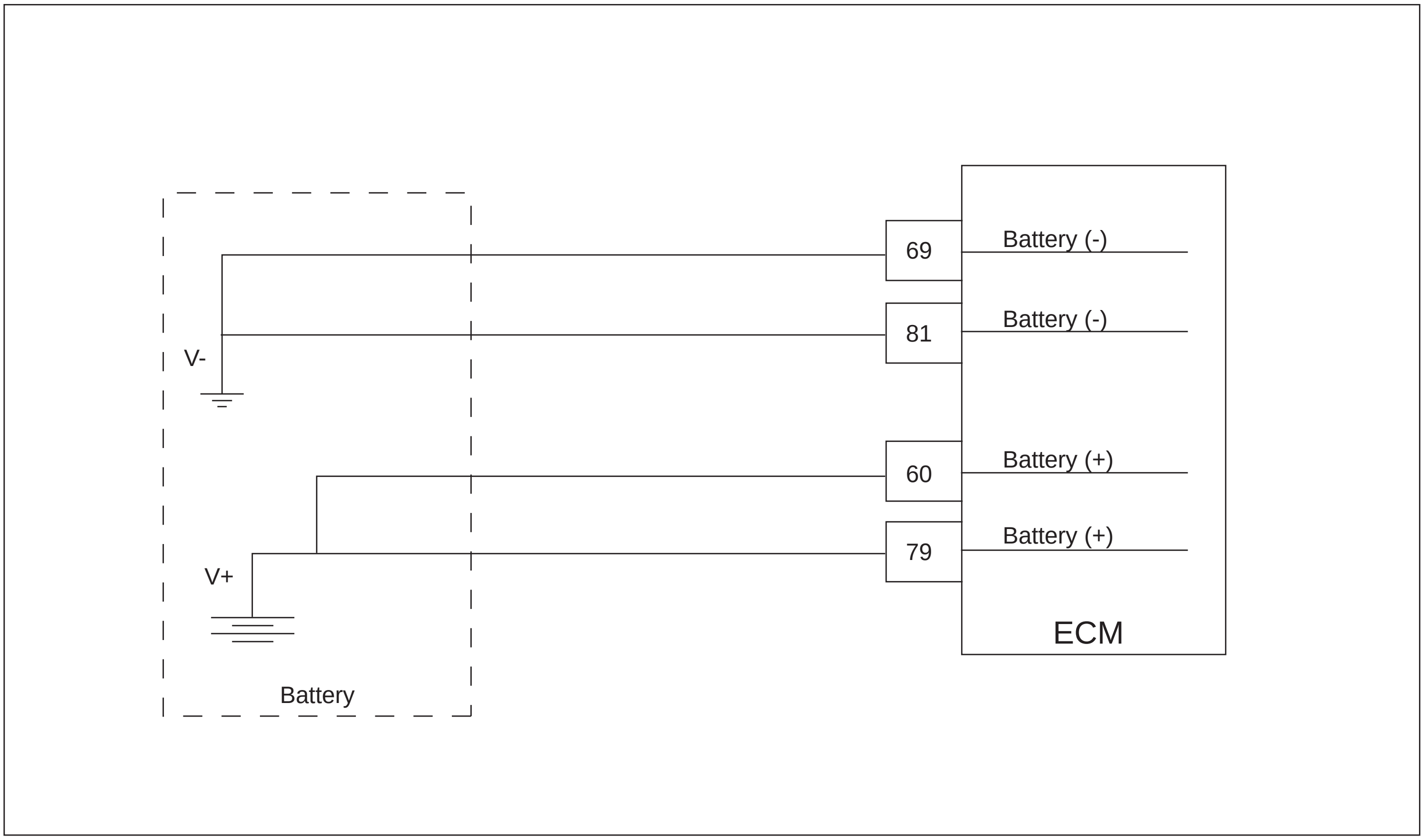
The battery voltage powers the ECM and must be within limits to correctly operate injector drivers, ignition coils, throttle, power supplies, and other powered devices that the ECM controls.

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



DTC 0563 - Battery Voltage (Vbat) High
SPN - 168; FMI - 15

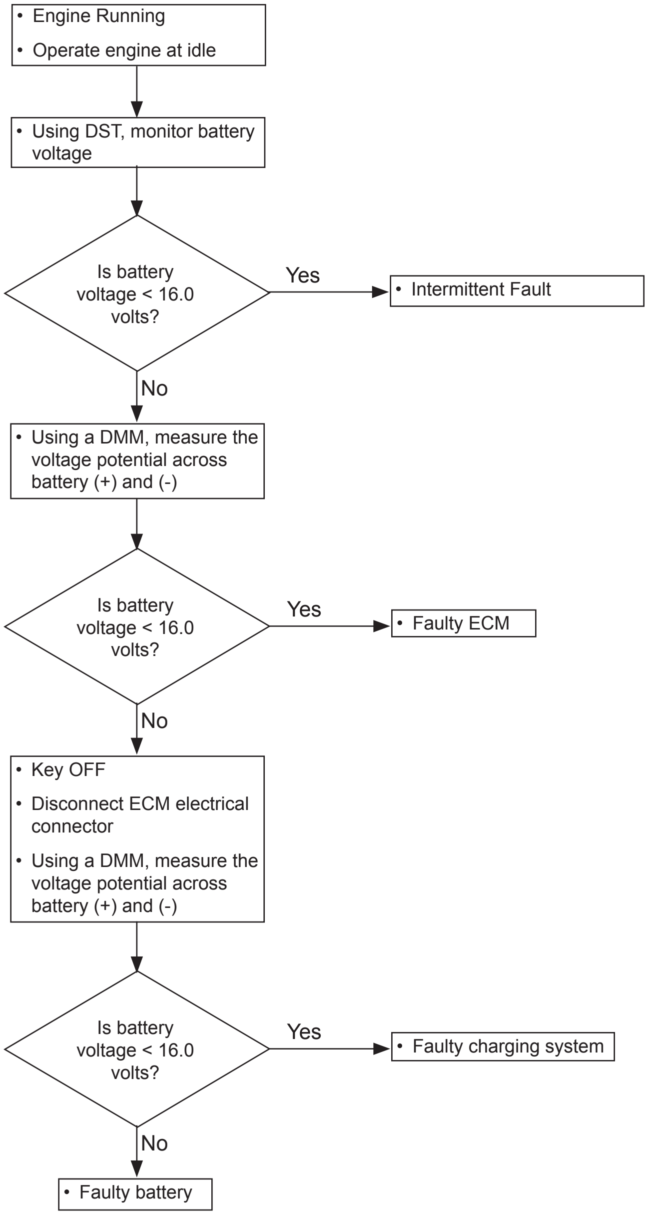


- System voltage to ECM
- *Check Condition* - Key on, Engine Cranking or Running
- *Fault Condition* - Battery voltage to ECM greater than 16.0 volts while the engine is running as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle
- Non-emissions related fault

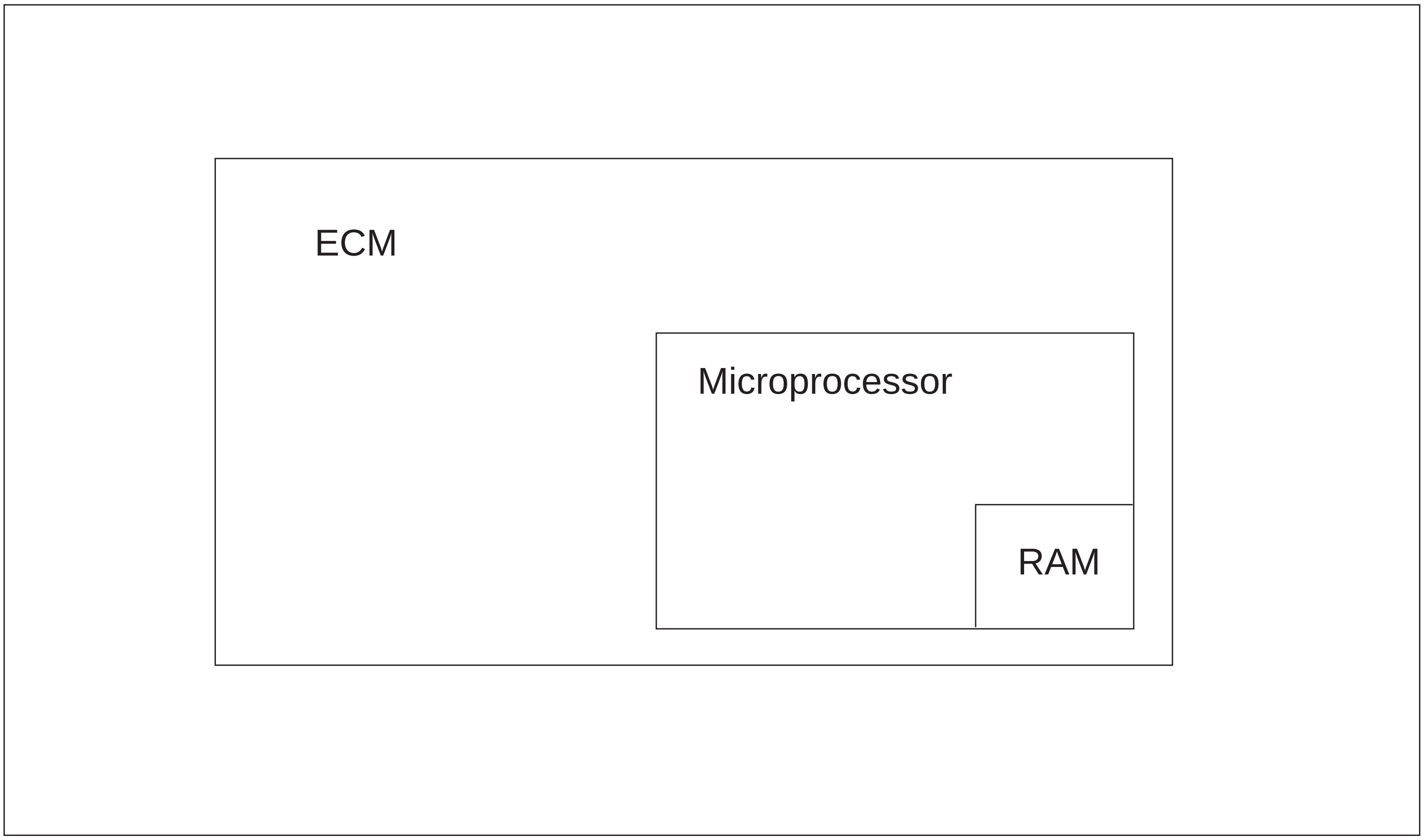
The battery voltage powers the ECM and must be within limits to correctly operate injector drivers, ignition coils, throttle, power supplies, and other powered devices that the ECM controls.

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



DTC 0601 - Microprocessor Failure - FLASH
SPN - 628; FMI - 13

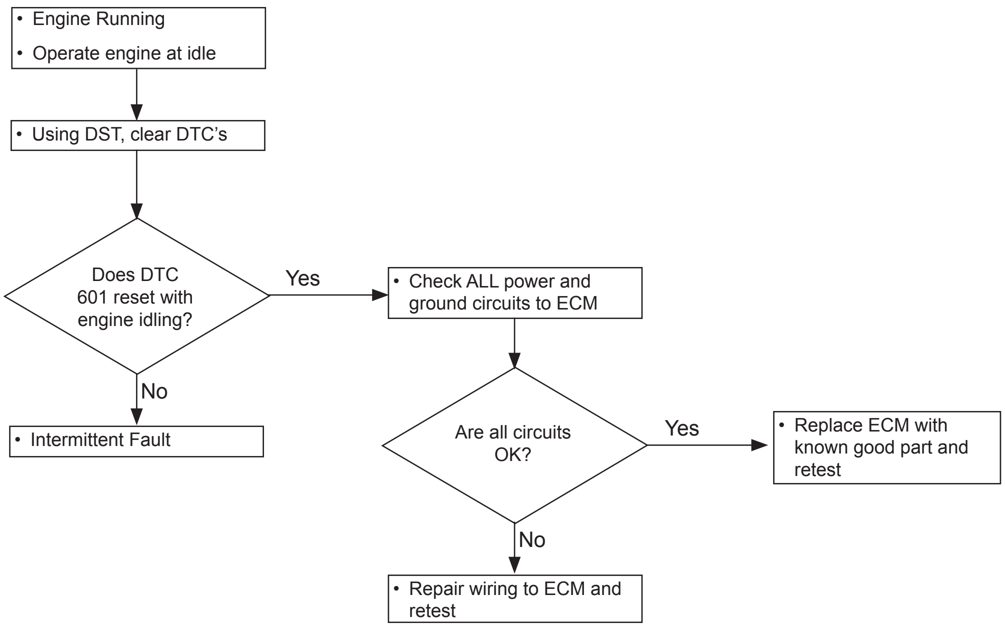


- Engine Control Module- Flash Memory
- *Check Condition* - Key on
- *Fault Condition* - Internal microprocessor error
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle, recommend power derate 2 and low rev limit to reduce possible engine damage and/or overspeed condition
- Non-emissions related fault

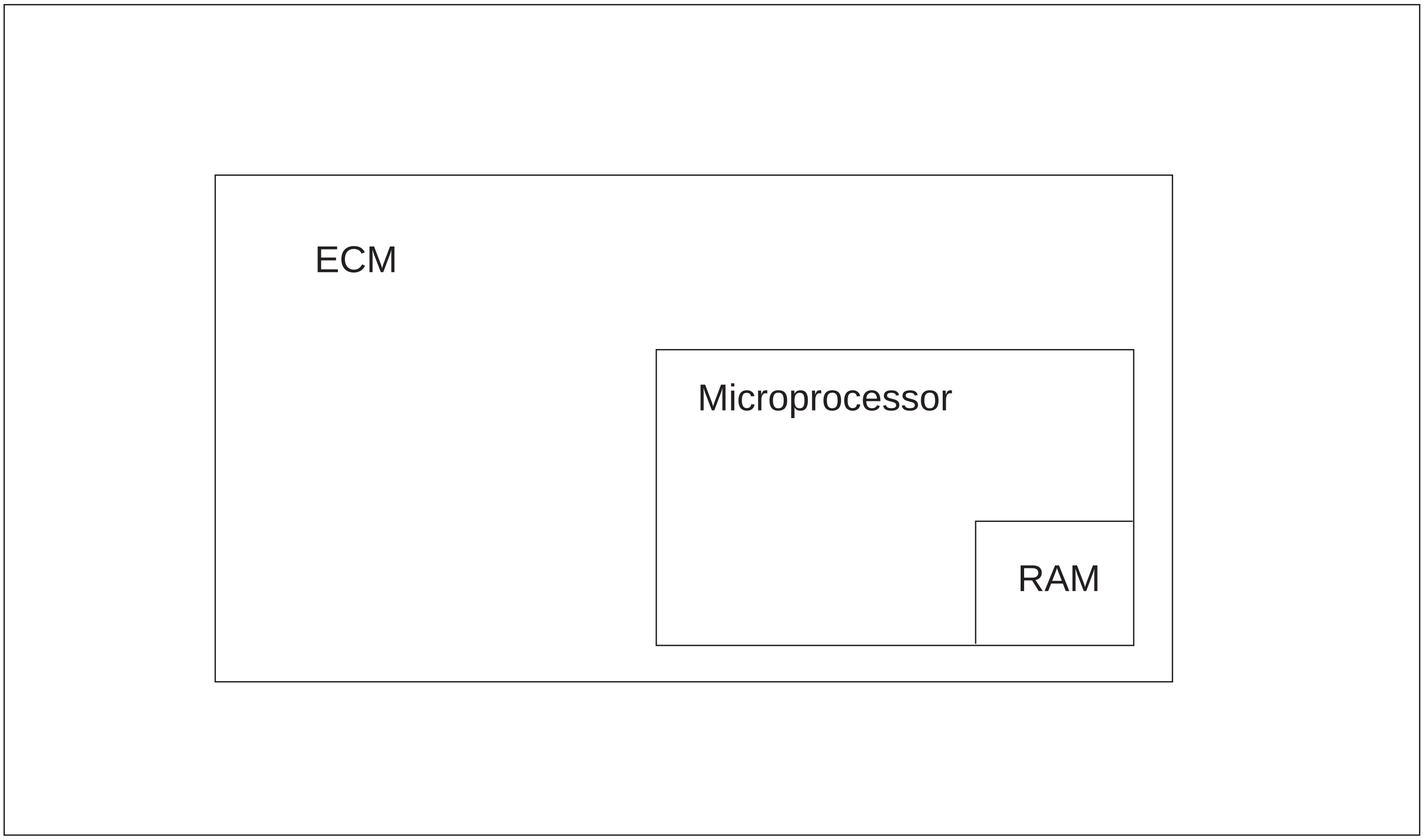
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault.

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



DTC 0604 - Microprocessor Failure - RAM
SPN - 630; FMI - 12

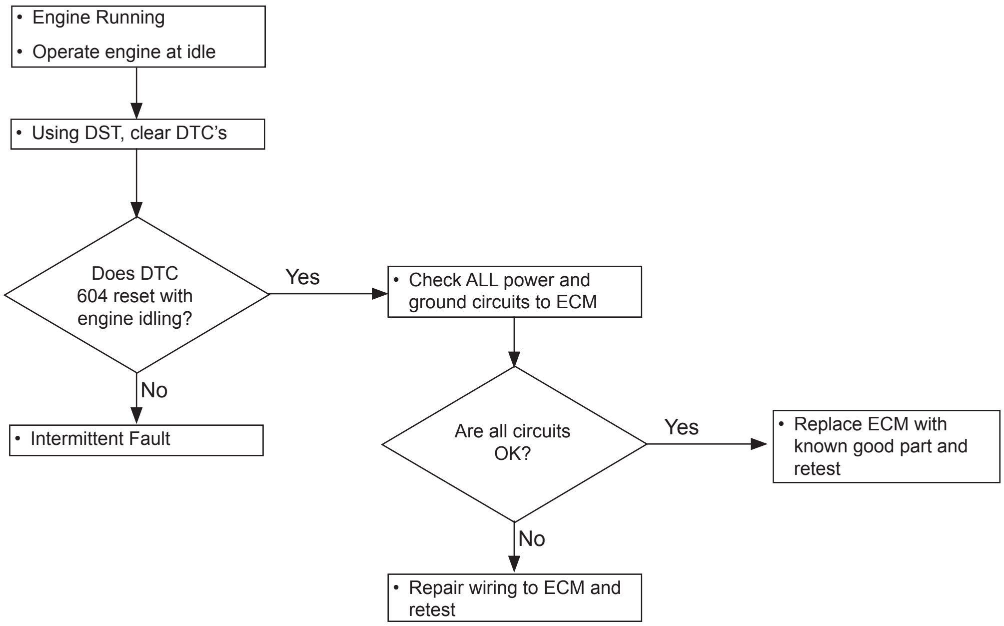


- Engine Control Module- Random Access Memory
- *Check Condition* - Key on
- *Fault Condition* - Internal ECM microprocessor memory access failure
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle, recommend power derate 2 and low rev limit to reduce possible engine damage and/or overspeed condition
- Non-emissions related fault

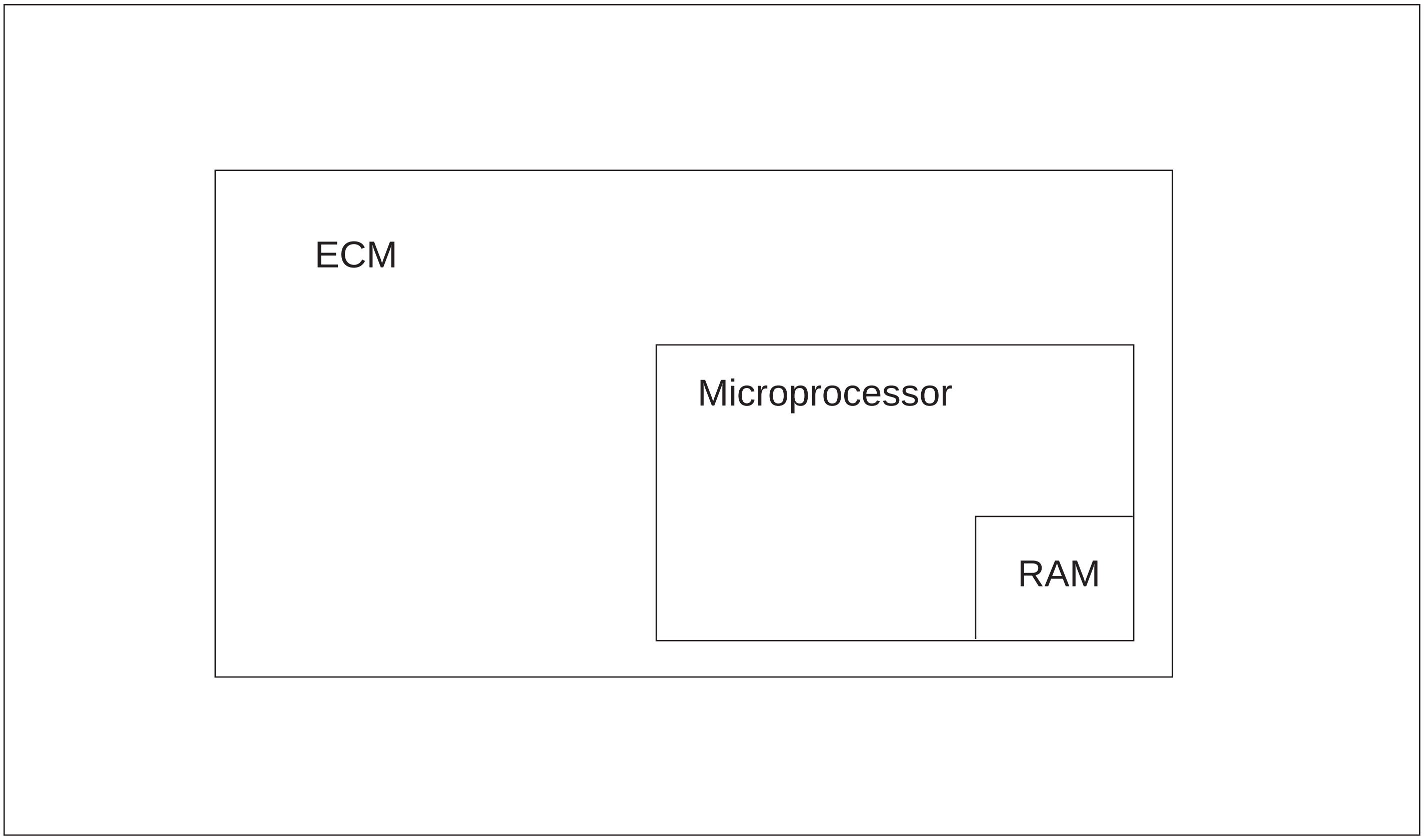
Random Access Memory is located within the microprocessor and can be read from or written to at any time. Data stored in RAM include DTCs (when fault configuration is set to “Battery Power Retained”), adaptive fuel learn tables, octane adaptation table, misfire adaption tables, and closed loop fuel multipliers. 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



DTC 0606 - Microprocessor Failure - COP
SPN - 629; FMI - 31

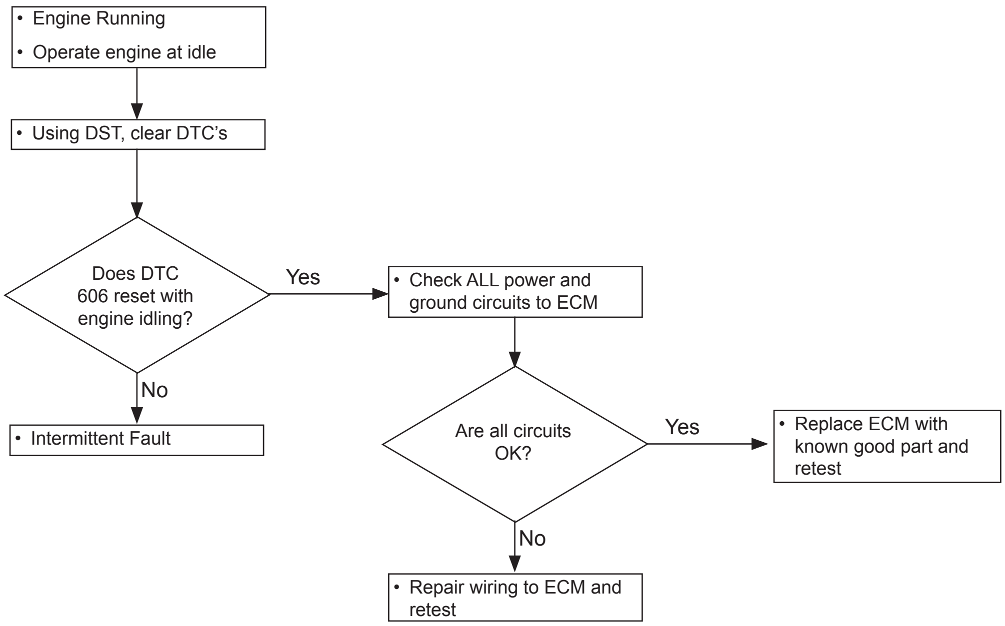


- Engine Control Module
- *Check Condition* - Key on
- *Fault Condition* - Internal microprocessor error
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle, recommend power derate 2 and low rev limit to reduce possible engine damage and/or overspeed condition
- Non-emissions related fault

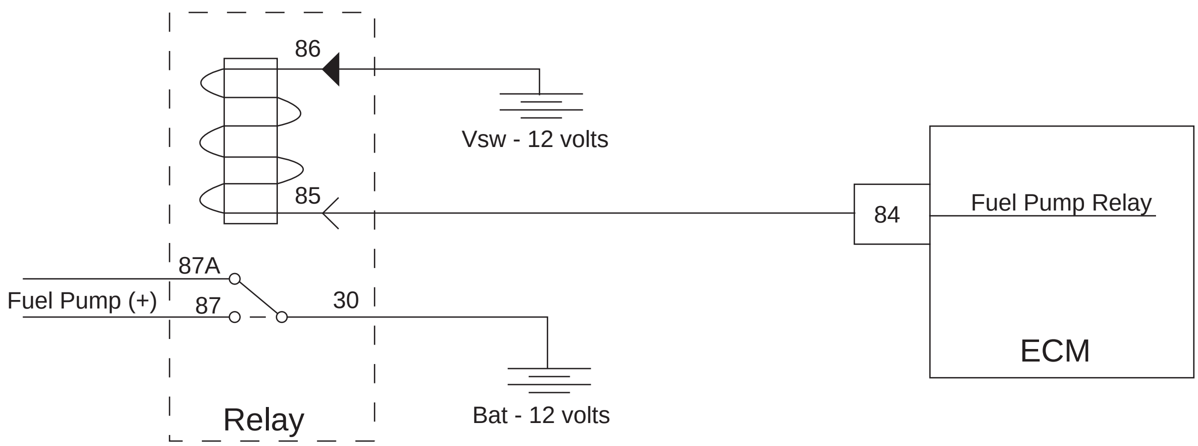
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault.

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



DTC 0627 - Fuel Pump Relay Coil Open
SPN - 1348; FMI - 5

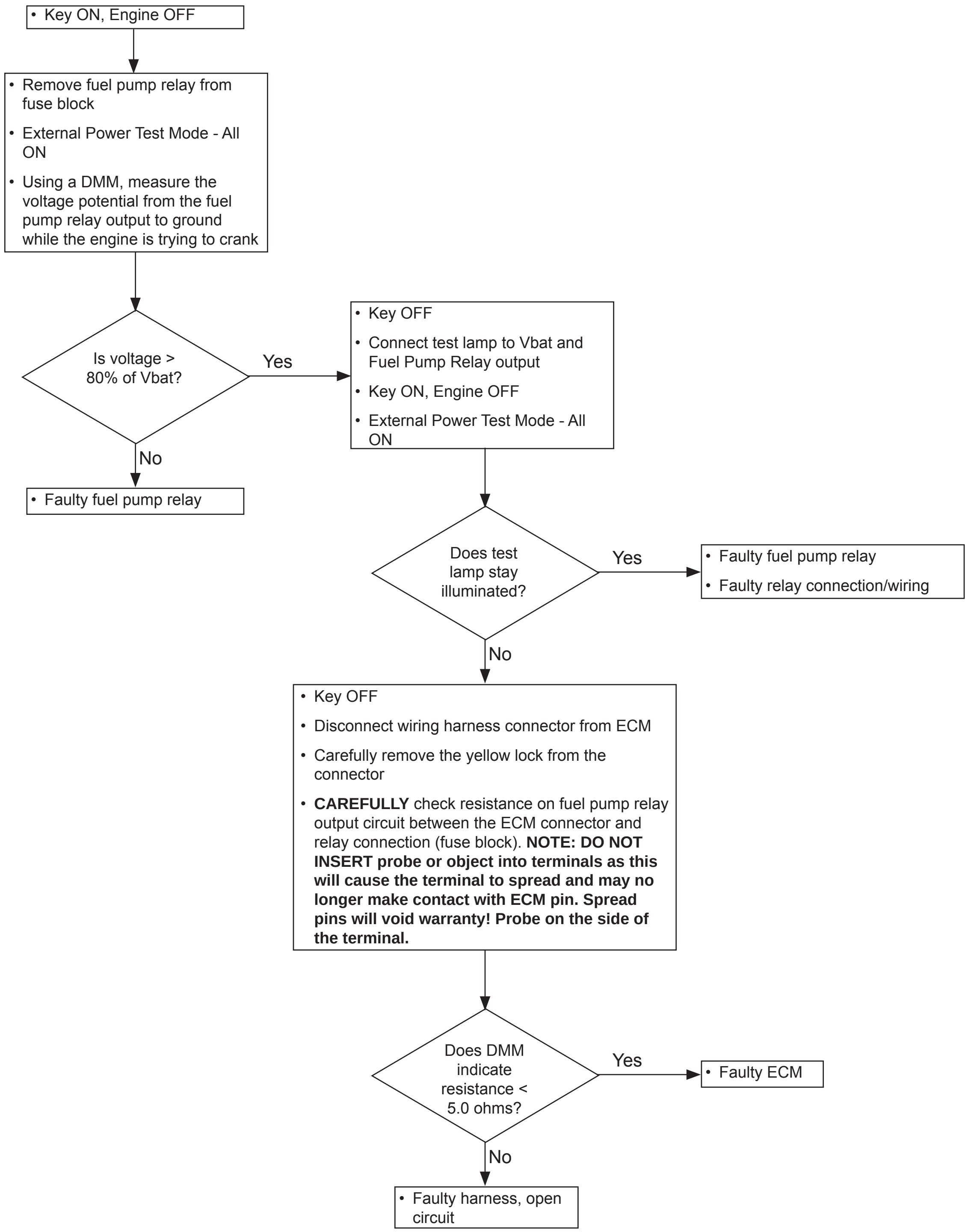


- Fuel Pump Relay
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - Fuel Pump relay coil output open circuit
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

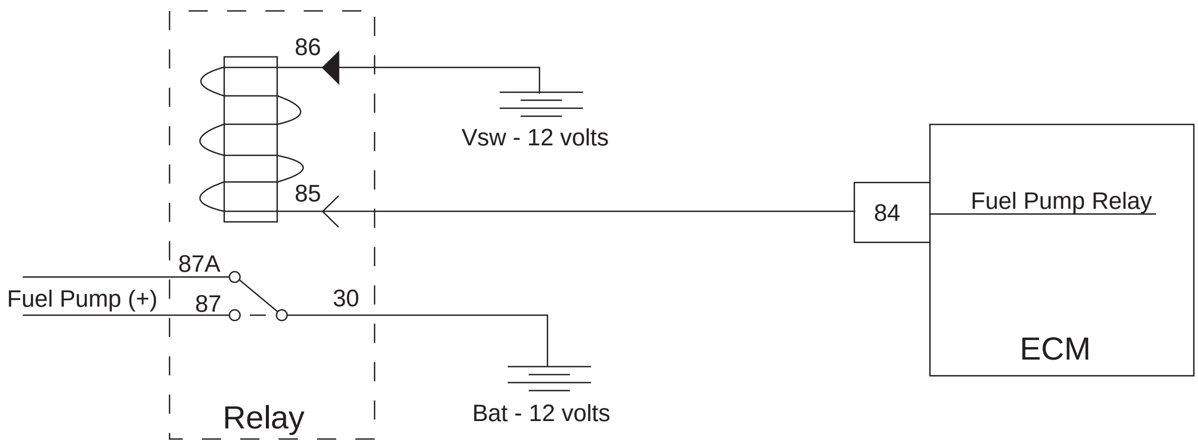
The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

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



DTC 0628 - Fuel Pump Relay Control Ground Short
SPN - 1348; FMI - 4

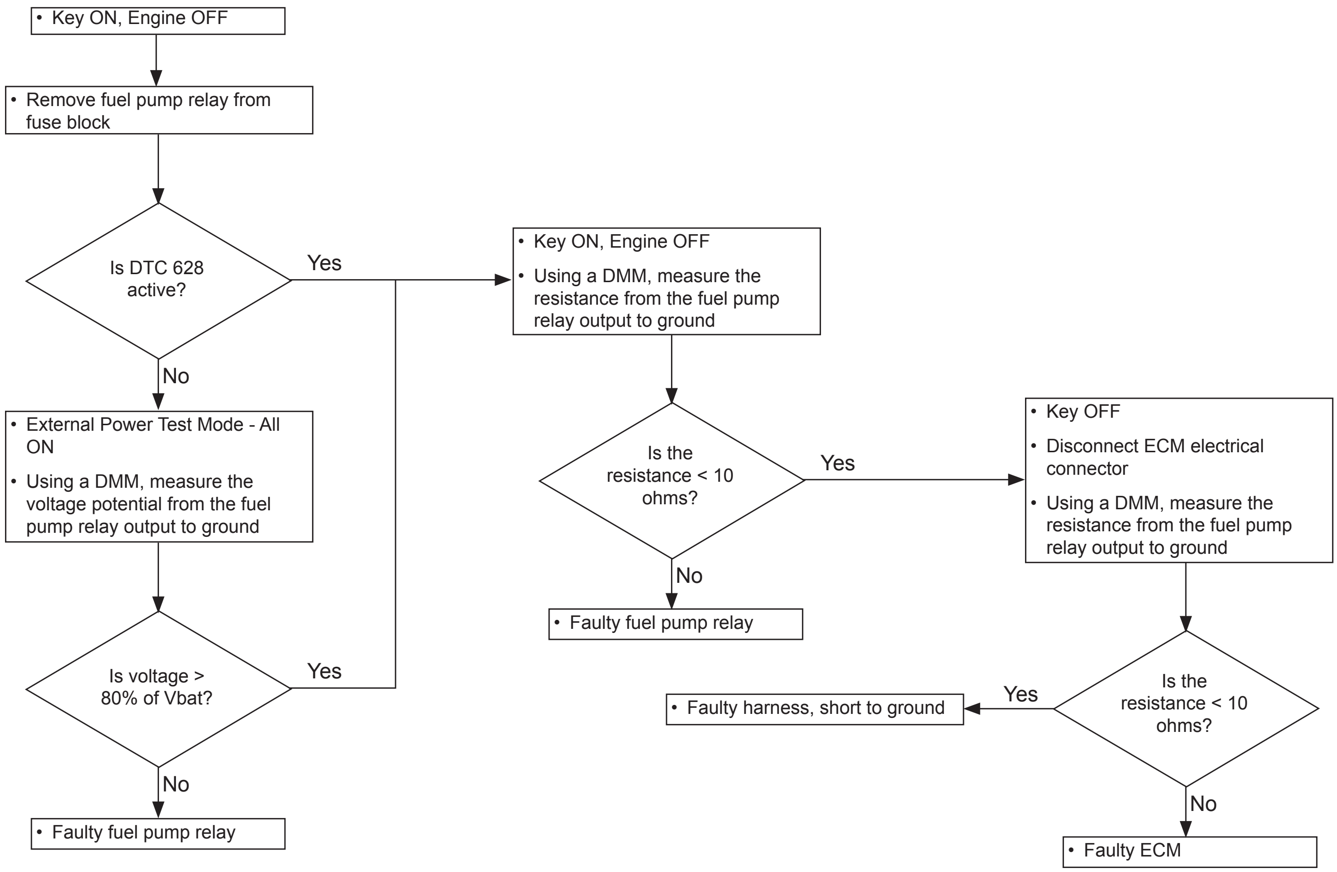


- Fuel Pump Relay
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - Fuel Pump relay coil output shorted to ground
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

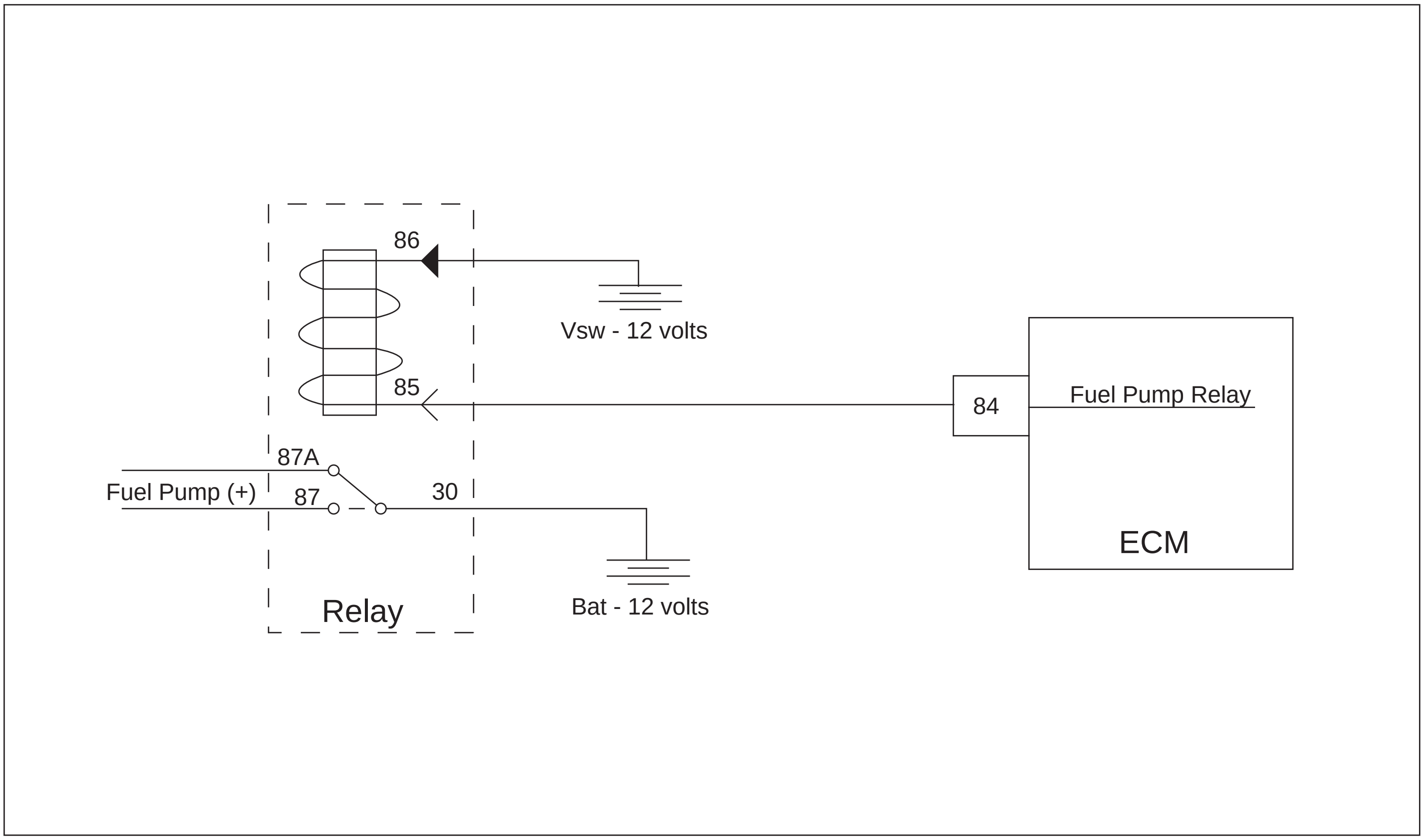
The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

