

# ***Indmar***

MARINE ENGINES

## **Service and Diagnostic Manual For Electronic Fuel Injection Systems With MEFI 5 and 5A Controllers**

**Version 3**

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## CAUTION

To reduce the chance of personal injury and/or property damage, the following instructions must be carefully observed.

Proper service and repair are important to the safety of the service technician and the safe, reliable operation of all Marine Electronic Fuel Injection (MEFI) equipped engines. If part replacement is necessary, the part must be replaced with one of the same part number or with an equivalent part. Do not use a replacement part of lesser quality.

The service procedures recommended and described in this service manual are effective methods of performing service and repair. Some of these procedures require the use of tools specifically designed for the purpose.

Accordingly, anyone who intends to use a replacement part, service procedure, or tool which is not recommended by the vehicle manufacturer, must first determine that neither his safety nor the safe operation of the vehicle will be jeopardized by the replacement part, service procedure or tool selected.

It is important to note that this manual contains various Cautions and Notices that must be carefully observed in order to reduce the risk of personal injury during service or repair, or the possibility that improper service or repair may damage the vehicle or render it unsafe. It is also important to understand that these 'Cautions' and 'Notices' are not exhaustive, because it is impossible to warn of all the possible hazardous consequences that might result from failure to follow these instructions.

# MARINE ELECTRONIC FUEL INJECTION (MEFI) DIAGNOSTIC MANUAL

At the beginning of each individual section is a Table of Contents which gives the page number on which each subject begins.

When reference is made in this manual to a brand name, number or specific tool, an equivalent product may be used in place of the recommended item.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication approval. The right is reserved to make changes at any time without notice.

**NOTICE:** When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

## FOREWORD

This service manual includes general description, diagnosis, symptoms and on-board service procedures for the fuel control and ignition systems used on Indmar equipped Marine Electronic Fuel Injection (MEFI) engines.

## INTRODUCTION

The following manual has been prepared for effective diagnosis of the Marine Electronic Fuel Injection (MEFI) system.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication approval. The right is reserved to make changes at any time without notice.

This manual should be kept in a handy place for ready reference. If properly used, it will meet the needs of technicians and vehicle owners.

This manual is intended for use by professional, qualified technicians. Attempting repairs or service without the appropriate training, tools and equipment could cause injury to you or others and damage to vehicle that may cause it not to operate safely and properly.

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## Section 1

## General Information

## Contents

<b>General Description</b> .....	Page 2		
Visual/Physical Inspection .....	Page 2	How Diagnostic Trouble Codes Are Set .....	Page 3
Basic Knowledge and Tools Required .....	Page 2	Clearing Diagnostic Trouble Codes .....	Page 4
Electrostatic Discharge Damage .....	Page 2	Non-Scan Diagnosis of Driveability Concerns (No DTCs Set) .....	Page 4
Engine Wiring .....	Page 2	Tools Needed to Service the System .....	Page 4
Engine Control Module (ECM)		Service Precautions .....	Page 5
Self-Diagnostics.....	Page 2	Special Tools (1 of 2) .....	Page 6
Malfunction Indicator Lamp (MIL) .....	Page 2	Special Tools (2 of 2) .....	Page 7
Intermittent Malfunction Indicator Lamp (MIL) .....	Page 2	Abbreviations.....	Page 8
Reading Diagnostic Trouble Codes (DTCs) .....	Page 3	<b>Diagnosis</b> .....	Page 9
On-Board Diagnostic (OBD)		<b>On-Board Service</b> .....	Page 9
System Check .....	Page 3	Wiring Harness Service.....	Page 9
DLC Scan Tools .....	Page 3	Wiring Connector Service.....	Page 10
Scan Tool Use With Intermittents .....	Page 3	Metri-Pack Series 150 Terminals .....	Page 10
		Weather-Pack Connectors .....	Page 11
		Diagnosing Electrical Circuits.....	Page 12

## General Description

### Visual / Physical Inspection

**A careful visual and physical inspection must be performed as part of any diagnostic procedure. This can often lead to fixing a problem without further diagnostics.**

Inspect all vacuum hoses for correct routing, pinches, cracks or disconnects. Be sure to inspect hoses that are difficult to see. Inspect all the wires in the engine compartment for proper connections, burned or chafed spots, pinched wires or contact with sharp edges or hot manifolds. This visual/physical inspection is very important. It must be done carefully and thoroughly.

### Basic Knowledge and Tools Required

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

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

### Electrostatic Discharge Damage

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

There are several ways a person can become statically charged. The most common methods of charging are by friction and by induction. An example of charging by friction is a person sliding across a seat, in which a charge of as much as 25,000 volts can build up. Charging by induction occurs when a person with well insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off, leaving the person highly charged with the opposite polarity. Static charges of either type can cause damage. Therefore, it is important to use care when handling and testing electronic components.

### Engine Wiring

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

### Engine Control Module (ECM) Self-Diagnostics

The Engine Control Module (ECM) performs a continuous self-diagnosis on certain control functions. This diagnostic capability is complemented by the diagnostic procedures contained in this manual. The ECM's language for communicating the source of a malfunction is a system of Diagnostic Trouble Codes (DTC's). The DTC's are identified by two sets of numbers. The first number, labeled a SPN, identifies the location of the problem and the second number, a FMI, identifies the type of problem is occurring at the location. When a malfunction is detected by the ECM, a DTC is set and the Malfunction Indicator Lamp (MIL) is illuminated.

### Malfunction Indicator Lamp (MIL)

The Malfunction Indicator Lamp (MIL) is designed to alert the operator that a problem has occurred and that the vehicle should be taken for service as soon as reasonably possible.

As a bulb and system check, the light will come "ON" with the key "ON," engine "OFF." When the engine is started, the light will turn "OFF." If the light remains "ON," the self-diagnostic system has detected a problem. If the problem goes away, the light will go out in most cases after 10 seconds, but a DTC will remain stored in the ECM.

When the light remains "ON" while the engine is running, or when a malfunction is suspected due to a driveability problem, the "On-Board Diagnostic (OBD) System Check" must be performed as the first step. These checks will expose malfunctions which may not be detected if other diagnostics are performed prematurely.

### Intermittent Malfunction Indicator Lamp (MIL)

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

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

### Reading Diagnostic Trouble Codes (DTC's)

The provision for communicating with the ECM is the Data Link Connector (DLC) (Figure 1-1). It is part of the engine wiring harness, and is a 6-pin connector, which is electrically connected to the ECM. It is used in the assembly plant to receive information in checking that the engine is operating properly before it leaves the plant. The DTC(s) stored in the ECM's memory can be retrieved through a scan tool, a hand-held diagnostic scanner plugged into the DLC: or a PC based software program designed to interface with the ECM datastream.

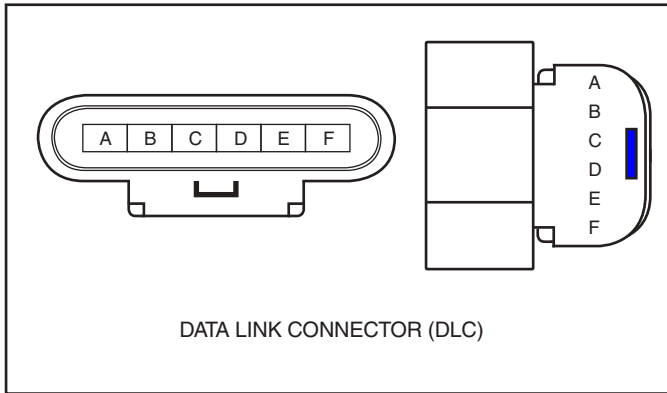


Figure 1-1 - Data Link Connector (DLC)

### On-Board Diagnostic (OBD) System Check

After the visual/physical inspection, the "On-Board Diagnostic (OBD) System Check" is the starting point for all diagnostic procedures. Refer to *Diagnosis* section.

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

1. Are the on-board diagnostics working? This is determined by performing the "On-Board Diagnostic (OBD) System Check." Since this is the starting point for the diagnostic procedures, always begin here. If the on-board diagnostics are not working, the OBD system check will lead to a diagnostic table in the *Diagnosis* section to correct the problem. If the on-board diagnostics are working properly, the next step is:
2. Is there a DTC stored? If a DTC is stored, go directly to the number DTC table in the *Diagnosis* section. This will determine if the fault is still present.

### DLC Scan Tools

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

With an understanding of the data which the scan tool displays, and knowledge of the circuits involved, the scan tool can be very useful in obtaining information which would be more difficult or impossible to obtain with other equipment.

A scan tool does not make the use of diagnostic tables unnecessary, nor do they indicate exactly where the problem is in a particular circuit. Diagnostic tables incorporate diagnostic procedures that are designed to function only with a scan tool or PC based scan program.

### Scan Tool Use With Intermittents

The scan tool provides the ability to perform a "wobble test" on wiring harnesses or components with the engine not running, while observing the scan tool display.

The scan tool can be plugged in and observed while driving the vehicle under the condition when the MIL turns "ON" or the engine driveability is poor. If the problem seems to be related to certain parameters that can be checked on the scan tool, they should be checked while driving the vehicle. If there does not seem to be any correlation between the problem and any specific circuit, the scan tool can be checked on each position, watching for a period of time to see if there is any change in the readings that indicates an intermittent operation.

The scan tool is also an easy way to compare the operating parameters of a poorly operating engine with those of a known good one. For example, a sensor may shift in value but not set a DTC. Comparing the sensor's readings with those of a known good identical vehicle may uncover the problem.

The scan tool has the ability to save time in diagnosis and prevent the replacement of good parts. The key to using the scan tool successfully for diagnosis lies in the technicians ability to understand the system they are trying to diagnose, as well as an understanding of the scan tool operation and limitations. The technician should read the tool manufacturer's operating manual to become familiar with the tool's operation.

### How Diagnostic Trouble Codes (DTC) Are Set

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

If a sensor is within its operating or acceptable parameters (Figure 1-2), the ECM does not detect a problem. When a sensor voltage signal falls out of this "window," the ECM no longer receives a signal voltage within the operating "window." When the ECM does not receive the "window" voltage for a calibratable length of time, a DTC will be stored. The MIL will be illuminated and a known default value will replace the sensor value to restore engine performance.

### Clearing Diagnostic Trouble Codes

1. Install scan tool or P.C.
2. Start engine.
3. Select "clear DTC's" function.
4. Clear DTC's.
5. Turn ignition "OFF" for at least 20 seconds.
6. Turn ignition "ON" and read DTC's. If DTC's are still present, check "Notice" below and repeat procedure following from step 2.

**NOTICE:** When clearing DTC's with the use of a scan tool, the ignition must be cycled to the "OFF" position or the DTC's will not clear.