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



DTC 0629 - Fuel Pump Relay Coil Short to Power
SPN - 1348; FMI - 3

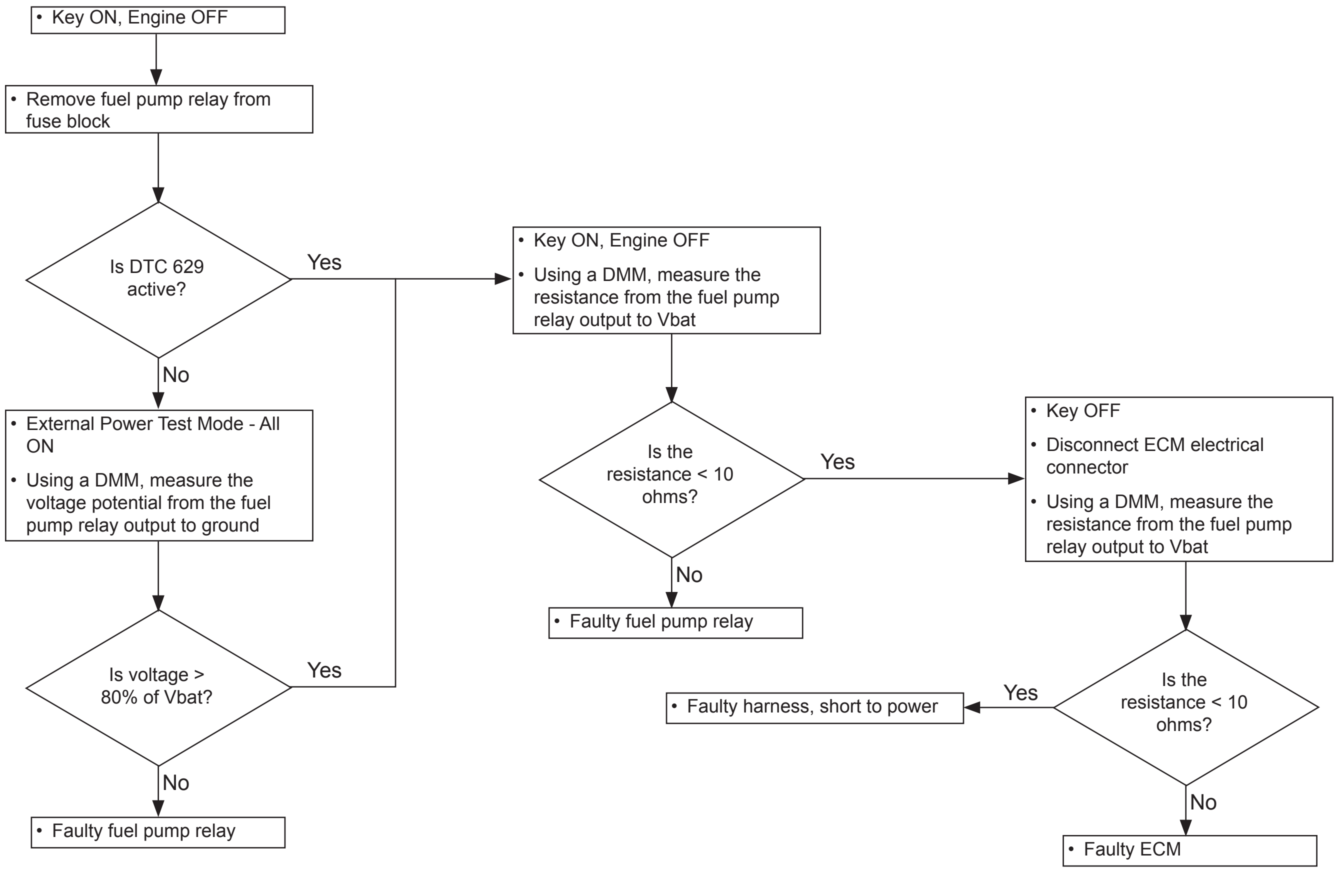


- Fuel Pump Relay
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - Fuel Pump relay coil output short to power/voltage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

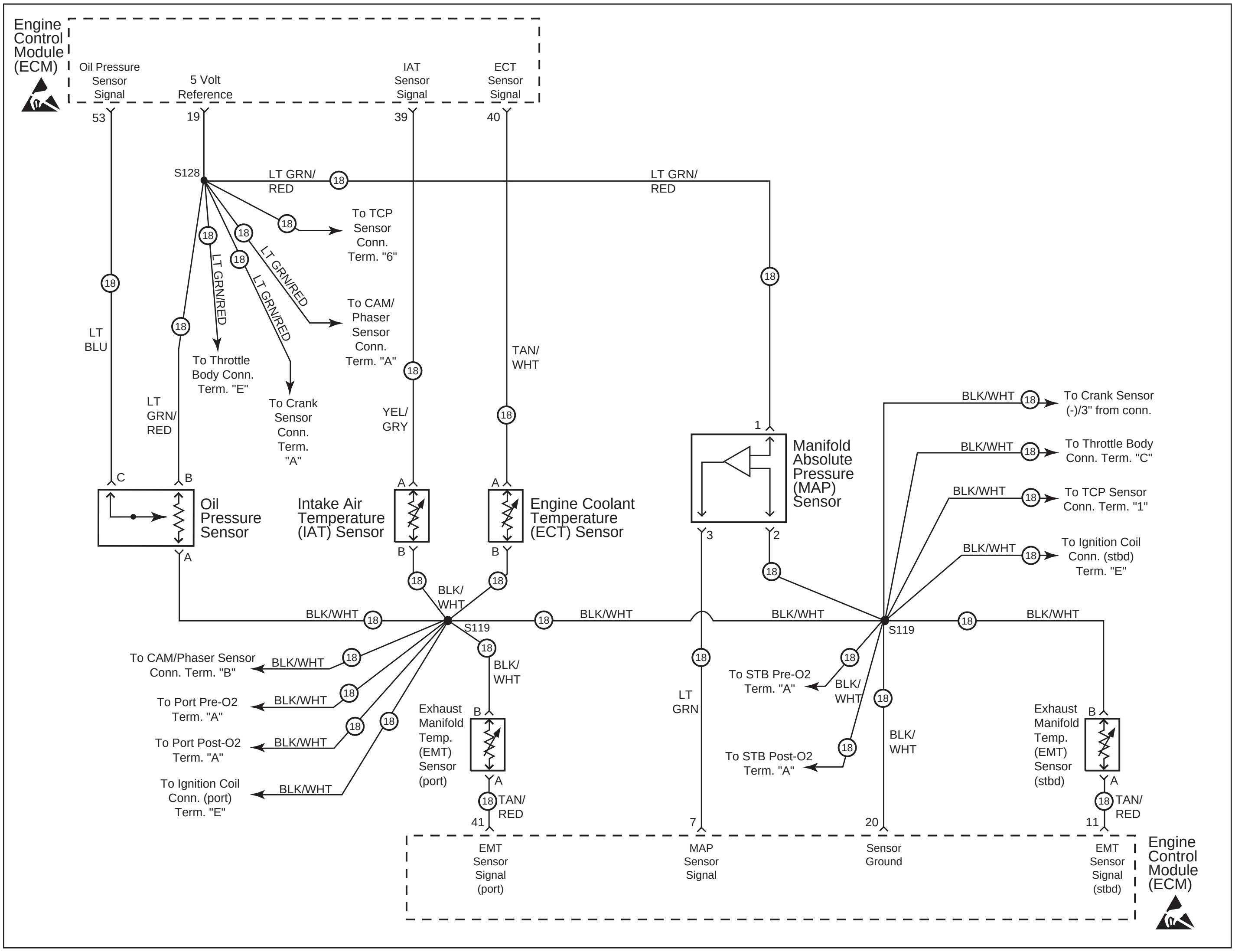
The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

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



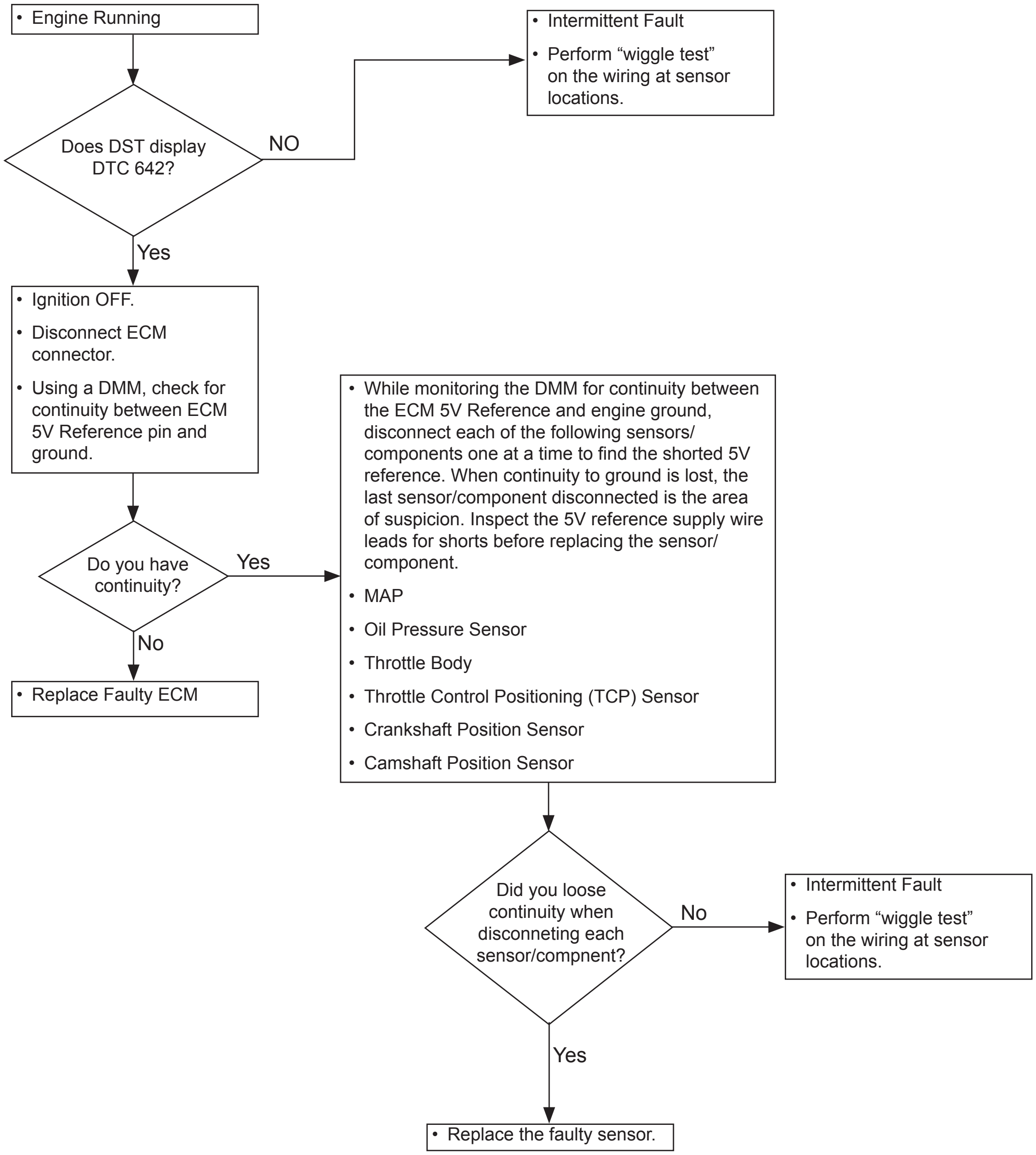
DTC 0642 - Sensor Supply Voltage 1 Low (5Vref1)
SPN - 1079; FMI - 4



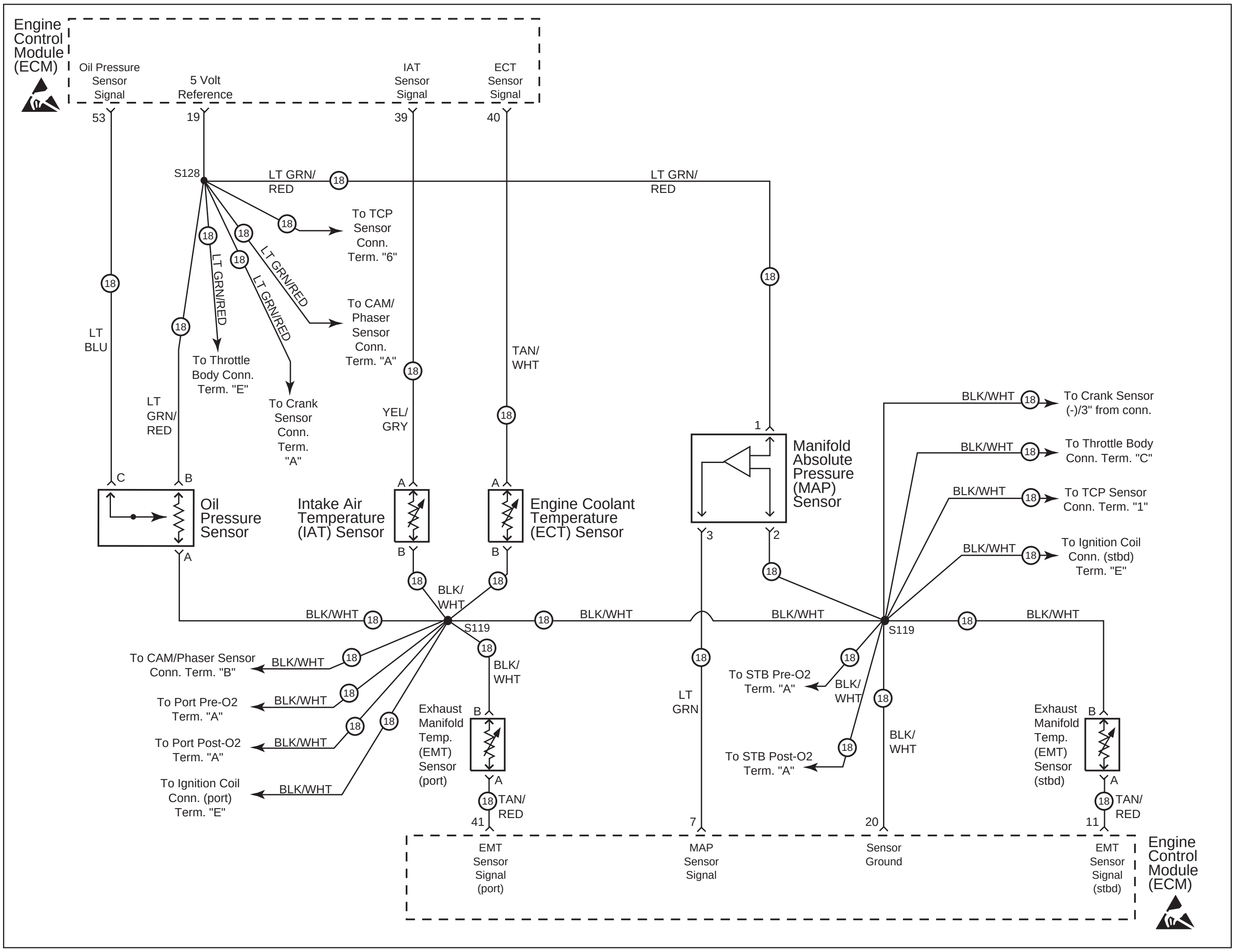
- External 5V Reference
- *Check Condition* - Cranking with battery voltage greater than 8 volts or engine running.
- *Fault Condition* - 5V Reference voltage lower than 4.6 volts.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning
- Non-emissions related fault

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



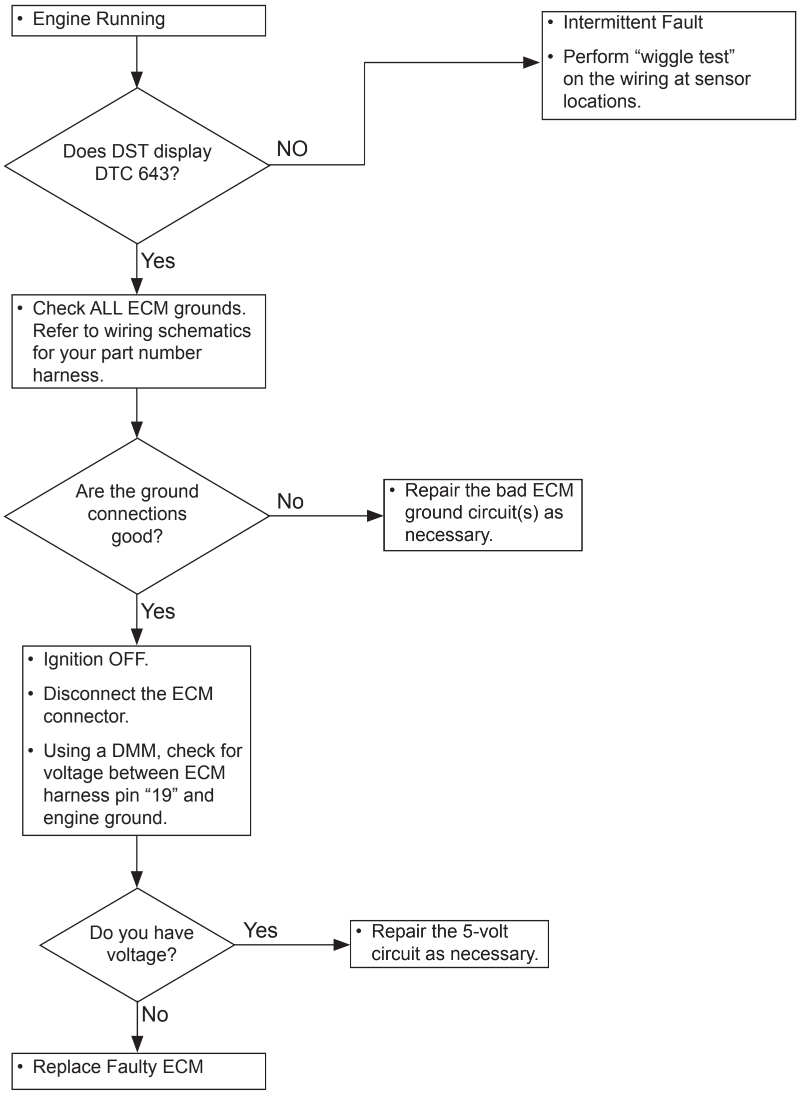
DTC 0643 - Sensor Supply Voltage 1 High (5Vref1)
SPN - 1079; FMI - 3



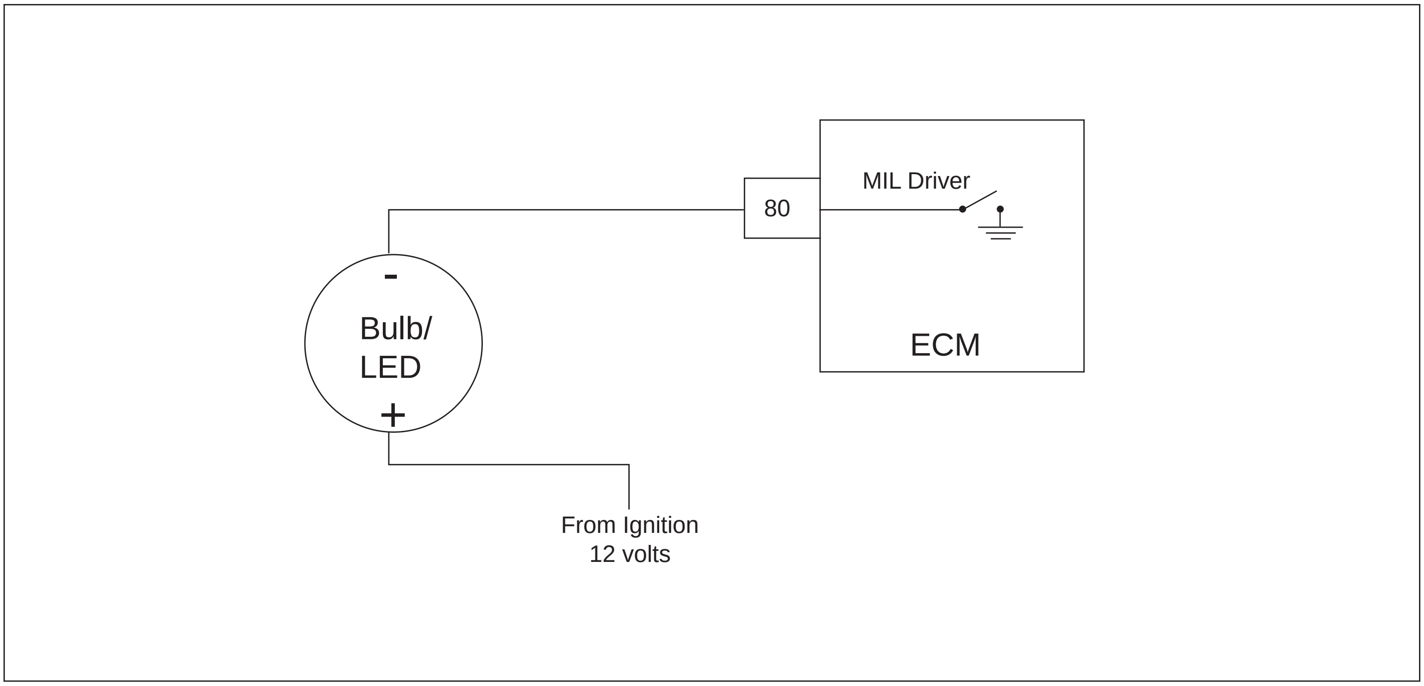
- External 5V Reference
- *Check Condition* - Cranking with battery voltage greater than 8 volts or engine running.
- *Fault Condition* - 5V Reference voltage higher than 5.4 volts.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning
- Non-emissions related fault

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



DTC 0650 - Malfunction Indicator Lamp (MIL) Open
SPN - 1213; FMI - 5

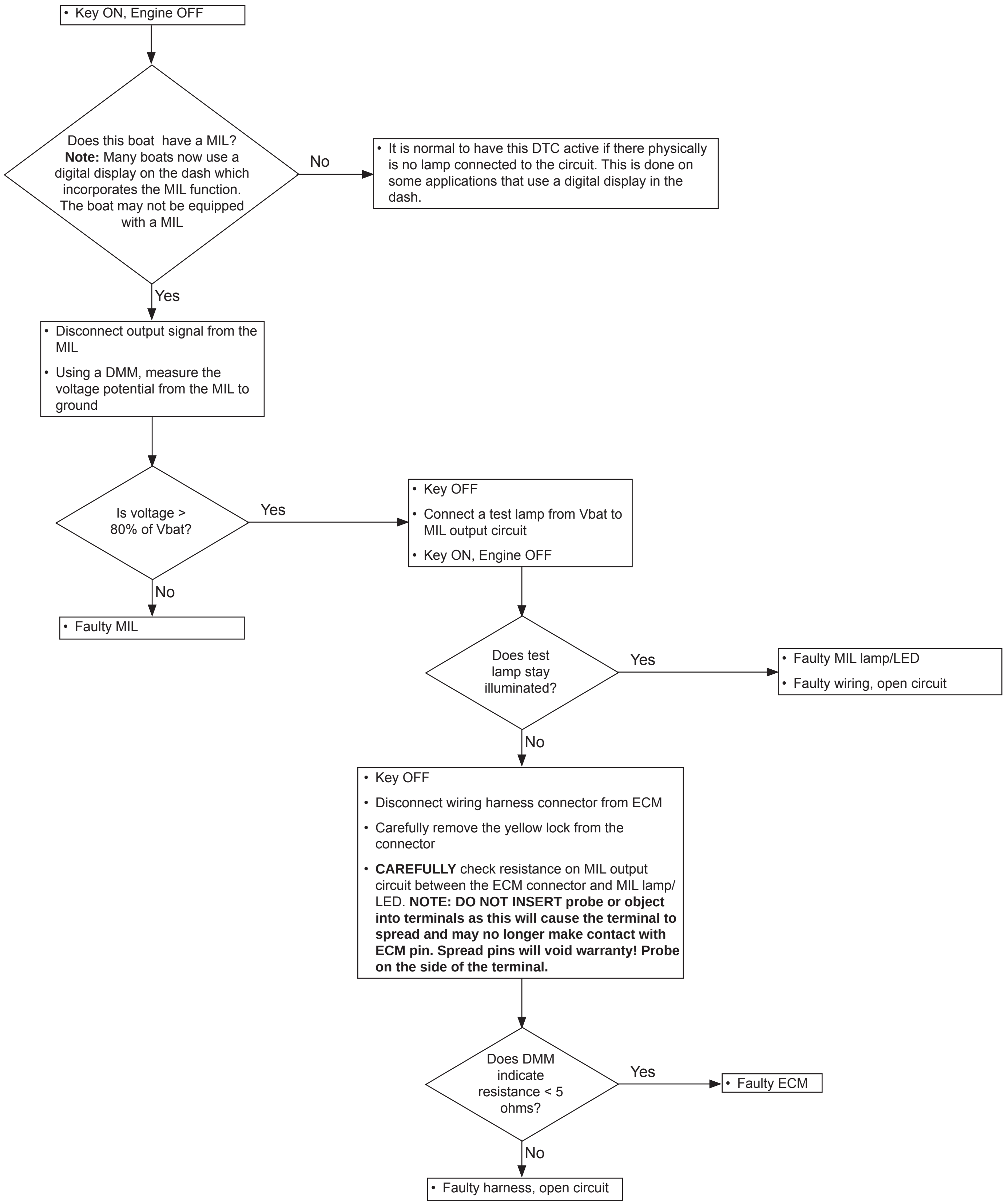


- MIL
- *Check Condition* - Key On, Engine Off or Running
- *Fault Condition* - ECM MIL output open circuit.
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

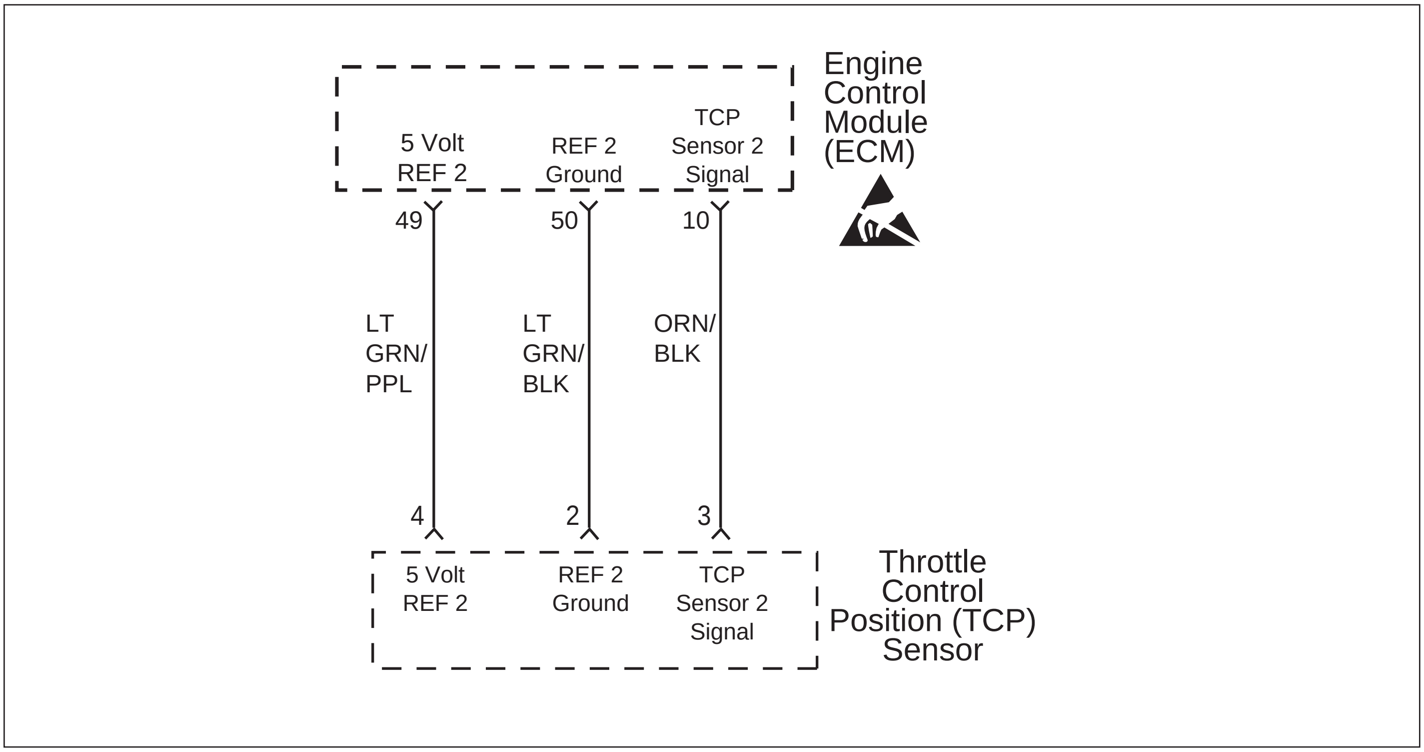
This ECM output is used to provide a low-side switch to a MIL that is used to indicate that an emission related fault has been set.

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 seperate 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



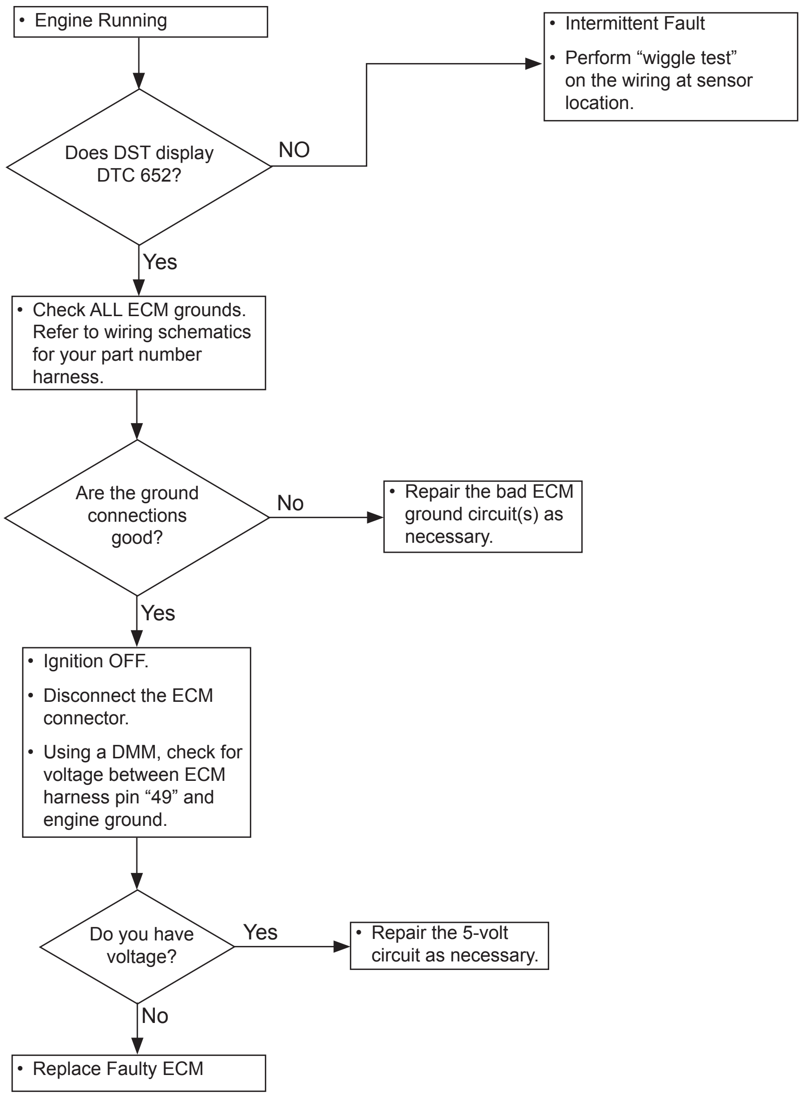
DTC 0652 - Sensor Supply Voltage 2 Low (5Vref2)
SPN - 1080; FMI - 4



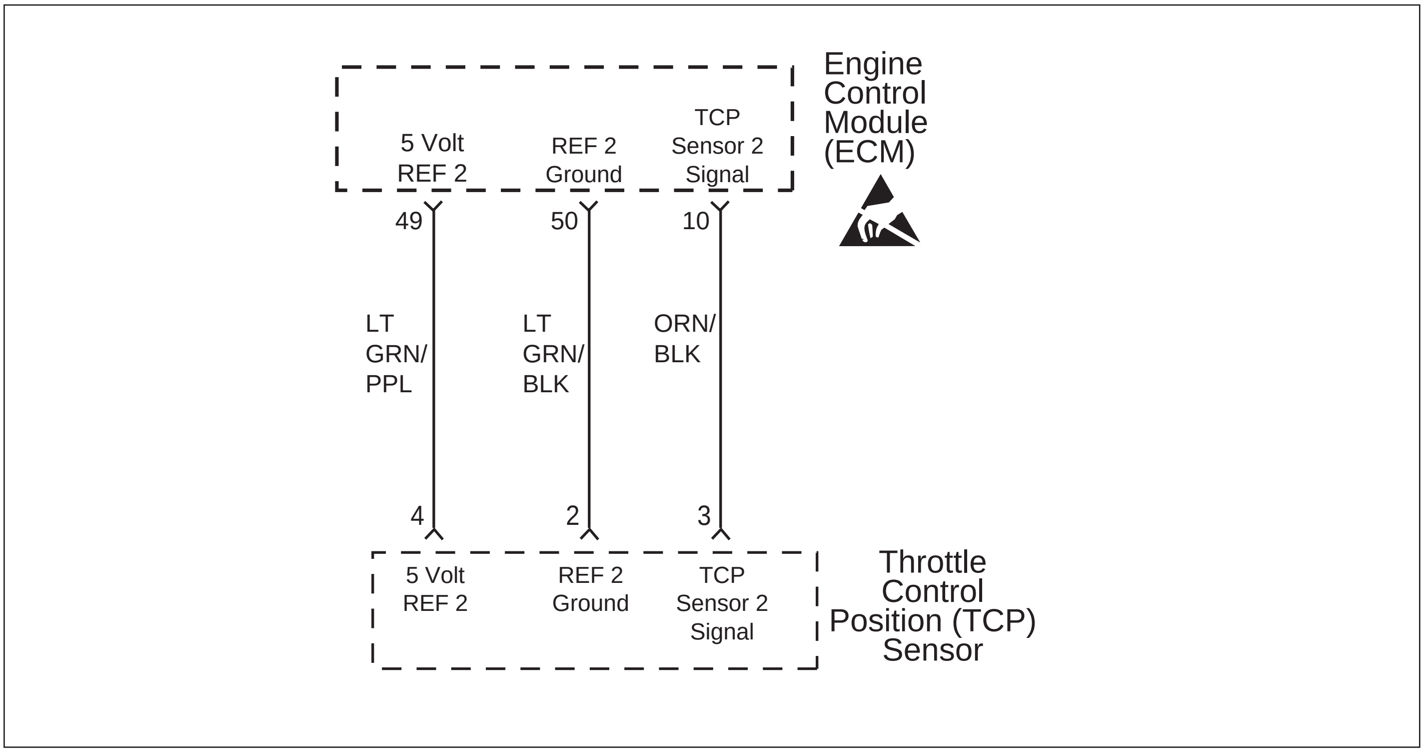
- External 5V Reference
- *Check Condition* - Cranking with battery voltage greater than 8 volts or engine running.
- *Fault Condition* - 5V Reference 2 voltage lower than 3.0 volts.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning
- Non-emissions related fault

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



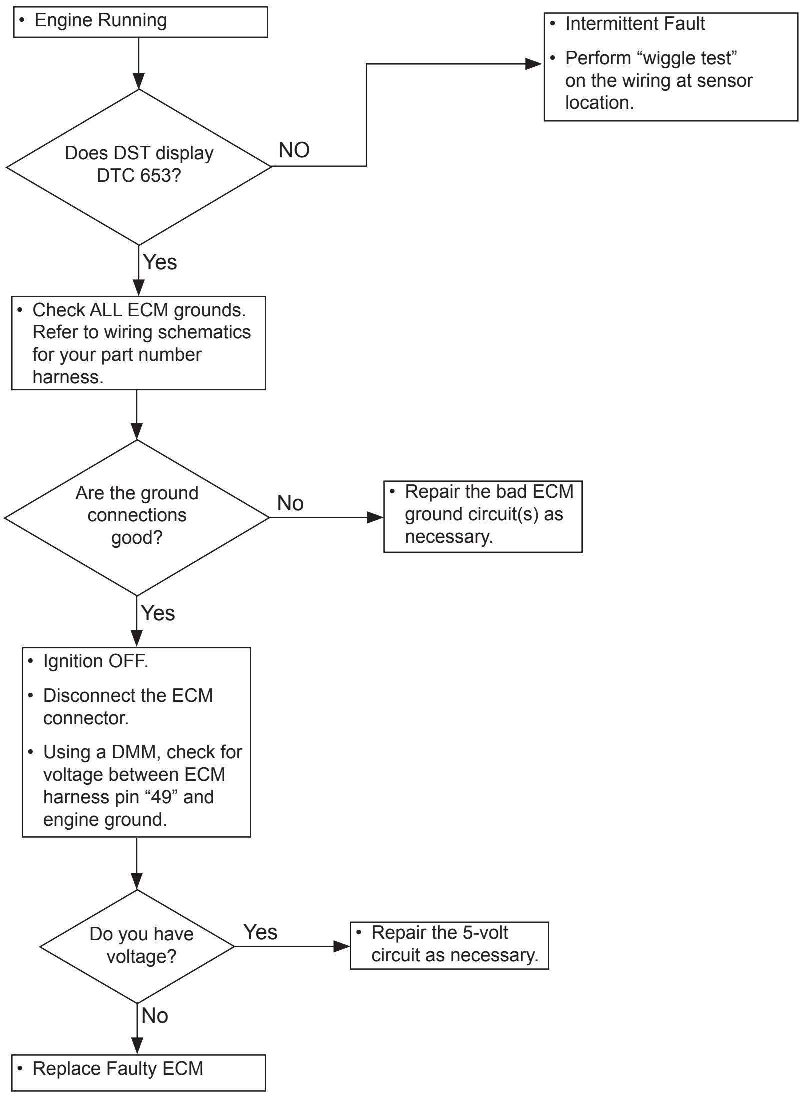
DTC 0653 - Sensor Supply Voltage 2 High (5Vref2)
SPN - 1080; FMI - 3



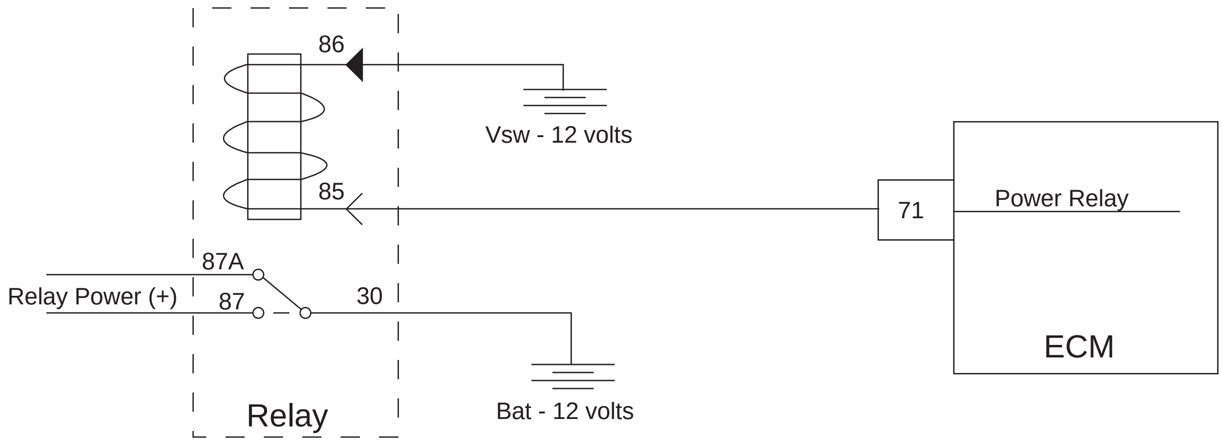
- External 5V Reference
- *Check Condition* - Cranking with battery voltage greater than 8 volts or engine running.
- *Fault Condition* - 5V Reference 2 voltage higher than 5.4 volts.
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning
- Non-emissions related fault

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



DTC 0685 - Power Relay Coil Open
SPN - 1485; FMI - 5

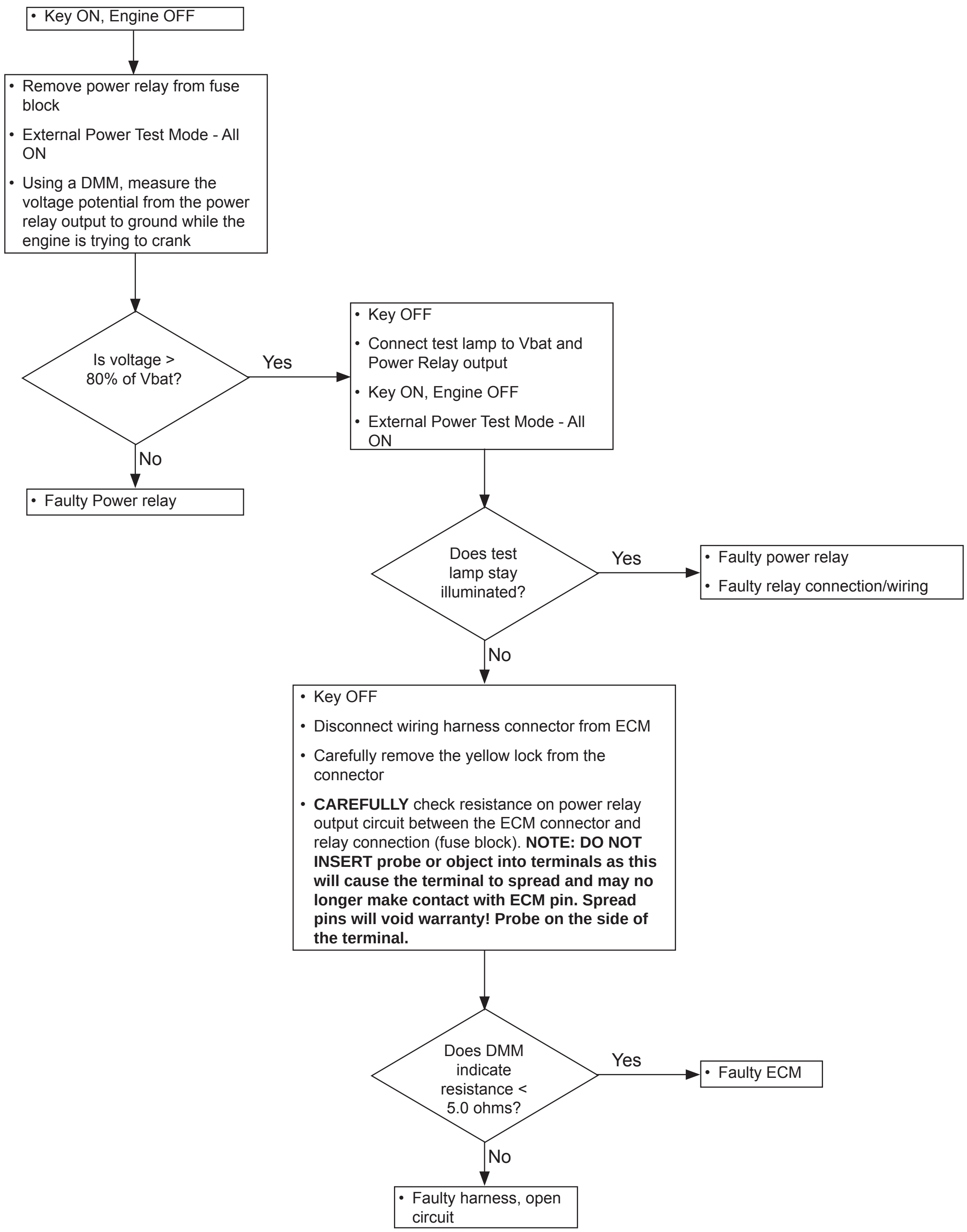


- Power Relay
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - Power relay coil output open circuit
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