### Non-Scan Diagnosis Of Driveability Concerns (No DTC's Set)

If a driveability concern still exists after following the OBD system check and reviewing the Symptoms tables, an out of range sensor may be suspected. Because of the unique

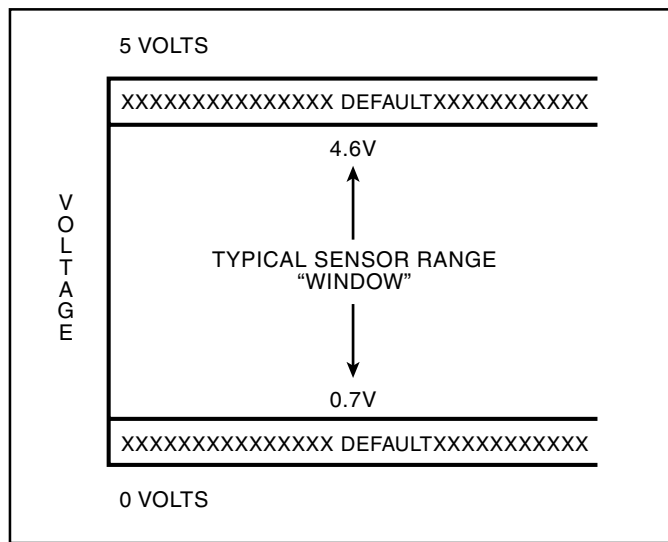


Figure 1-2 - Example of Sensor Normal Operation

design of the MEFI system, the ECM will replace sensed values with calibrated default values in the case of a sensor or circuit malfunction. By allowing this to occur, limited engine performance is restored until the vehicle is repaired. A basic understanding of sensor operation is necessary to be able to diagnose an out of range sensor.

If the sensor is out of range, but still within the operating "window" of the ECM, the problem will go undetected by the ECM and may result in a driveability concern.

A good example of this would be if the coolant sensor was reading incorrectly and indicating to the ECM that coolant temperature was at 50°F, but actual coolant temperature was at 150°F (Figure 1-3). This would cause the ECM to deliver more fuel than what was actually needed by the engine. This resulted in an overly rich condition, causing rough running. This condition would not have caused a DTC to set, as the ECM interprets this as within the operating "window."

To identify a sensor that is out of range, you may unplug the sensor electrical connector while the engine is running. After about 2 minutes, the DTC for that sensor will set, illuminate the MIL, and replace the sensed value with a calibrated default value. If at that point, a noticeable performance increase is observed, the non-scan DTC table for that particular sensor should be followed to correct the problem.

**NOTICE:** Be sure to clear each DTC after disconnecting and reconnecting each sensor. Failure to do so may result in a misdiagnosis of the driveability concern.

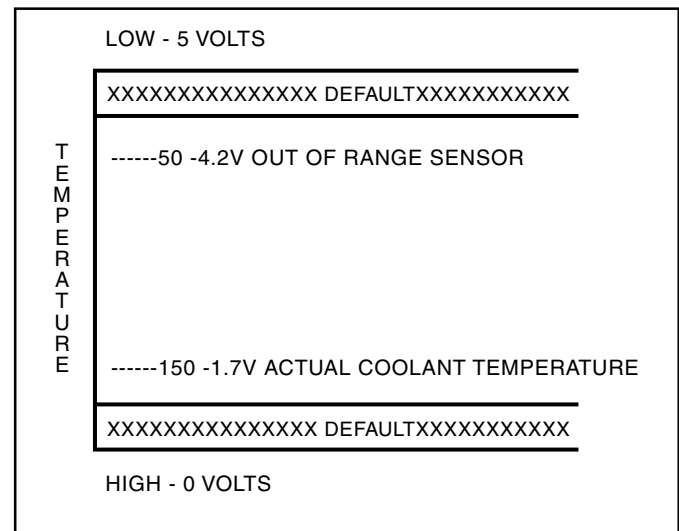


Figure 1-3 - Example of Shifted Sensor Operation

### Tools Needed To Service The System

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



### Service Precautions

The following requirements must be observed when working on engines.

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

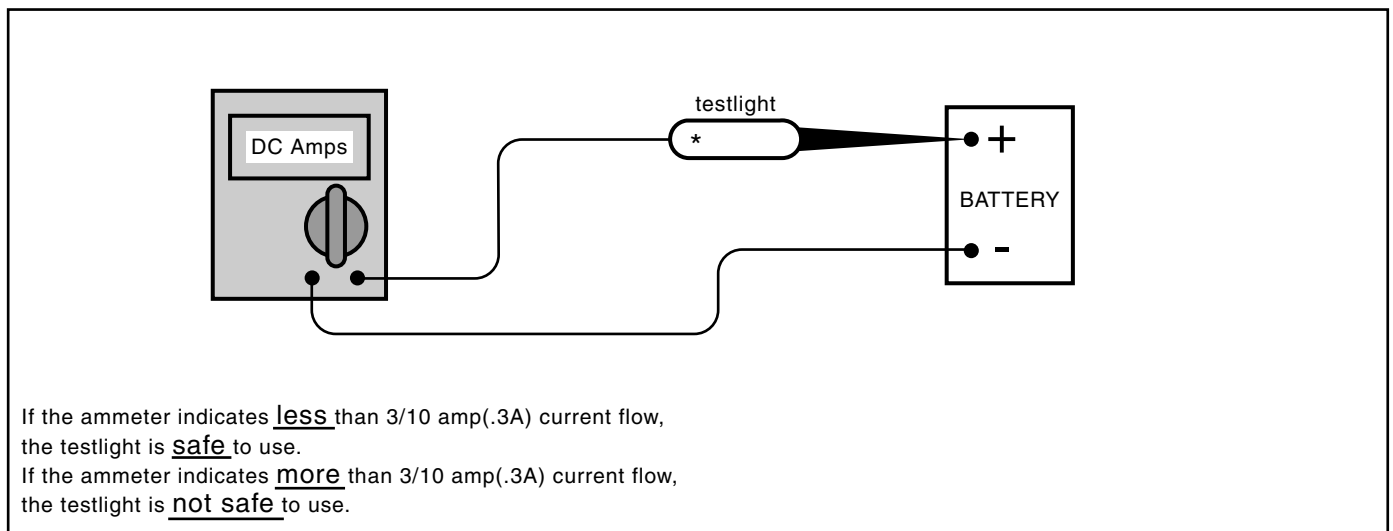


Figure 1-4 - Test Light Amperage Draw Test

## Special Tools and Equipment

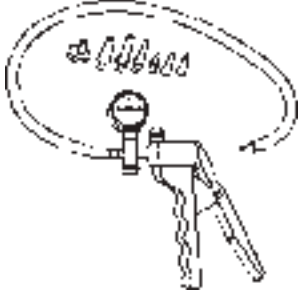
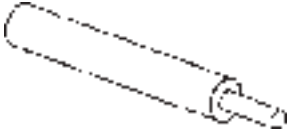

Illustration	Tool Number/Description
	J 23738-A Vacuum Pump
	J 28742-A Weather Pack Terminal Remover
	J 34142-B Test Lamp

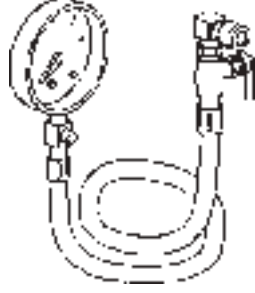
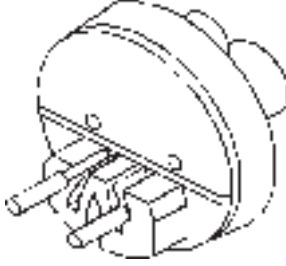



Illustration	Tool Number/Description
	J 34730-1A Fuel Pressure Gauge
	J 34730-405 Injector Test Lamp
	J 35314-A Exhaust Back Pressure Tester
	J 35616-A Connector Test Adapter Kit
	J 35689-A Metri-Pack Terminal Kit


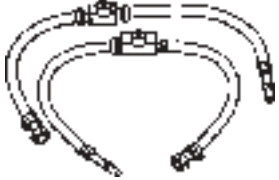

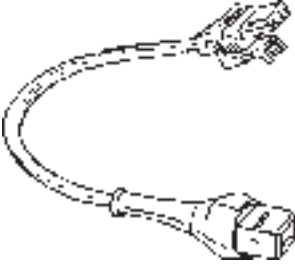


Illustration	Tool Number/Description
	<p>J 37088-A Fuel Line Quick Connect Separator</p>
	<p>J 37287 Inlet and Return Fuel Line Shut-Off Adapters</p>
	<p>J 39021 Fuel Injector Coil and Balance Tester</p>
	<p>J 39021-380 Fuel Injector Test Harness</p>
	<p>Fluke 78 or J 39200 Digital Multimeter</p>

Illustration	Tool Number/Description
	<p>Scan Tool or PC with Diagnostic Software</p>

## ABBREVIATIONS

BARO	-	BAROMETRIC PRESSURE	IC	-	IGNITION CONTROL
BAT	-	BATTERY, BATTERY POSITIVE TERMINAL, BATTERY OR SYSTEM VOLTAGE	IGN	-	IGNITION
B+	-	BATTERY POSITIVE	INJ	-	INJECTOR
CAN	-	CONTROLLER AREA NETWORK	I/O	-	INPUT/OUTPUT
CCP	-	CAN COMMUNICATION PROTOCOL	kPa	-	KILOPASCAL
CEFI	-	COMMERCIAL ELECTRONIC FUEL INJECTION	KS	-	KNOCK SENSOR
CKT	-	CIRCUIT	KV	-	KILOVOLTS
CONN	-	CONNECTOR	MAP	-	MANIFOLD ABSOLUTE PRESSURE
CYL	-	CYLINDER	MFI	-	MULTIPOINT FUEL INJECTION
DEG	-	DEGREES	MIL	-	MALFUNCTION INDICATOR LAMP
DI	-	DISTRIBUTOR IGNITION	MSEC	-	MILLSECOND
DIAG	-	DIAGNOSTIC	N/C	-	NORMALLY CLOSED
DIST	-	DISTRIBUTOR	N/O	-	NORMALLY OPEN
DLC	-	DATA LINK CONNECTOR	NV RAM-	-	NON VOLATILE RANDOM ACCESS MEMORY
DTC	-	DIAGNOSTIC TROUBLE CODE	OBD	-	ON-BOARD DIAGNOSTIC
DVOM	-	DIGITAL VOLT OHMMETER	OPT	-	OPTIONAL
ECM	-	ENGINE CONTROL MODULE	PFI	-	PORT FUEL INJECTION
ECT	-	ENGINE COOLANT TEMPERATURE	PPS	-	PEDAL POSITION SENSOR
EEPROM-	-	ELECTRONIC ERASABLE PROGRAMMABLE READ ONLY MEMORY	PWM	-	PULSE WIDTH MODULATION
EI	-	ELECTRONIC IGNITION	RAM	-	RANDOM ACCESS MEMORY
EMI	-	ELECTROMAGNETIC INTER- FERENCE	REF HI	-	REFERENCE HIGH
ENG	-	ENGINE	REF LO	-	REFERENCE LOW
EOP	-	ENGINE OIL PRESSURE	ROM	-	READ ONLY MEMORY
EST	-	ELECTRONIC SPARK TIMING	SLV	-	SLAVE
E-STOP	-	EMERGENCY STOP	SPN	-	SUSPECT PARAMETER NUMBER
ETC	-	ELECTRONIC THROTTLE CONTROL	SW	-	SWITCH
FL	-	FUEL LEVEL	TAC	-	THROTTLE ACTUATOR CONTROL
FMI	-	FAILURE MODE INDICATOR	TACH	-	TACHOMETER
GND	-	GROUND	TBI	-	THROTTLE BODY INJECTION
GOV	-	GOVERNOR	TERM	-	TERMINAL
GPH	-	GALLONS PER HOUR	TP	-	THROTTLE POSITION
HO <sub>2</sub>	-	HEATED OXYGEN SENSOR	TPS	-	THROTTLE POSITION SENSOR
“HG”	-	INCHES OF MERCURY	T-SC	-	THROTTLE-SHIFT CONTROL
IAC	-	IDLE AIR CONTROL	V	-	VOLTS
IAT	-	INTAKE AIR TEMPERATURE	VAC	-	VACUUM
			VSS	-	VEHICLE SPEED SENSOR
			WOT	-	WIDE OPEN THROTTLE

## Diagnosis

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

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

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

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

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

## On-Board Service

### Wiring Harness Service

Figure 1-7

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

With the low current and voltage levels found in the system, it is important that the best possible bond be made at all wire splices by soldering the splices as shown in Figure 1-7.

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

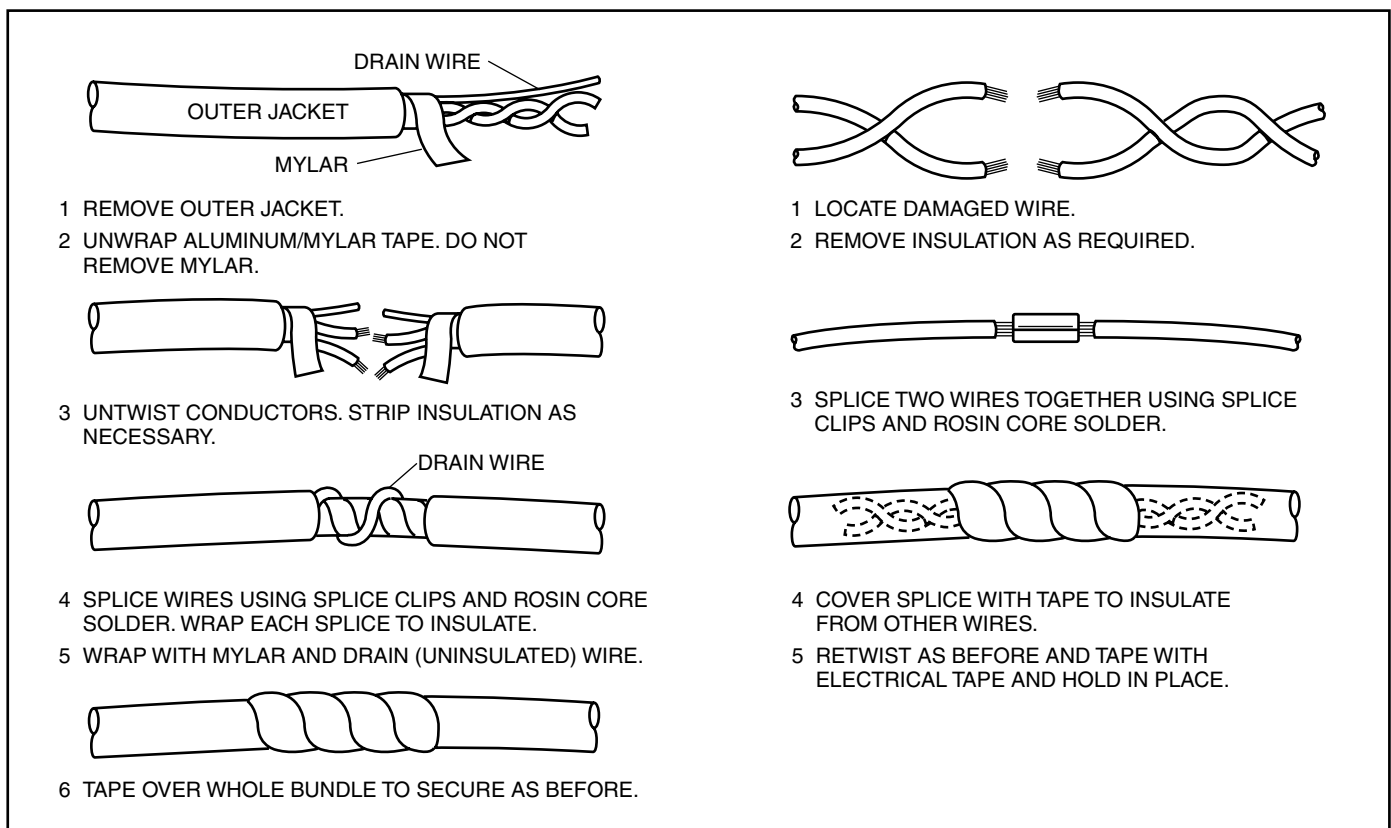


Figure 1-7 - Wiring Harness Repair

## Wiring Connector Service

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

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

Before making a connector repair, be certain of the type of connector. Some connectors look similar but are serviced differently. Replacement connectors and terminals are listed in the parts catalog.

## Metri-Pack Series 150 Terminals

### Figure 1-8

Some ECM harness connectors contain terminals called Metri-Pack (Figure 1-8). These are used at some of the sensors and the distributor connector.

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

To remove a terminal:

1. Slide the seal back on the wire.
2. Insert tool J 35689 or equivalent, as shown in Figure 1-5, to release the terminal locking tang.
3. Push the wire and terminal out through the connector. If the terminal is being reused, reshape the locking tang.

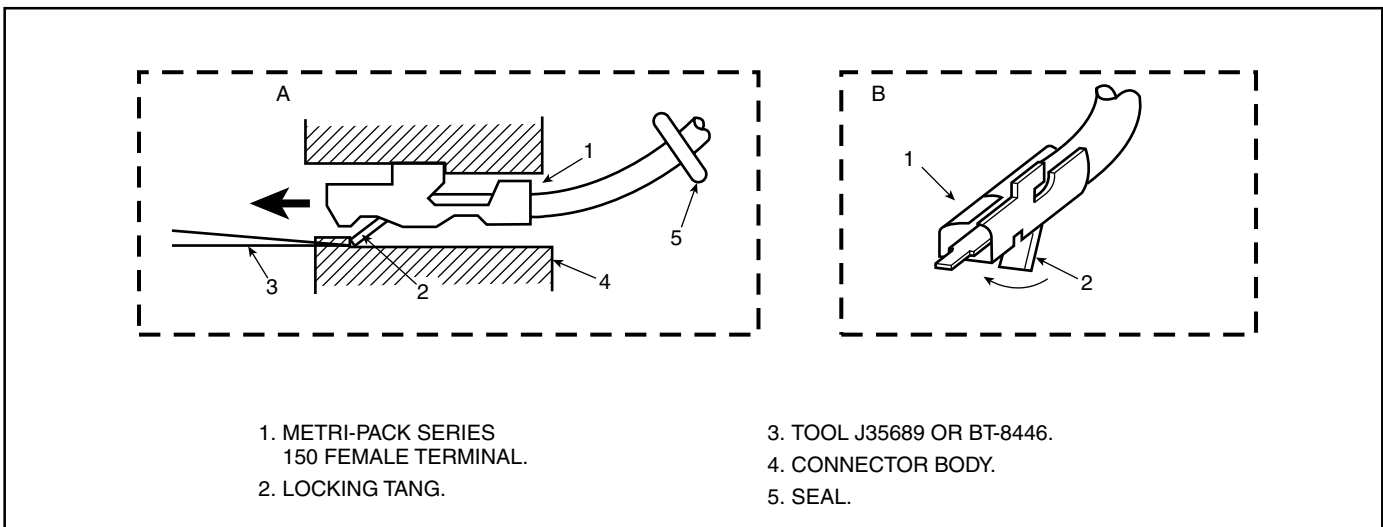


Figure 1-8 Metri-Pack Series 150 Terminal Removal

**Weather-Pack Connectors**

*Figure 1-9*

Figure 1-9 shows a Weather-Pack connector and the tool (J28742 or equivalent) required to service it. This tool is used to remove the pin and sleeve terminals. If terminal removal is attempted without using the special tool required, there is a good chance that the terminal will be bent or deformed, and unlike standard blade type terminals, these terminals cannot be straightened once they are bent.

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

Weather-Pack connections cannot be replaced with standard connections. Instructions are provided with Weather-Pack connector and terminal packages.

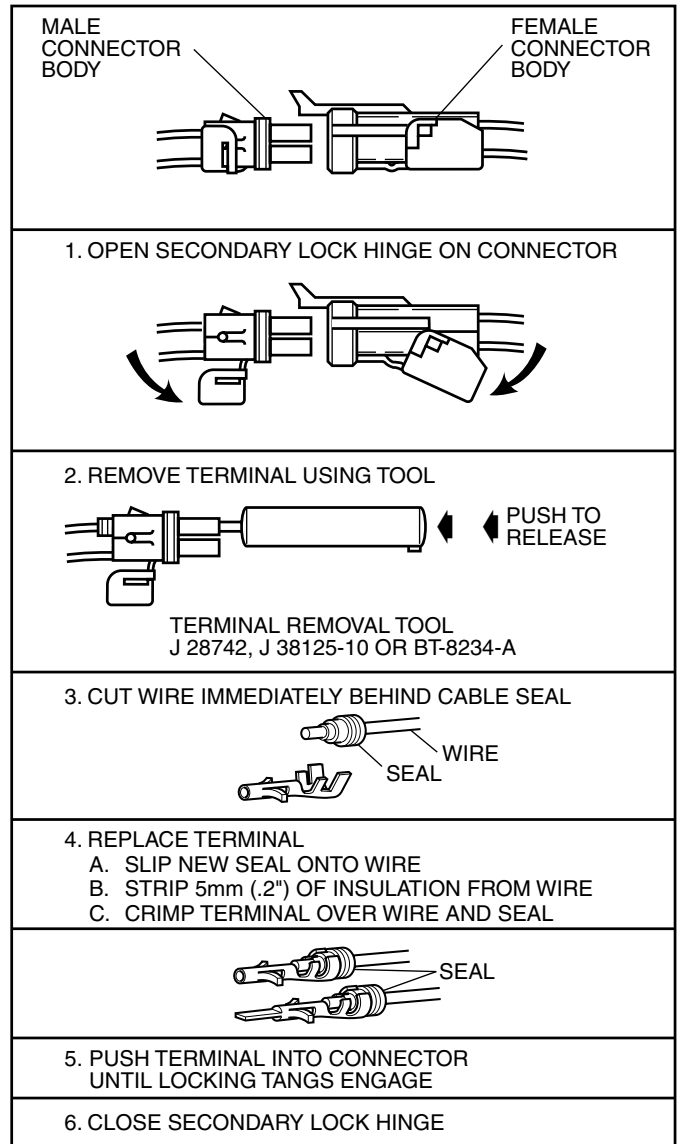


Figure 1-9 - Weather-Pack Terminal Repair

## General Electrical Diagnosis Procedures

### Basic Knowledge Required

Without a basic knowledge of electricity, it will be difficult to use the diagnostic procedures contained in the service manual. You should understand the basic theory of electricity, and know the meanings voltage (volts), current (amps), and resistance (ohms). You should also be able to read and understand a wiring diagram as well as understand what happens in a circuit with an open or a shorted wire.