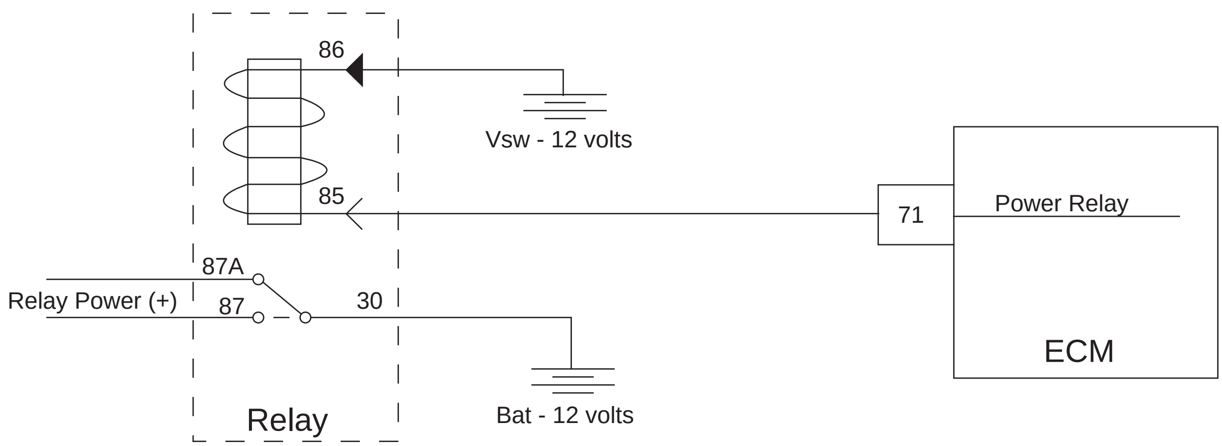
The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

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



DTC 0686 - Power Relay Control Ground Short
SPN - 1485; FMI - 4

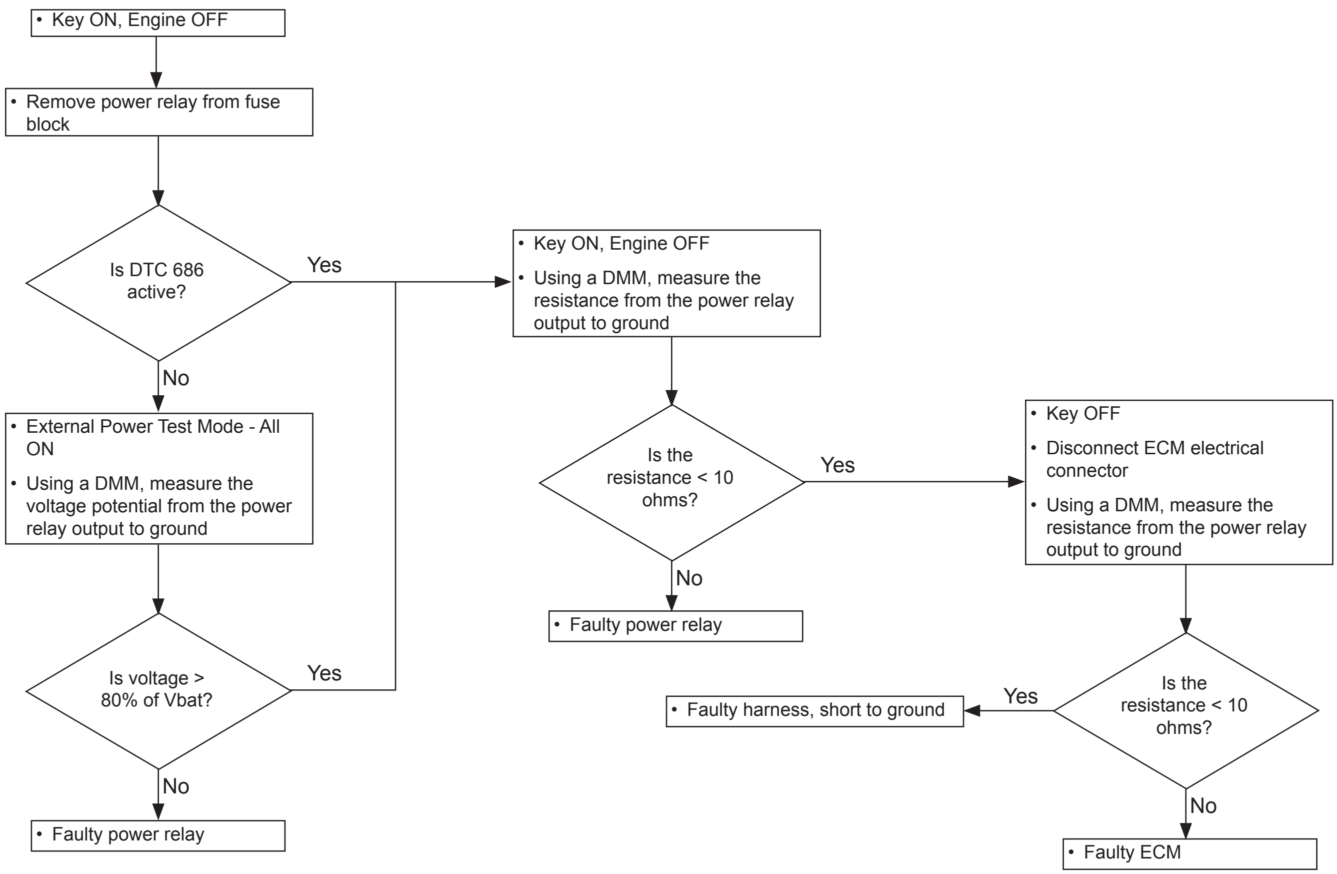


- Power Relay
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - Power relay coil output shorted to ground
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

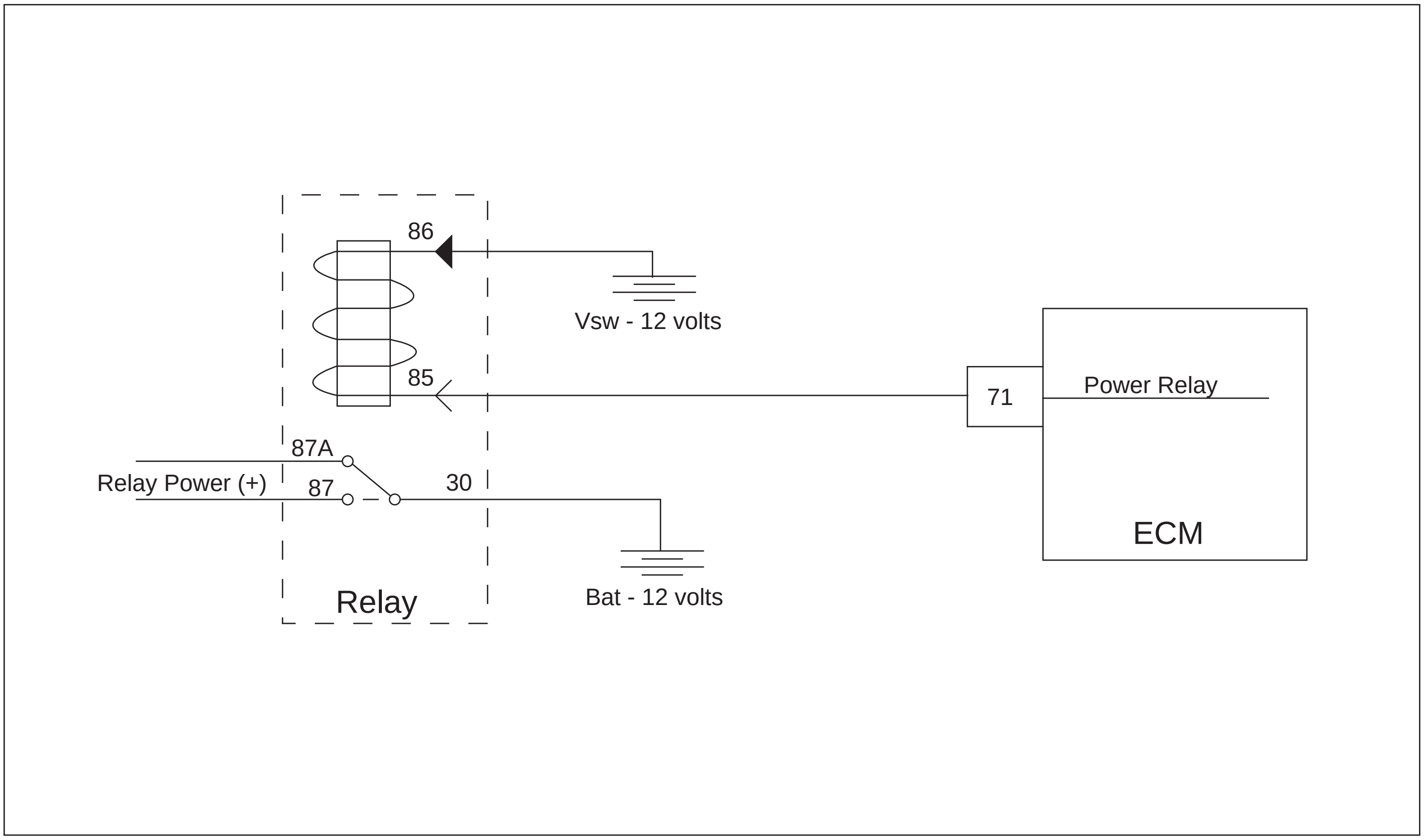
The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

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



DTC 0687 - Power Relay Coil Short to Power
SPN - 1485; FMI - 3

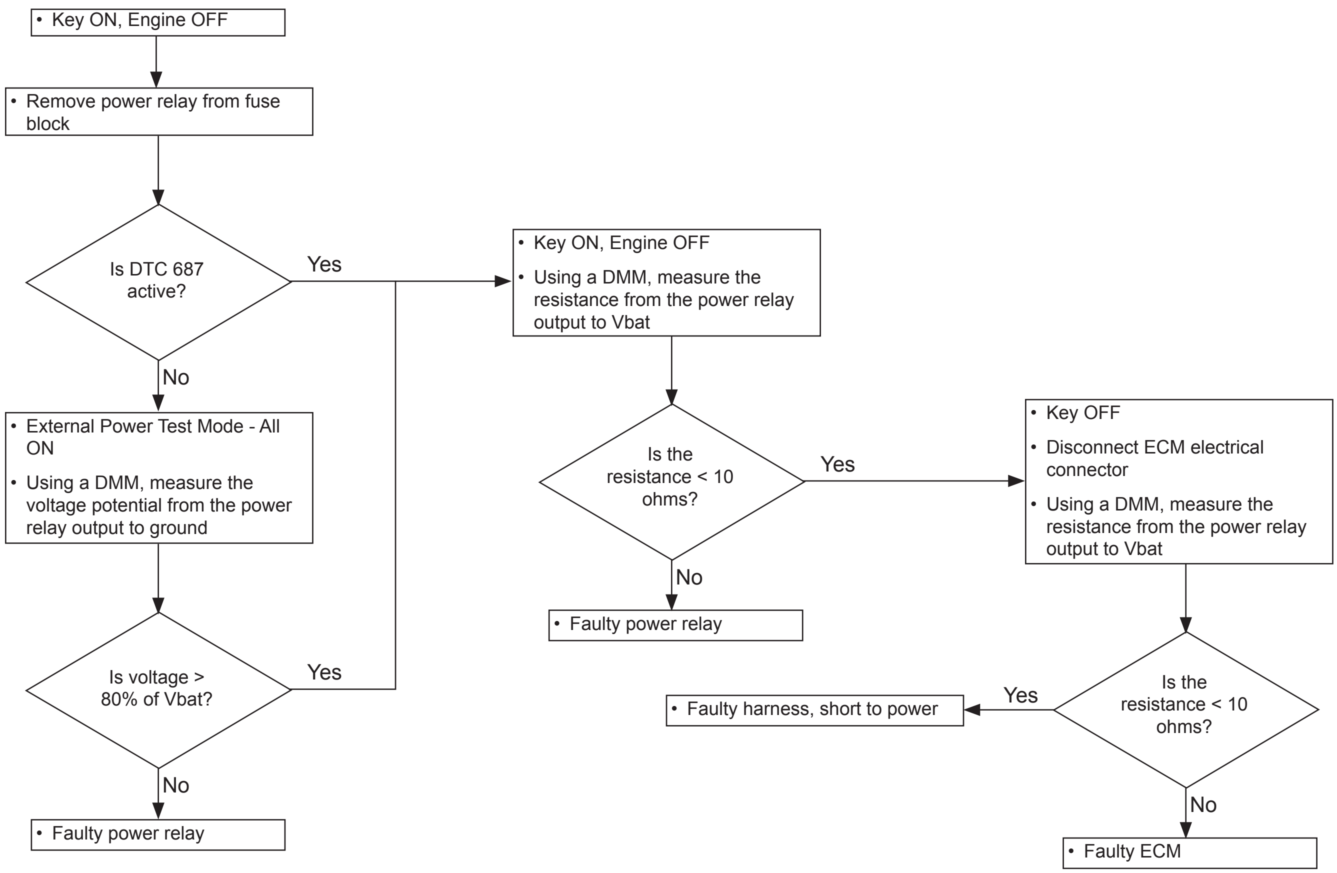


- Power Relay
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - Power relay coil output short to power/voltage
- *Corrective Action(s)* - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

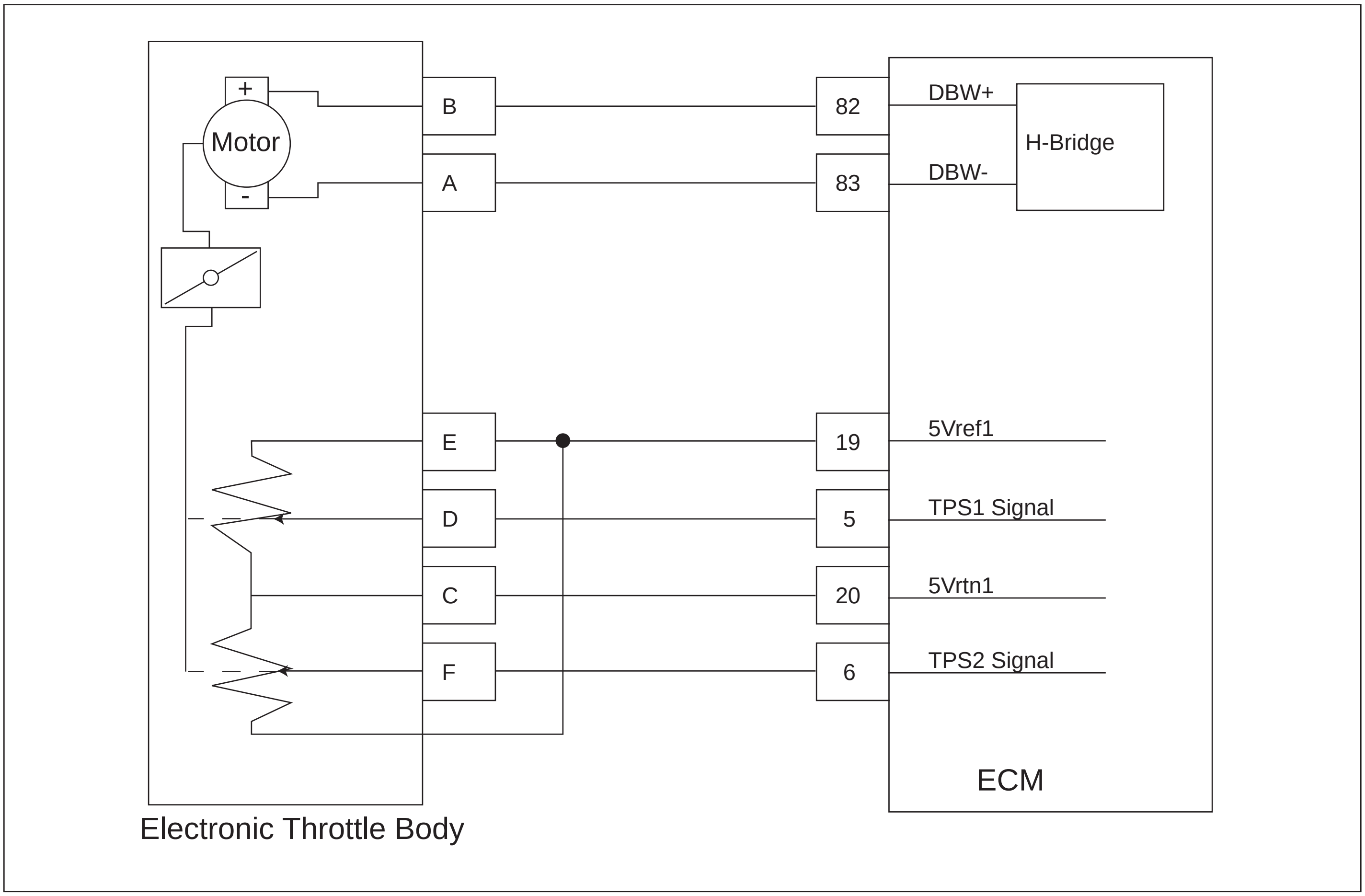
The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

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



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.

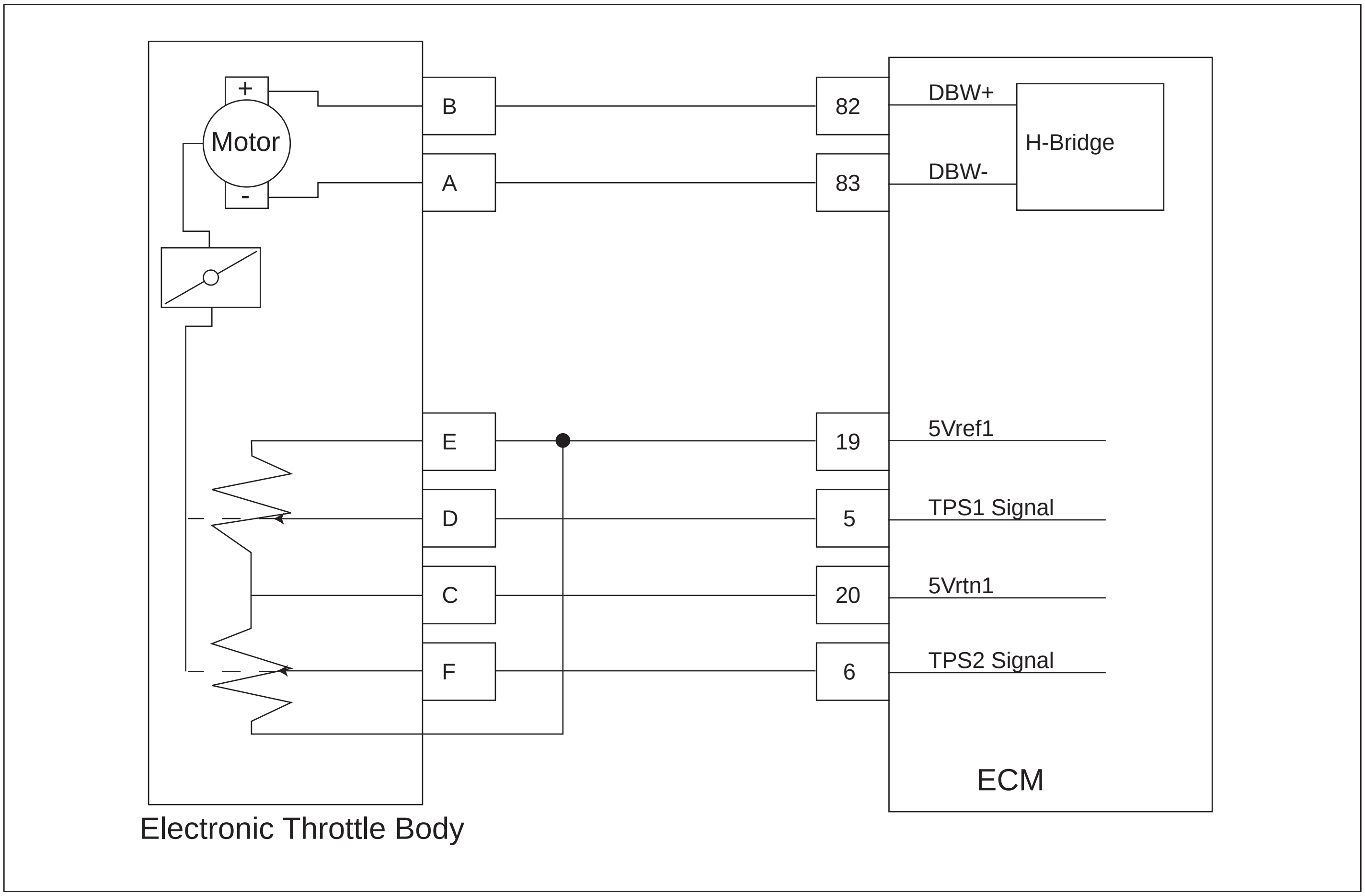
DTC 1111 - RPM Above Fuel Rev Limit Level
SPN - 515; FMI - 16

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

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.

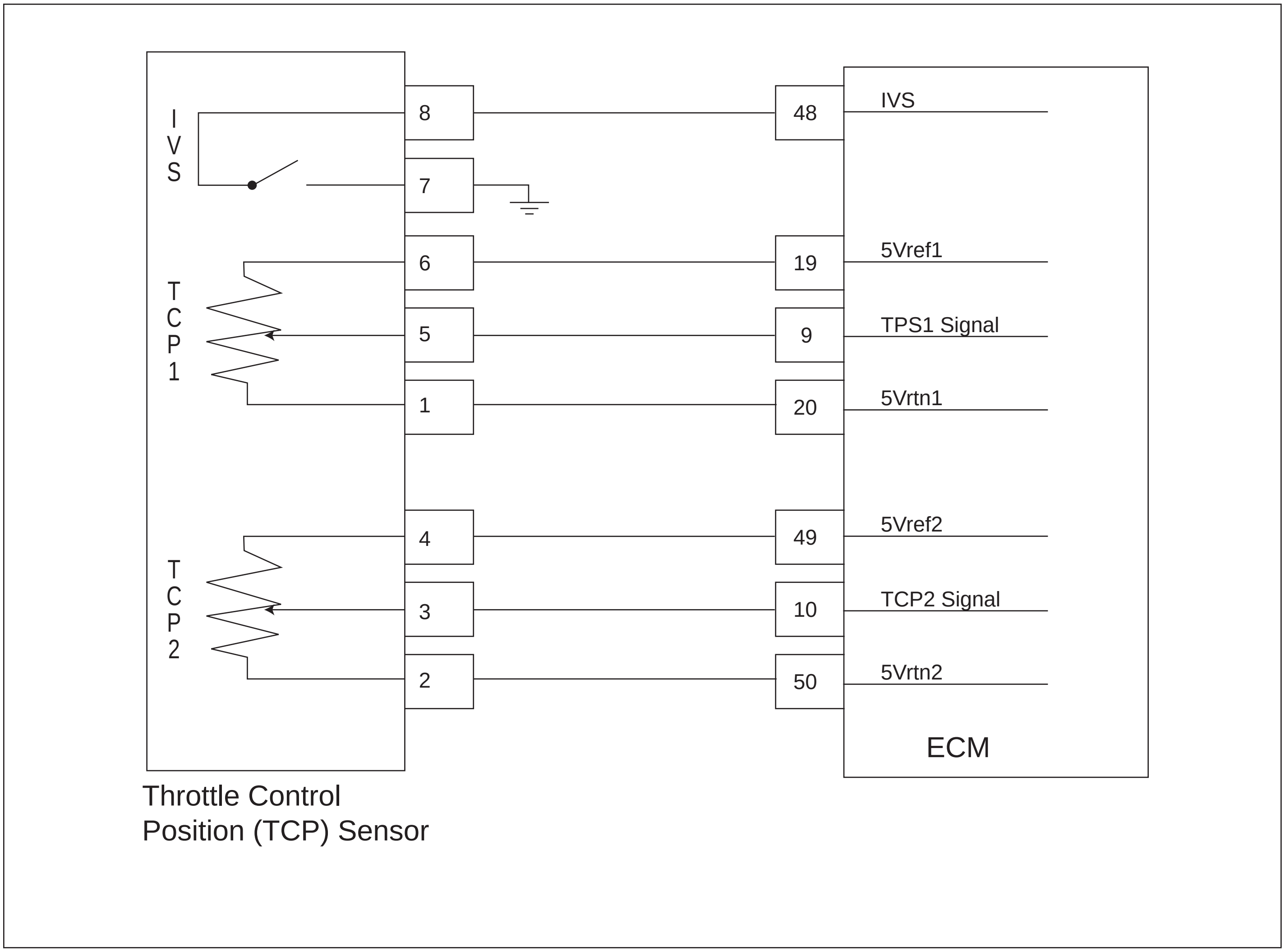
DTC 1112 - RPM Above Spark Rev Limit Level
SPN - 515; FMI - 0

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

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.

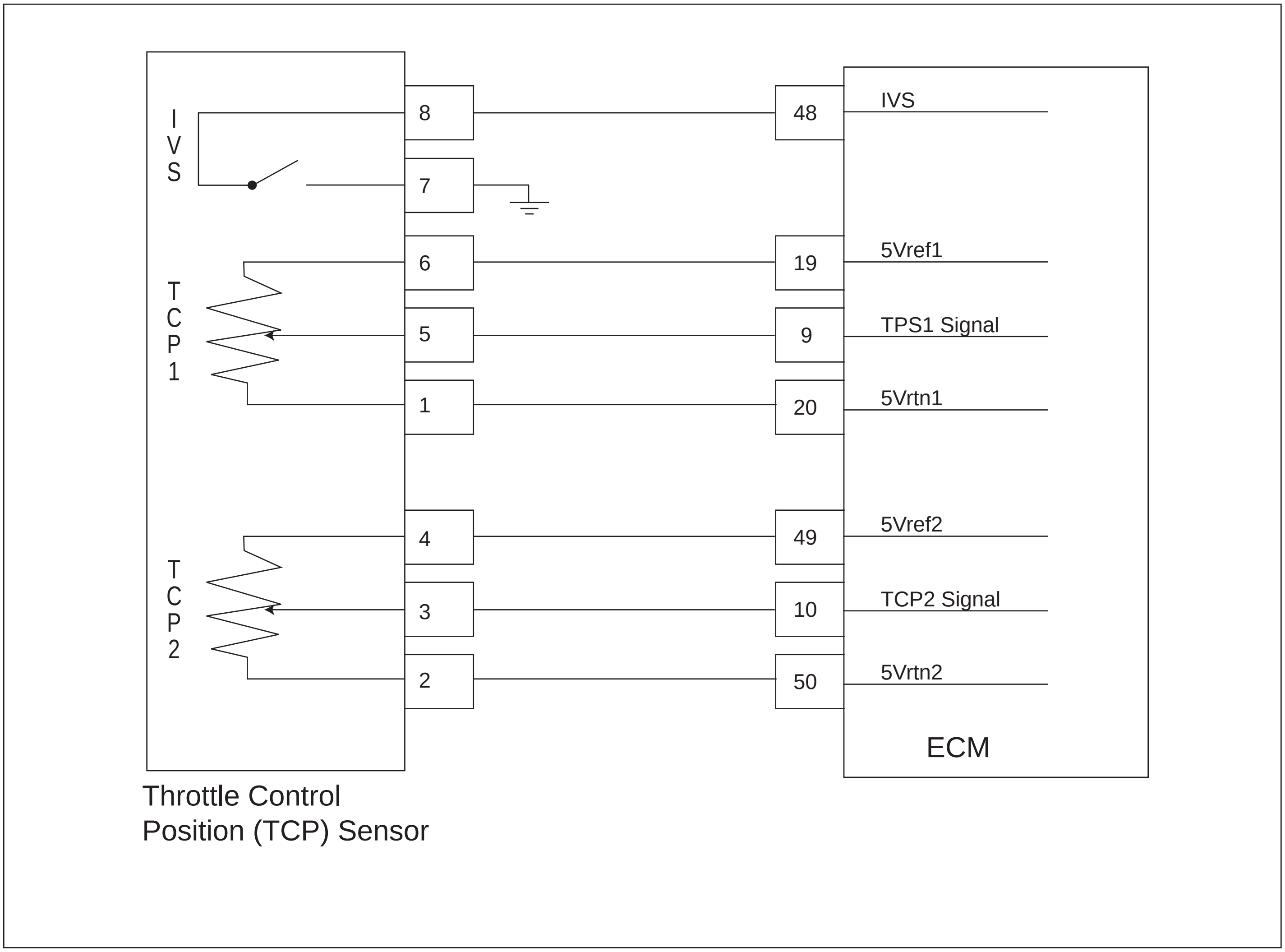
This fault is only applicable for dual potentiometer/single IVS sensors and indicates that TCP1 and TCP2 percentages correlate and register an off-idle condition but the IVS state reads at idle throughout the entire operating range.

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.

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.

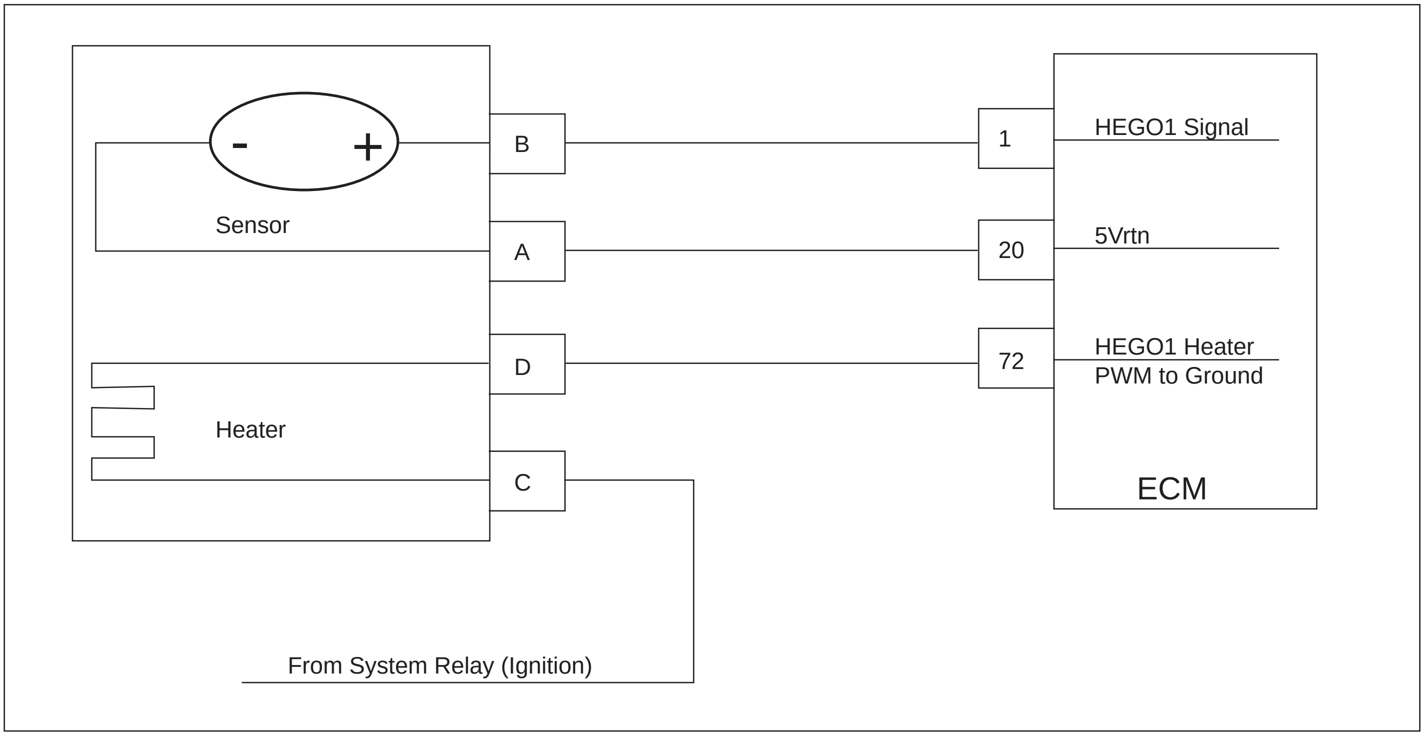
This fault is only applicable for dual potentiometer/single IVS sensors and indicates that TCP1 and TCP2 percentages do not correlate with each other and neither of the two potentiometers correlate with the IVS.

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.

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.

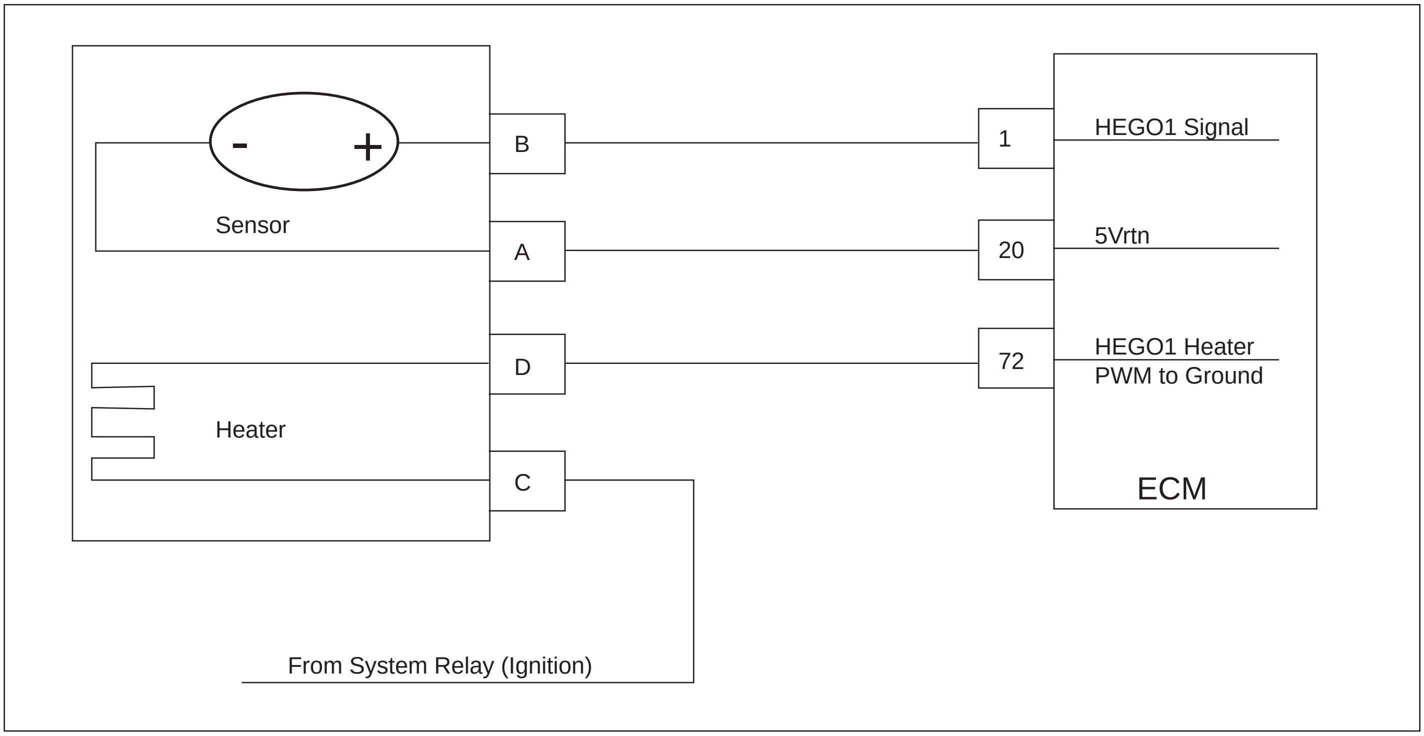
DTC 1155 - Closed Loop Bank 1 High
SPN - 4236; FMI - 0

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.

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.

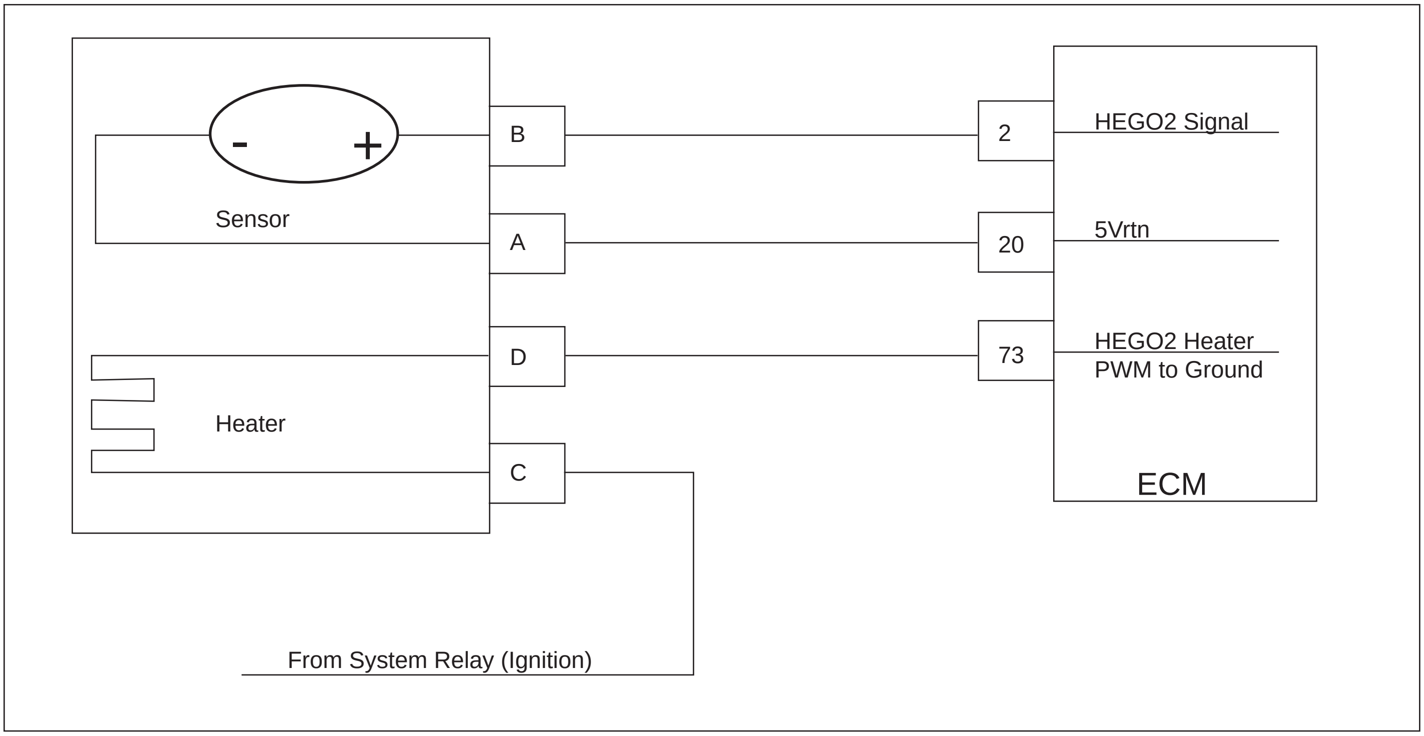
DTC 1156 - Closed Loop Bank 1 Low
SPN - 4236; FMI - 1

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.

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.

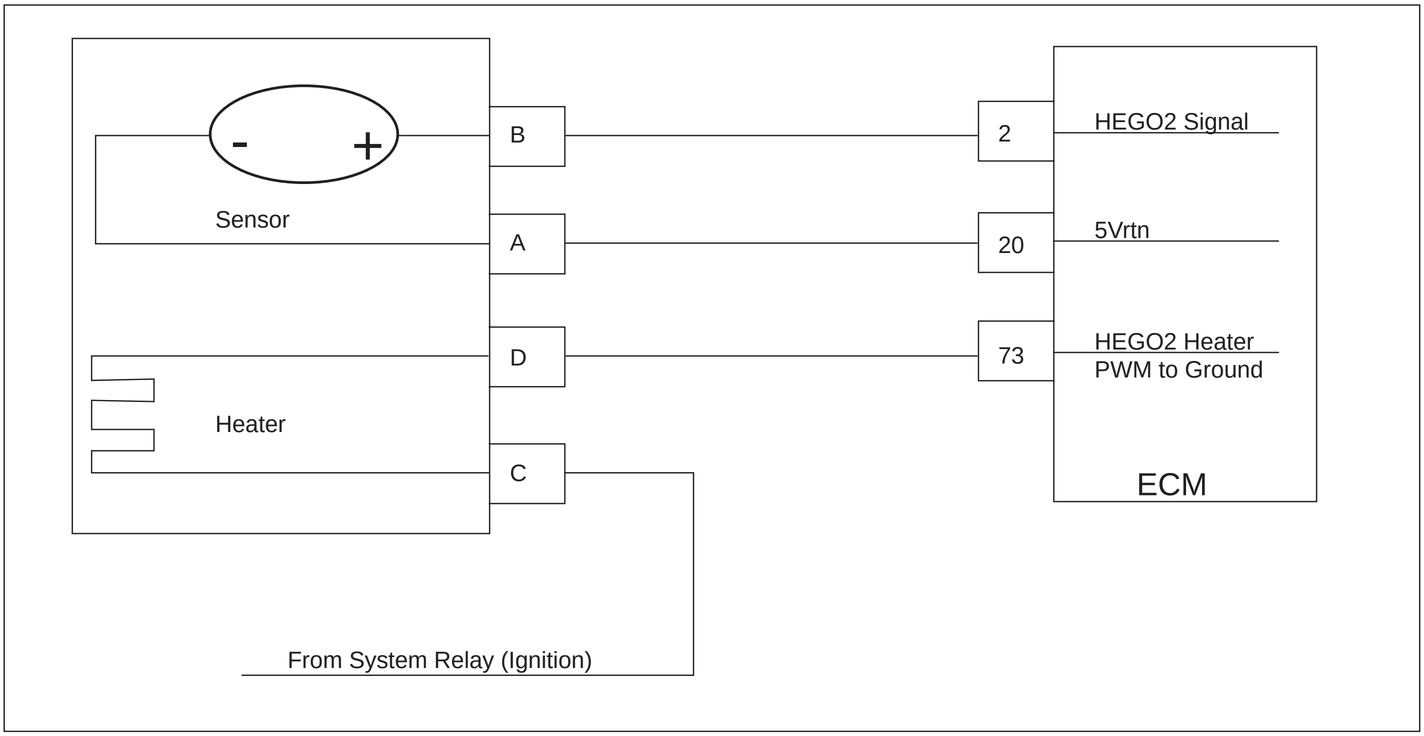
DTC 1157 - Closed Loop Bank 2 High
SPN - 4238; FMI - 0

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.

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.

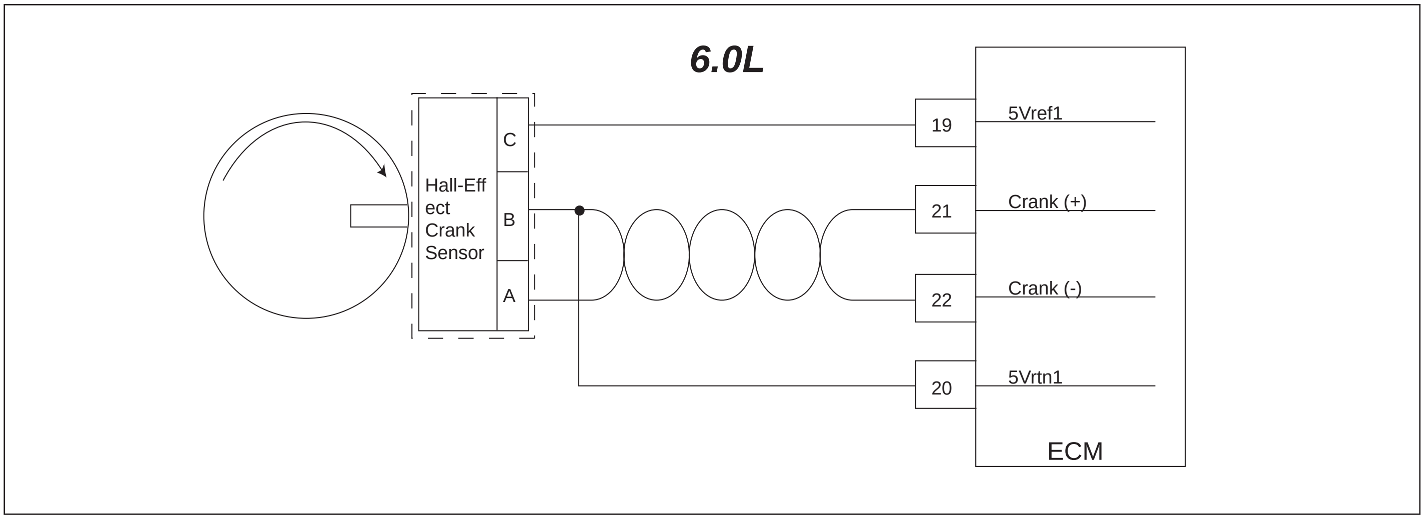
DTC 1158 - Closed Loop Bank 2 Low
SPN - 4238; FMI - 1

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.

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 banks 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.

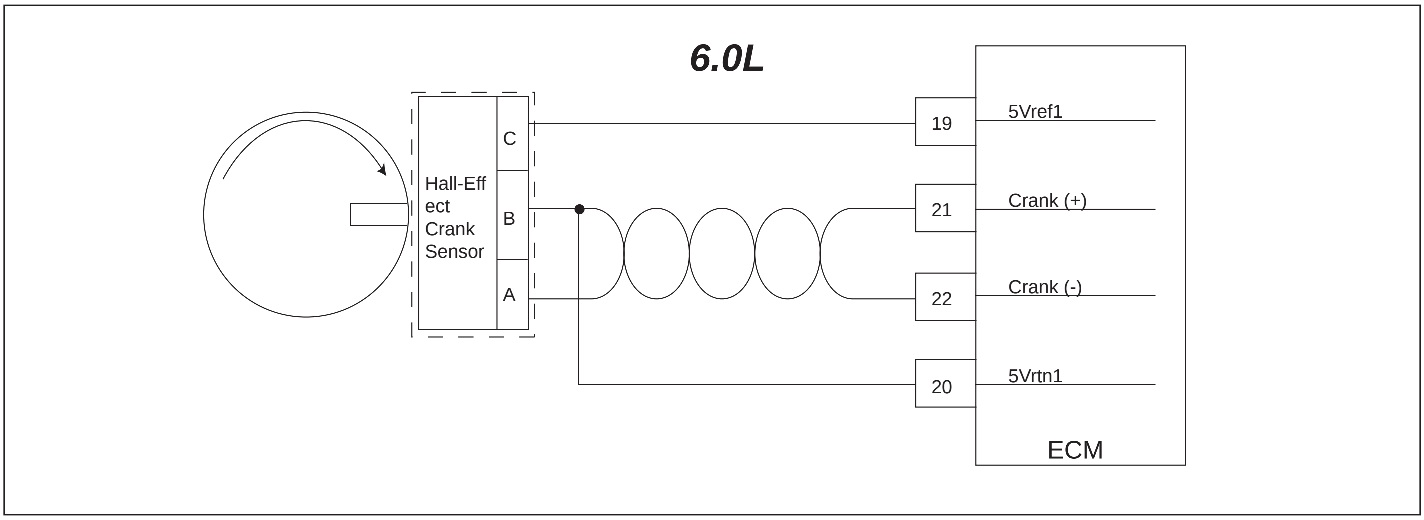
This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

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).

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 banks 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 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.

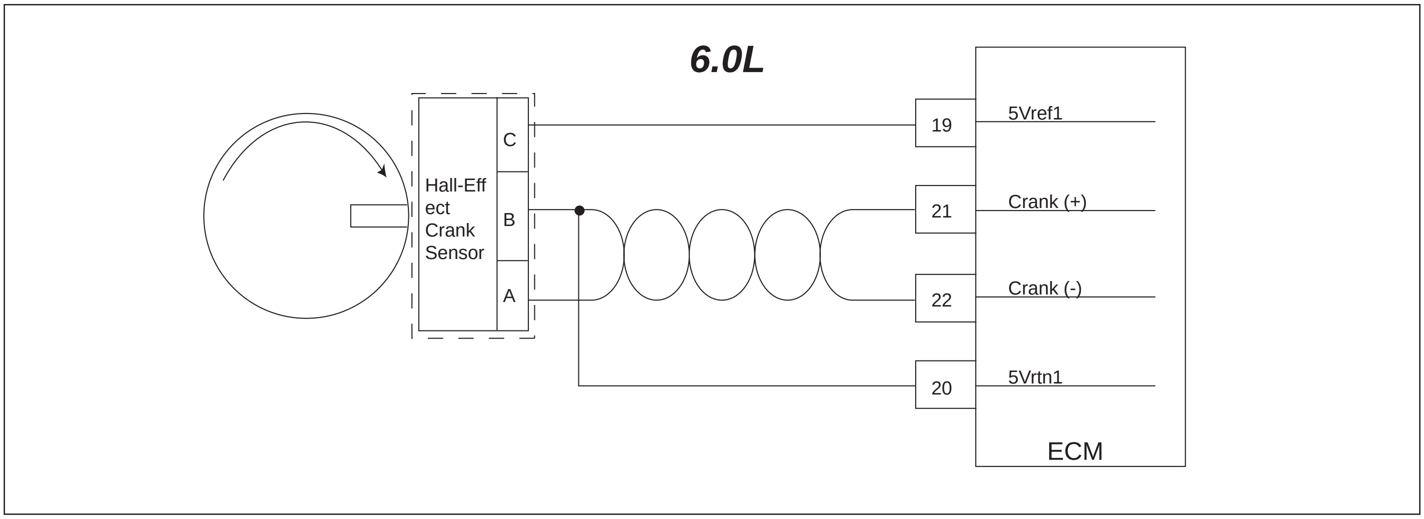
This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

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).

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 banks 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 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.

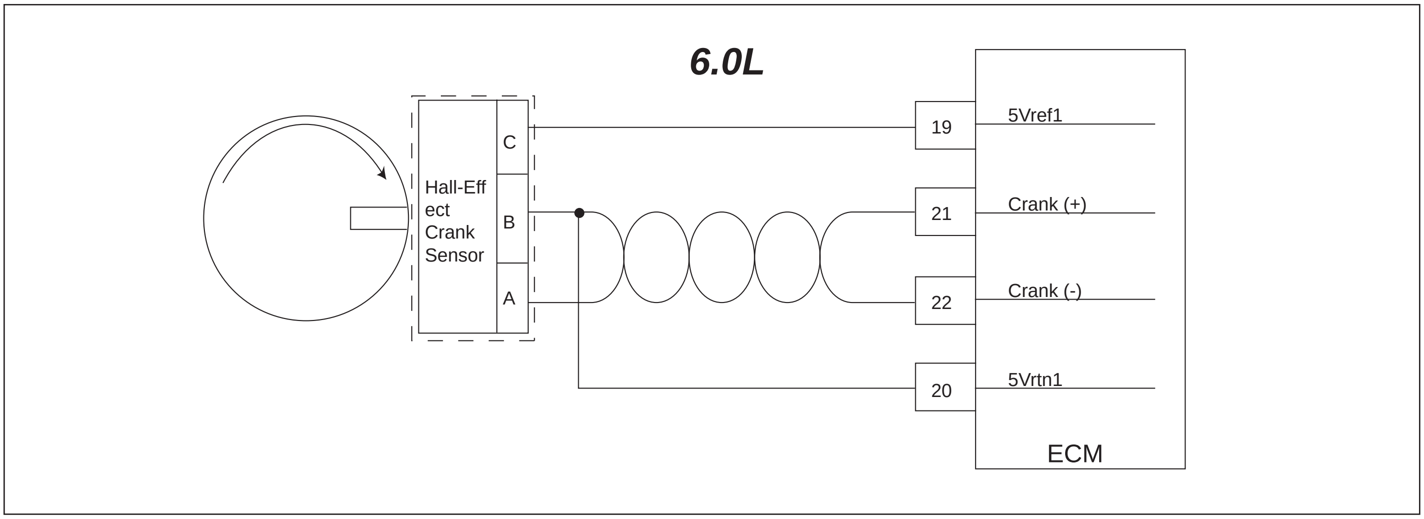
This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

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).

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 banks 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 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.

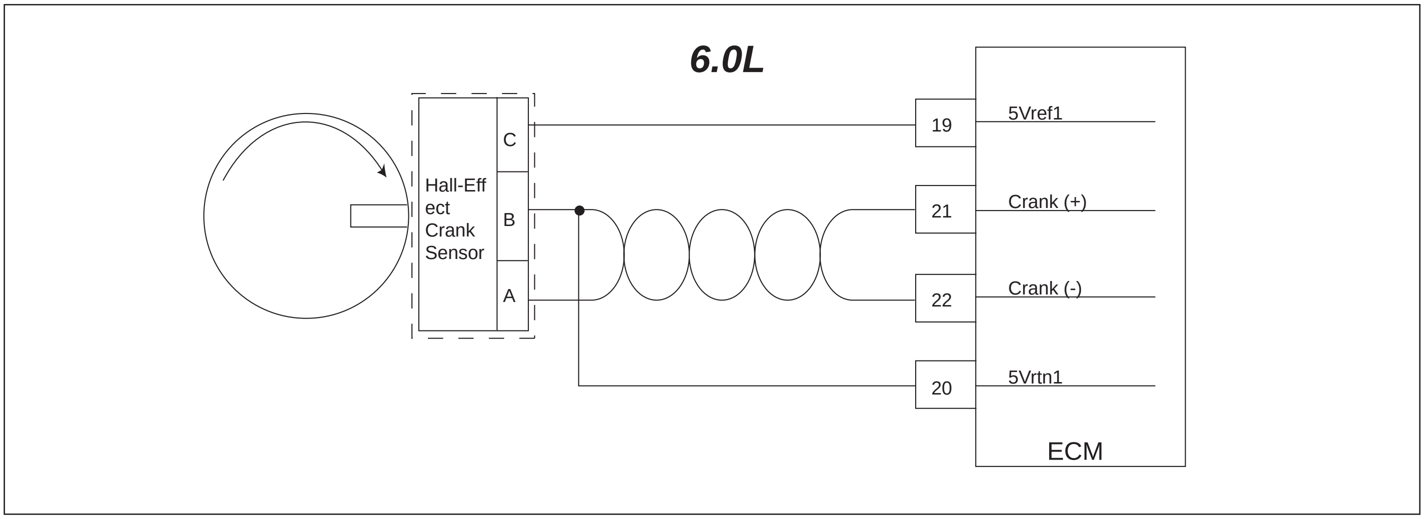
This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

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).

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 banks 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 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.

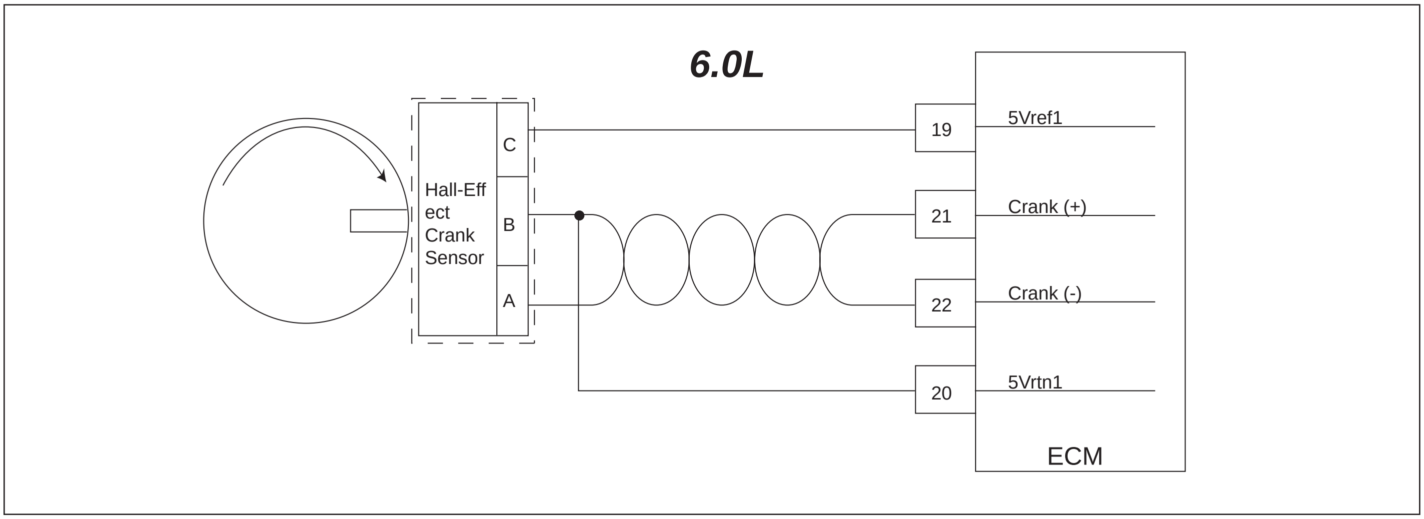
This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

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).

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 banks 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 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.

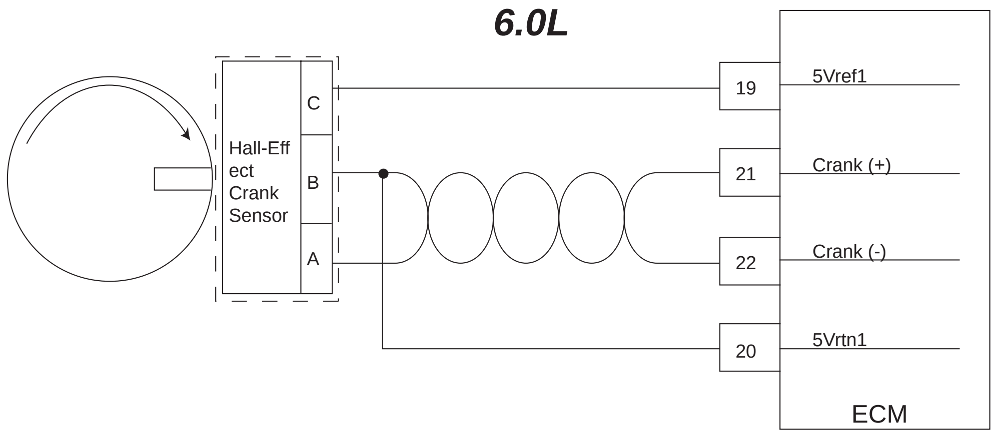
This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

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).

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 banks 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.

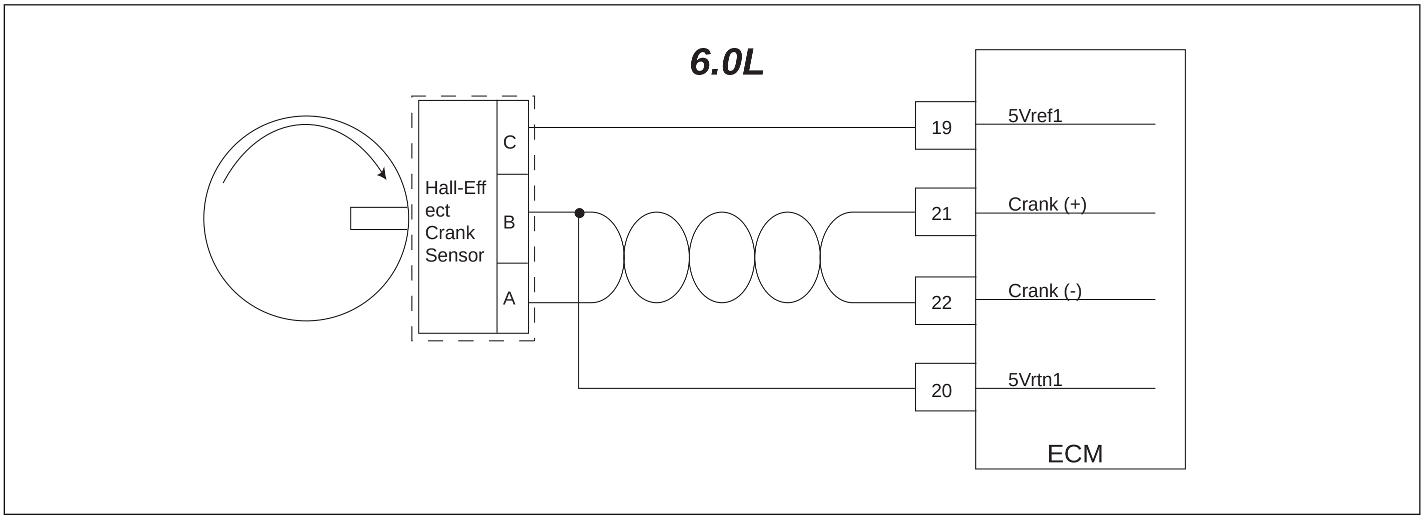
This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

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).

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 banks 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 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.

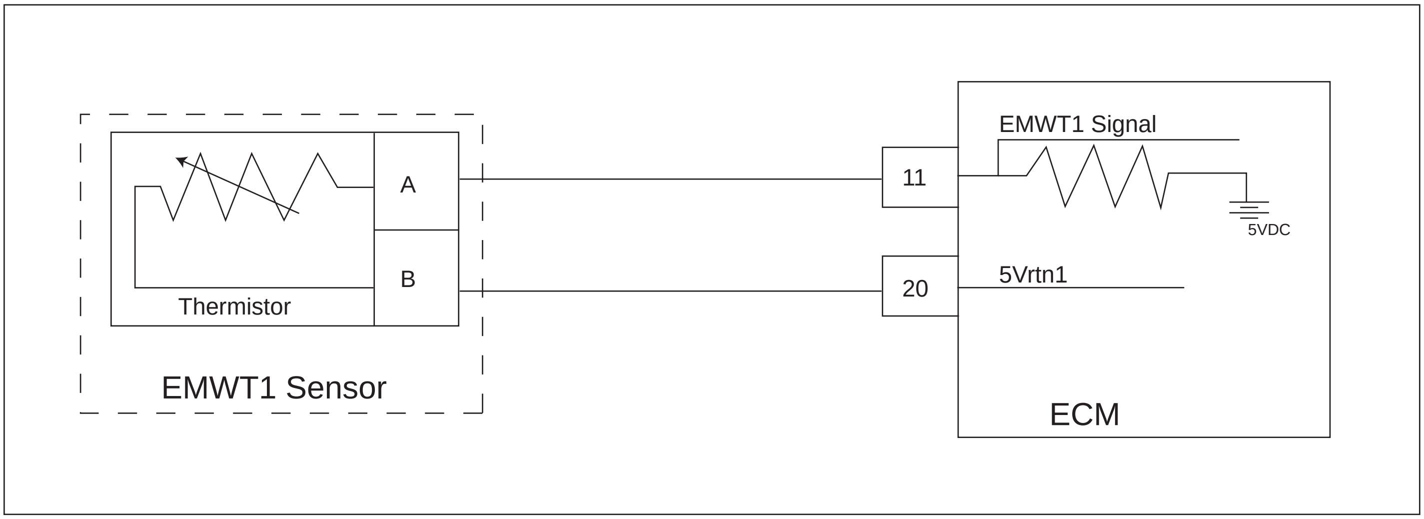
This fault sets if the misfire counter for cylinder #1 exceeds the driveability misfire limit set in the misfire diagnostic calibration and is based on a percentage of misfire over a certain number of engine cycles.

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).

DTC 1411 - Exhaust Manifold Water Temperature (EMWT) Sensor 1 Voltage High
SPN - 441; FMI - 3

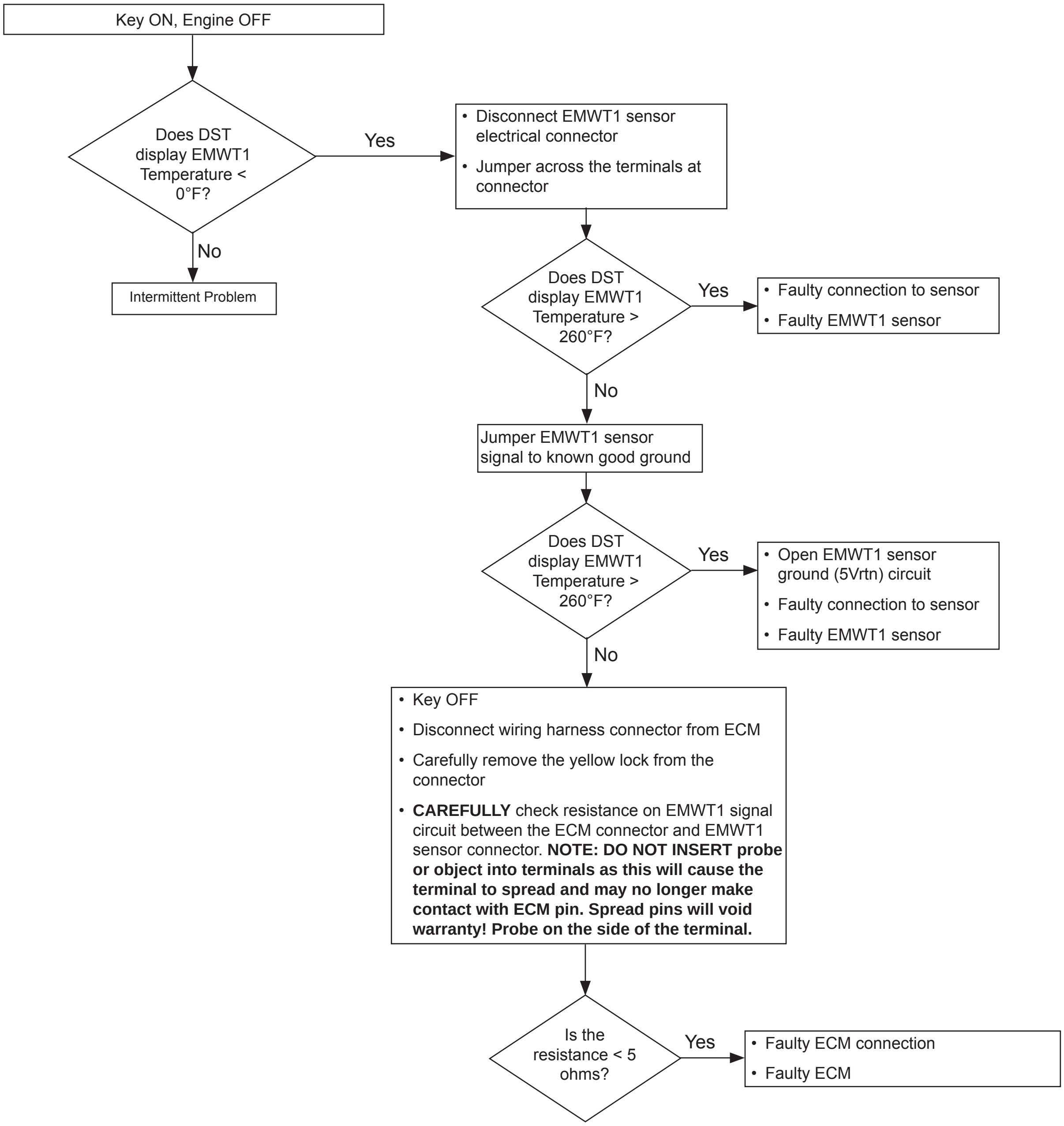


- Exhaust Manifold Water Temperature (EMWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - EMWT1 sensor voltage higher than the limit defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn 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

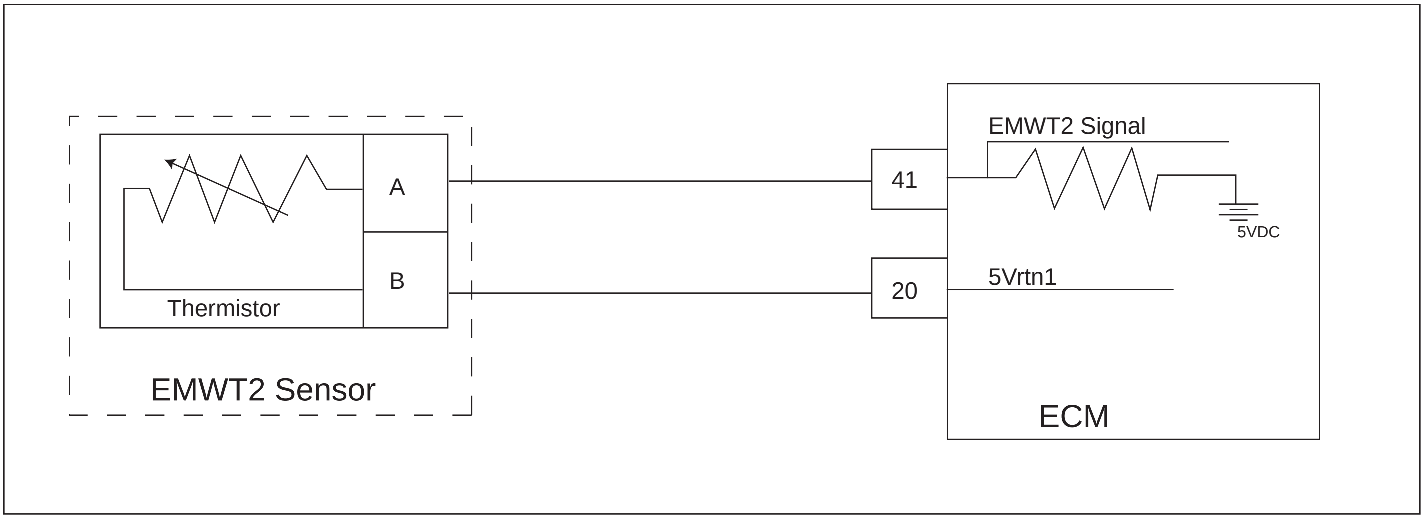
The EMWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

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



DTC 1412 - Exhaust Manifold Water Temperature (EMWT) Sensor 2 Voltage High
SPN - 442; FMI - 3

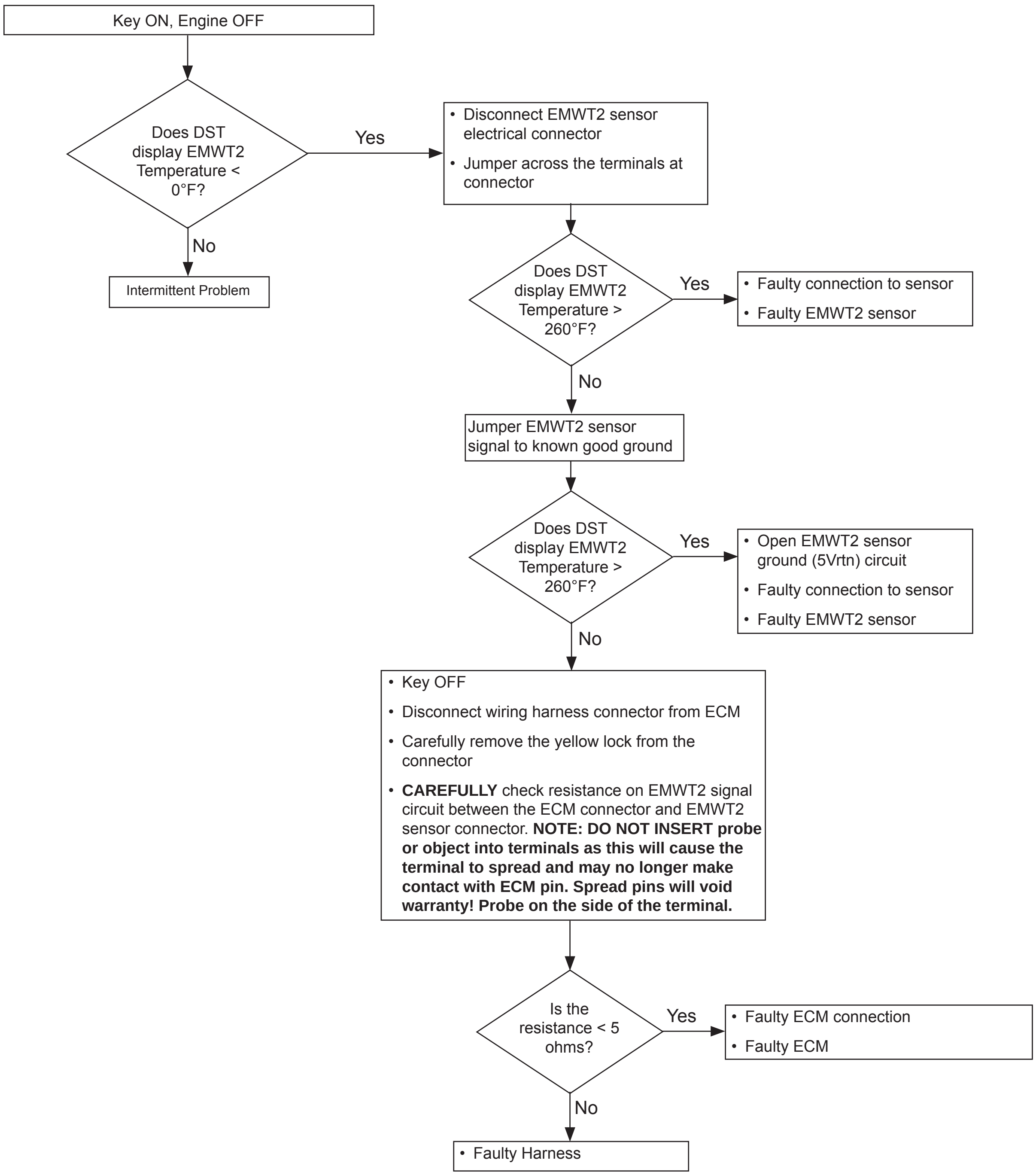


- Exhaust Manifold Water Temperature (EMWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - EMWT2 sensor voltage higher than the limit defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn 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

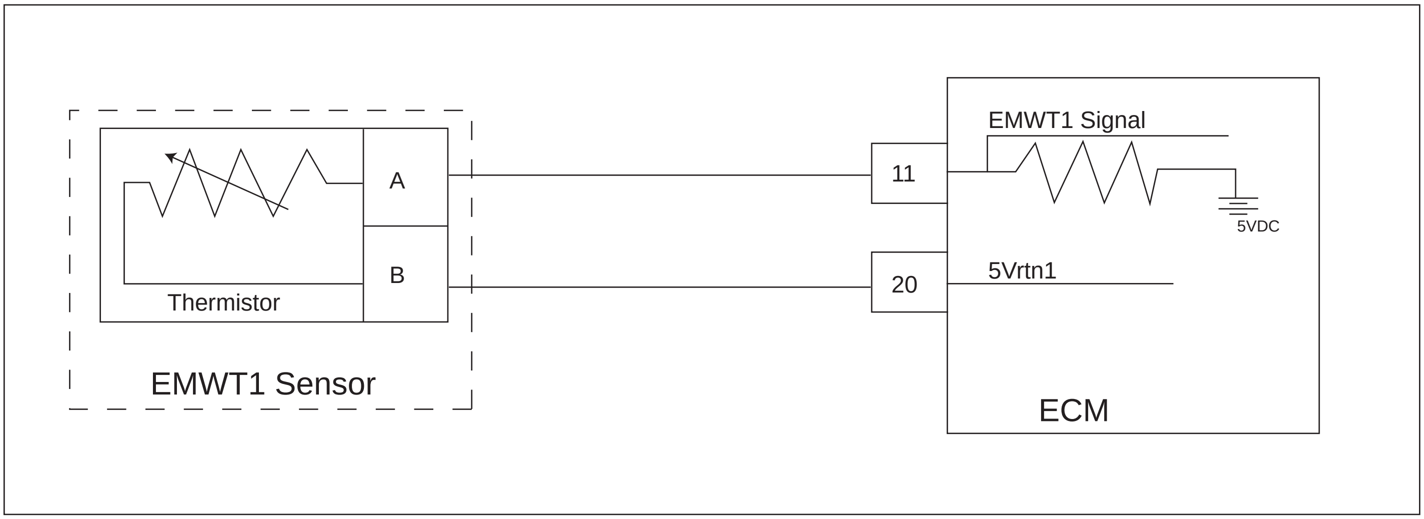
The EMWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

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



DTC 1413 - Exhaust Manifold Water Temperature (EMWT) Sensor 1 Voltage Low
SPN - 441; FMI - 4

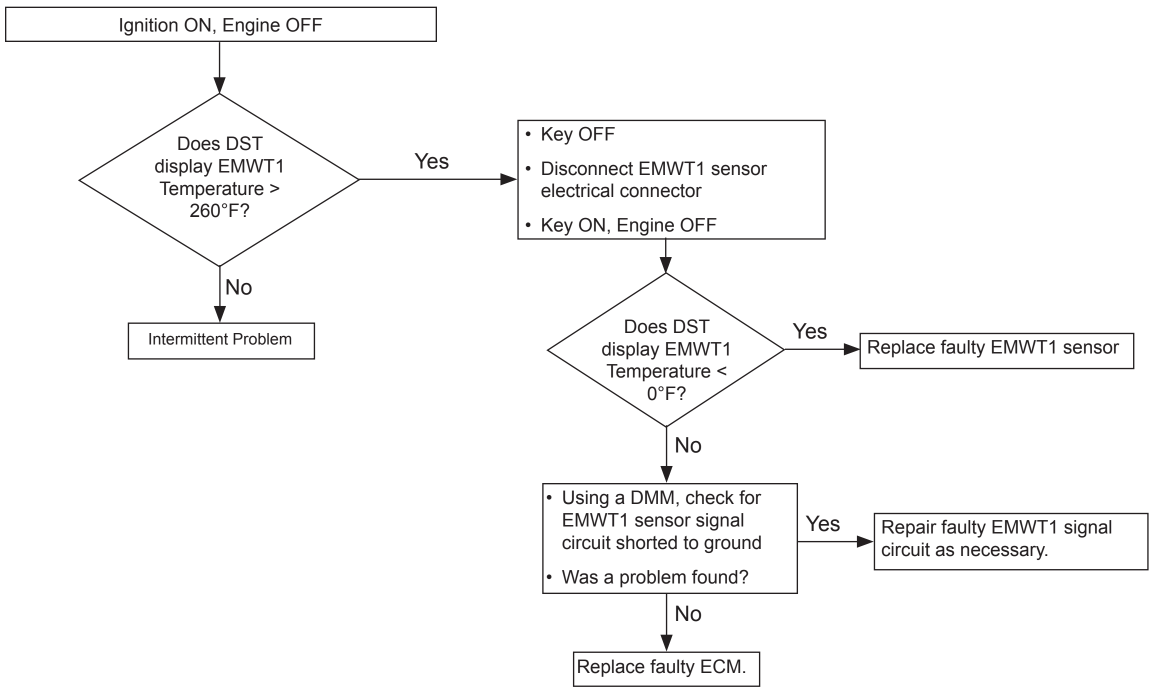


- Exhaust Manifold Water Temperature (EMWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - ECT sensor voltage less than the limit defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling 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

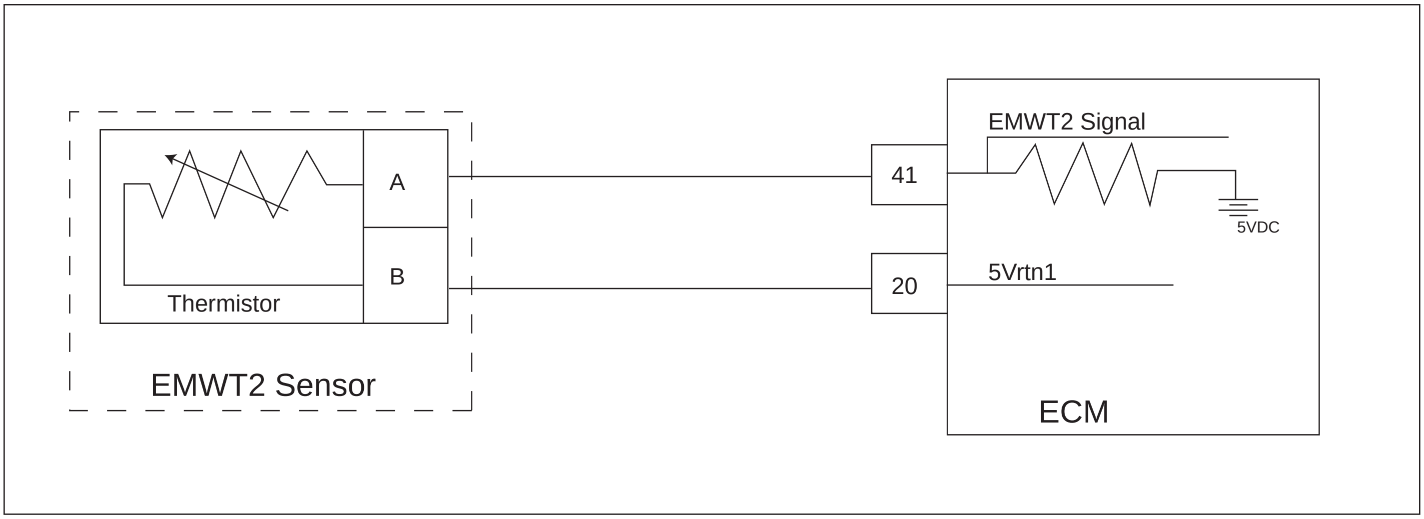
The EMWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

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



DTC 1414 - Exhaust Manifold Water Temperature (EMWT) Sensor 2 Voltage Low
SPN - 442; FMI - 4

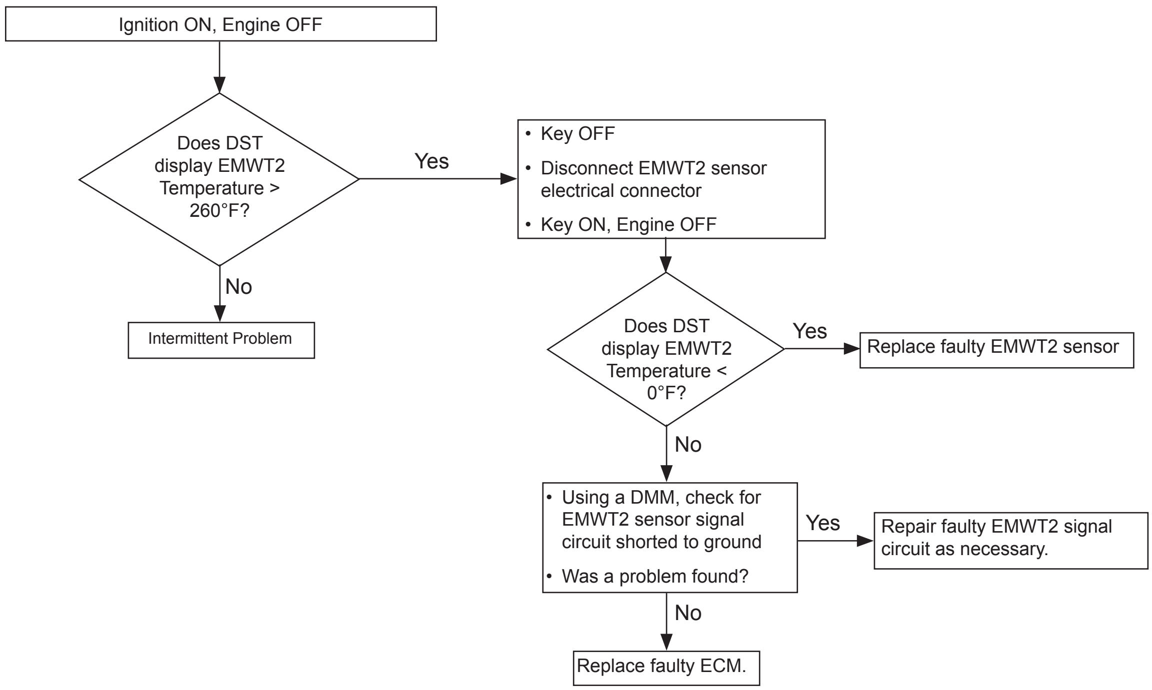


- Exhaust Manifold Water Temperature (EMWT) Sensor
- *Check Condition* - Engine Running
- *Fault Condition* - ECT sensor voltage less than the limit defined in the diagnostic calibration
- *Corrective Action(s)* - Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling 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

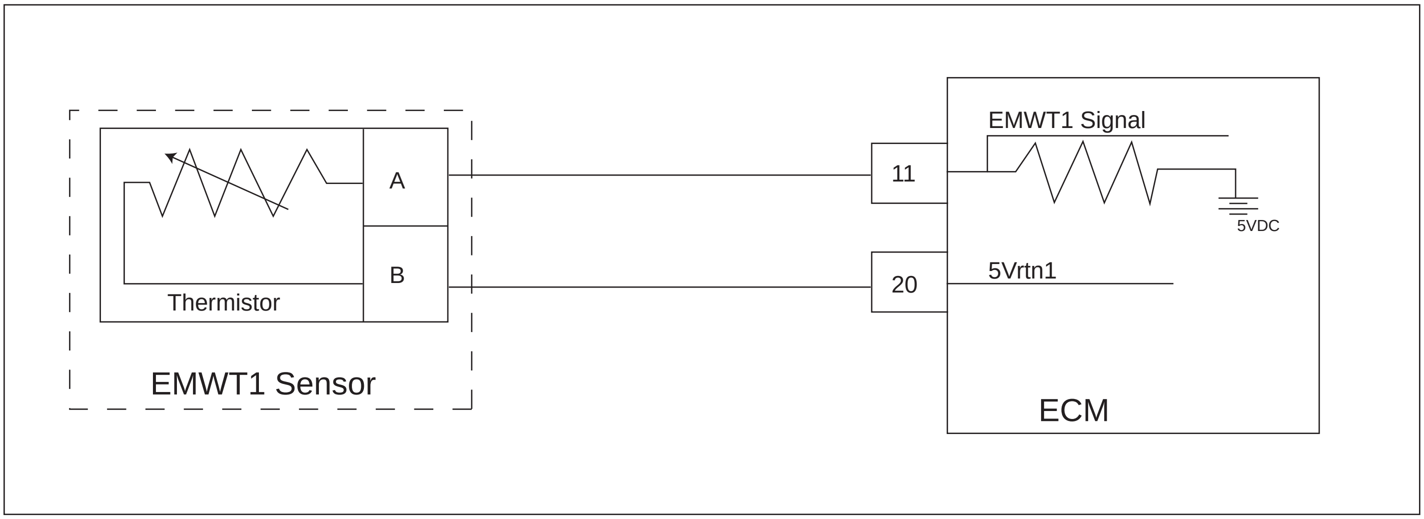
The EMWT sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. There is one located in each CES exhaust manifold. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

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



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.