### Circuit Testing

The Circuit Testing section contains the following diagnostic testing information. Using this information along with the diagnostic procedures will identify the cause of the electrical malfunction.

- Using Connector Test Adapters
- Probing Electrical Connectors
- Troubleshooting with a Digital Multimeter
- Troubleshooting with a Test Lamp
- Using Fused Jumper Wires
- Measuring Voltage
- Measuring Voltage Drop
- Measuring Frequency
- Testing for Continuity
- Testing for Short to Ground
- Testing for Short to Voltage

### Using Connector Test Adapters

**Notice:** Do not insert test equipment probes into any connector or fuse block terminal. The diameter of the test probes will deform most terminals. A deformed terminal can cause a poor connection, which can result in system failures. Always use the J 35616-B Connector Test Adapter Kit or the J 42675 Flat Wire Probe Adapter Kit in order to frontprobe terminals. Do not use paper clips or other substitutes as they can damage terminals and cause incorrect measurements.

### Probing Electrical Connectors

**Important:** Always be sure to reinstall the connector position assurance (CPA) and terminal position assurance (TPA) when reconnecting connectors or replacing terminals.

#### Frontprobe

Disconnect the connector and probe the terminals from the mating side (front) of the connector.

**Notice:** Do not insert test equipment probes into any connector or fuse block terminal. The diameter of the test probes will deform most terminals. A deformed terminal can cause a poor connection, which can result in system failures. Always use the J 35616-B Connector Test Adapter Kit or the J 42675 Flat Wire Probe Adapter Kit in order to frontprobe terminals. Do not use paper clips or other substitutes as they can damage terminals and cause incorrect measurements.

Refer to the following table as a guide in selecting the correct test adapter for frontprobing connectors:

#### Backprobe

##### Important:

- Backprobe connector terminals only when specifically required in diagnostic procedures.
- Do not backprobe a sealed (Weather Pack®) connector, less than a 280 series Metri-Pack connector, a Micro-Pack connector, or a flat wire (dock and lock) connector.
- Backprobing can be a source of damage to connector terminals. Use care in order to avoid deforming the terminal, either by forcing the test probe too far into the cavity or by using too large of a test probe.
- After backprobing any connector, inspect for terminal damage. If terminal damage is suspected, test for proper terminal contact.

Do not disconnect the connector and probe the terminals from the harness side (back) of the connector.



## Troubleshooting with a Digital Multimeter

Test Probe Notice

**Important:** Circuits which include any solid state control modules, such as the ECM, should only be tested with a 10 megohm or higher impedance digital multimeter such as the J 39200, Fluke 78, or equivalent.

The J 39200 instruction manual is a good source of information and should be read thoroughly upon receipt of the DMM as well as kept on hand for future reference.

A DMM should be used instead of a test lamp in order to test for voltage in high impedance circuits. While a test lamp shows whether voltage is present, a DMM indicates how much voltage is present.

The ohmmeter function on a DMM shows how much resistance exists between 2 points along a circuit. Low resistance in a circuit means good continuity.

**Important:** Disconnect the power feed from the suspect circuit when measuring resistance with a DMM. This prevents incorrect readings. DMMs apply such a small voltage to measure resistance that the presence of voltages can upset resistance reading.

Diodes and solid state components in a circuit can cause a DMM to display a false reading. To find out if a component is affecting a measurement take a reading once, then reverse the leads and take a second reading. If the readings differ the solid state component is affecting the measurement.

- Backprobe
- Disconnect the harness at both ends of the suspected circuit where it connects either to a compound or to other harnesses.
- If the system that is being diagnosed has a specified pinout or breakout box, it may be used in order to simplify connecting the DMM to the circuit or for testing multiple circuits quickly.

## Troubleshooting with a Test Lamp

### Tools Required

J 34142-B 12-Volt Unpowered Test Lamp

**Notice:** Refer to Test Probe Notice

A test lamp can simply and quickly test a low impedance circuit for voltage.

The J 34142-B is Micro-Pack compatible and comprised of a 12-volt light bulb with an attached pair of leads.

To properly operate this tool use the following procedure.

1. Attach 1 lead to ground.
2. Touch the other lead to various points along the circuit where voltage should be present.
3. When the bulb illuminates, there is voltage at the point being tested.

## Using Fused Jumper Wires

### Tools Required

J 36169-A Fused Jumper Wire

**Important:** A fused jumper may not protect solid state components from being damaged.

The J 36169-A includes small clamp connectors that provide adaptation to most connectors without damage. This fused jumper wire is supplied with a 20-A fuse which may not be suitable for some circuits. Do not use a fuse with higher rating than the fuse that protects the circuit being tested.

## Measuring Voltage

**Notice:** Refer to Test Probe Notice

The following procedure measures the voltage at a selected point in a circuit.

1. Disconnect the electrical harness connector for the circuit being tested, if necessary.
2. Enable the circuit and/or system being tested. Use the following methods:
  - Turn ON the ignition, with the engine OFF.
  - Turn ON the engine.
  - Turn ON the circuit and/or system with a scan tool in Output Controls.
  - Turn On the switch for the circuit and/or system being tested.
3. Select the V (AC) or V (DC) position on the DMM.
4. Connect the positive lead of the DMM to the point of the circuit to be tested.
5. Connect the negative lead of the DMM to a good ground.
6. The DMM displays the voltage measured at that point.

## Measuring Voltage Drop

**Notice:** Refer to Test Probe Notice

The following procedure determines the difference in voltage potential between 2 points:

1. Set the rotary dial of the DMM to the V (DC) position.
2. Connect the positive lead of the DMM to 1 point of the circuit to be tested.
3. Connect the negative lead of the DMM to the other point of the circuit.
4. Operate the circuit—under its normal load.
5. The DMM displays the **difference** in voltage between the 2 points.

## Measuring Frequency

**Notice:** Refer to Test Probe Notice

The following procedure determines the frequency of a signal.

**Important:** A Connecting the DMM to the circuit before pressing the Hz button will allow the DMM to autorange to an appropriate range.

1. Apply power to the circuit.
2. Set the rotary dial of the DMM to the V (AC) position.
3. Connect the positive lead of the DMM to the circuit to be tested.
4. Connect the negative lead of the DMM to a good ground.
5. Press the Hz button on the DMM.
6. The DMM will display the frequency measured.

## Testing for Continuity

**Notice:** Refer to Test Probe Notice

The following procedures verify good continuity in a circuit.

### With a DMM

1. Set the rotary dial of the DMM to the  $\Omega$  position.
2. Disconnect the power feed (i.e. fuse, control module) from the suspect circuit.
3. Disconnect the load.
4. Press the MIN MAX button or select the continuity position on the DMM.
5. Connect one lead of the DMM to one end of the circuit to be tested.
6. Connect the other lead of the DMM to the other end of the circuit.
7. If the DMM displays low or no resistance and a tone is

heard, the circuit has good continuity.

### With a Test Lamp

**Important:** Only use the test lamp procedure on low impedance power and ground circuits.

1. Remove the power feed (i.e. fuse, control module) from the suspect circuit.
2. Disconnect the load.
3. Connect 1 lead of the test lamp to 1 end of the circuit to be tested.
4. Connect the other lead of the test lamp to battery positive voltage.
5. Connect the other end of the circuit to ground.
6. If the test lamp illuminates (full intensity), then the circuit has good continuity.

## Testing for Short to Ground

**Notice:** Refer to Test Probe Notice

The following procedures test for a short to ground in a circuit.

### With a DMM

1. Remove the power feed (i.e. fuse, control module) from the suspect circuit.
2. Disconnect the load.
3. Set the rotary dial of the DMM to the  $\Omega$  position.
4. Connect 1 lead of the test lamp to 1 end of the circuit to be tested.
5. Connect the other lead of the DMM to a good ground.
6. If the DMM does NOT display infinite resistance (OL), there is a short to ground in the circuit.

### With a Test Lamp

1. Remove the power feed (i.e. fuse, control module) from the suspect circuit.
2. Disconnect the load.
3. Connect 1 lead of the test lamp to battery positive voltage.
4. Connect the other lead of the test lamp to 1 end of the circuit to be tested.
5. If the test lamp illuminates, there is a short to ground in the circuit.

## Testing for Intermittent and Poor Connections

Most intermittent conditions are caused by faulty electrical connections or wiring. Inspect for the following items:

- Wiring broken inside the insulation
- Poor connection between the male and female terminal at a connection.
- Poor terminal to wire connection—Some conditions which fall under this description are poor crimps, poor solder joints, crimping over the wire insulation rather than the wire itself and corrosion in the wire to terminal contact area, etc.
- Wire insulation which is rubbed through—This causes an intermittent short as the bare area touches other wiring or parts of the vehicle.

## Service Precautions

The following requirements must be observed when working on engines.

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

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## Section 2

### Engine Control Module (ECM) and Sensors

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

#### Contents

<b>General Description .....</b>	<b>Page 2</b>		
Computers and Voltage Signals .....	Page 2	Manifold Absolute Pressure (MAP)	
Analog Signals .....	Page 2	Sensor .....	Page 8
Three-Wire Sensors .....	Page 2	Knock Sensor .....	Page 8
Two-Wire Sensors .....	Page 2	Ignition Control (IC) Reference .....	Page 8
Digital Signals .....	Page 3	Discrete Switch Inputs (Optional).....	Page 8
Switch Types .....	Page 3	<b>Diagnosis .....</b>	Page 9
Pulse Counters.....	Page 3	Engine Control Module (ECM).....	Page 9
Engine Control Module (ECM).....	Page 4	<b>On-Board Service .....</b>	Page 9
ECM Function.....	Page 4	Engine Control Module (ECM)	
Memory.....	Page 4	Replacement.....	Page 9
ROM .....	Page 4	Engine Coolant Temperature (ECT)	
RAM.....	Page 4	Sensor.....	Page 10
EEPROM .....	Page 4	Manifold Absolute Pressure (MAP)	
Speed Density System .....	Page 5	Sensor.....	Page 10
Speed .....	Page 5	Throttle Position Sensor .....	Page 11
Density.....	Page 5	Idle Air Control (IAC) Function.....	Page 11
ECM Inputs and Sensor Descriptions.....	Page 5	Knock Sensor (KS) .....	Page 12
Inputs and Outputs .....	Page 6	<b>Torque Specifications .....</b>	Page 12
Engine Coolant Temperature (ECT)			
Sensor .....	Page 7		

## General Description

This Electronic Fuel Injection system is equipped with a computer that provides the operator with state-of-the-art control of fuel and spark delivery. Before we discuss the computers in this application, let's discuss how computers use voltage to send and receive information.