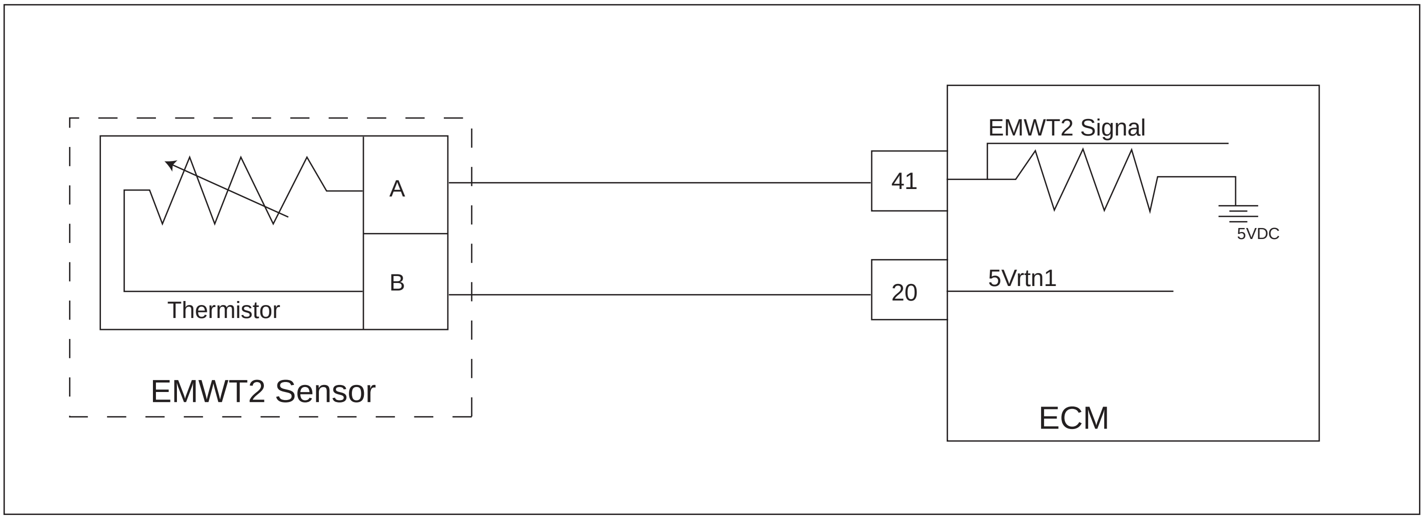
This fault will help protect the engine in the event of over temperature. When the coolant exceeds x deg. F and engine RPM exceeds y RPM for the latch time this fault will set.

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

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.

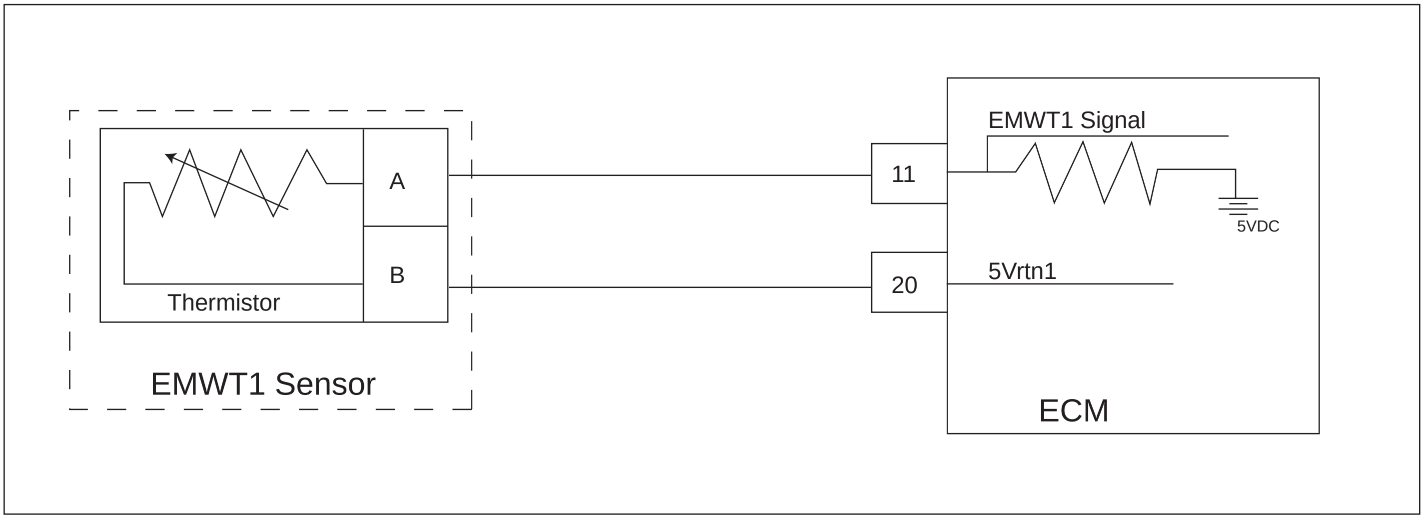
This fault will help protect the engine in the event of over temperature. When the coolant exceeds x deg. F and engine RPM exceeds y RPM for the latch time this fault will set.

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

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.

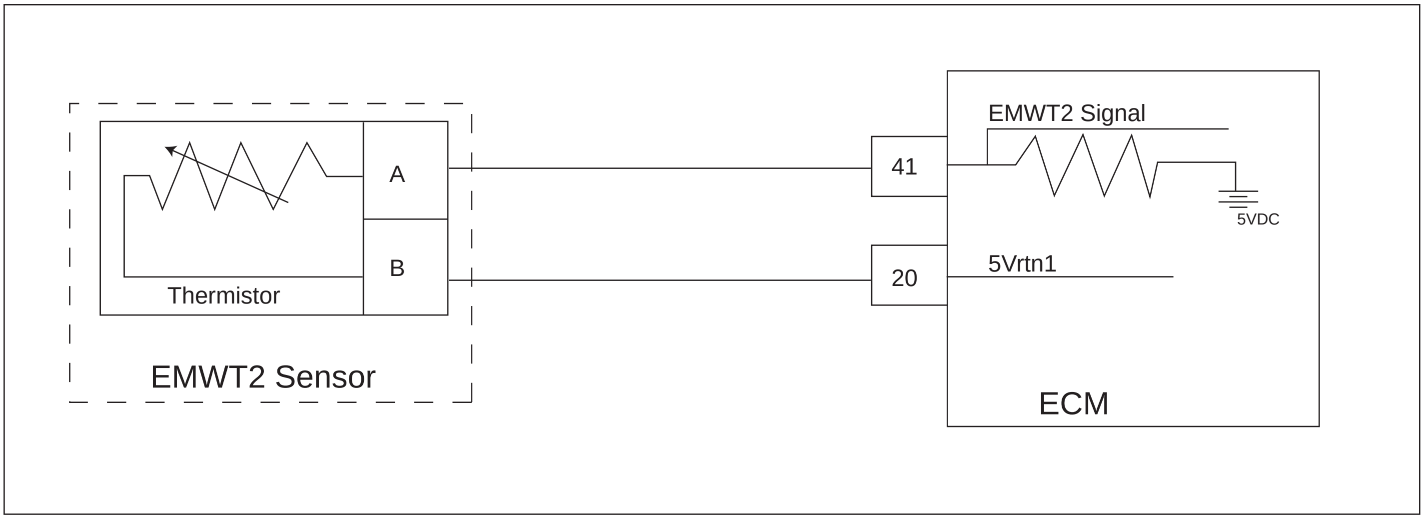
This fault will help protect the engine in the event of over temperature. When the coolant exceeds x deg. F and engine RPM exceeds y RPM for the latch time this fault will set.

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

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.

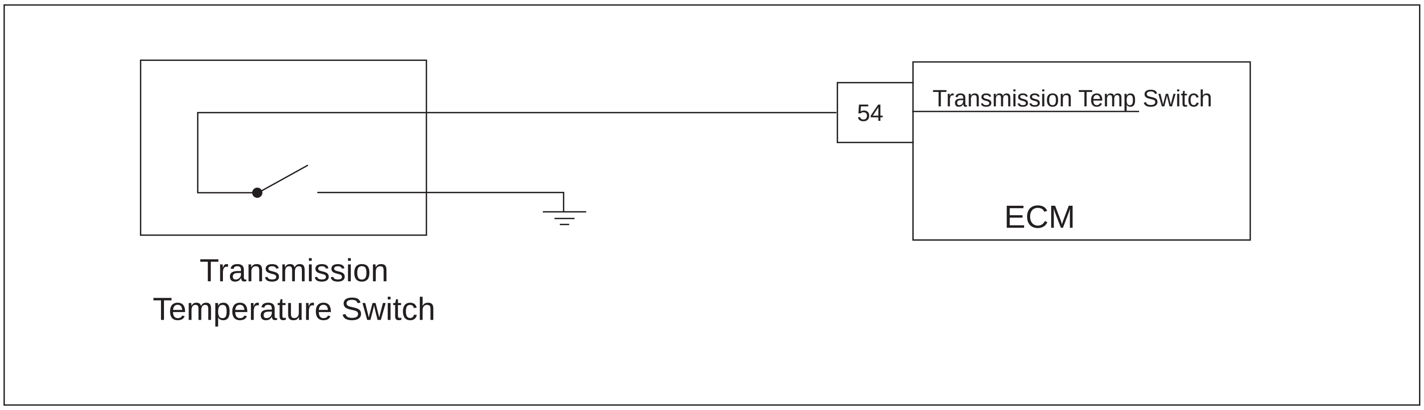
This fault will help protect the engine in the event of over temperature. When the coolant exceeds x deg. F and engine RPM exceeds y RPM for the latch time this fault will set.

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

DTC 1542 - AUX Analog PUD 1 - Low Voltage
SPN - 704; FMI - 4



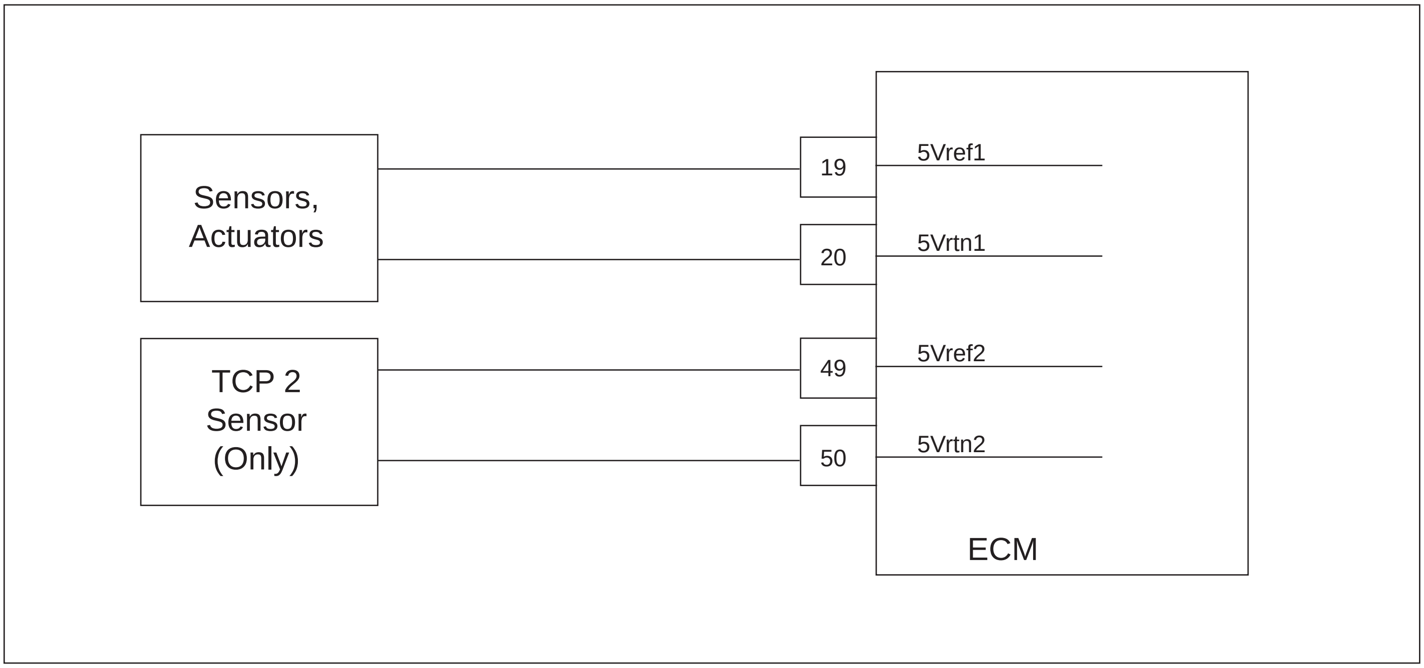
- AUX Analog PUD1 - Transmission Overtemp Switch
- *Check Condition* - Key on, Engine Cranking or Running
- *Fault Condition* - Battery voltage to ECM greater than x volts while the engine is running as defined in the diagnostic calibration
- *Corrective Action(s)* - Illuminate MIL and/or sound audible 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

DTC 1611 - Sensor Supply Voltage (5Vref 1/2) Simultaneously Out-of-Range
SPN - 1079; FMI - 31

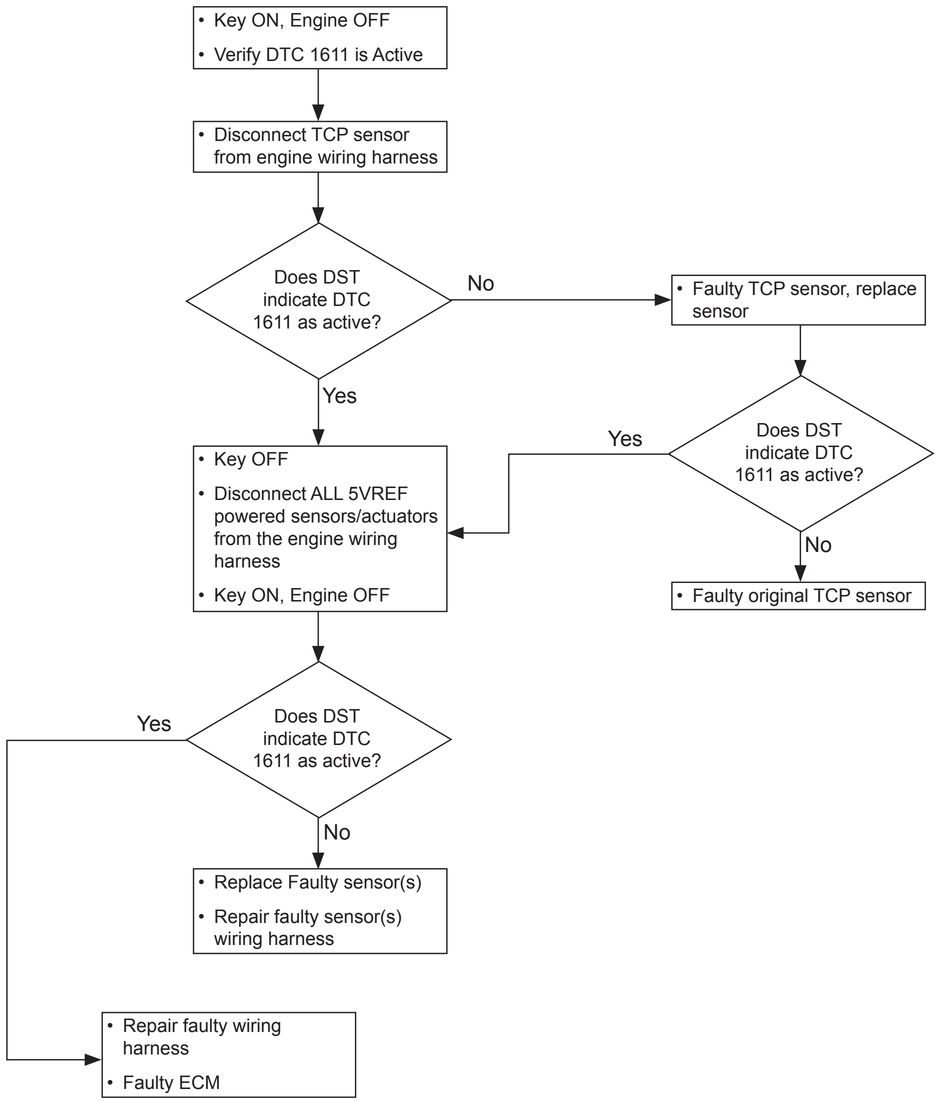


- Powered sensors/actuators and FPP2
- *Check Condition* - Engine on
- *Fault Condition* - high or low voltage feedback on both 5V_ext1 and 5V_ext2
- *Corrective Action(s)* - Illuminate MIL, sound audible warning or illuminate secondary warning lamp, and forced idle
- Non-emissions related fault

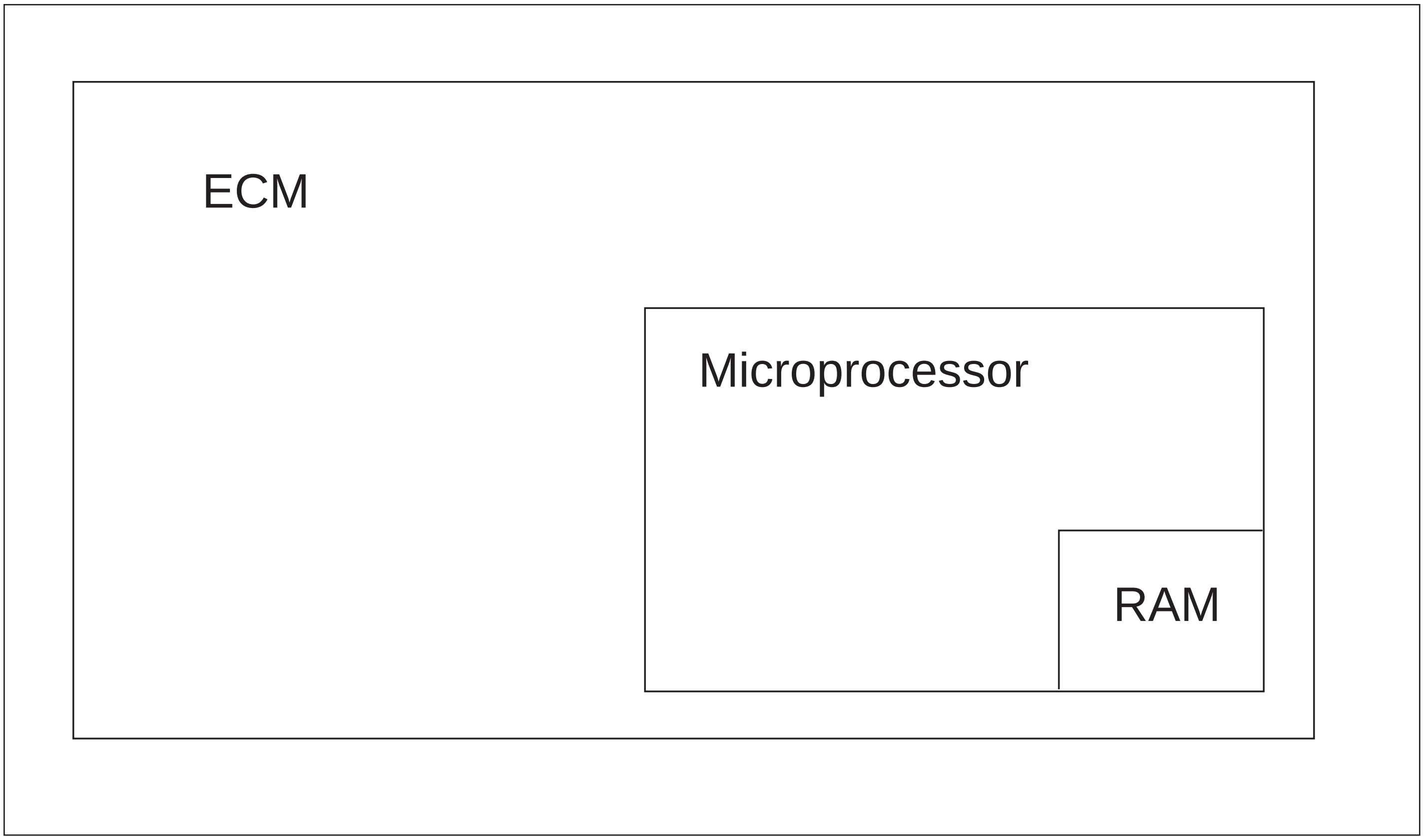
5V_ext1 is a regulated 5 VDC output that supplies power to sensors and actuators. This power is generally supplied, but is not limited to hall-effects, potentiometers, switches, and pressure transducers. 5V_ext2 is a low-current 5 VDC power supply intended solely for powering a second potentiometer used 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



DTC 1612 - Microprocessor Failure - RTI 1
SPN - 629; FMI - 31

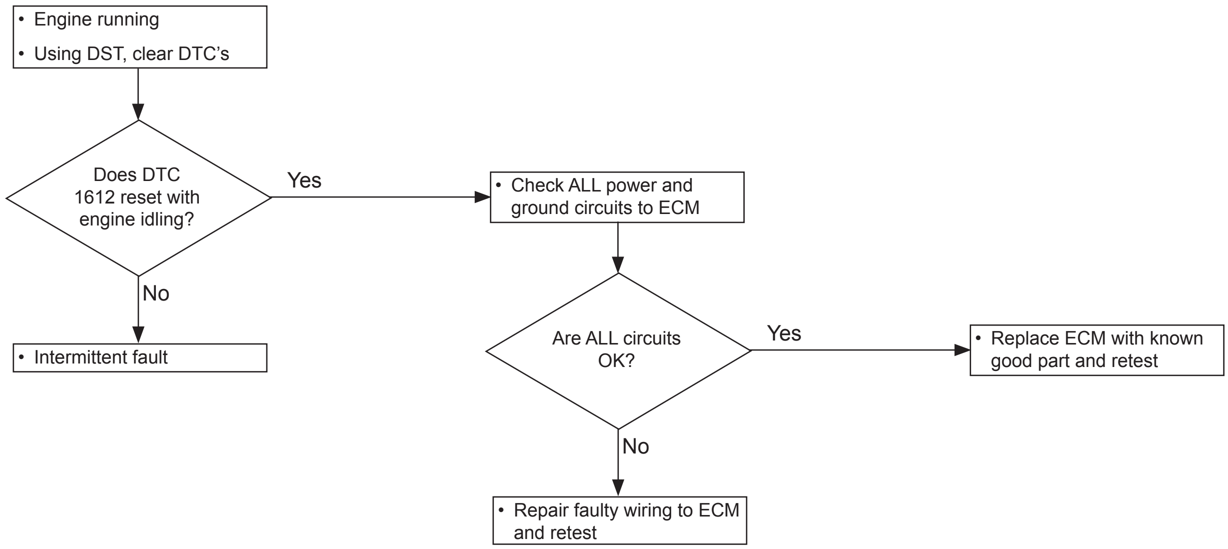


- Engine Control Module
- *Check Condition* - Key on
- *Fault Condition* - Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive - Disabled for the remainder of the key-on cycle
- Closed Loop - Enabled
- Power Derate (level 2 until fault is cleared manually)

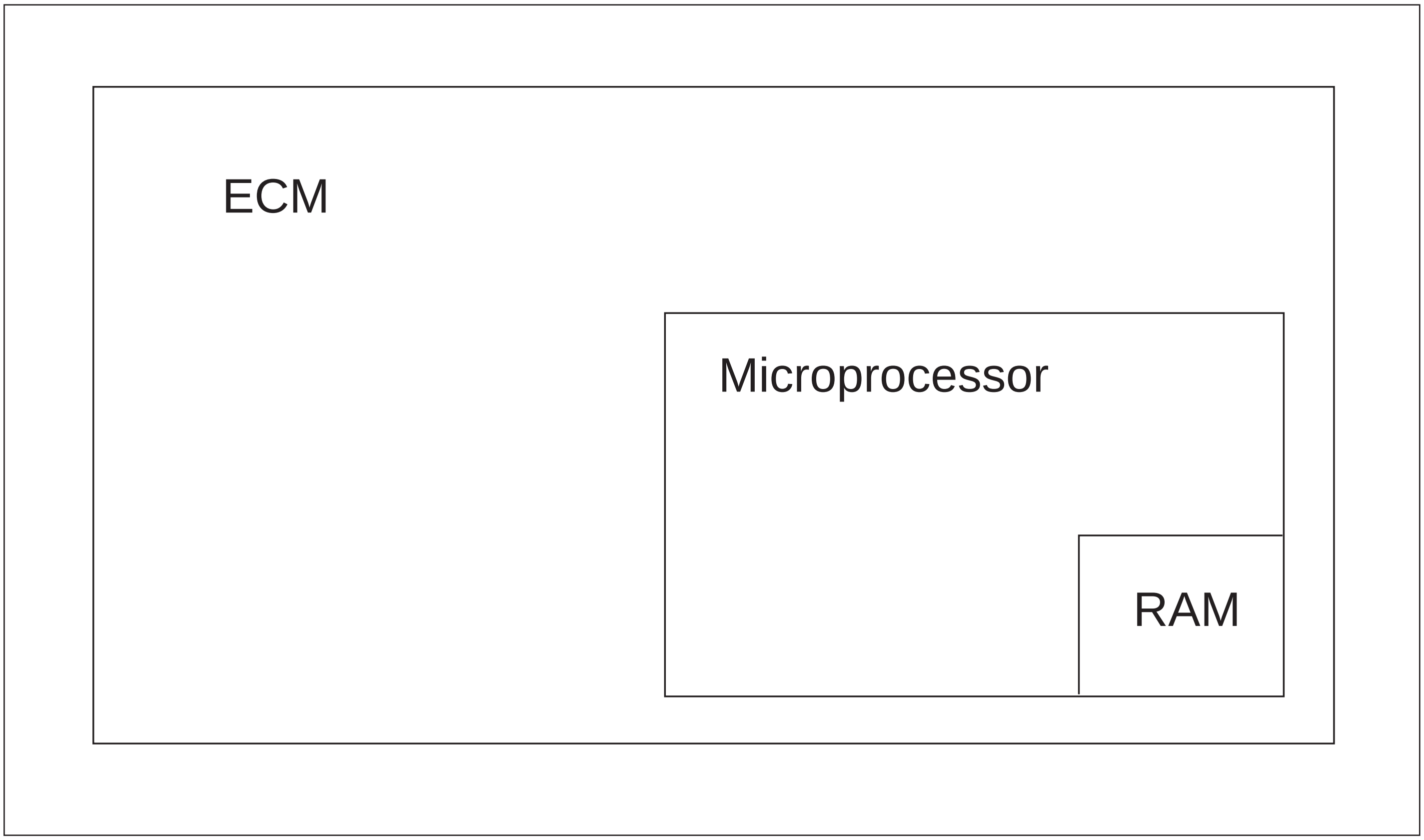
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased 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



DTC 1613 - Microprocessor Failure - RTI 2
SPN - 629; FMI - 31

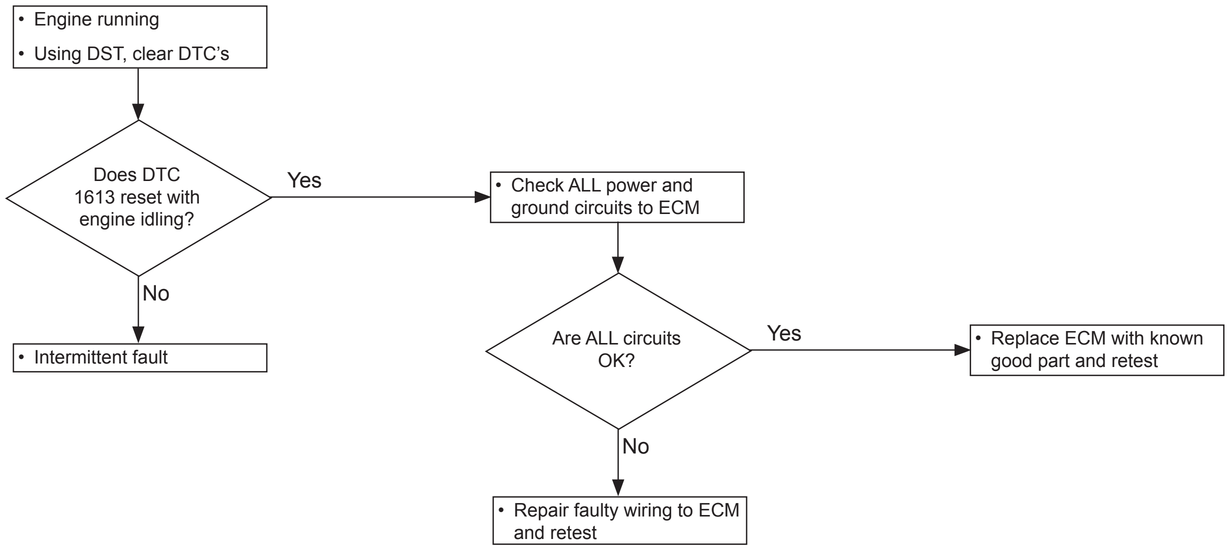


- Engine Control Module
- *Check Condition* - Key on
- *Fault Condition* - Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive - Disabled for the remainder of the key-on cycle
- Closed Loop - Enabled
- Power Derate (level 2 until fault is cleared manually)

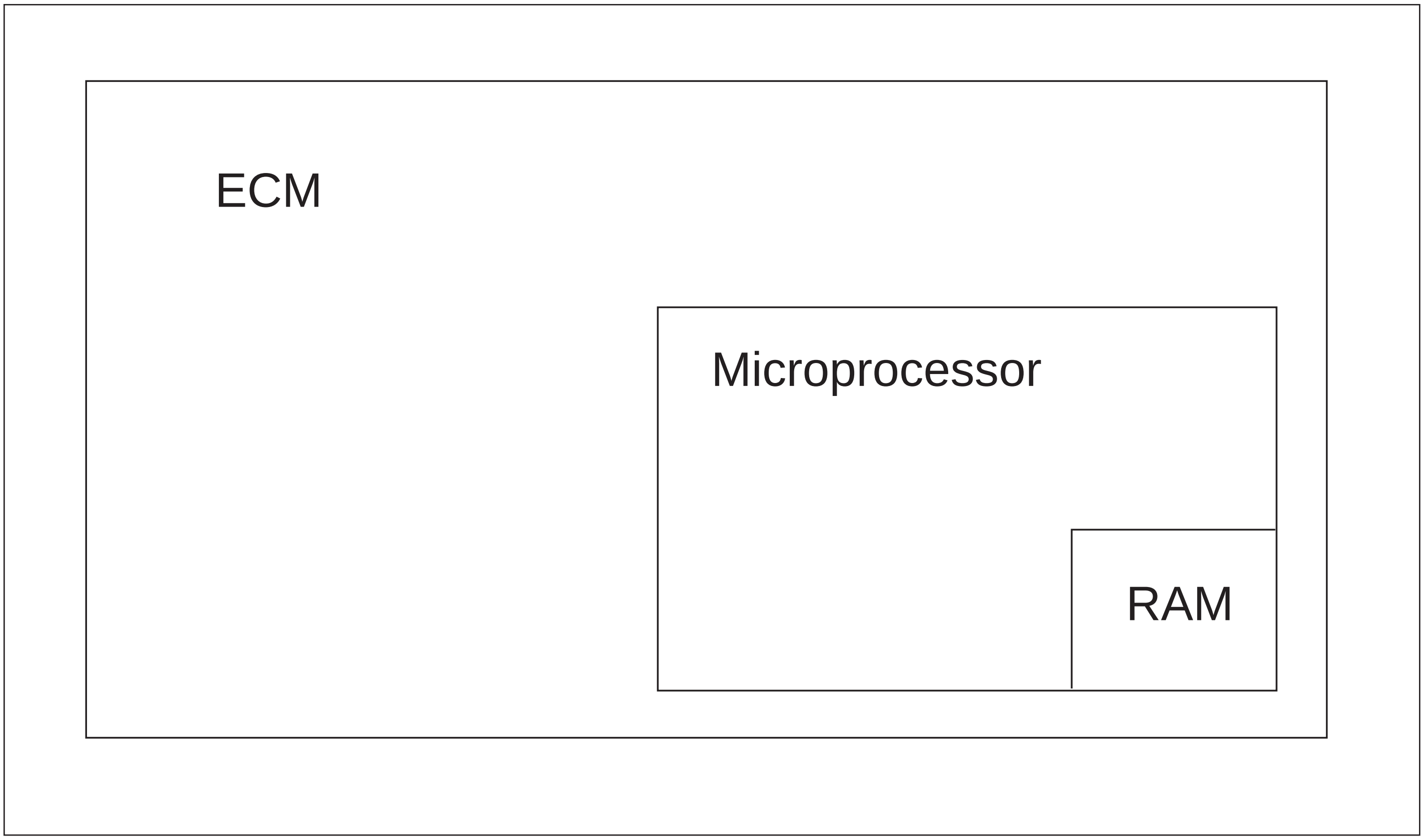
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased 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



DTC 1614 - Microprocessor Failure - RTI 3
SPN - 629; FMI - 31

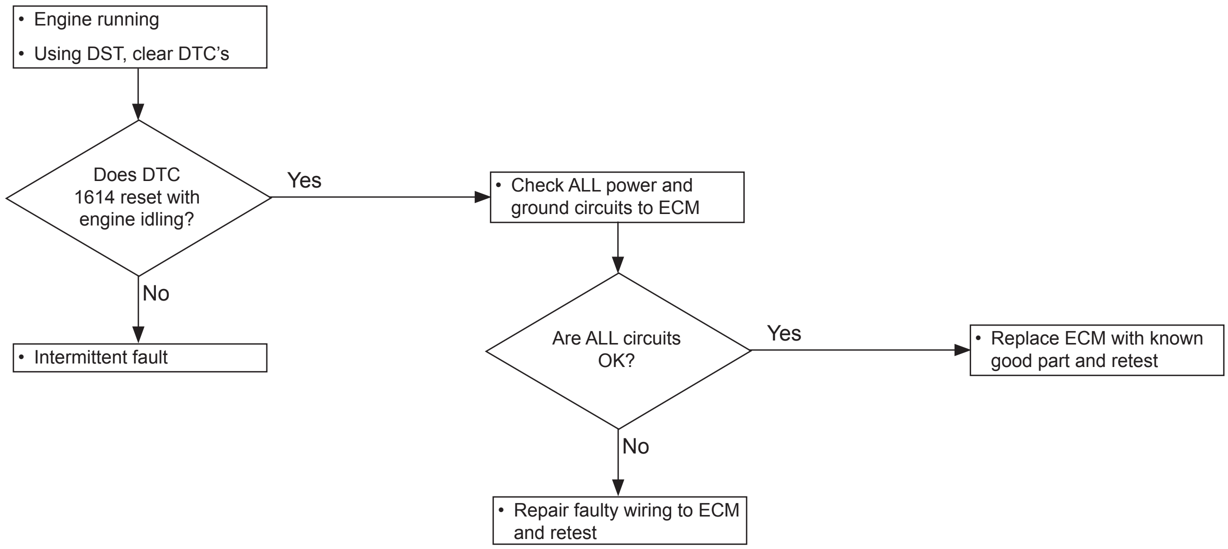


- Engine Control Module
- *Check Condition* - Key on
- *Fault Condition* - Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive - Disabled for the remainder of the key-on cycle
- Closed Loop - Enabled
- Power Derate (level 2 until fault is cleared manually)

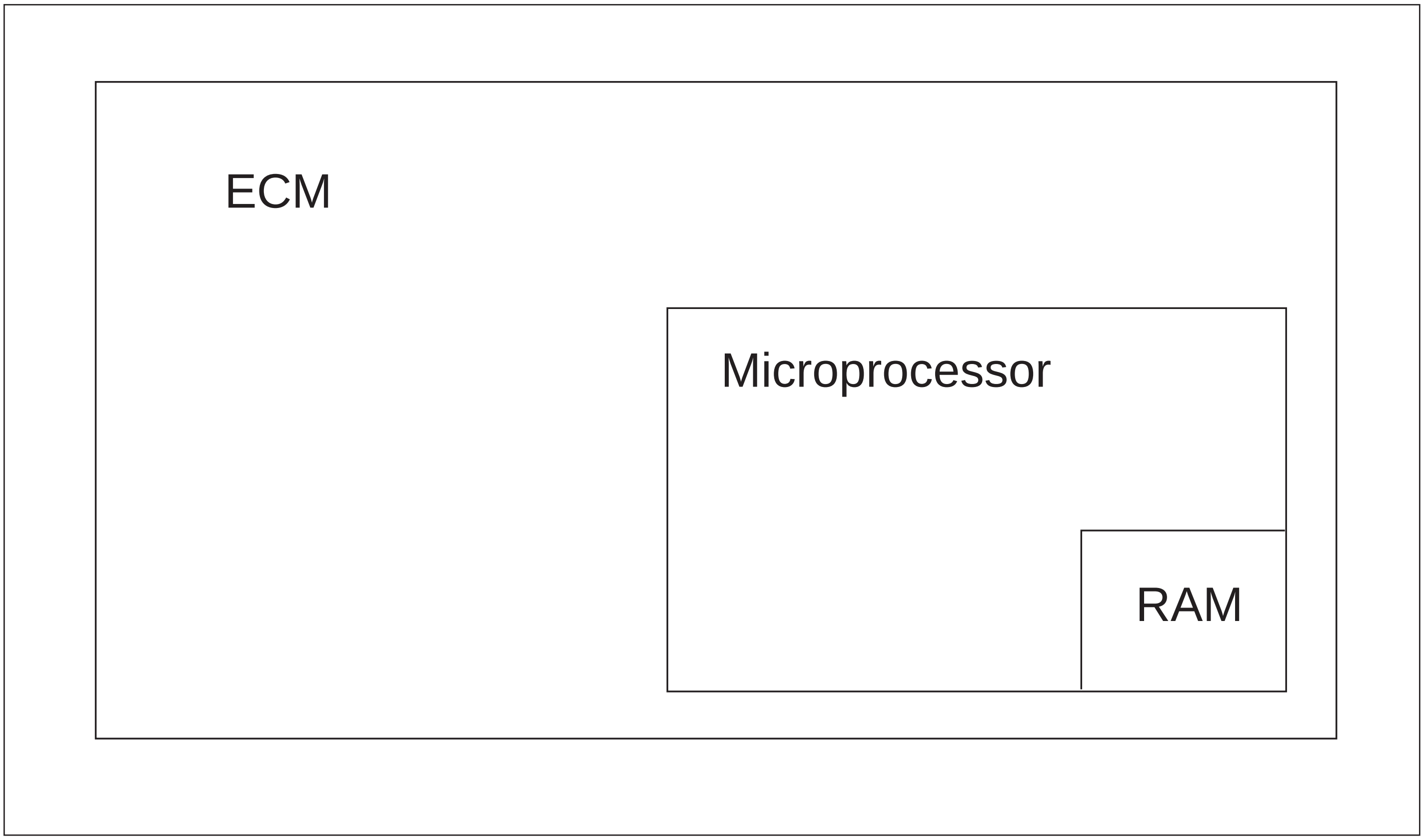
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased 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



DTC 1615 - Microprocessor Failure - A/D
SPN - 629; FMI - 31

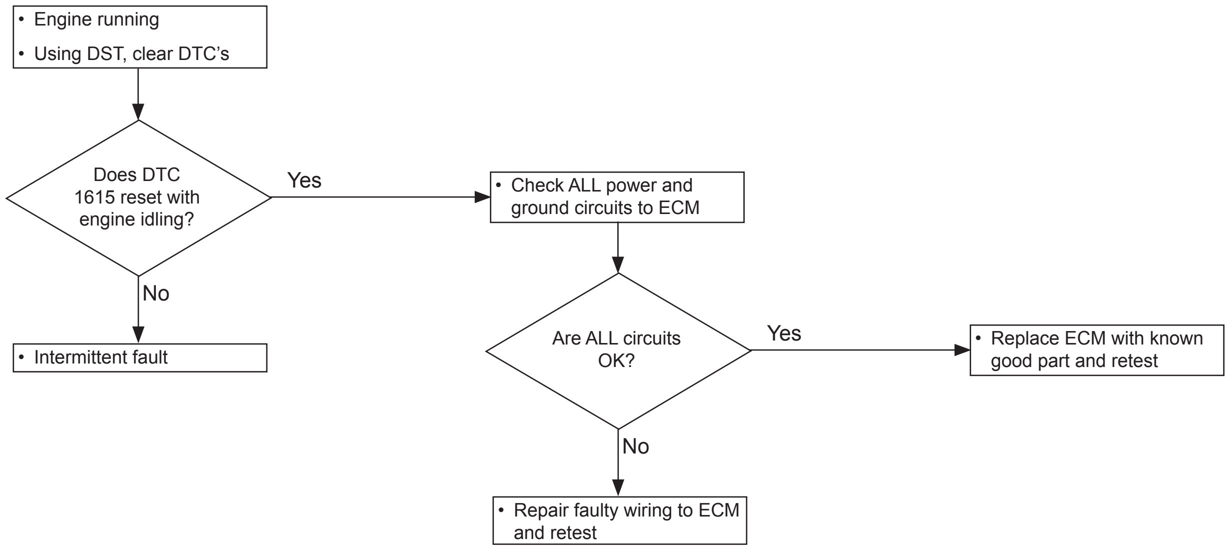


- Engine Control Module
- *Check Condition* - Key on
- *Fault Condition* - Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive - Disabled for the remainder of the key-on cycle
- Closed Loop - Enabled
- Power Derate (level 2 until fault is cleared manually)

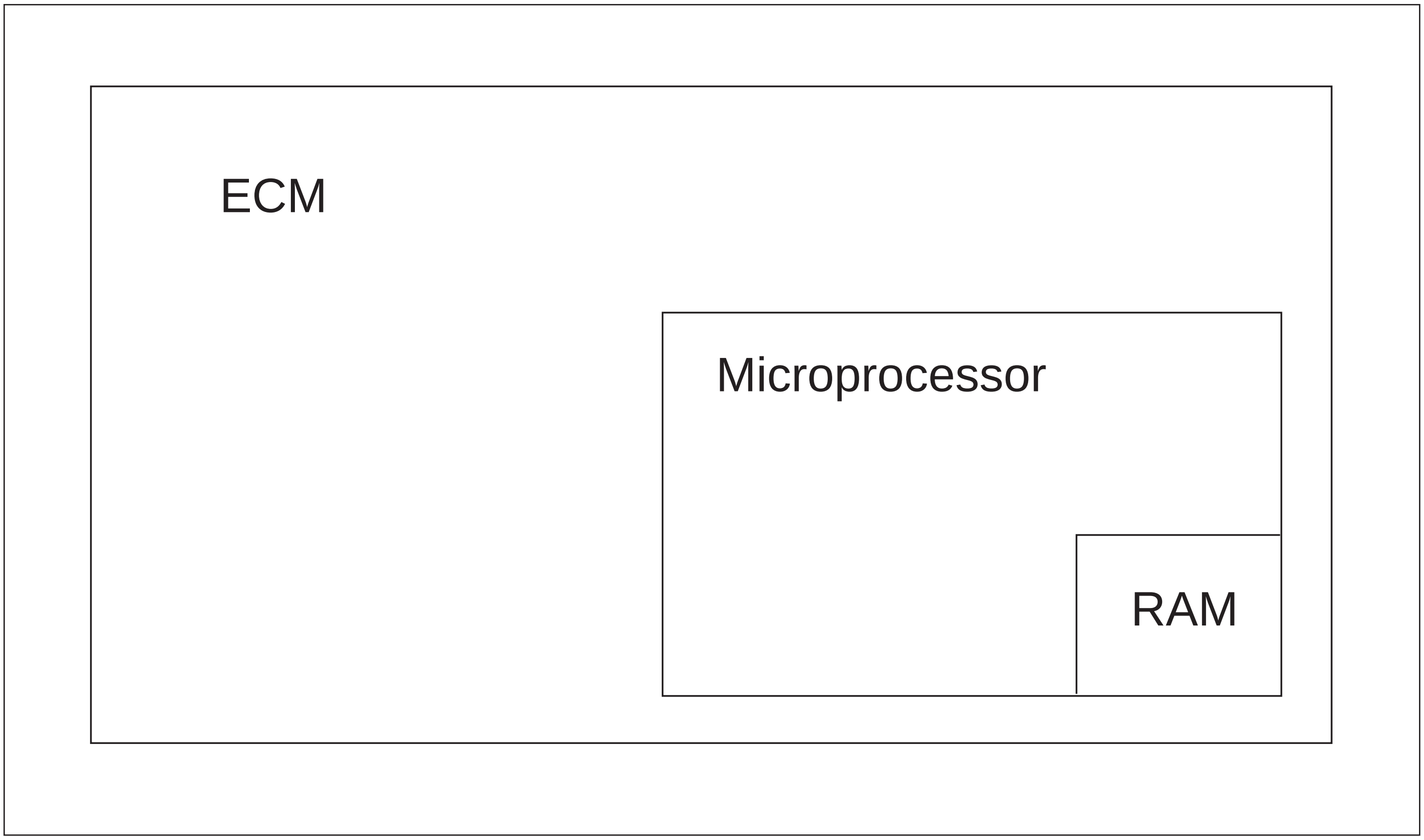
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased 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



DTC 1616 - Microprocessor Failure - Interrupt
SPN - 629; FMI - 31

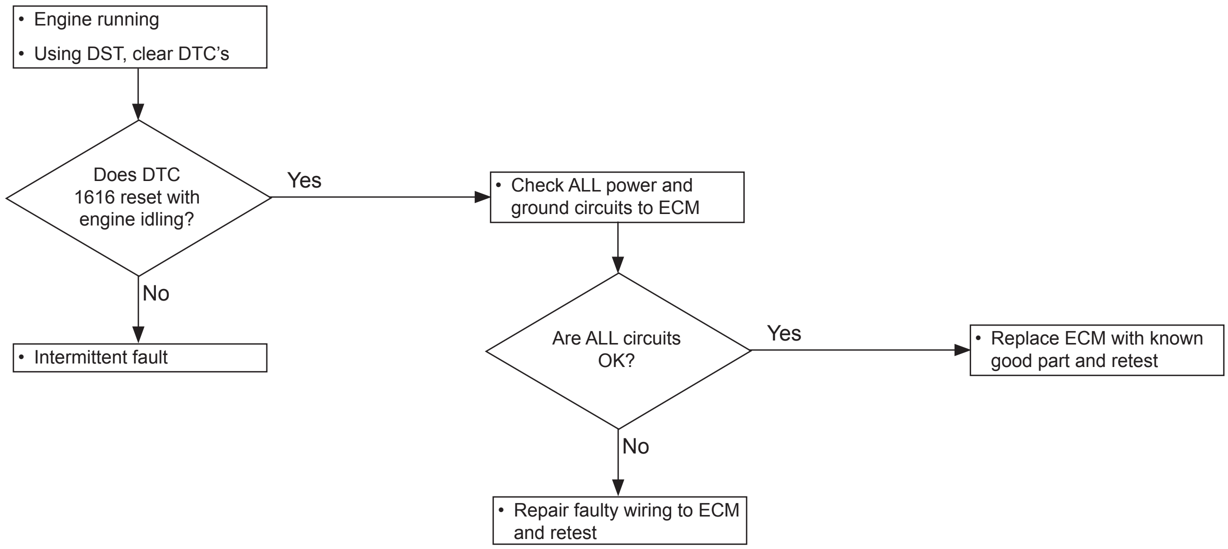


- Engine Control Module
- *Check Condition* - Key on
- *Fault Condition* - Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive - Disabled for the remainder of the key-on cycle
- Closed Loop - Enabled
- Power Derate (level 2 until fault is cleared manually)

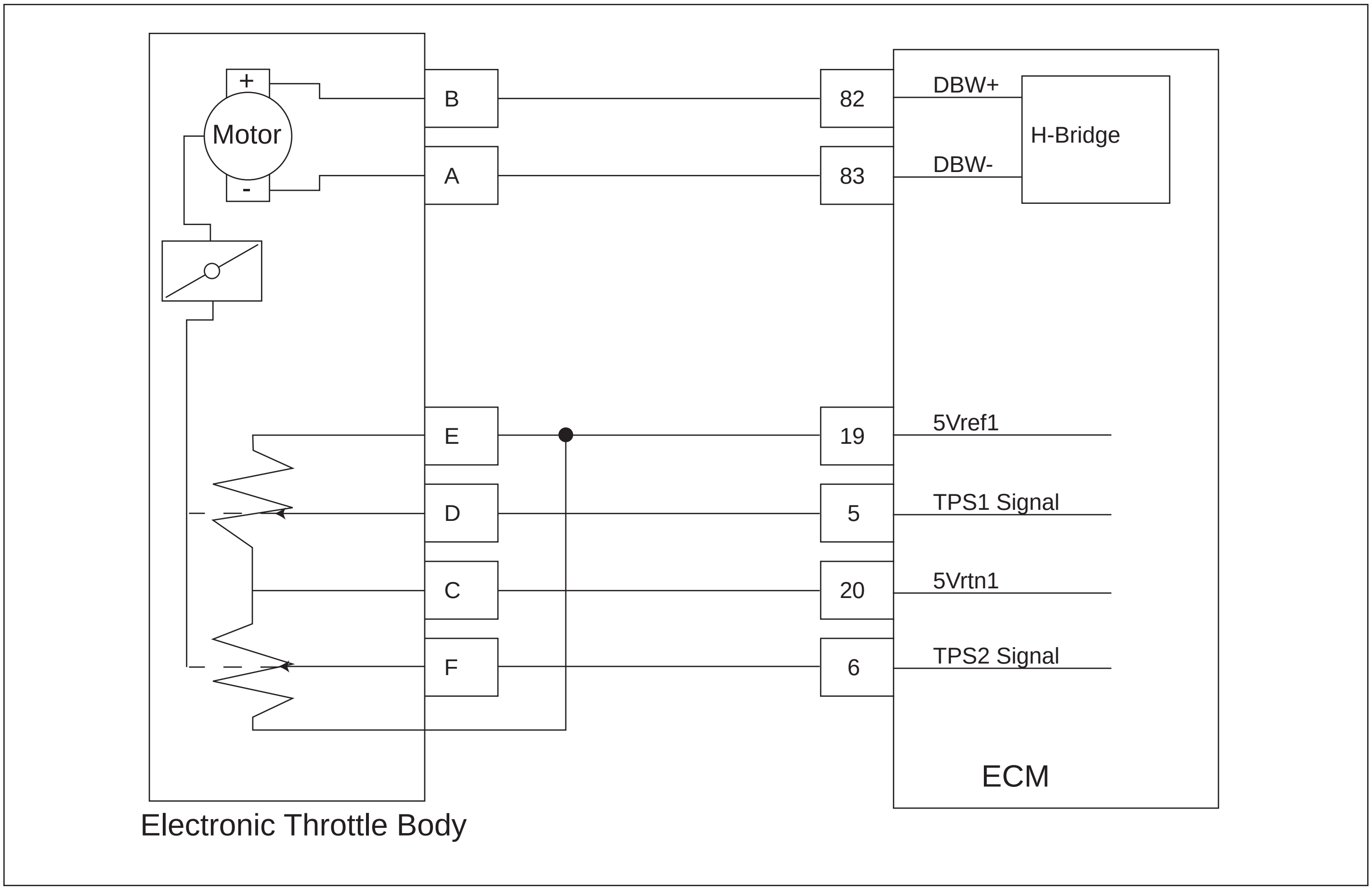
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased 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



DTC 2111 - Unable to Reach Lower TPS
SPN - 51; FMI - 7

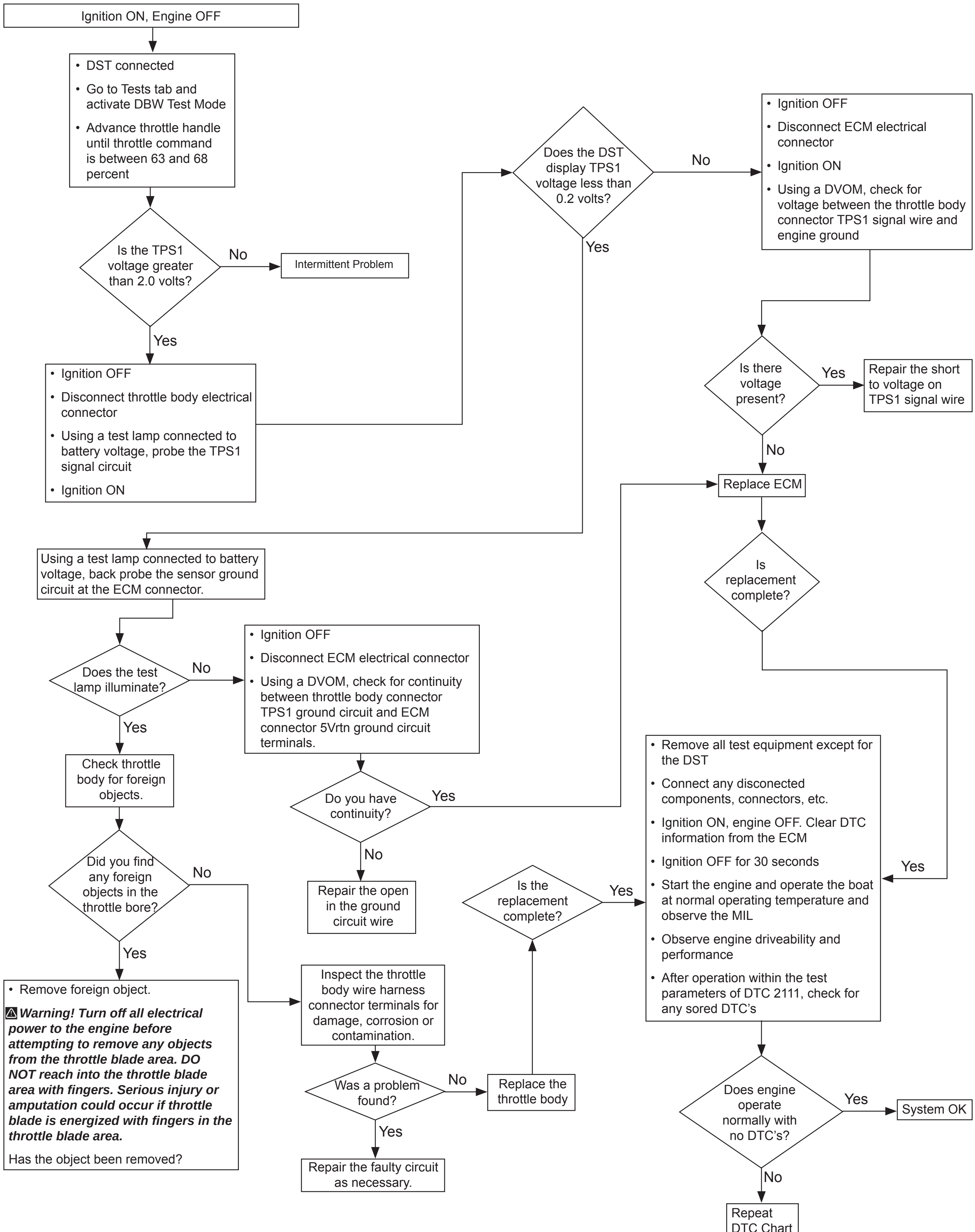


- Throttle Body / Throttle Position Sensor
- *Check Condition* - Cranking or Running
- *Fault Condition* - Throttle command is 20 percent less than the throttle position for 200ms or longer.
- MIL - On during active fault
- Buzzer - On during active fault
- Low Rev Limit and Forced Idle is activated

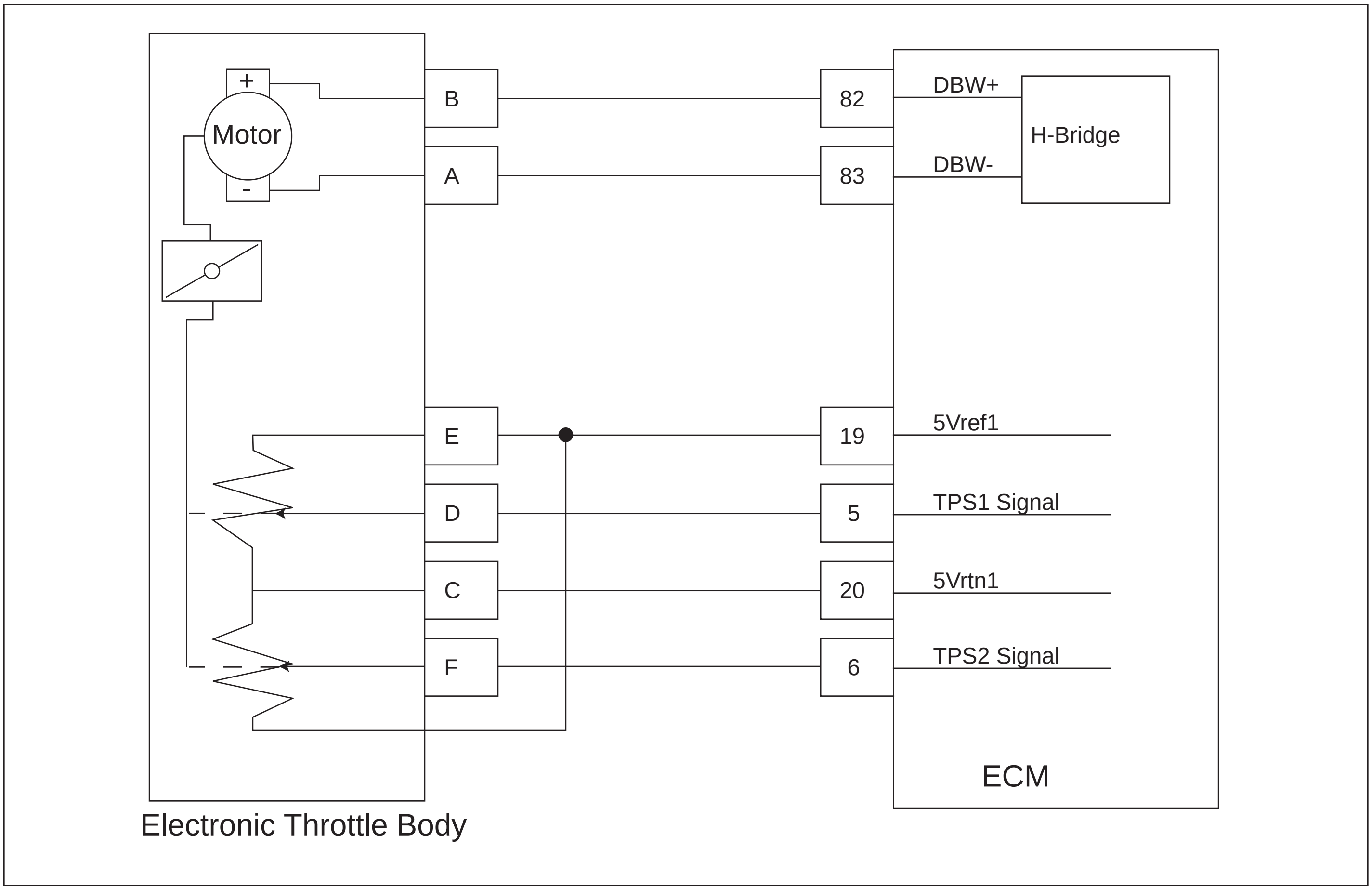
There are two throttle position sensors located within the throttle body which use variable resistors to determine signal voltage vased on the throttle blade position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from 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



DTC 2112 - Unable to Reach Higher TPS
SPN - 51; FMI - 7

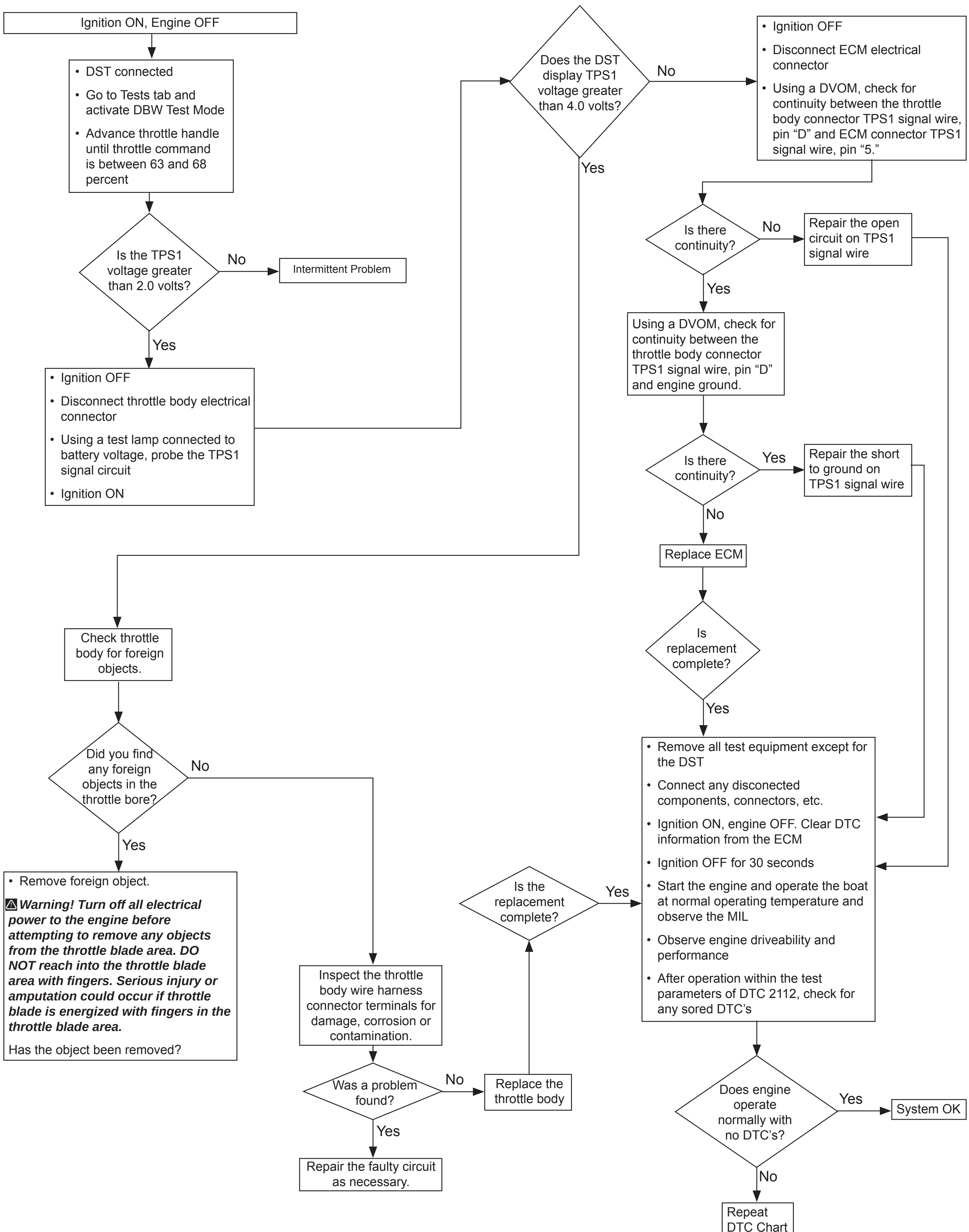


- Throttle Body / Throttle Position Sensor
- *Check Condition* - Cranking or Running
- *Fault Condition* - Throttle command is 20 percent more than the throttle position for 200ms or longer.
- MIL - On during active fault
- Buzzer - On during active fault
- Low Rev Limit and Forced Idle is activated

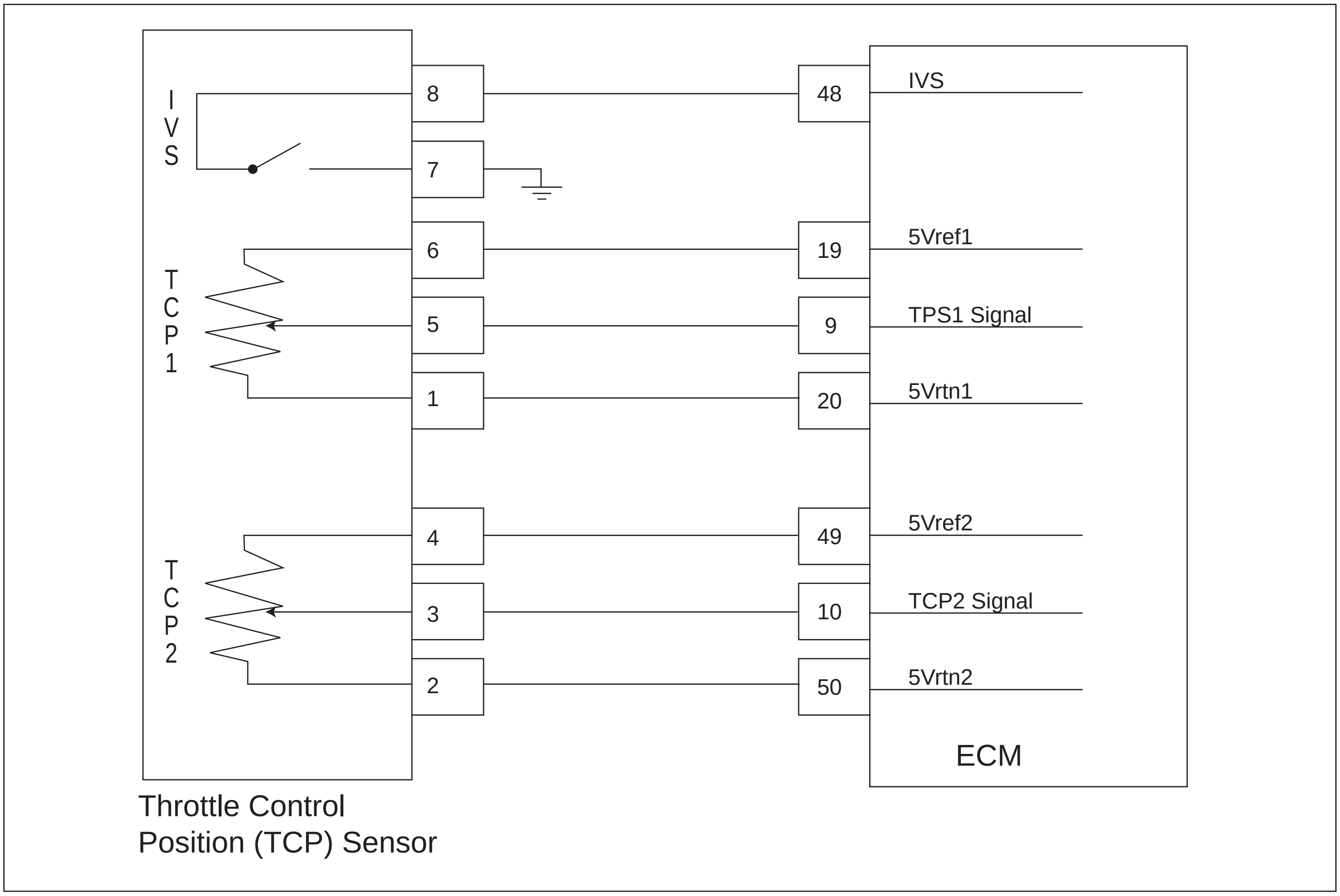
There are two throttle position sensors located within the throttle body which use variable resistors to determine signal voltage vased on the throttle blade position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from 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



DTC 2115 - TCP Sensor 1 Higher Than IVS Limit
SPN - 91; FMI - 0

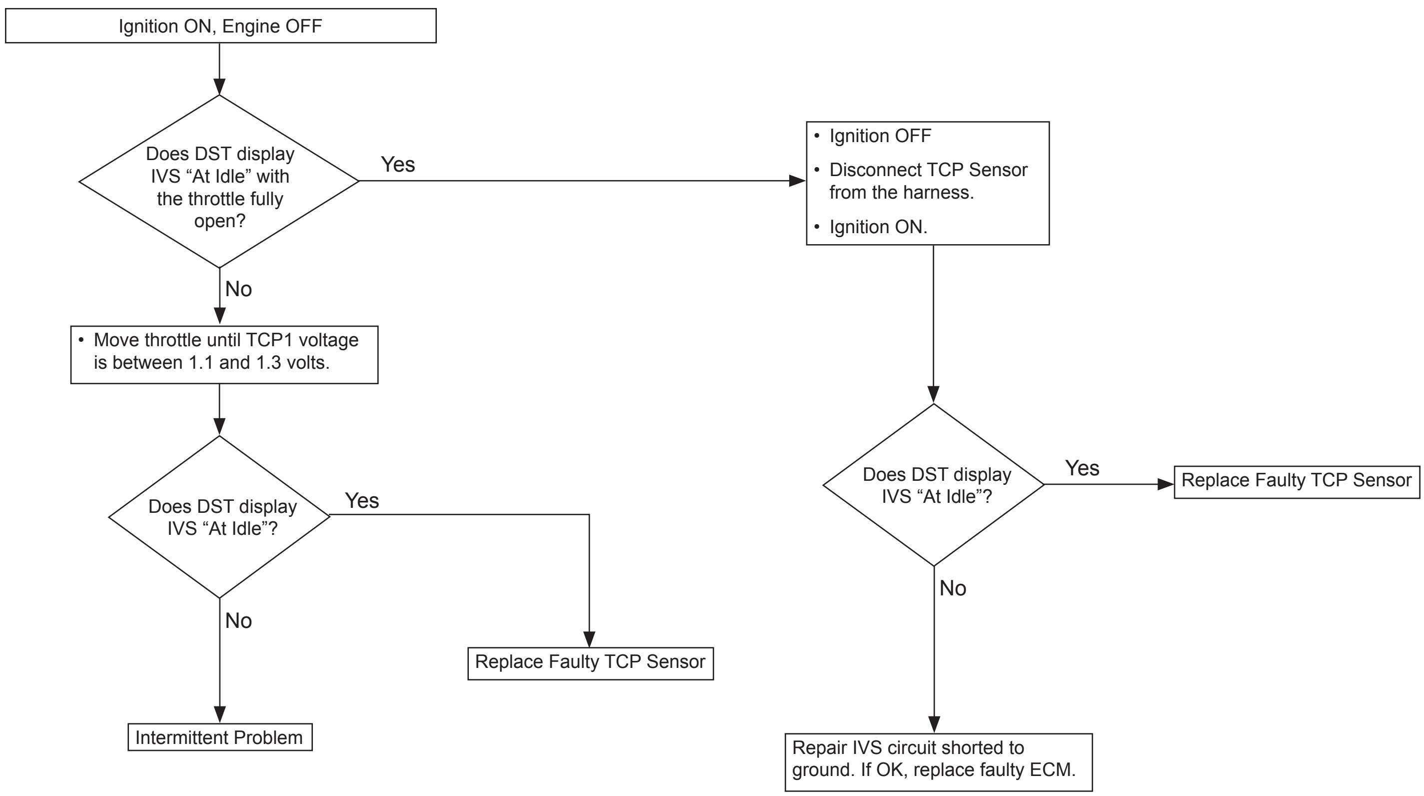


- Throttle Control Position/Idle Validation Switch (IVS)
- *Check Condition* - Engine Cranking or Running
- *Fault Condition* - IVS at idle and TCP voltage greater than 1.2 volts
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycle

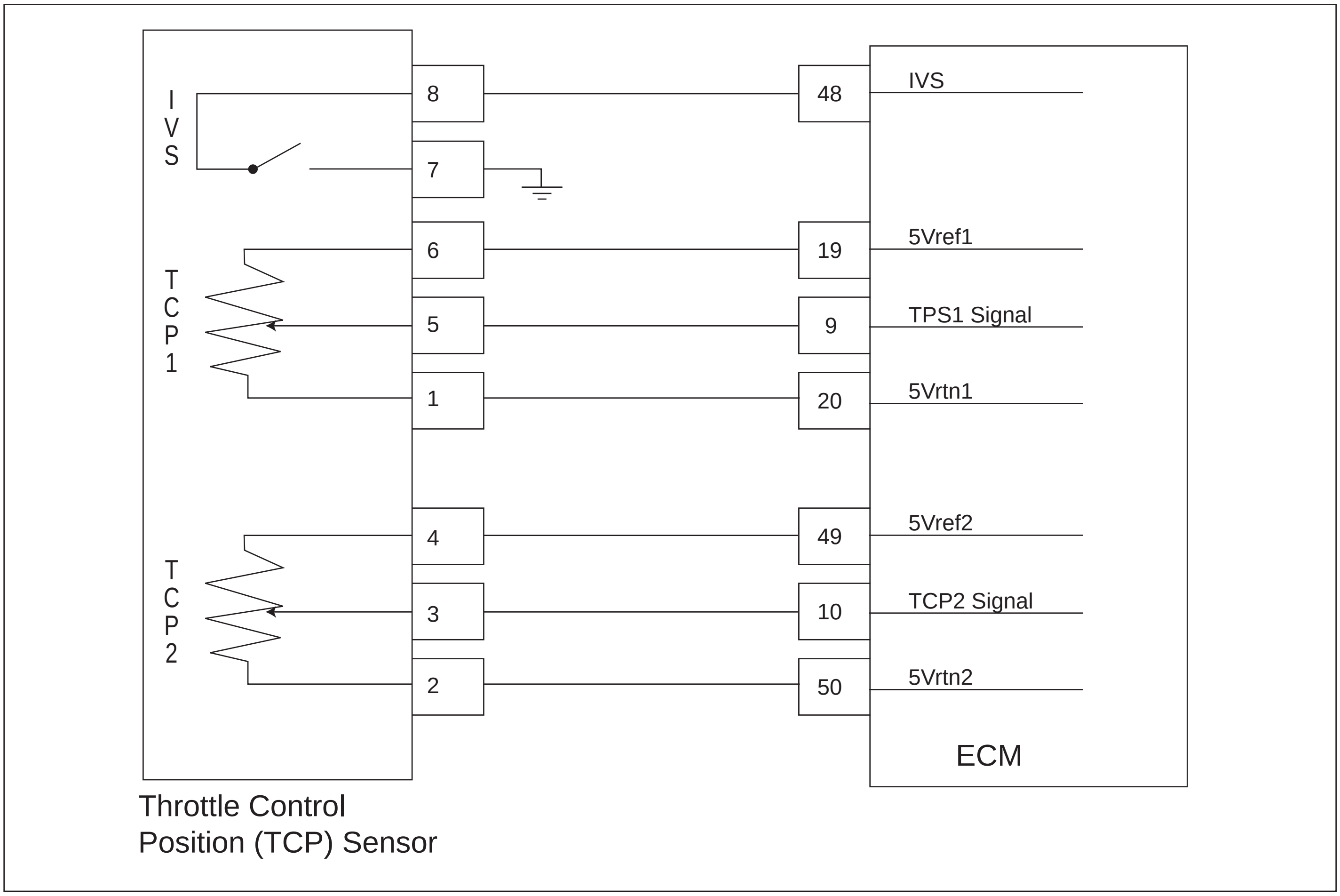
The engine load command to the ECM is determined by operator depression of the electronic foot pedal. The ECM monitors the foot pedal position and controls the throttle to maintain the commanded power level. Because a problem with the foot pedal signal can result in a higher or lower power than intended 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



DTC 2116 - TCP Sensor 2 Higher Than IVS Limit
SPN - 29; FMI - 0

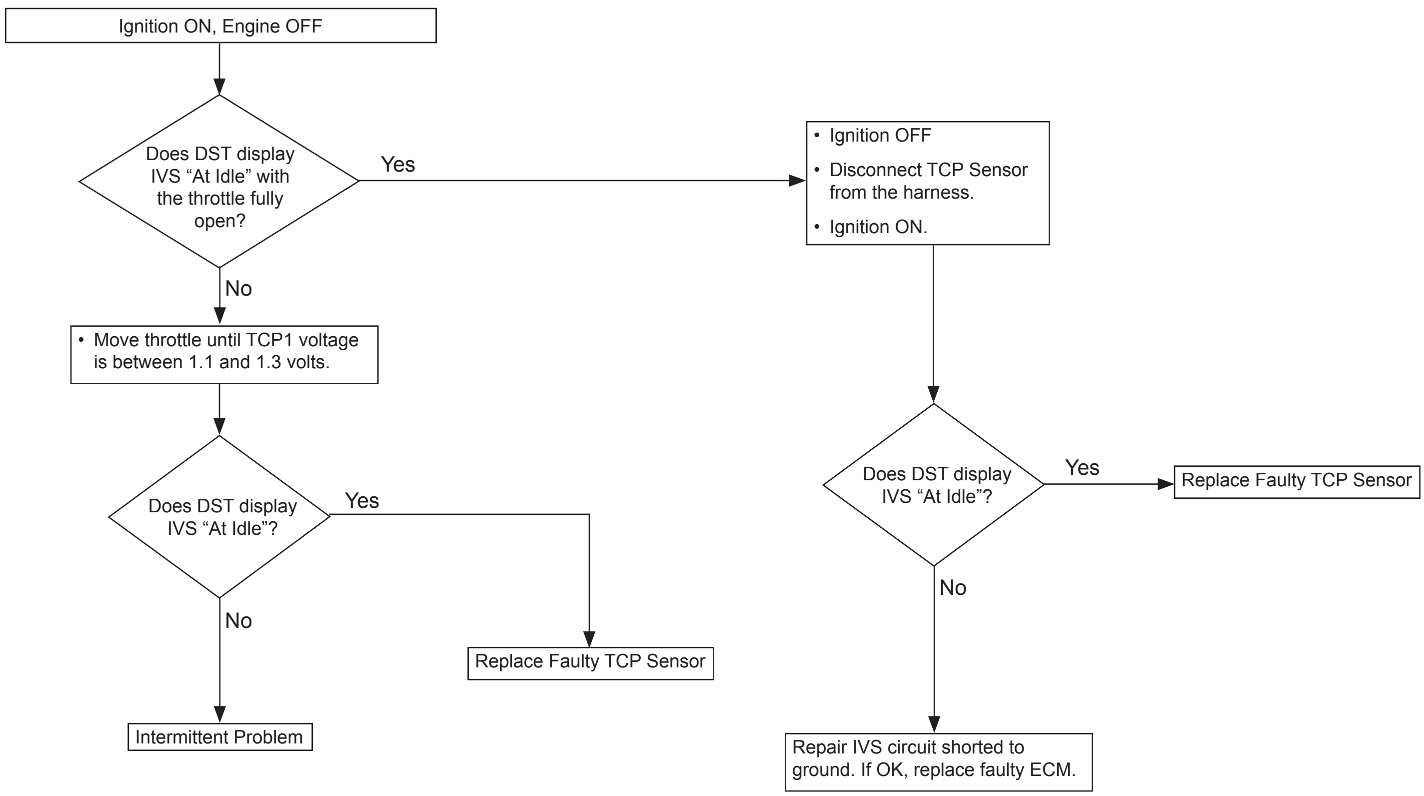


- Throttle Control Position/Idle Validation Switch (IVS)
- *Check Condition* - Engine Cranking or Running
- *Fault Condition* - IVS at idle and TCP voltage greater than 1.2 volts
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycle

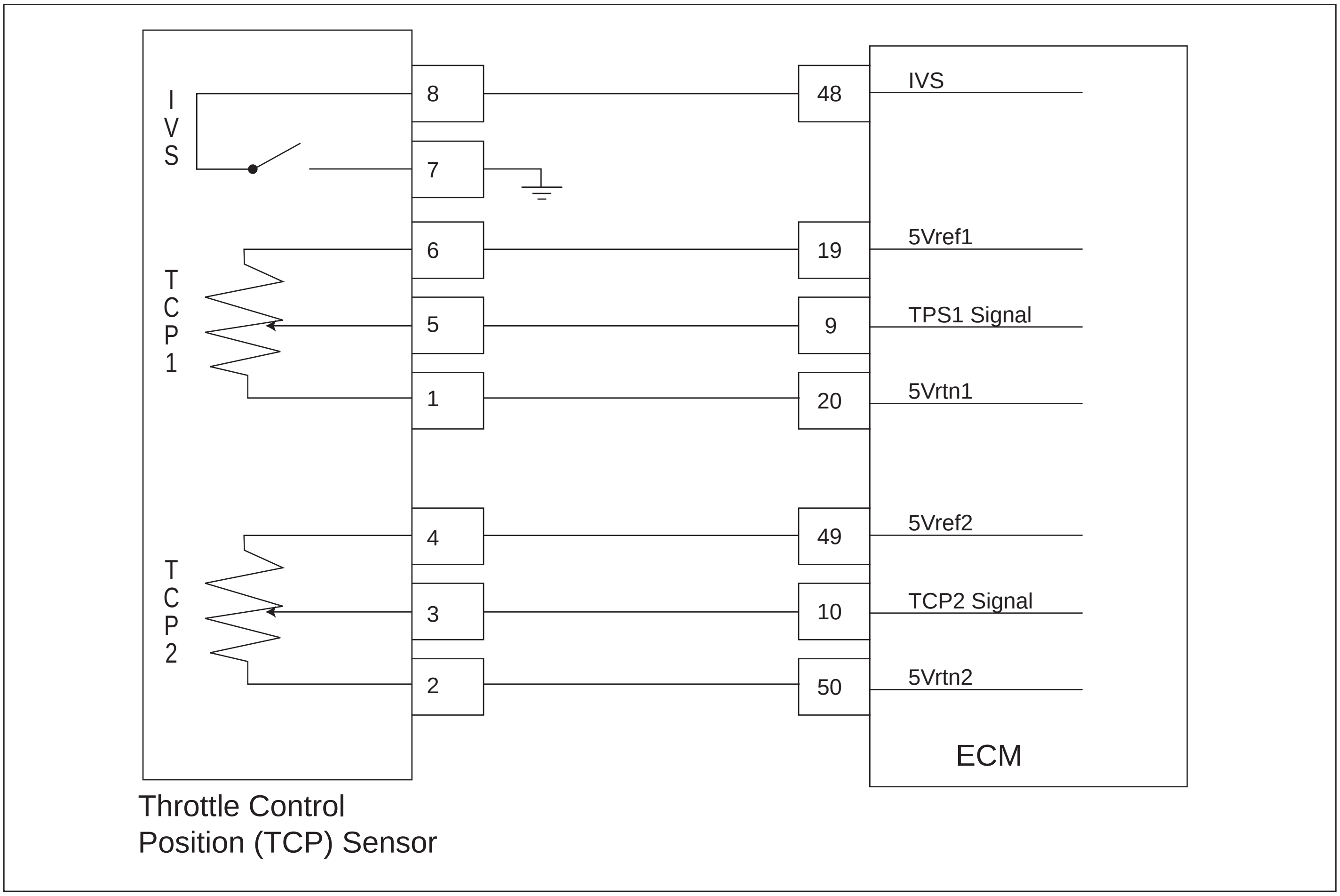
The engine load command to the ECM is determined by operator depression of the electronic foot pedal. The ECM monitors the foot pedal position and controls the throttle to maintain the commanded power level. Because a problem with the foot pedal signal can result in a higher or lower power than intended 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



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.