### Computers and Voltage Signals

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

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

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

### Analog Signals

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

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

### Three-Wire Sensors

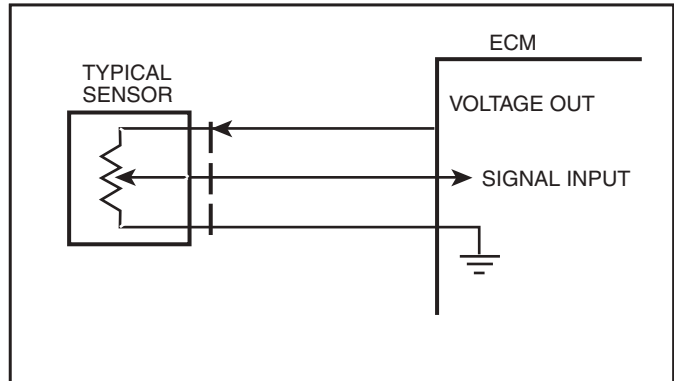


Figure 2-1 - Three-Wire Sensors

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

### Two-Wire Sensors

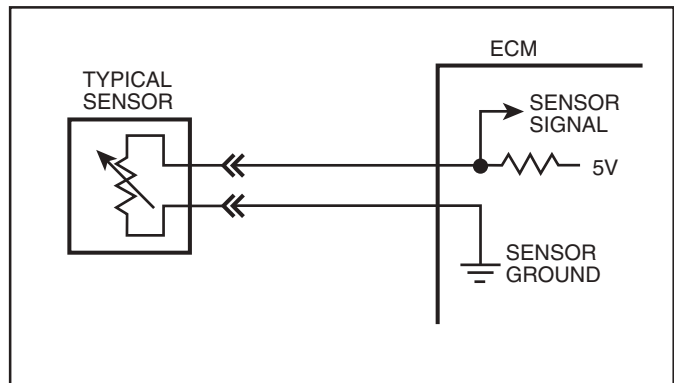


Figure 2-2 - Two-Wire Sensors

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

## Digital Signals

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

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

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

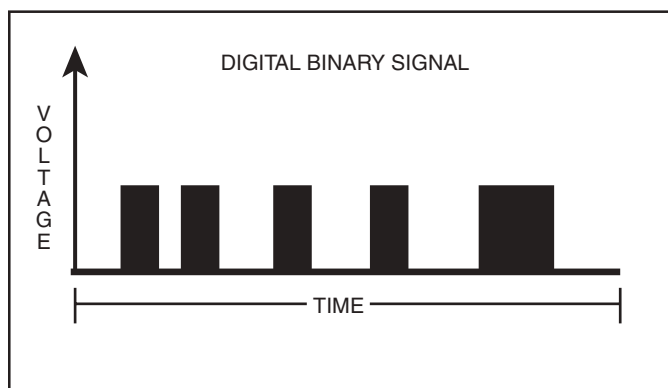


Figure 2-3 - Digital Voltage Signal

## Switch Types

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

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

## Pulse Counters

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

An example of a pulse counter type of input is the distributor reference pulse input. The ECM can count a train of pulses, a given number of pulses per engine revolution. In this way, the ECM can determine the RPM of the engine.

## CAN

Controller area network

The data transmission function for the MEFI controller is known as CAN or Controller Area Network. CAN communication protocol is available in a number of different formats. The MEFI controller uses the SAE J1939 format.

The communication rate for J1939 CAN is 250 kbps and messages are transmitted on a twisted pair of wires.

J1939 is a high speed, Class C type communications network designed to support real-time closed loop control functions between electronic control devices which may be physically distributed throughout the vehicle or vessel.

J1939 uses the CAN protocol which permits any device to transmit a message on the network when the bus is idle. Every message includes an identifier which defines the message priority, what device sent it, and what data is contained within it. Collisions are avoided due to the arbitration process that occurs while the identifier is transmitted. This, permits high priority messages to get through with low delay times because there is equal access on the network for any device.

Although the CAN communication currently occurs mainly between engine control devices such as the electronic throttle and the ECM, it is likely that future applications will include ordinary switching devices for control of lighting, accessory devices, and the like.

## Engine Control Module (ECM)

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

- Fuel metering system.
- Ignition timing.
- Idle speed.
- On-board diagnostics for engine functions.

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

### ECM Function

The ECM supplies either 5 or 12 volts to power various sensors or switches. This is done through resistances in the ECM which are so high in value that a test light will not light when connected to the circuit. In some cases, even an ordinary shop voltmeter will not give an accurate reading because its resistance is too low. Therefore, a digital voltmeter with at least 10 megohms input impedance is required to ensure accurate voltage readings. Tool J 39978 or the Fluke 78 multimeter meet this requirement.

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

## Memory

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

### ROM

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

### RAM

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

### EEPROM

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

The EEPROM is not replaceable. If the ECM is replaced, the new ECM will need to be programmed by the OEM with the calibration information that is specific to each application.

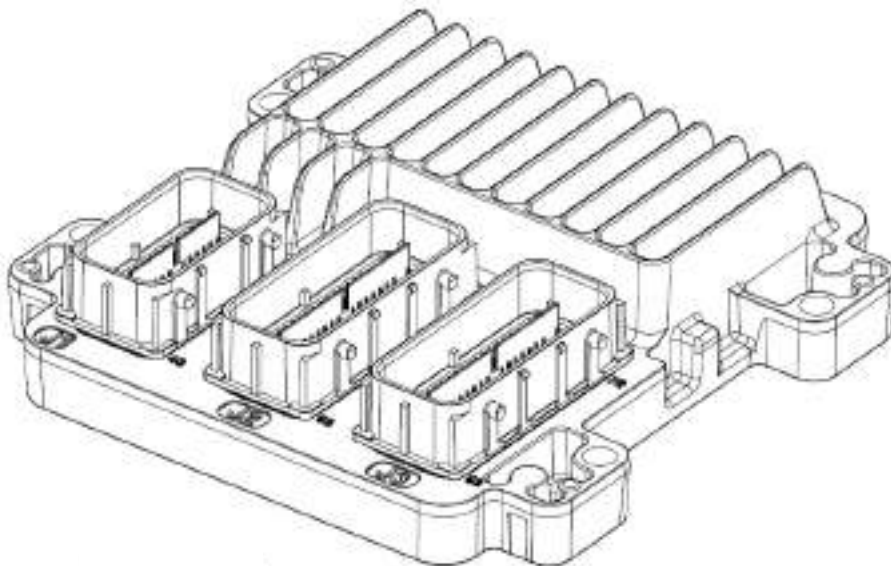


Figure 2-4 - Engine Control Module (ECM) MEFI 5



## Speed Density System

This System is a speed and air density system. The system is based on “speed density” fuel management.

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

### Speed

The engine speed signal comes from the Crank Position Sensor. The ECM uses this information to determine the “speed” or RPM factor for fuel and spark management.

### Density

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

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

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

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

## ECM Inputs and Sensor Descriptions

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

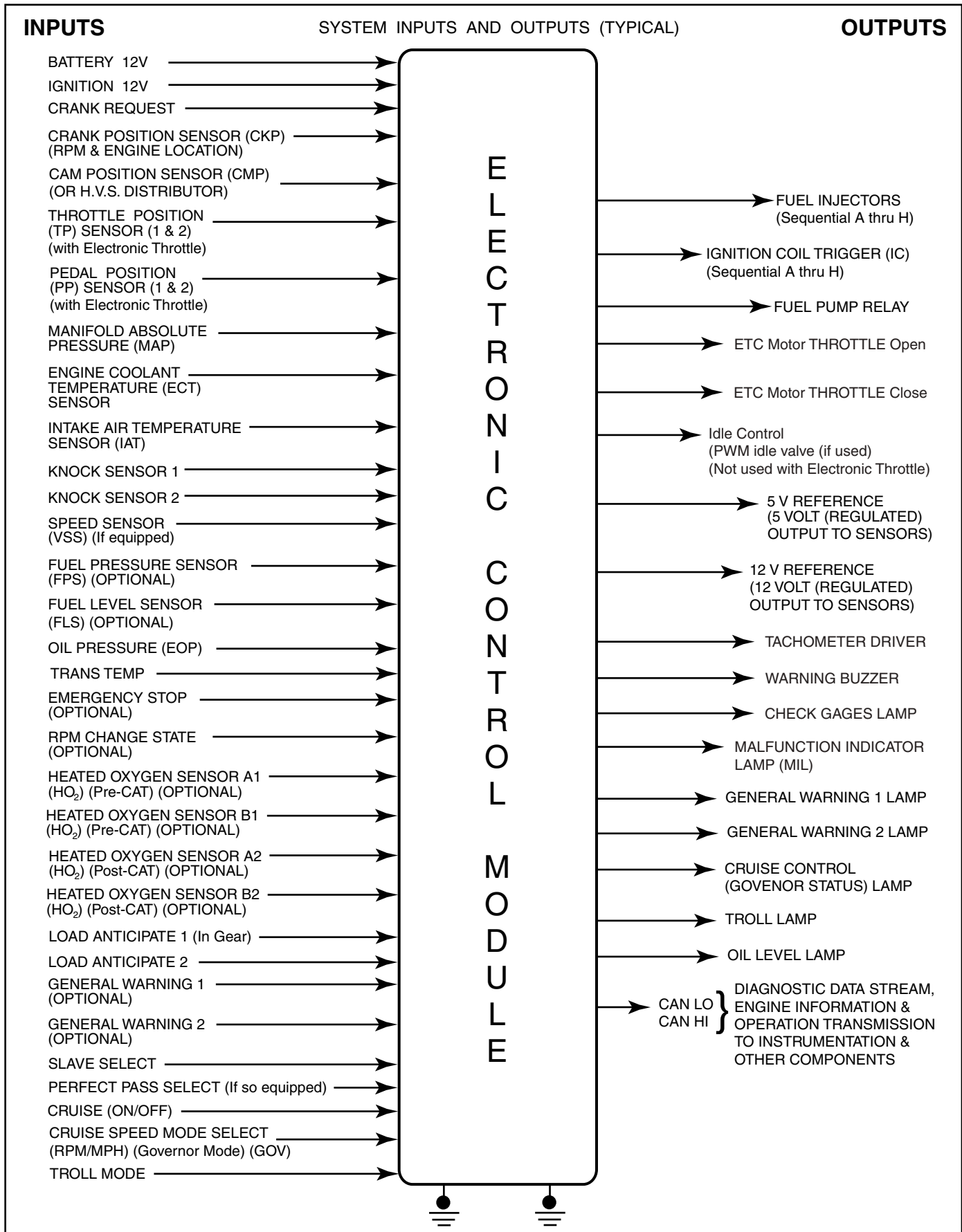


Figure 2-5 - ECM Inputs and Outputs (Typical)

**Engine Coolant Temperature (ECT) Sensor**

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

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

A hard fault in the engine coolant sensor circuit should set SPN 110 FMI 3 or 4; an intermittent fault may or may not set a DTC. The DTC "Diagnostic Aids" also contains a chart to check for sensor resistance values relative to temperature.