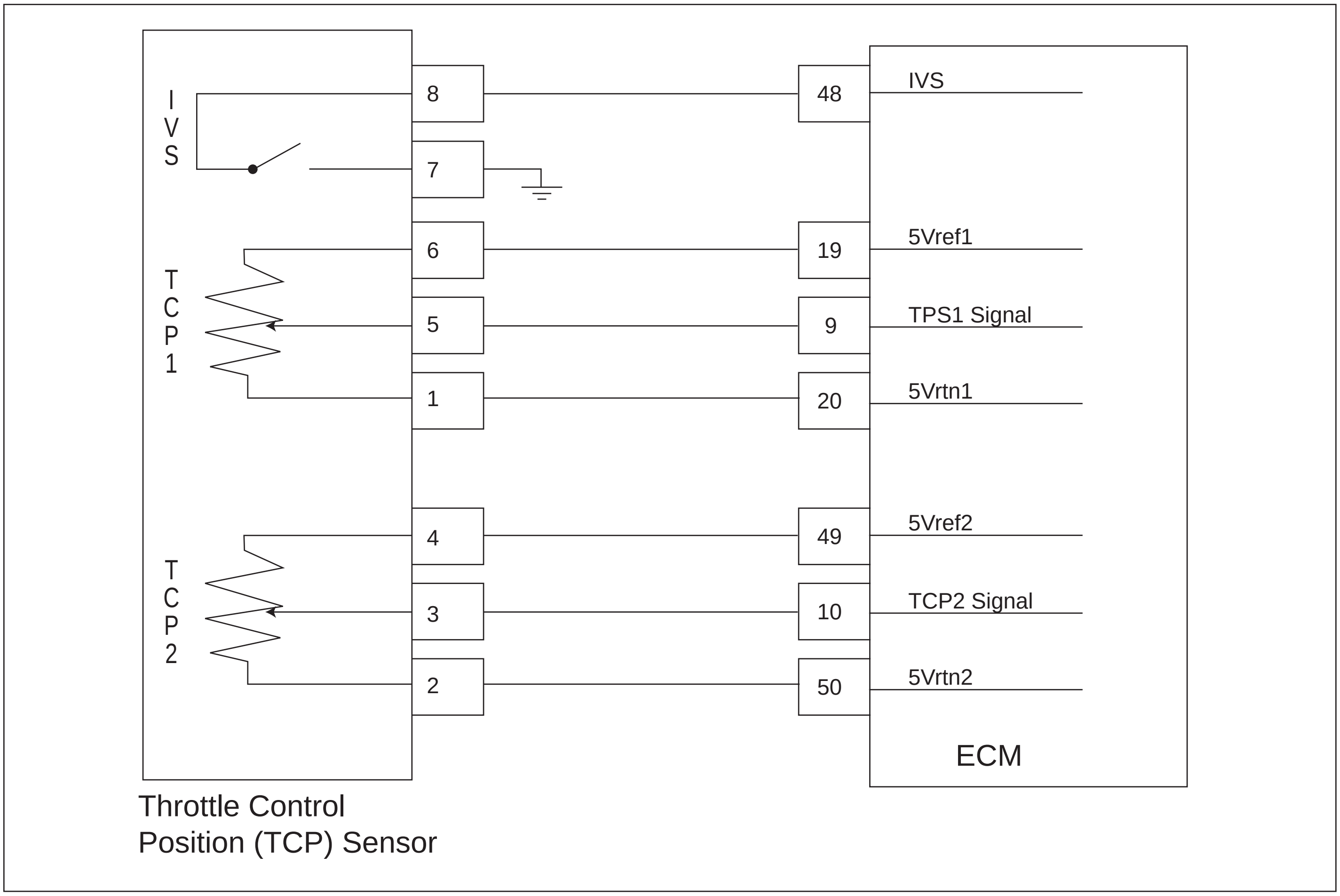
This fault is only applicable with dual potentiometer/single IVS sensors and indicates that TCP1 voltage is out-of-range and TCP2% does not correlate with the IVS state resulting in a loss of redundancy.

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.

DTC 2121 - TCP Sensor 1 Lower Than TCP Sensor 2
SPN - 91; FMI - 18

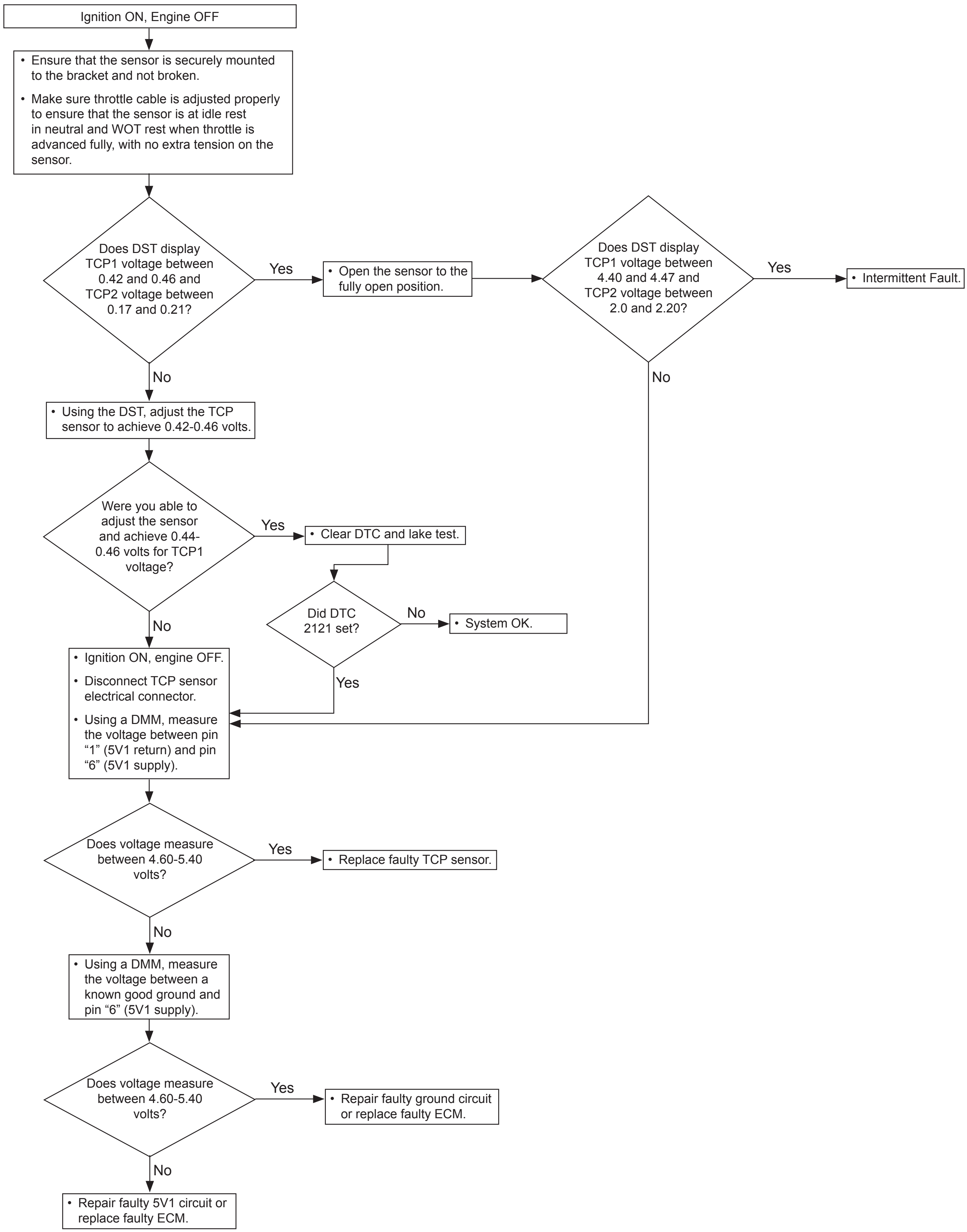


- Electronic foot pedal/throttle control sensor
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - TCP1% lower than TCP2%
- Corrective Action(s) - Illuminate MIL, sound audible warning and power derate, low rev limit, or forced idle
- Non-emissions related fault

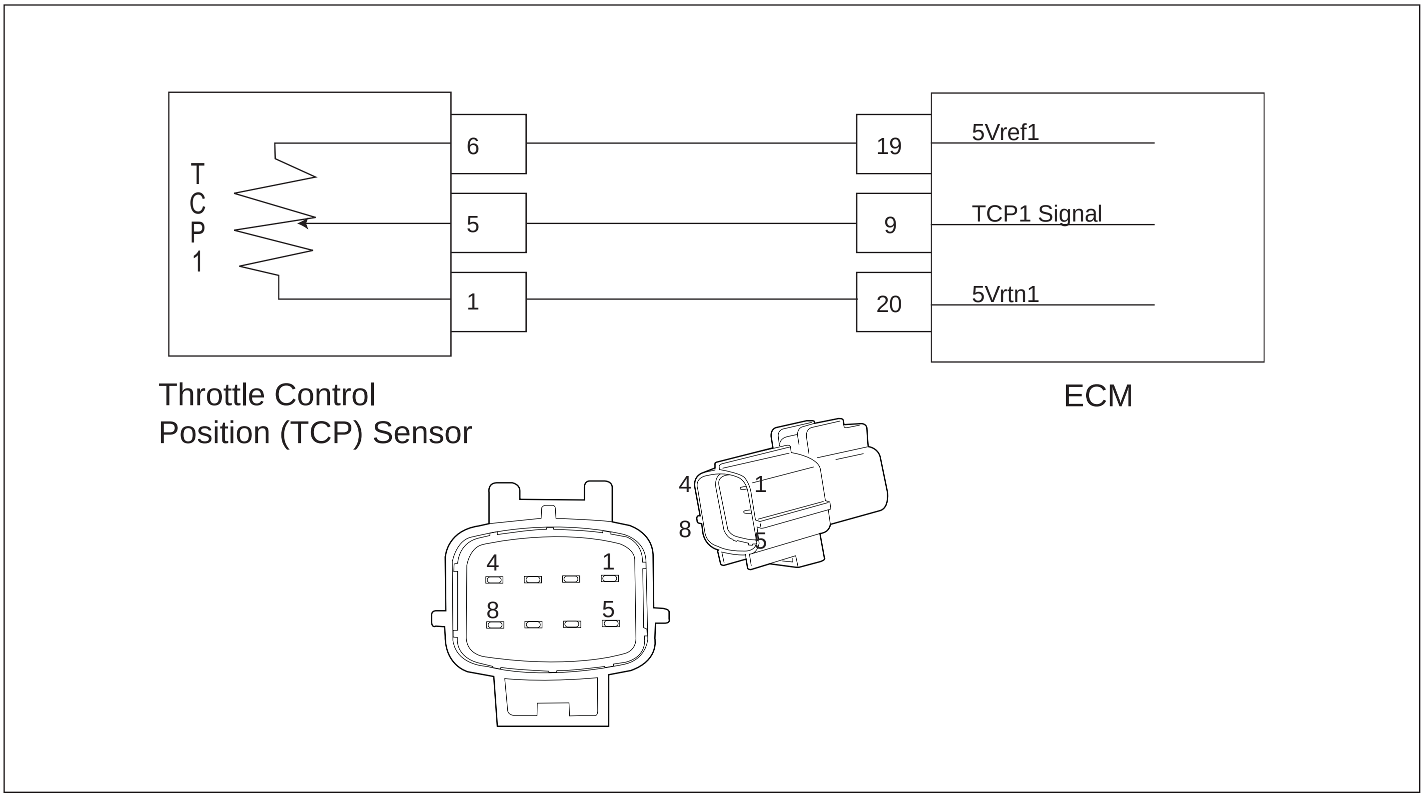
The TCP sensor is an electronic device that is coupled to a mechanically driven input as commanded by the engine operator. A TCP sensor may be, but is not limited to a foot pedal assembly, a cable-lever-sensor assembly, or a rotary potentiometer. General sensor configurations consist of two potentiometers 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



DTC 2122 - TCP Sensor 1 High Voltage
SPN - 91; FMI - 3

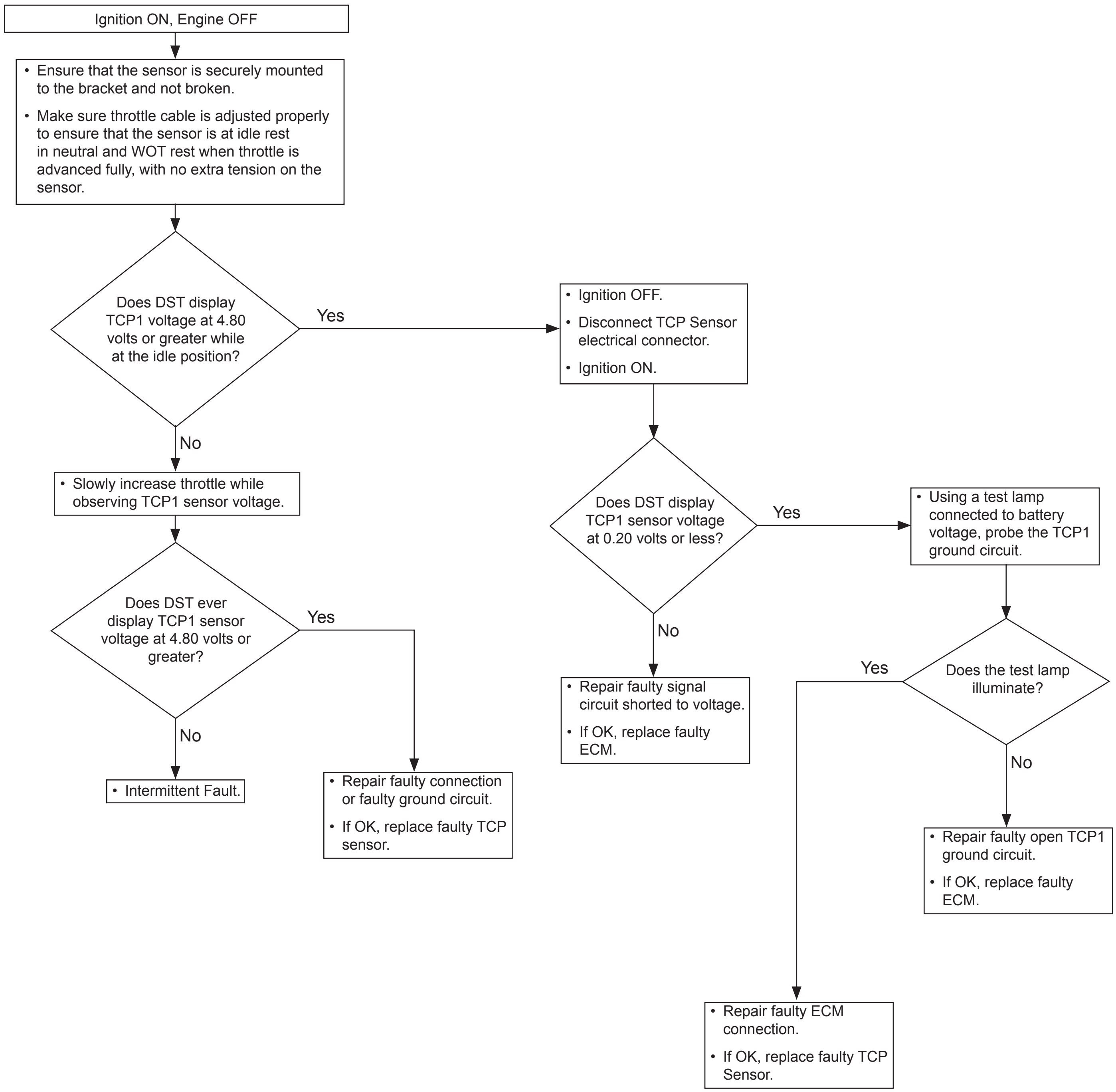


- Throttle Control Position (TCP) Sensor
- *Check Condition* - Ignition ON
- *Fault Condition* - TCP1 sensor voltage exceeds 4.8
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycled

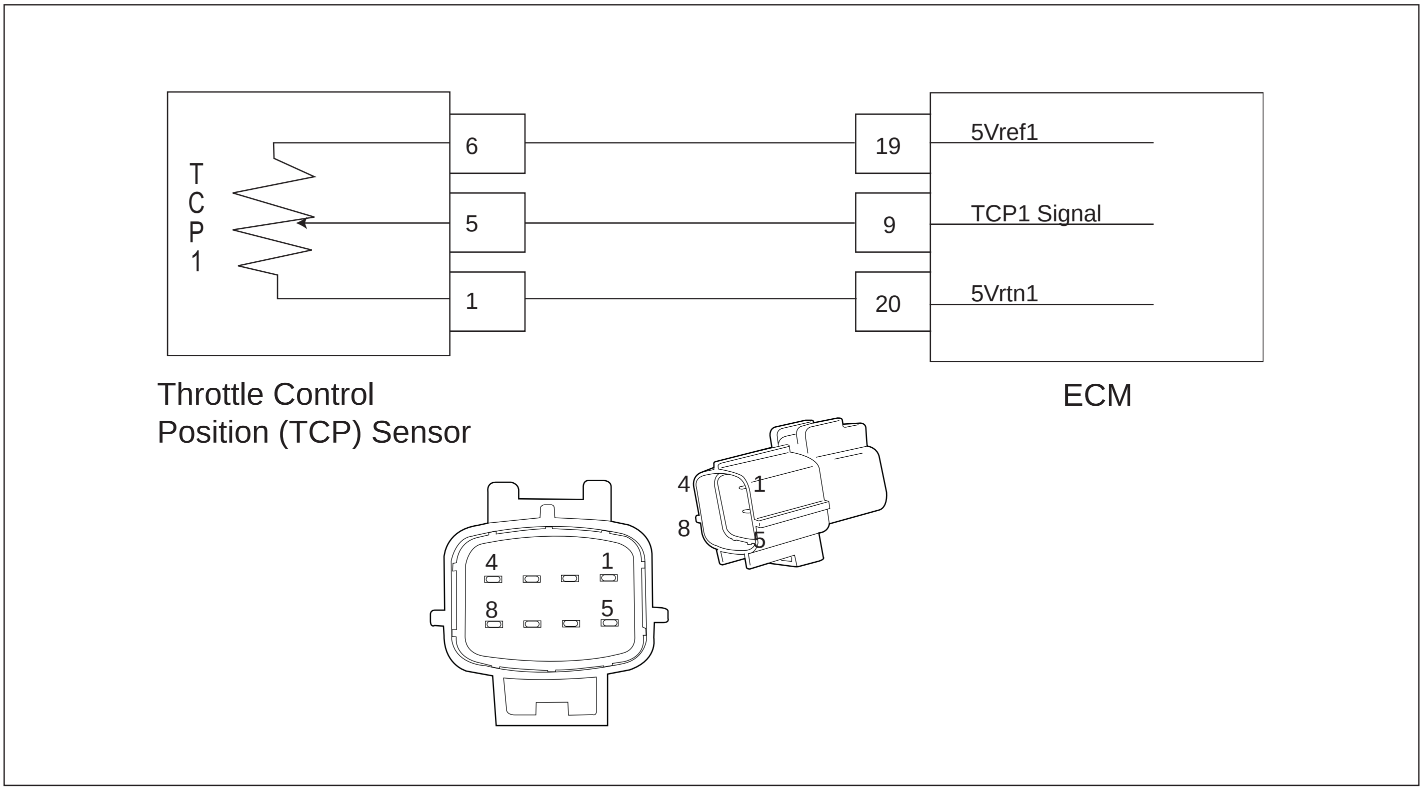
The Throttle Control Position (TCP) sensor uses a variable resistor to determine signal voltage based on throttle lever position. Less movement of the throttle lever results in lower voltage, and greater movement results in higher voltage.

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



DTC 2123 - TCP Sensor 1 Low Voltage
SPN - 91; FMI - 4

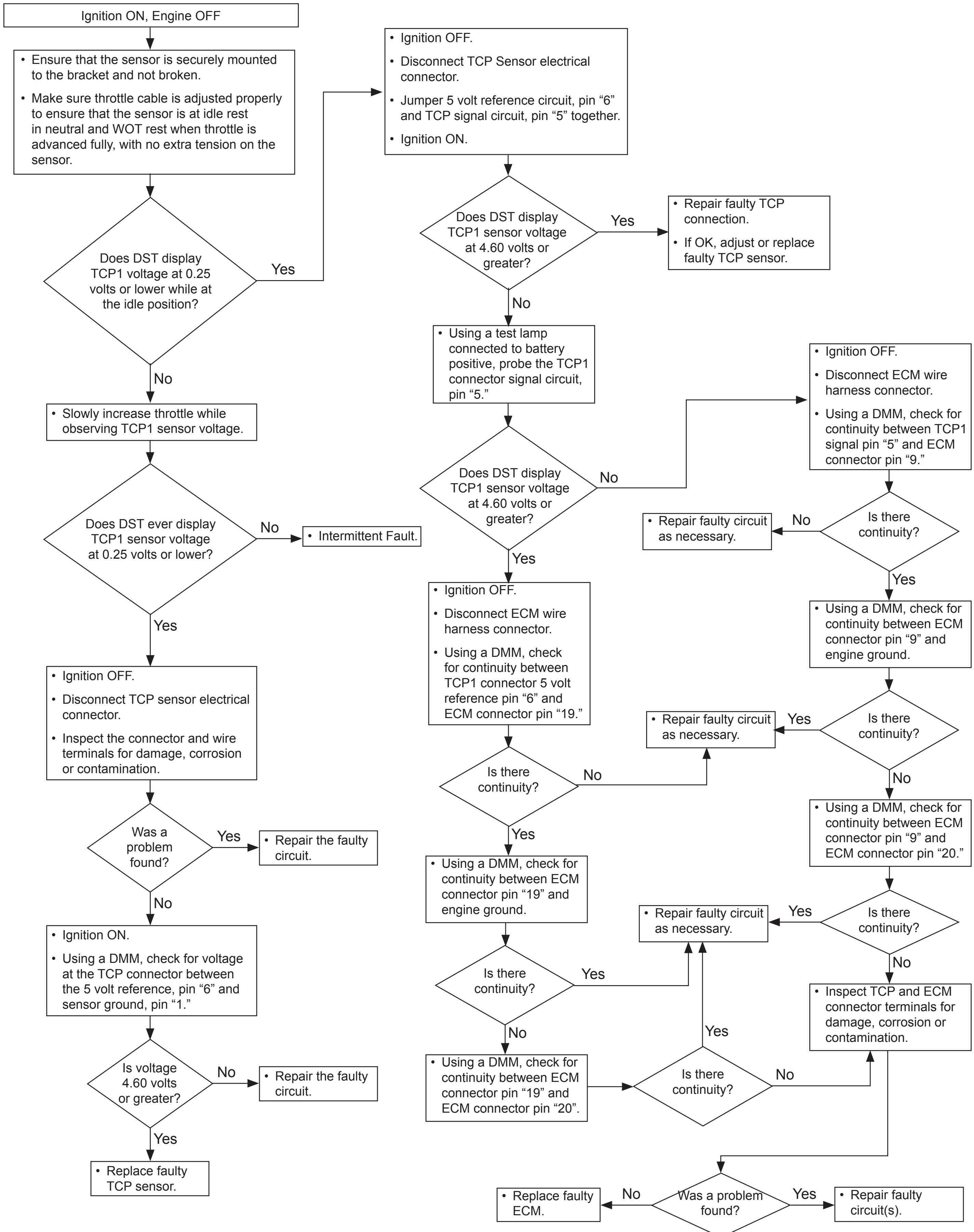


- Throttle Control Position (TCP) Sensor
- *Check Condition* - Ignition ON
- *Fault Condition* - TCP1 sensor voltage lower than 0.2 volts
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycled

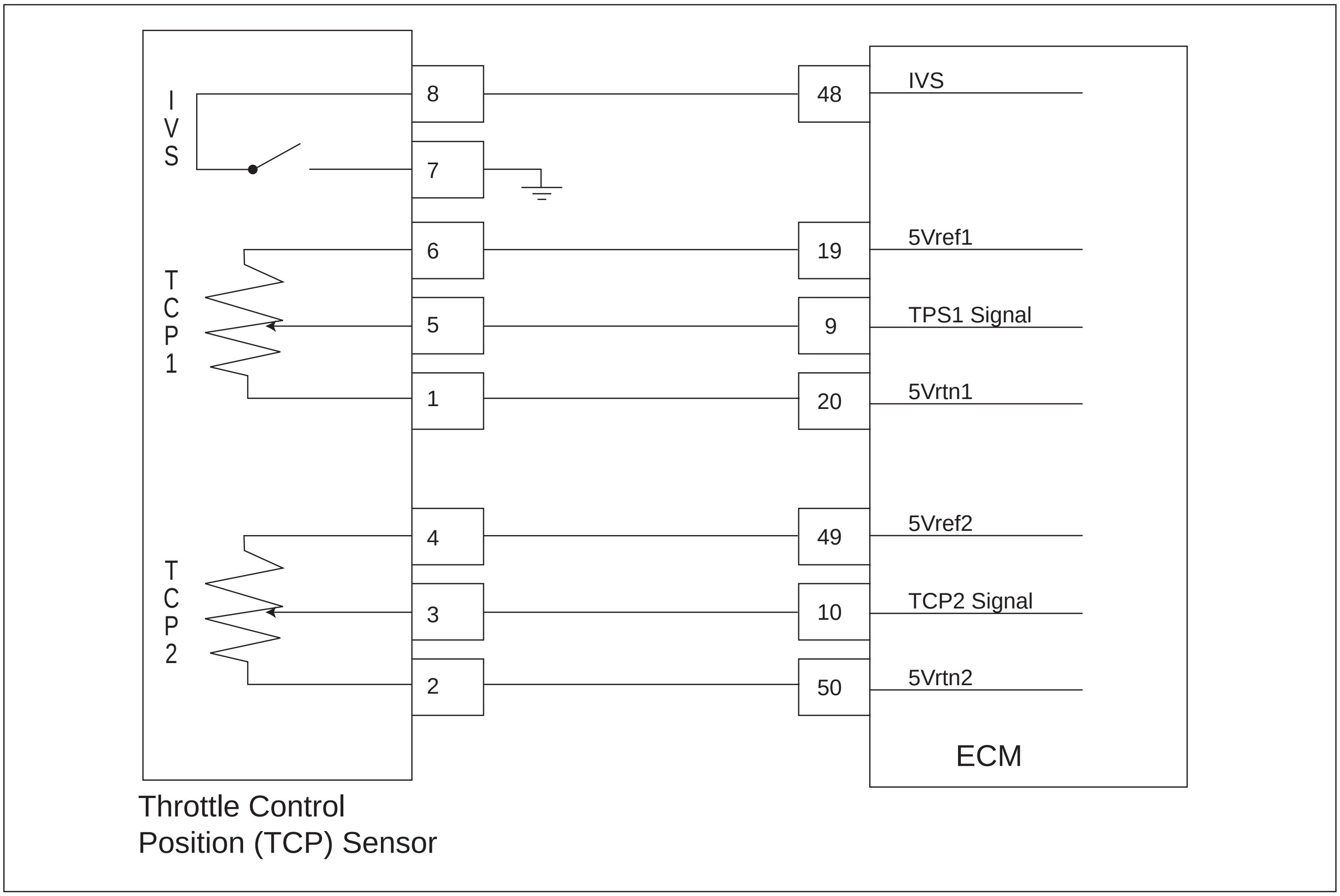
The Throttle Control Position (TCP) sensor uses a variable resistor to determine signal voltage based on throttle lever position. Less movement of the throttle lever results in lower voltage, and greater movement results in higher voltage.

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



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.

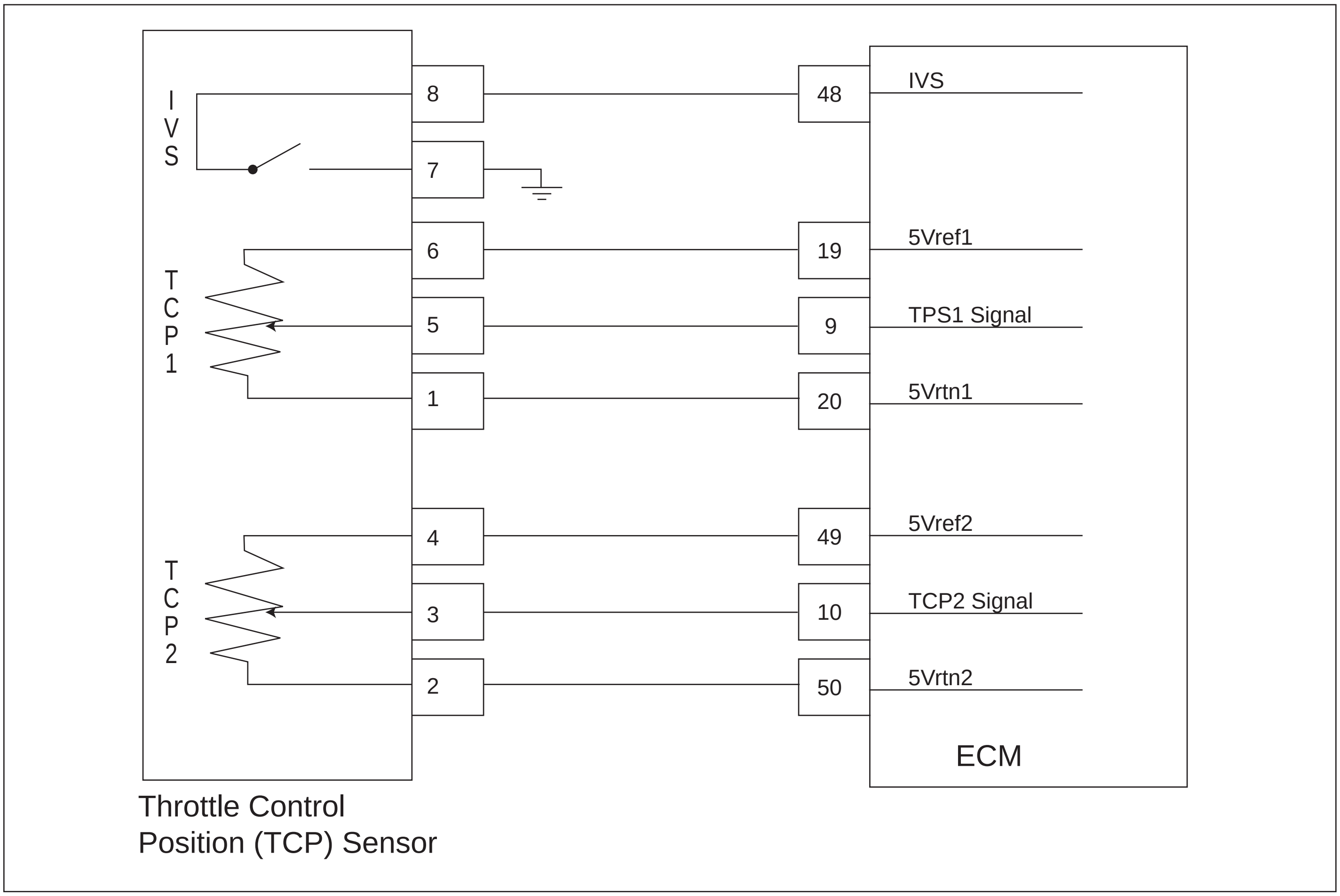
This fault is only applicable with dual potentiometer/single IVS sensors and indicates that TCP2 voltage is out-of-range and TCP1% does not correlate with the IVS state resulting in a loss of redundancy.

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.

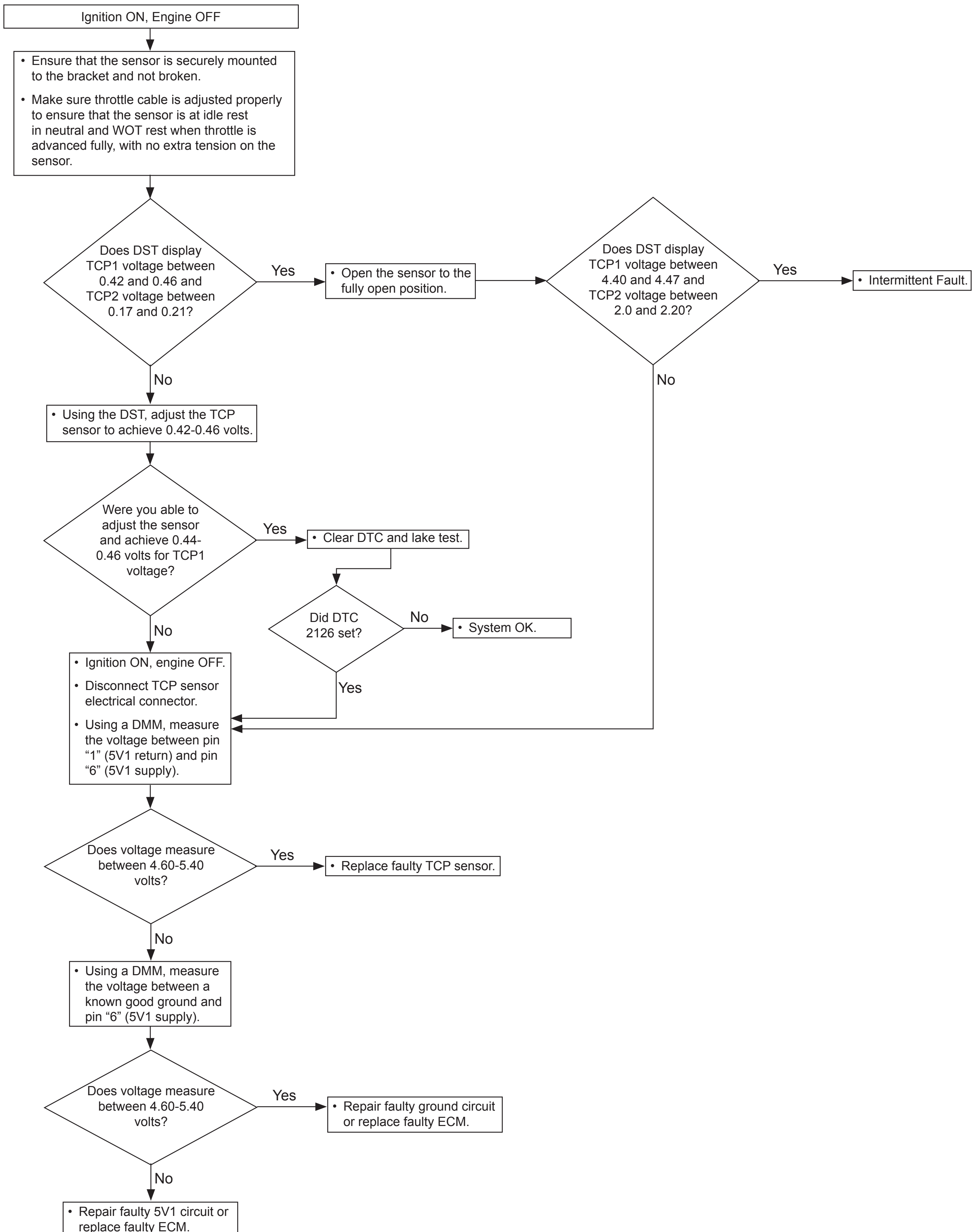
DTC 2126 - TCP Sensor 1 Higher Than TCP Sensor 2
SPN - 91; FMI - 16



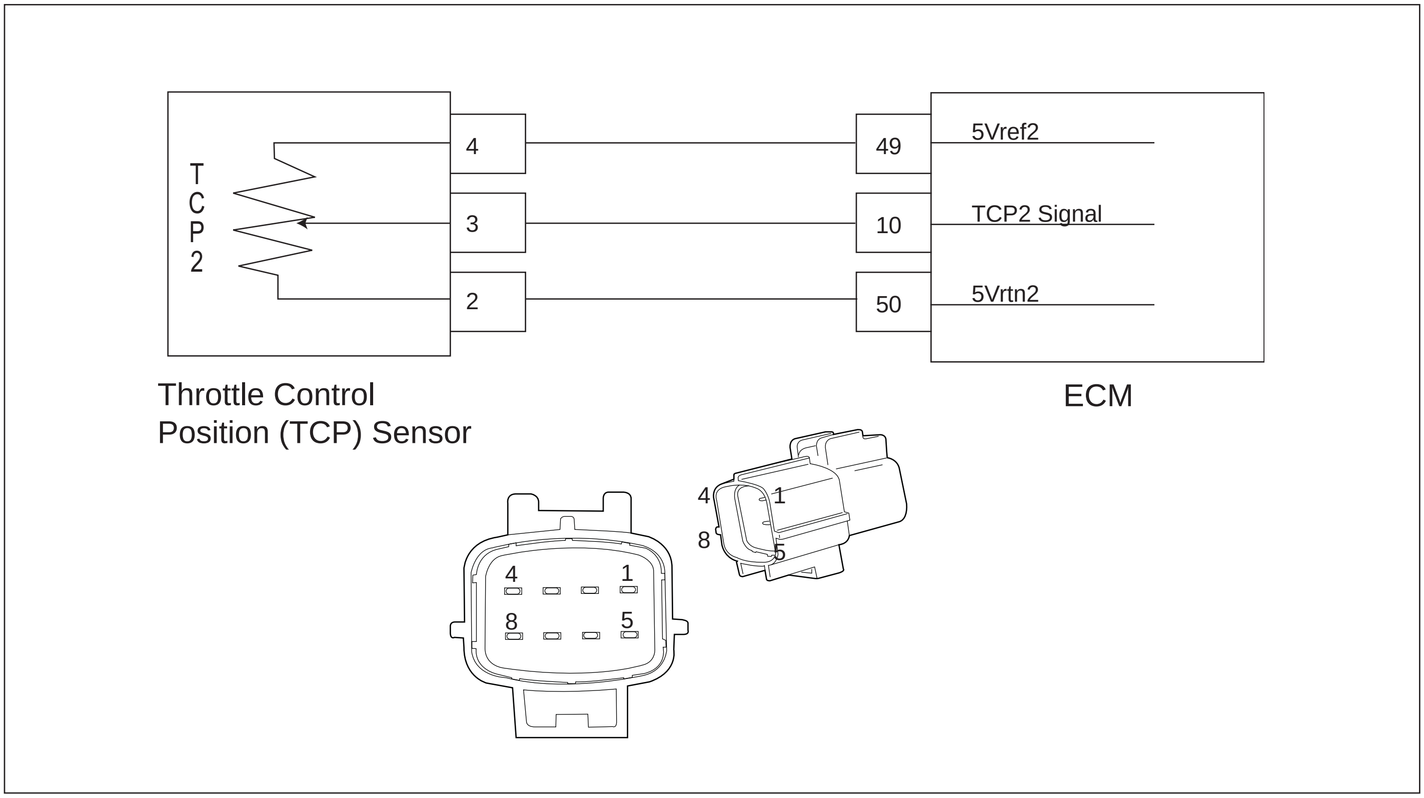
- Electronic foot pedal/throttle control sensor
- *Check Condition* - Key On, Engine Off
- *Fault Condition* - TCP1% higher than TCP2%
- Corrective Action(s) - Illuminate MIL, sound audible warning and power derate, low rev limit, or forced idle
- Non-emissions related fault