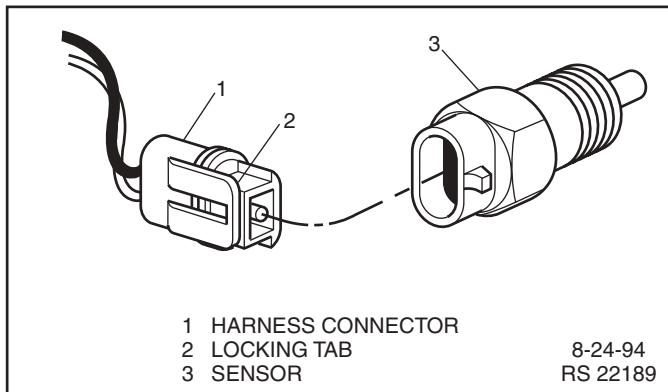


Figure 2-6 - Engine Coolant Temperature (ECT) Sensor

**Temperature vs Resistance**

C	F	OHMS
Temperature vs Resistance Values (Approximate)		
150	302	47
140	284	60
130	266	77
120	248	100
110	230	132
100	212	177
90	194	241
80	176	332
70	158	467
60	140	667
50	122	973
45	113	1188
40	104	1459
35	95	1802
30	86	2238
25	77	2796
20	68	3520
15	59	4450
10	50	5670
5	41	7280
0	32	9420
-5	23	12300
-10	14	16180
-15	5	21450
-20	-4	28680
-30	-22	52700
-40	-40	100700

### Manifold Absolute Pressure (MAP) Sensor

The Manifold Absolute Pressure (MAP) sensor (Figure 2-7) is a pressure transducer that measures the changes in the intake manifold pressure. The pressure changes as a result of engine load and speed change, and the MAP sensor converts this into a voltage output.

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

The ECM supplies a 5 volt reference voltage to the MAP sensor. As the manifold pressure changes, the electrical resistance of the MAP sensor also changes. By monitoring the sensor output voltage, the ECM knows the manifold pressure. A higher pressure, low vacuum (high voltage) requires more fuel. A lower pressure, high vacuum (low voltage) requires less fuel. The ECM uses the MAP sensor to control fuel delivery and ignition timing. A failure in the MAP sensor circuit should set a SPN 106 FMI 3 or 4.

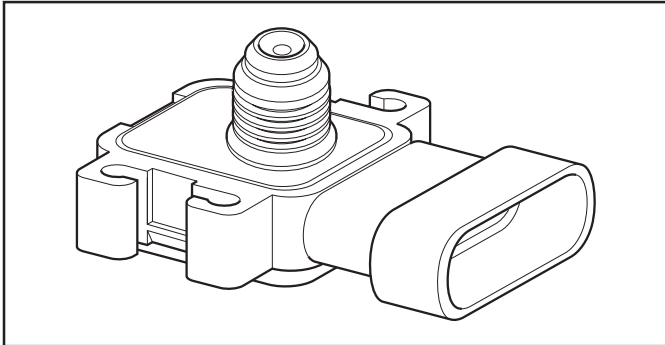


Figure 2-7 - Manifold Absolute Pressure (MAP) Sensor

### Knock Sensor

The knock sensor is mounted in the engine block. The location depends on engine application.

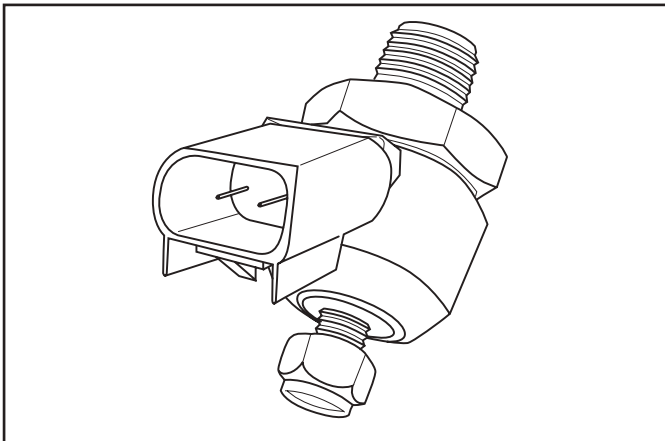


Figure 2-8 - Knock Sensor (Typical)

An ECM is used in conjunction with a knock sensor in order to control detonation. The knock module circuitry is internal in the ECM.

When knock is present, a flat response is produced by the knock sensor and transmitted to the ECM. An AC voltage monitor inside the ECM will detect the knock and start retarding spark timing.

### Ignition Control (IC) Reference

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

### Discrete Switch Inputs (Optional)

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

If a switch changes states from its normal at rest position, that is, normally closed to open, or normally open to closed, the ECM senses a change in voltage and responds by entering RPM reduction mode.

This engine protection feature allows the operator normal engine operation up to OEM specifications (approx. 1400-2000 RPM), but causes RPM reduction with a control algorithm that overrides normal electronic throttle control. This throttle override feature takes over normal throttle operation to allow the engine to operate only at the reduced throttle RPM. This feature allows the operator a safe maneuvering speed while removing the possibility of high RPM engine operation until the problem is corrected.

Switches that may be used with this system to detect critical engine operation parameters are:

- |                  |     |
|------------------|-----|
| • Oil level      | N/O |
| • Oil pressure   | N/O |
| • Emergency stop | N/O |

## Diagnosis

### Engine Control Module (ECM)

To read and clear diagnostic trouble codes, use a scan tool or Diagnostic Trouble Code (DTC) tool.

**Important:** Use of a scan tool is recommended to clear diagnostic trouble codes from the ECM memory.

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

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

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

## On-Board Service

### Engine Control Module (ECM)

*Figure 2-9*

**Notice:** When replacing the ECM, the ignition must be "OFF" and disconnect the battery before disconnecting or reconnecting the ECM "J1", "J2" and "J3" connectors to prevent internal damage to the ECM.

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

#### Remove or Disconnect

1. Negative battery cable.
2. "J1", "J2" and "J3" connectors from ECM.
3. Four ECM mounting screws.
4. ECM from mounting bracket.

#### Important

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

#### Install or Connect

1. New ECM to mounting bracket.
2. Four ECM mounting screws. Torque to 10-14 N•m (88-124 lb.in.).
3. "J1", "J2" and "J3" connectors to ECM.
4. Negative battery cable.

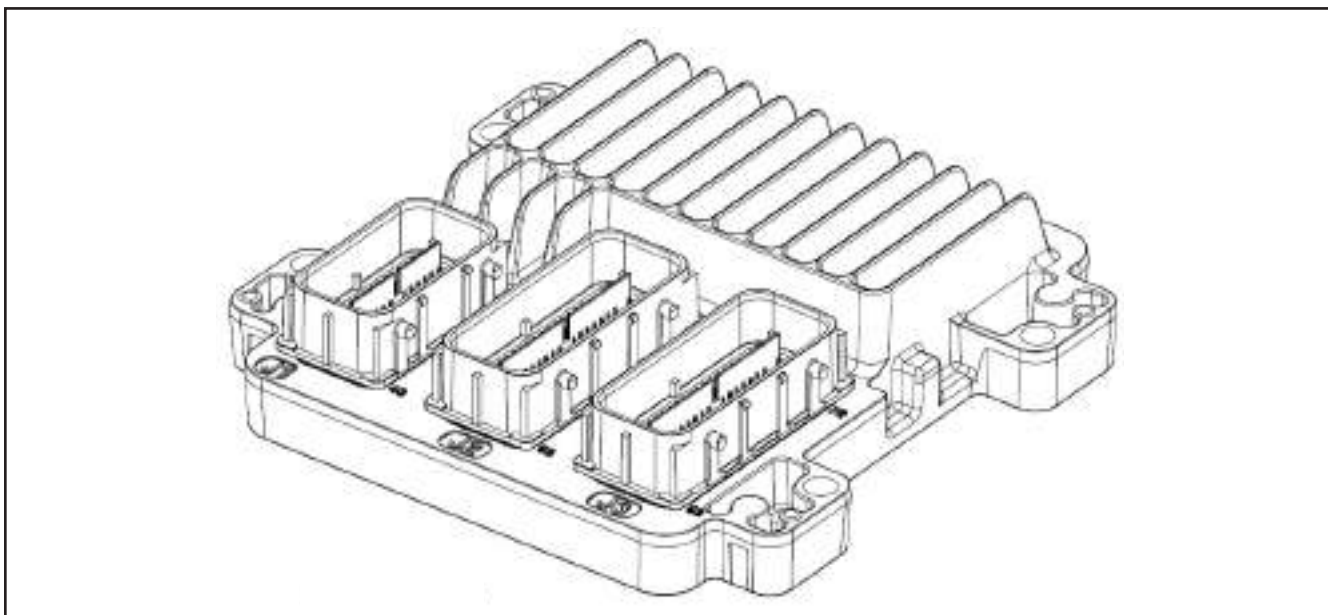


Figure 2-9 - Engine Control Module (ECM) MEFI 5

## Engine Coolant Temperature (ECT) Sensor

Figure 2-10

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

### Remove or Disconnect

1. Negative battery cable.
2. ECT electrical connector.
3. ECT sensor.

### Important

- Coat ECT sensor threads with Teflon tape sealant prior to installation.

### Install or Connect

1. ECT sensor. Torque to 12 N•m (108 lb. in.).
2. ECT electrical connector.
3. Negative battery cable.

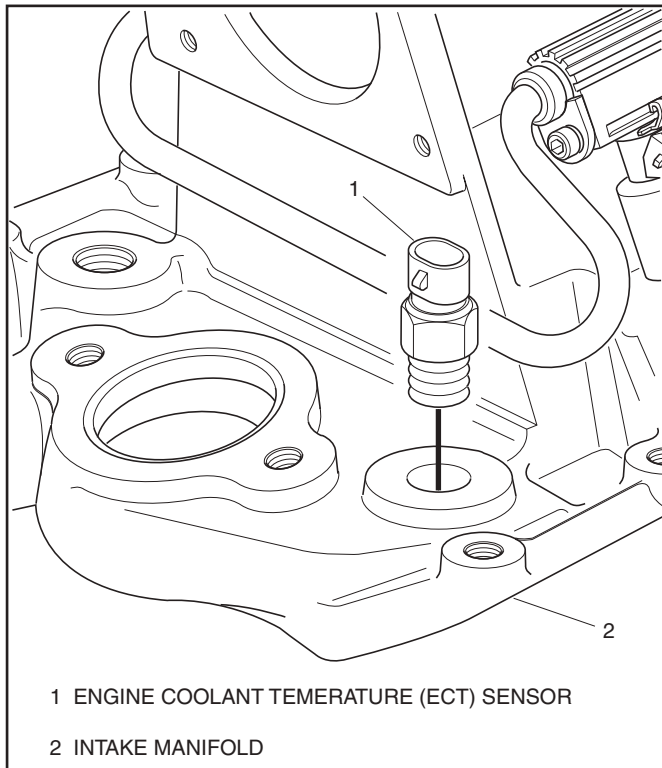


Figure 2-10 - Engine Coolant Temperature (ECT) Sensor

## Manifold Absolute Pressure (MAP) Sensor

Figures 2-11

### Remove or Disconnect

1. Negative battery cable.
2. MAP sensor electrical connector.
3. MAP sensor attaching screws.
4. MAP sensor with seal.

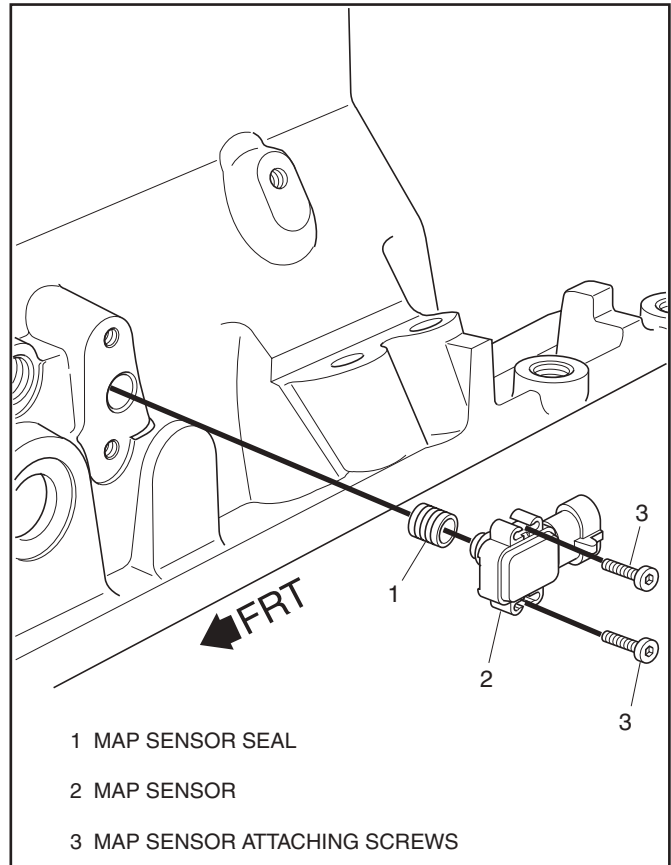


Figure 2-11 - MAP Sensor Mounting Location

### Important

- The MAP sensor is an electrical component. Do Not soak in any liquid cleaner or solvent, as damage may result.

### Install or Connect

1. New seal on MAP sensor.
2. MAP sensor.
3. MAP sensor attaching screws. Torque to 5-7 N•m (44-62 lb. in.).
4. MAP sensor electrical connector.
5. Negative battery cable.

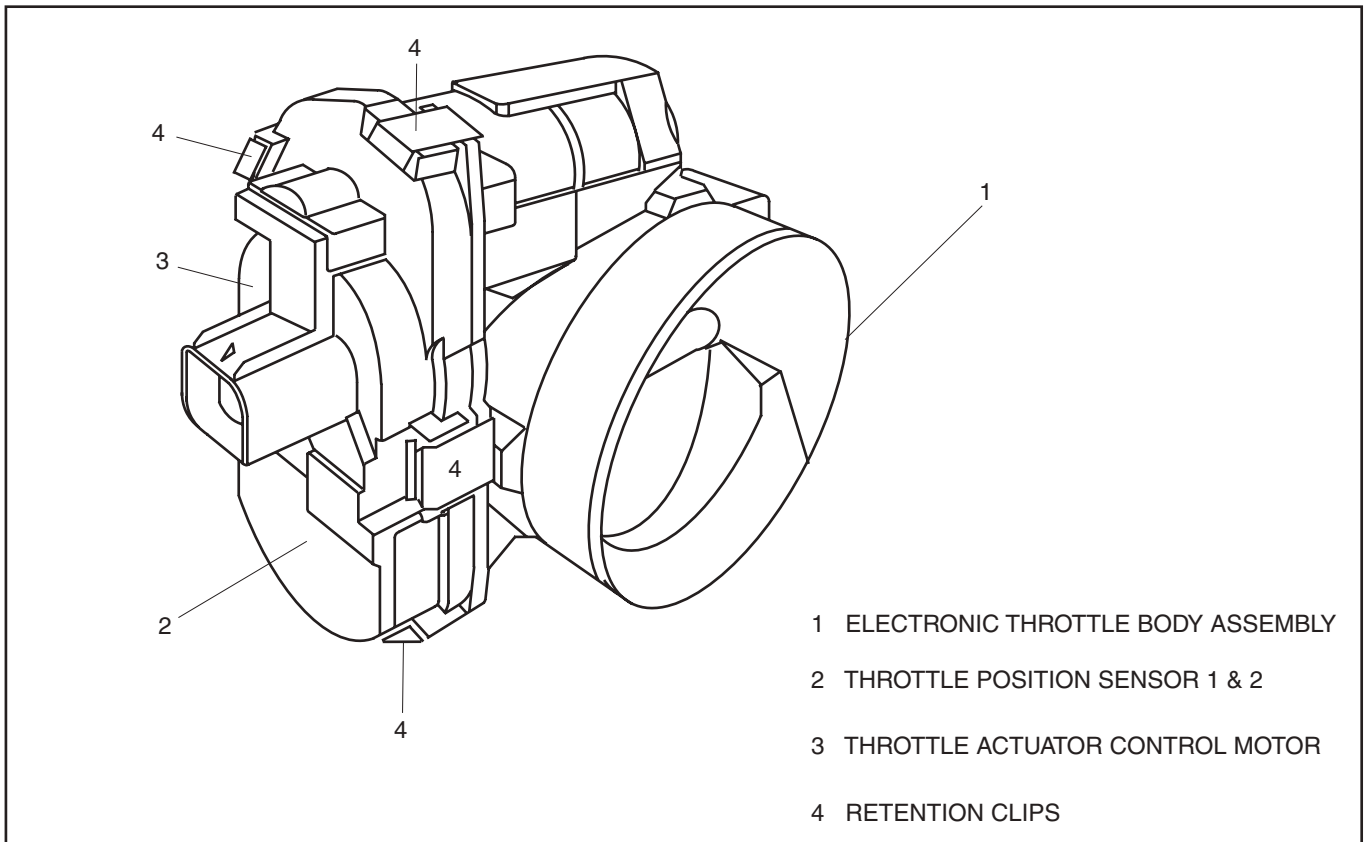


Figure 2-12 - Throttle Body Assembly

### Throttle Position (TP) Sensor

*Figure 2-12*

On this system there are two throttle position sensors both are contained within the plastic compartment that is attached to the side of the electronic throttle body.

This compartment also houses the throttle actuator control motor. If any component within this compartment should fail the whole compartment should be replaced.

### Idle Air Control (IAC)

On this system the idle air control function is managed by the ECM through the electronic throttle body. The throttle valve is adjusted by the TAC motor as commanded by the ECM.

## Knock Sensor (KS)

Figures 2-13 and 2-14

### Remove or Disconnect

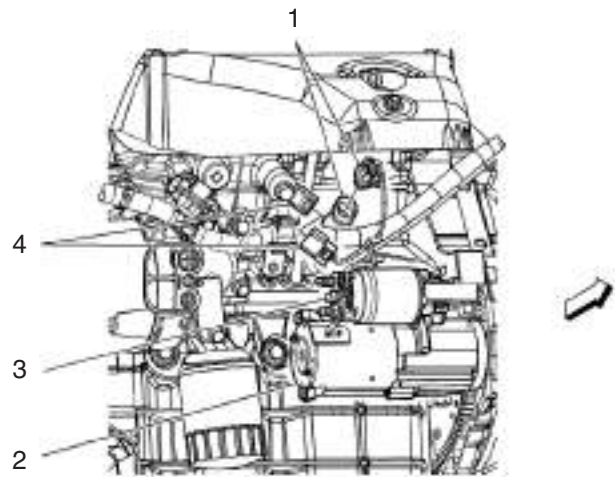
1. Negative battery cable.
2. Knock sensor electrical connector.
3. Knock sensor from engine block.

### Important

- If installing a new knock sensor, be sure to replace with an identical part number.
- When installing knock sensor, be sure to install in the same location removed from.
- If installing knock sensor in water jacket, use Teflon sealer #1052040 or equivalent.

### Install or Connect

1. Knock sensor into engine block. Be sure threads are clean. Torque to 15-22 N•m (11-16 lb. ft.).
2. Knock sensor electrical connector.
3. Negative battery cable.



1. Engine Oil Pressure (EOP) Switch
2. Starter
3. Starter Solenoid
4. Knock Sensor (KS) 2

Figure 2-13 - Knock Sensor Location

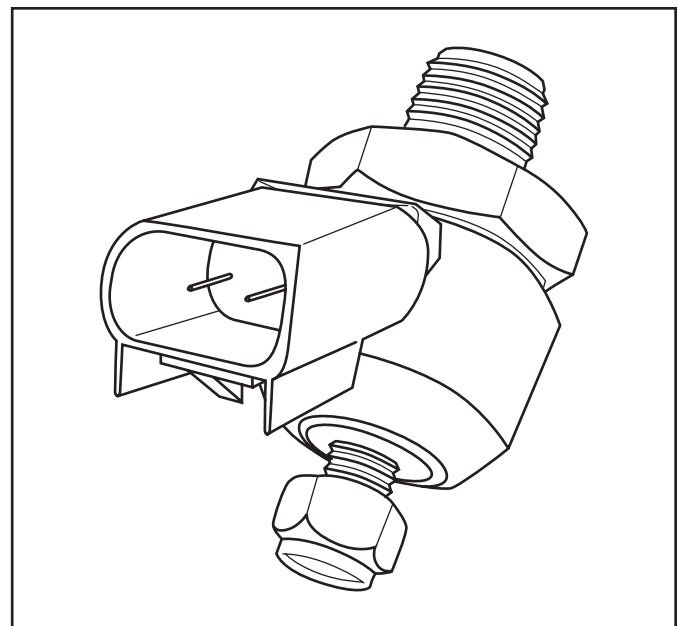


Figure 2-14 - Knock Sensor (Typical)

## Torque Specifications

### Fastener Tightening Specifications

Application	N•m	Lb. Ft	Lb. In
ECM Mounting Screws	10-14		88-124
ECT Sensor	12		108
MAP Sensor Attaching Screws	5-7		44-62
TP Sensor Attaching Screws	2		18
IAC Valve Attaching Screws	3.2		28
Knock Sensor	15-22	11-16	



## Section 3

### Fuel & Air Metering System - Port Fuel Injection (PFI) - 5.7L

This section describes how the fuel metering system operates, and provides a description of components used on the System4 Electronic Fuel Injection equipped engines. The fuel metering system information described in this manual is limited to Port Fuel Injection (PFI) used on the 5.7L. All other systems will be detailed in a separate manual. In distinguishing fuel systems used on specific applications, the following rules apply. PFI systems have separate injectors for each cylinder. The injectors are located in each of the intake manifold runners and are supplied by a fuel rail. TBI systems use two injectors mounted at the top of the throttle body assembly.