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



DTC 2127 - TCP Sensor 2 Low Voltage
SPN - 29; FMI - 4

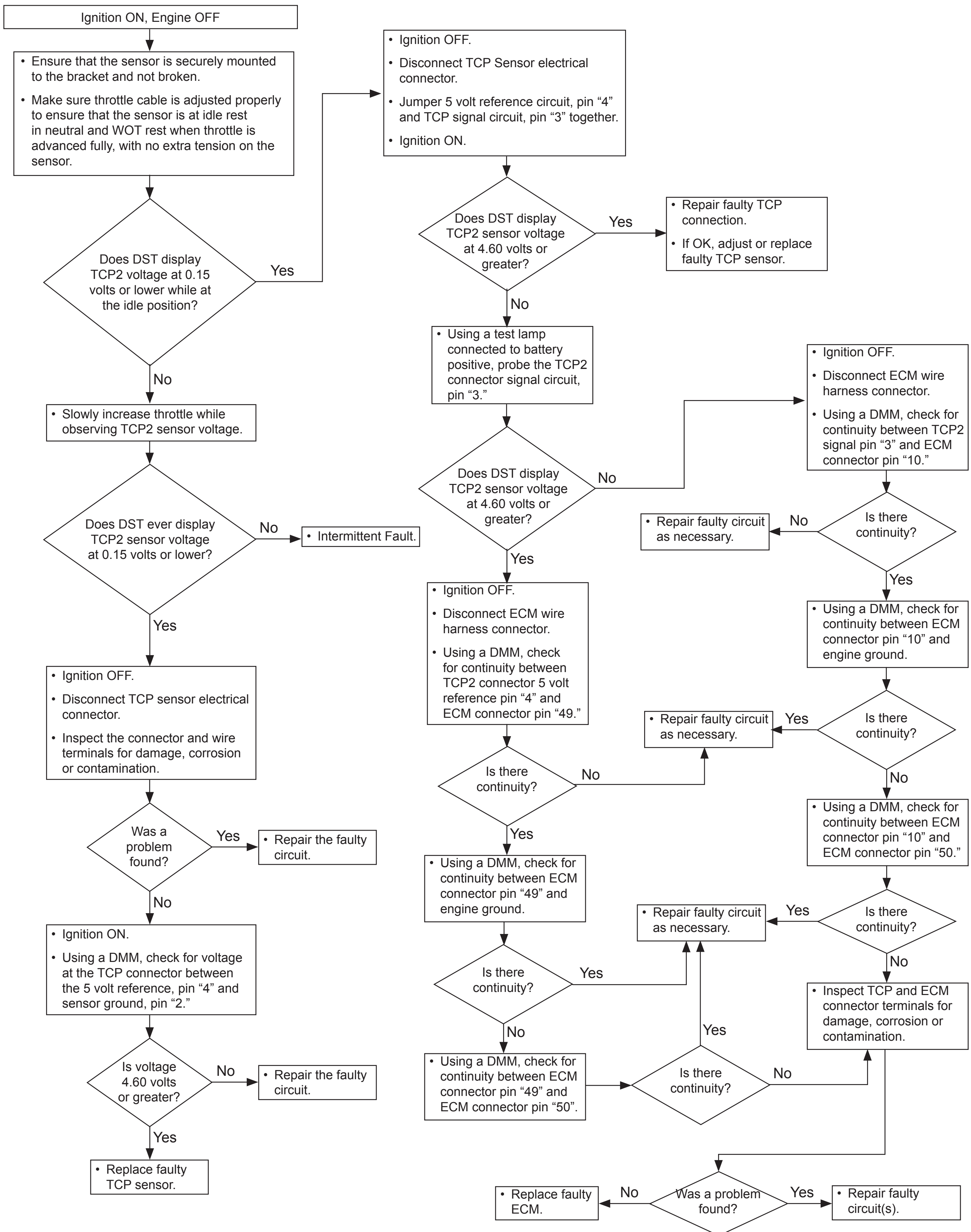


- Throttle Control Position (TCP) Sensor
- *Check Condition* - Ignition ON
- *Fault Condition* - TCP2 sensor voltage lower than 0.15 volts
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycled

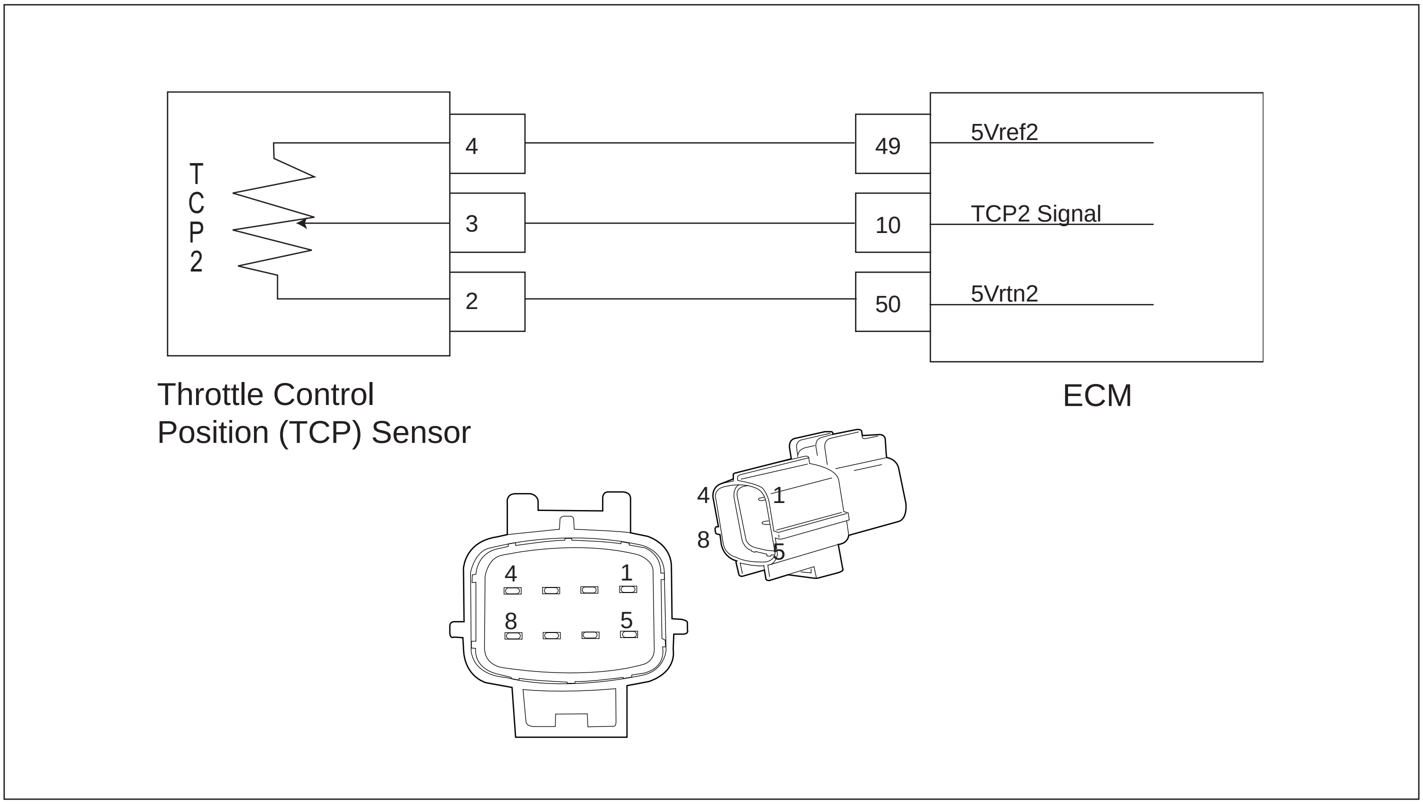
The Throttle Control Position (TCP) sensor uses a variable resistor to determine signal voltage based on throttle lever position. Less movement of the throttle lever results in lower voltage, and greater movement results in higher voltage.

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



DTC 2128 - TCP Sensor 2 High Voltage
SPN - 29; FMI - 3

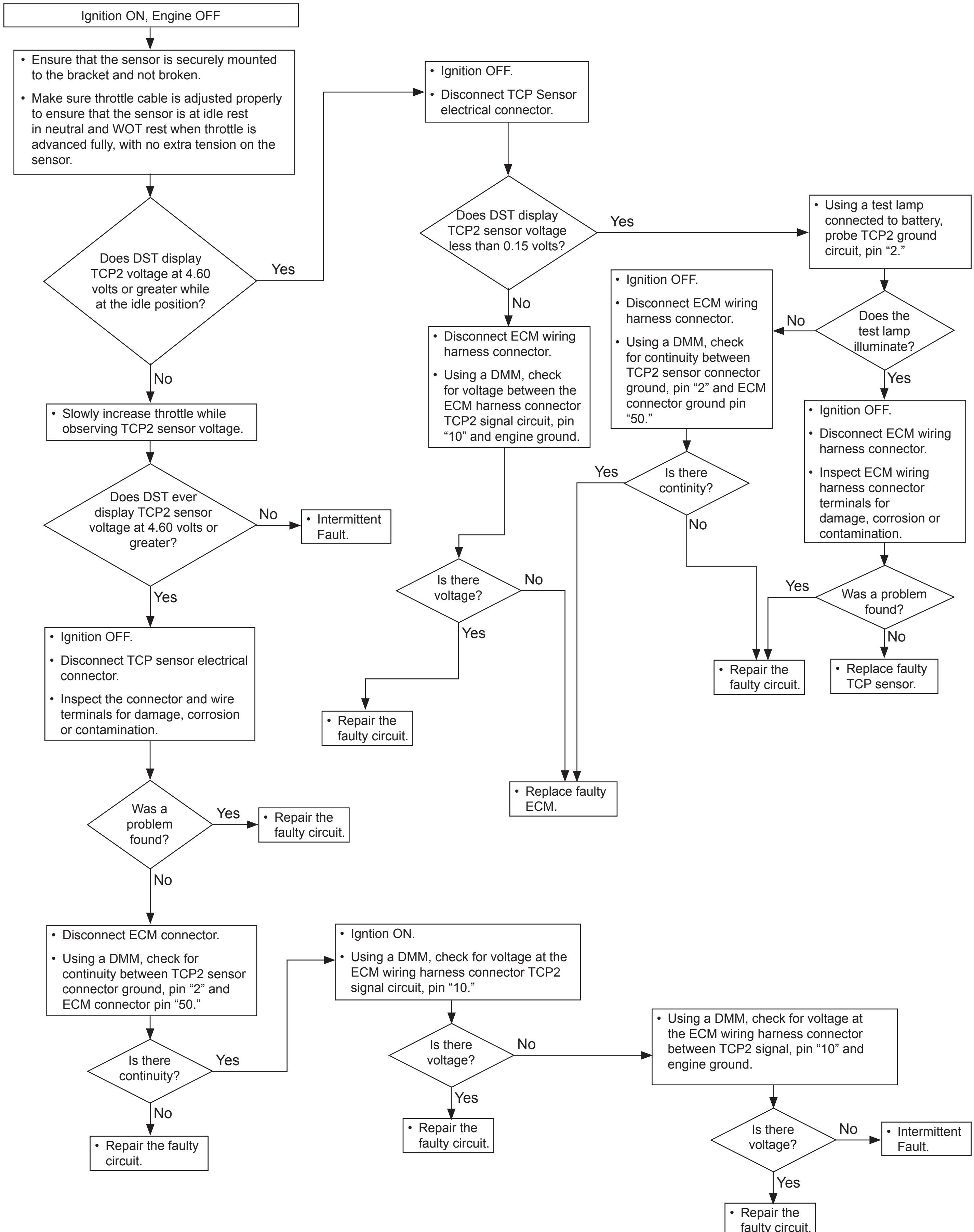


- Throttle Control Position (TCP) Sensor
- *Check Condition* - Ignition ON
- *Fault Condition* - TCP2 sensor voltage lower than 0.15 volts
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycled

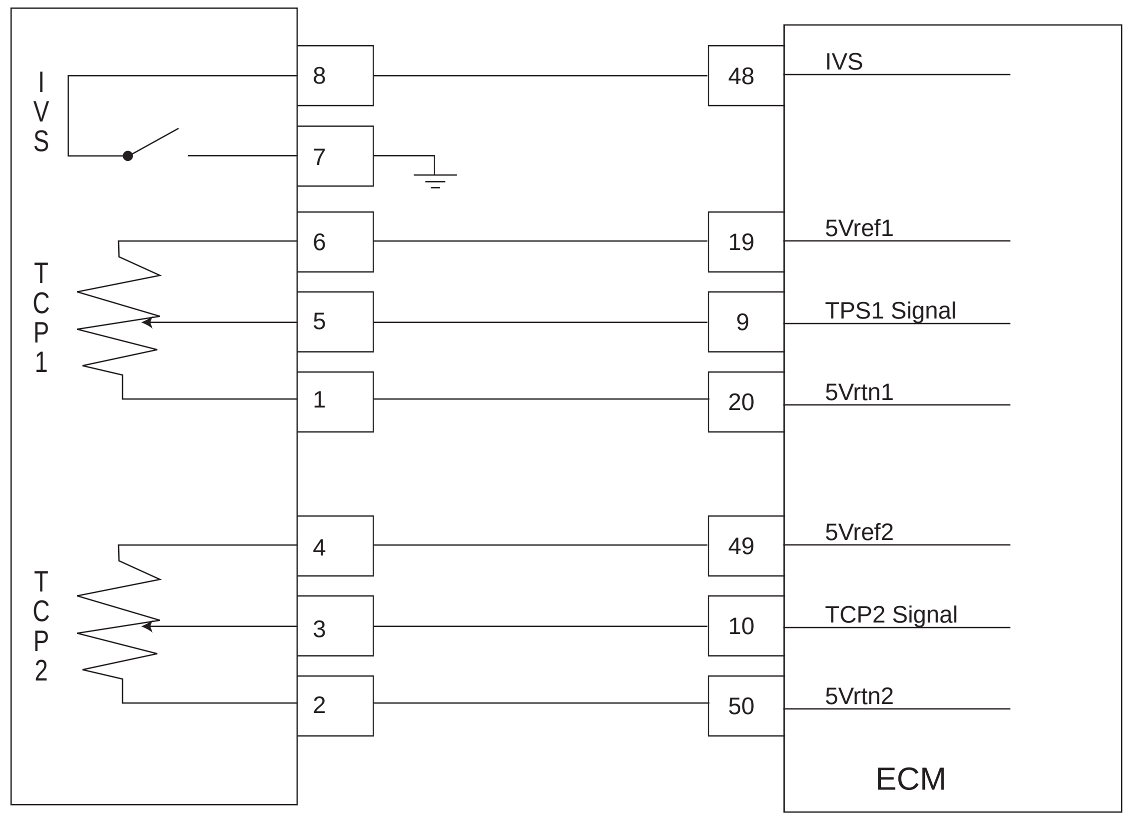
The Throttle Control Position (TCP) sensor uses a variable resistor to determine signal voltage based on throttle lever position. Less movement of the throttle lever results in lower voltage, and greater movement results in higher voltage.

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



DTC 2130 - IVS Stuck At Idle, TCP Sensors 1/2 Match
SPN - 558; FMI - 5



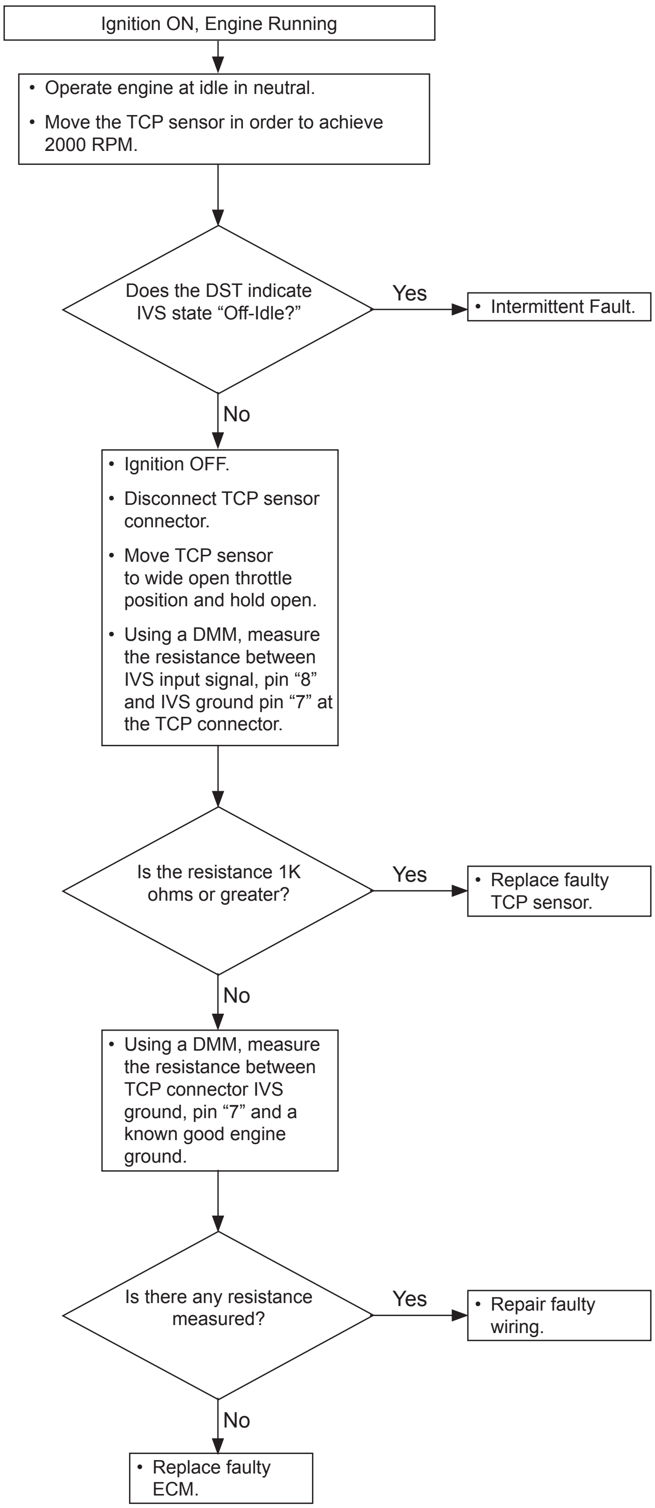
Throttle Control Position (TCP) Sensor

- 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

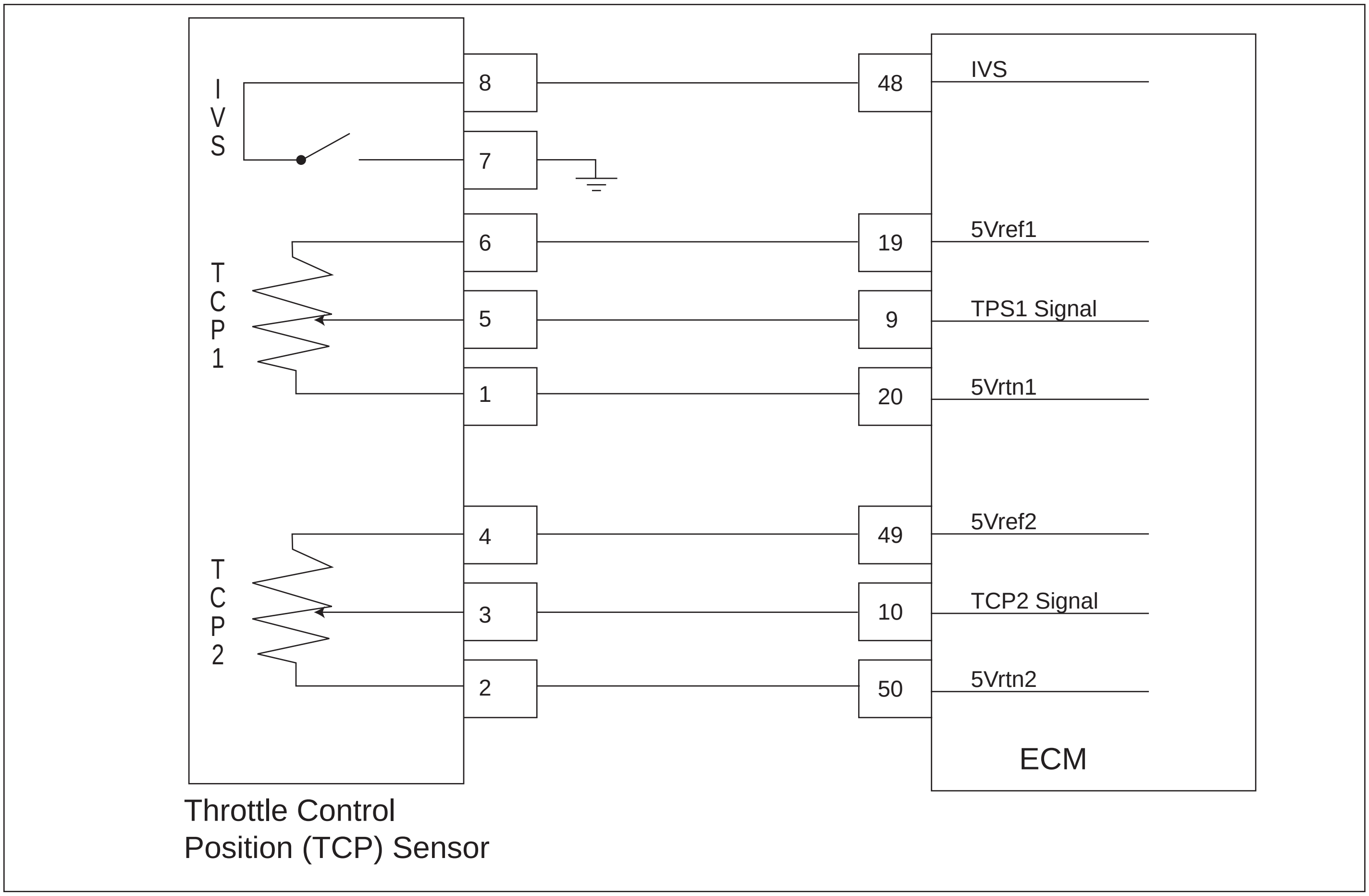
The Throttle Control Position (TCP) sensor consists of two potentiometers and an Idle Validation Switch (IVS). The TCP sensor outputs are proportional to the commanded input. The ECM uses the TCP sensor inputs to control the throttle and adjust the engine's load in order to achieve the requested power. 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



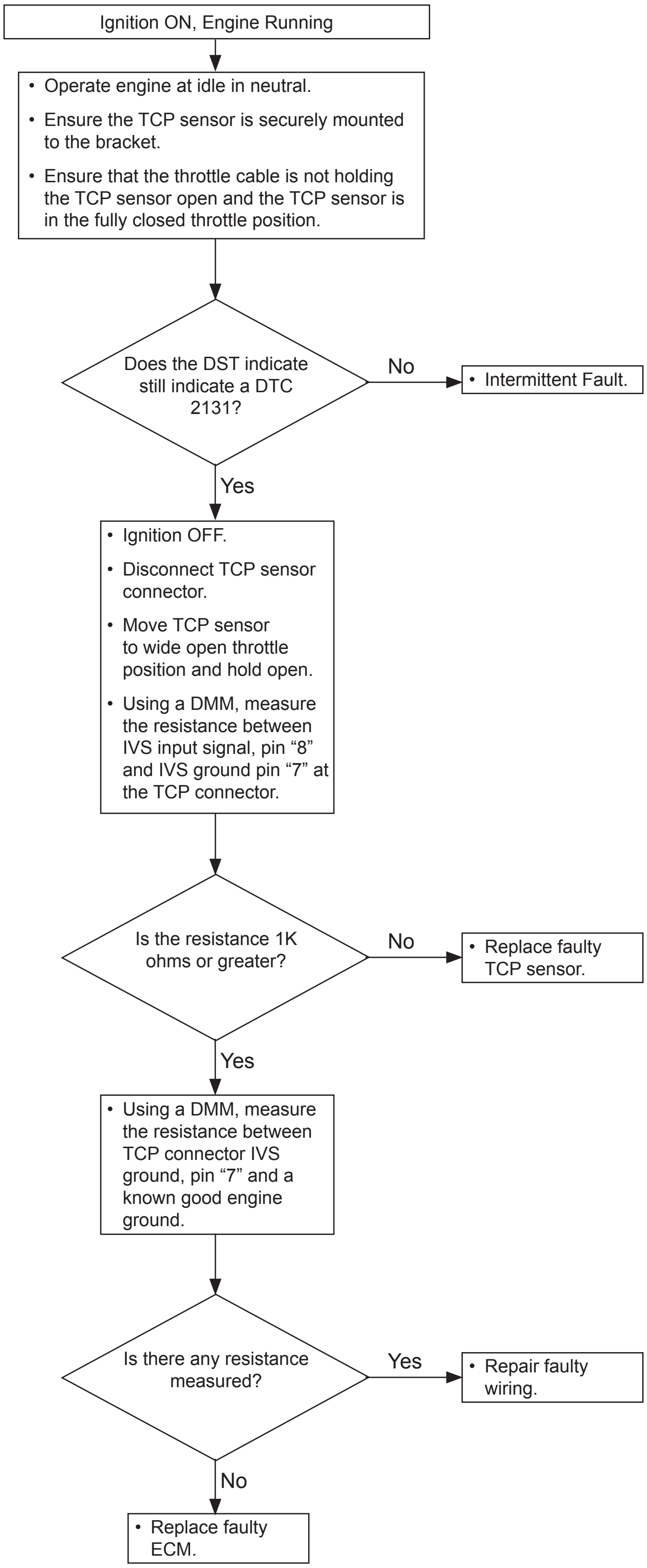
DTC 2131 - IVS Stuck Off Idle, TCP Sensors 1/2 Match
SPN - 558; FMI - 6



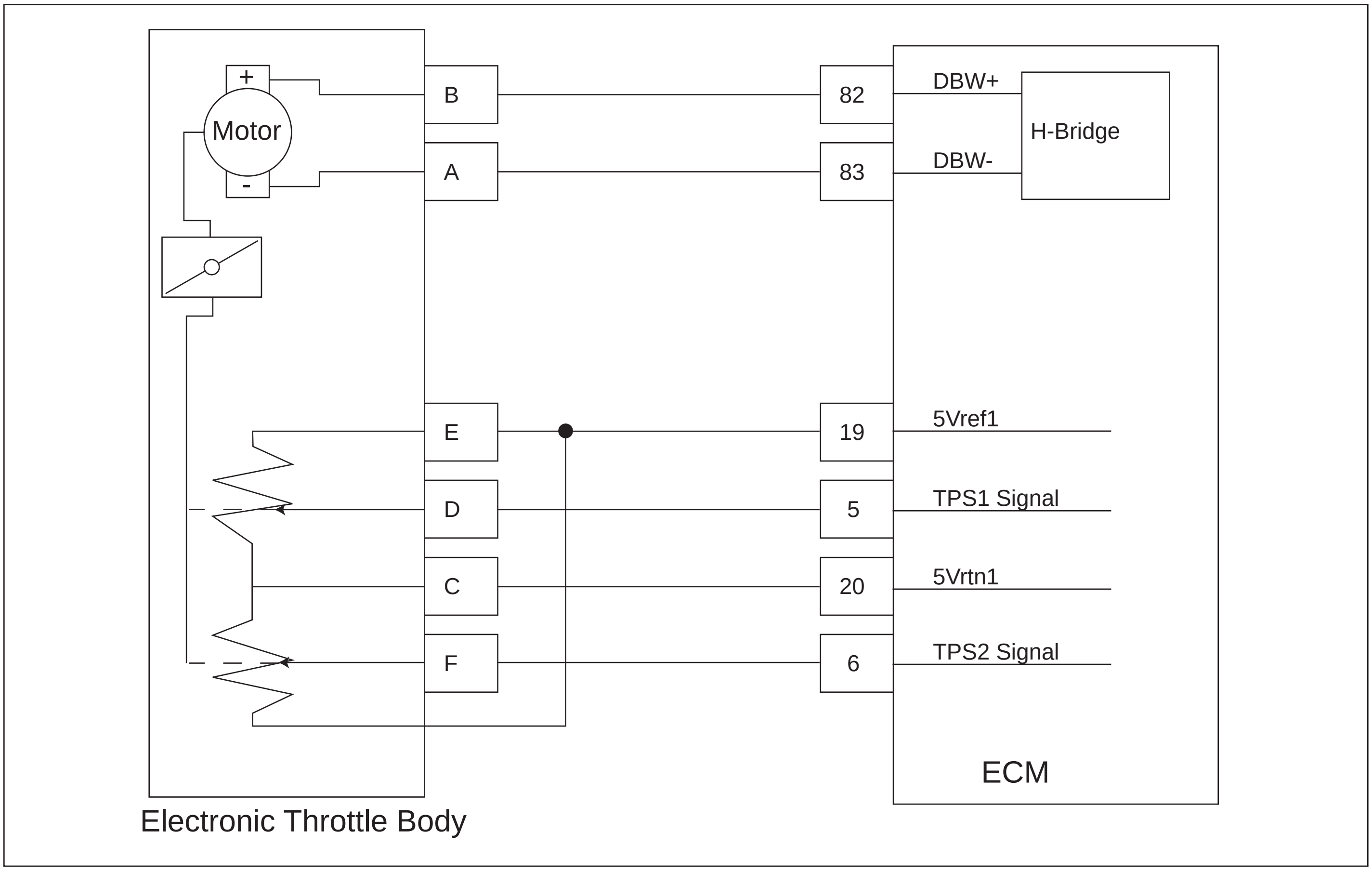
- Throttle Control Position (TCP) Sensor
- *Check Condition* - Ignition ON, engine running
- *Fault Condition* - TCP1 % is approximately TCP2 % and both are less than TCP idle validation % and IVS = off-idle
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the 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



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

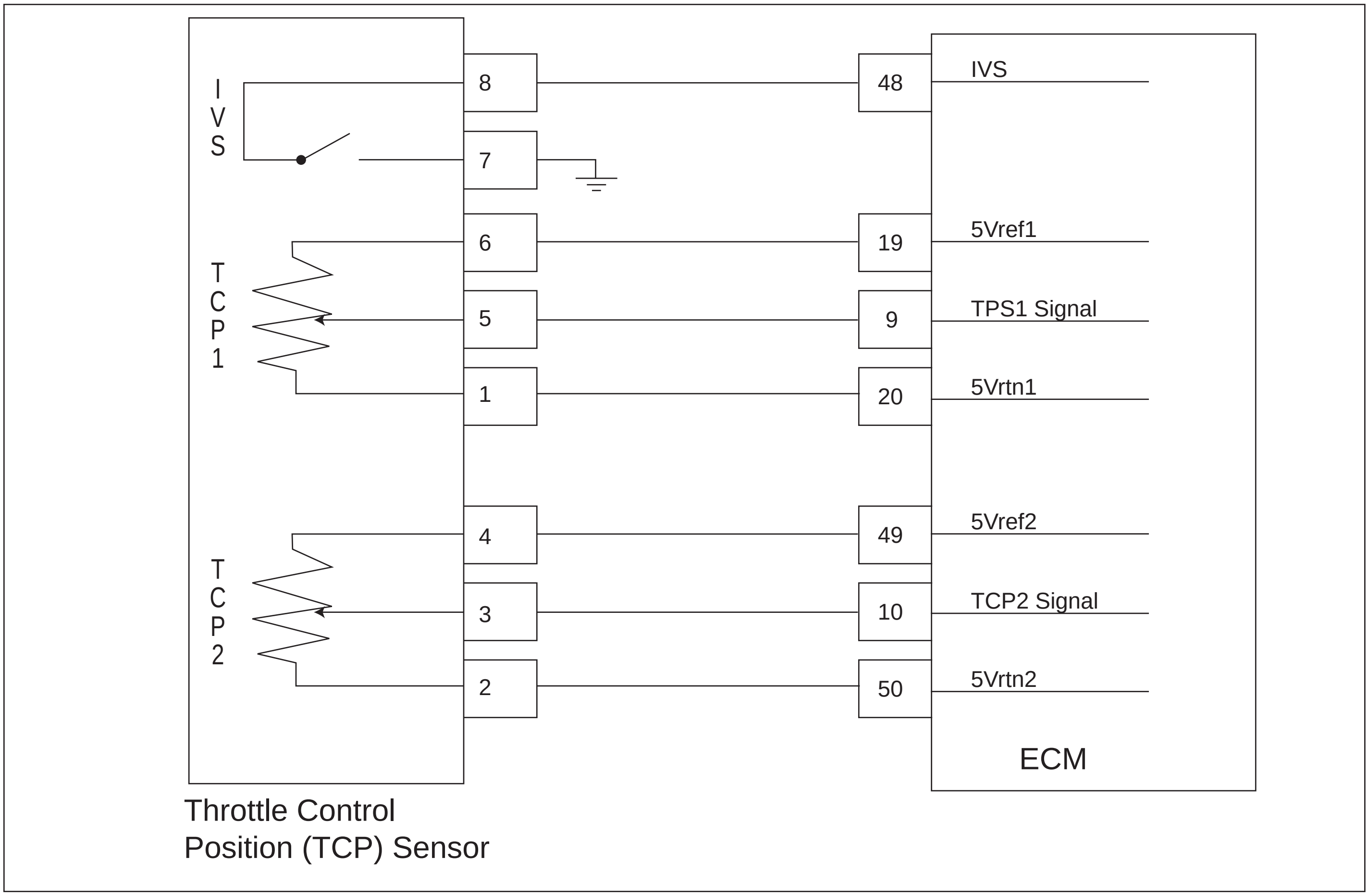
There are two throttle position sensors located within the throttle body which use variable resistors to determine the signal voltage based on throttle plate position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from 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 redundency 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.

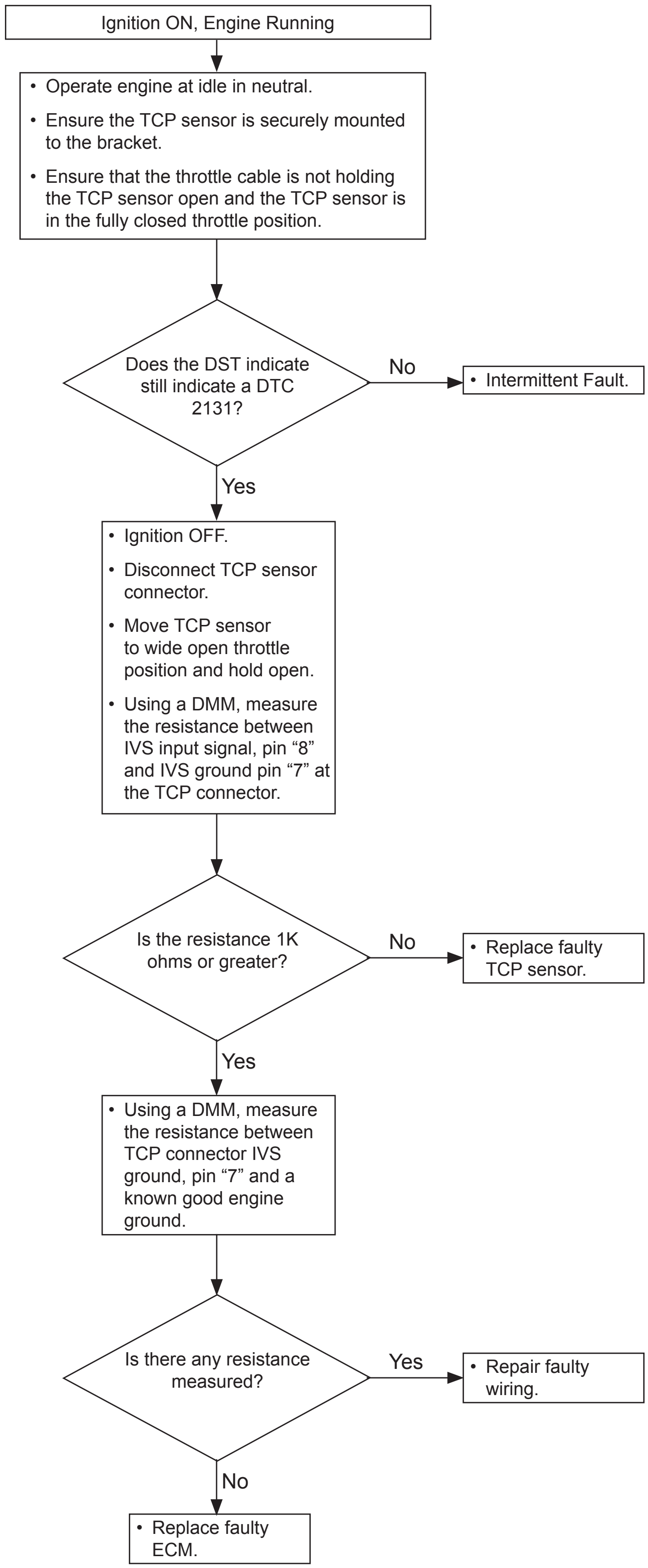
DTC 2139 - TCP Sensor 1 Lower Than IVS Limit
SPN - 91; FMI - 1



- Throttle Control Position (TCP) Sensor
- *Check Condition* - Ignition ON, engine running
- *Fault Condition* - IVS off-idle and TCP voltage less than 0.60 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 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 that 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 less than 0.60 volts.

DTC 2139 - TCP Sensor 1 Lower Than IVS Limit
SPN - 91; FMI - 1



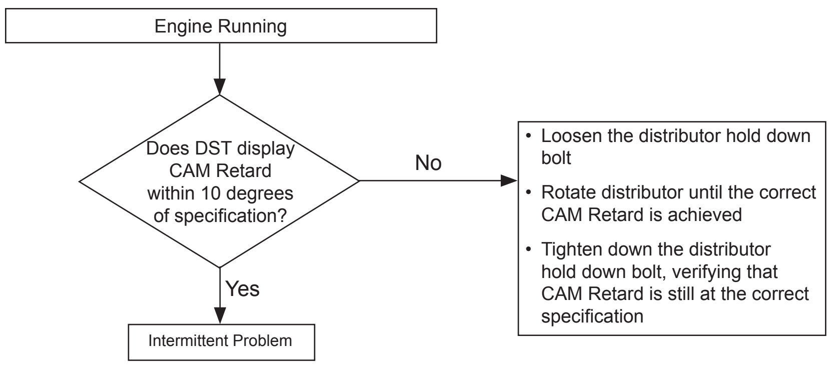
DTC 2140 - TCP Sensor 2 Lower Than IVS Limit
SPN - 29; FMI - 1

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

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 2140 - TCP Sensor 2 Lower Than IVS Limit
SPN - 29; FMI - 1



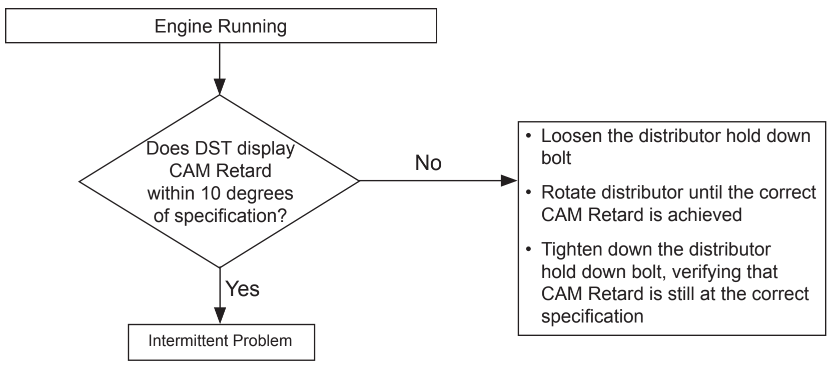
DTC 2229 - Barometric Pressure High
SPN - 108; FMI - 0

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

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 2229 - Barometric Pressure High
SPN - 108; FMI - 0



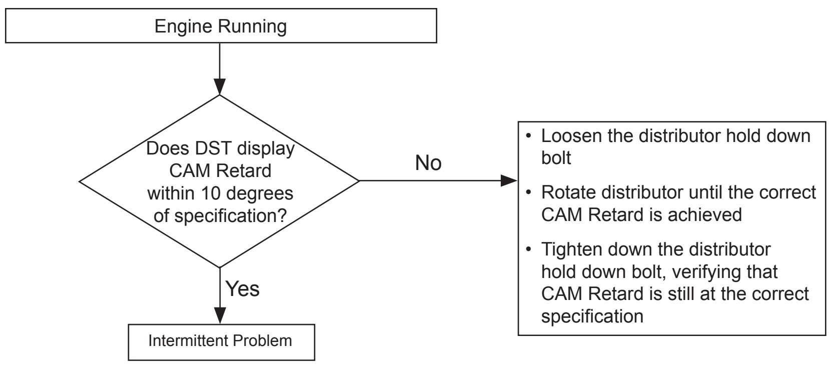
DTC 2618 - TACH Output Short to Ground
SPN - 645; FMI - 4

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

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 2618 - TACH Output Short to Ground
SPN - 645; FMI - 4



DTC 2619 - TACH Output Short to Power
SPN - 645; FMI - 3

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

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 2619 - TACH Output Short to Power
SPN - 645; FMI - 3