## Contents

<b>General Description</b> .....	Page 2		
Purpose.....	Page 2	<b>On-Board Service</b> .....	Page 5
Modes of Operation .....	Page 2	Fuel Control On-Board Service.....	Page 6
Starting Mode .....	Page 2	Fuel Pressure Relief Procedure.....	Page 6
Clear Flood Mode.....	Page 2	Flame Arrestor .....	Page 6
Run Mode .....	Page 2	Electronic Throttle Body Assembly .....	Page 7
Acceleration Mode.....	Page 2	Fuel Rail Assembly .....	Page 9
Fuel Cutoff Mode.....	Page 2	Fuel Injectors .....	Page 12
RPM Reduction Mode .....	Page 2	Fuel Pump (Pump-in-Tank).....	Page 13
Return and Returnless .....	Page 2	Fuel Pump Relay .....	Page 13
Fuel Metering System Components		In-Line Fuel Filter (Pump-in-Tank) .....	Page 14
(Pump-in-Tank).....	Page 3	Primary Fuel Filter (Pump-in-Tank).....	Page 14
Fuel Supply Components (Pump-in-Tank)....	Page 3	<b>Torque Specifications</b> .....	Page 15
Fuel Pump Electrical Circuit .....	Page 4	<b>Electronic Throttle Control (ETC)</b>	
Fuel Rail Assembly .....	Page 4	<b>Description</b> .....	Page 16
Fuel Injectors.....	Page 4	ECM Function .....	Page 17
Throttle Body Assembly .....	Page 5	Electronic Throttle Body Assembly .....	Page 17
		Throttle Position Sensor (TPS).....	Page 17
		Throttle Actuator Control (TAC) Motor .....	Page 17
		Pedal Position Sensor (PPS).....	Page 18
		Electronic Throttle Control (ETC) Basics .....	Page 19
		Optional Cruise Control System.....	Page 20

## General Description

### Purpose

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

### Modes Of Operation

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

### Starting Mode

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

### Clear Flood Mode

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

### Run Mode

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

### Acceleration Mode

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

### Fuel Cutoff Mode

No fuel is delivered by the injector when the ignition is “OFF,” to prevent dieseling. Also, injector pulses are not delivered if the ECM does not receive distributor reference pulses, which means the engine is not running. The fuel cutoff mode is also enabled at high engine RPM, as an overspeed protection for the engine. When fuel cutoff is in effect due to high RPM, injector pulses will resume after engine RPM drops below the maximum OEM RPM specification (Rev Limit).

### RPM Reduction Mode

The ECM recognizes a change of state in a discrete switch input that identifies an abnormal condition. This engine protection feature allows the operator normal engine operation up to OEM specifications (approx. 1400-2000 RPM), but causes RPM reduction with a control algorithm that overrides normal electronic throttle control. This throttle override feature takes over normal throttle operation to allow the engine to operate only at the reduced throttle RPM. This feature allows the operator a safe maneuvering speed while removing the possibility of high RPM engine operation until the problem is corrected.

### Return and Returnless

The type of fuel system, return or returnless, will vary depending on year, and engine. Removal and installation procedures are the same with the exception of return line removal or installation. Returnless fuel systems are not regulated at the fuel rail. Fuel pressure regulation is controlled at the module outlet filter, therefore the type of fuel system can be determined by the number of fuel lines from the pump-in-tank module to the engine.

### Fuel Metering System Components (Pump-in-Tank)

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

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

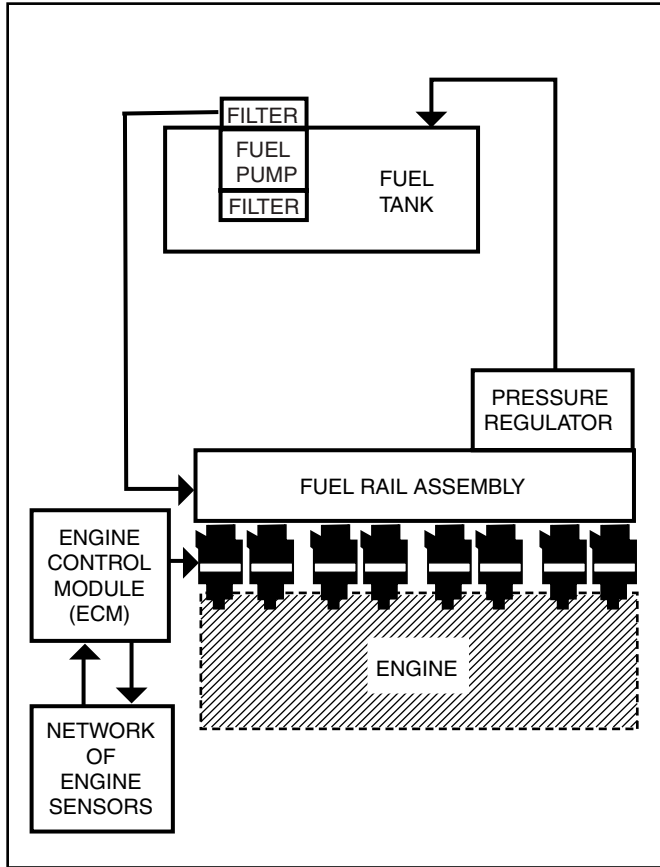


Figure 3-1 - Fuel Metering System (Pump-in-Tank Return)

### Fuel Supply Components (Pump-in-Tank)

The fuel supply is stored in the fuel tank. A fuel pump module (Figure 3-2), located in the fuel tank, pumps fuel through an in-line fuel filter to the fuel rail assembly. The pump is designed to provide fuel at a pressure greater than is needed by the injectors. The pressure regulator, part of the fuel rail assembly, keeps fuel available to the injectors at a regulated pressure. If the system uses a return line, then the unused fuel is returned to the fuel tank by a separate line.

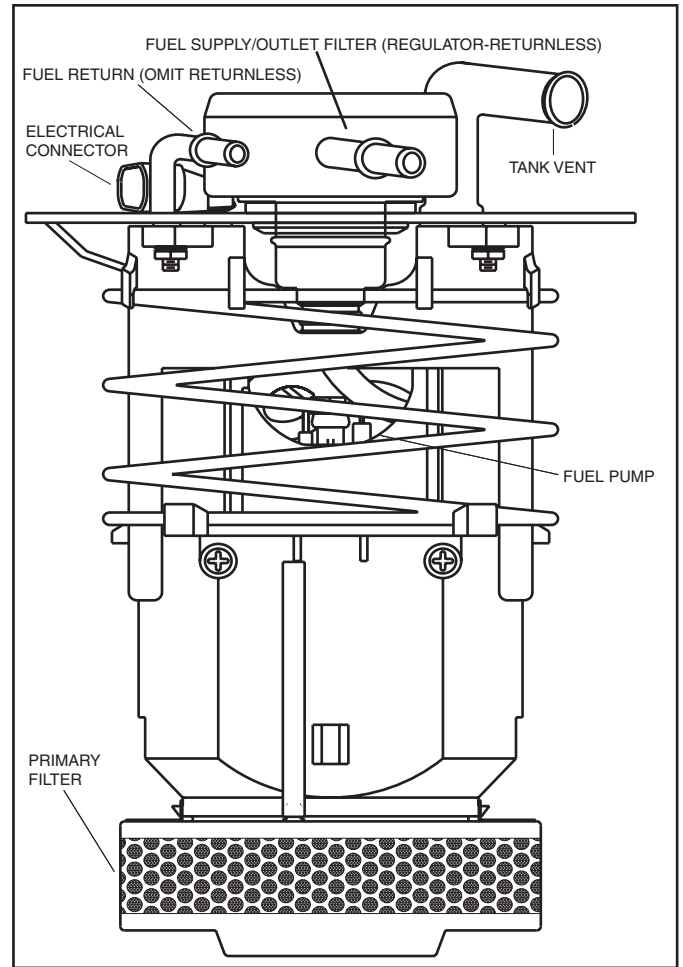


Figure 3-2 - Fuel Pump Module

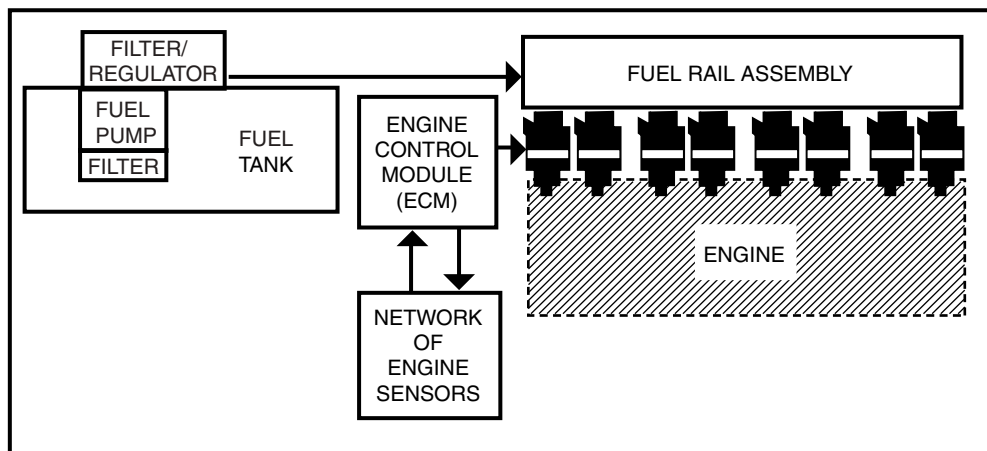


Figure 3-1b - Fuel Metering System (Pump-in-Tank Returnless)

**Fuel Pump Electrical Circuit**

When the ignition switch is turned “ON,” the ECM turns the fuel pump relay “ON” for two seconds causing the fuel pump to pressurize the fuel system.

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

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

An inoperative fuel pump relay will result in an “Engine Cranks But Will Not Run” condition.

**Fuel Rail Assembly**

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

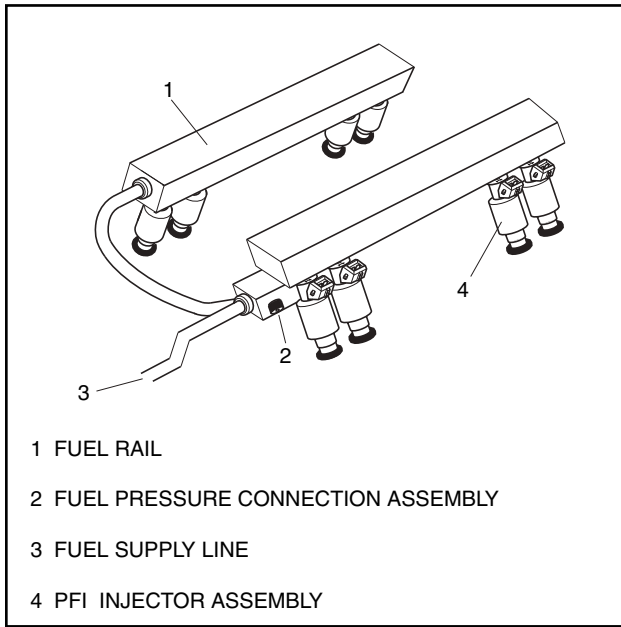


Figure 3-3 - Fuel Rail Assembly (Typical)

**Fuel Injectors**

The Port Fuel Injection (PFI) injector assembly is a solenoid-operated device, controlled by the ECM, that meters pressurized fuel to a single engine cylinder (Figure 3-4). The ECM energizes the injector solenoid, which opens a ball valve, allowing fuel to flow past the ball valve, and through a recessed flow director plate. The director plate has six machined holes that control the fuel flow, generating a conical spray pattern of finely atomized fuel at the injector tip. Fuel is directed at the intake valve, causing it to become further atomized and vaporized before entering the combustion chamber.

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

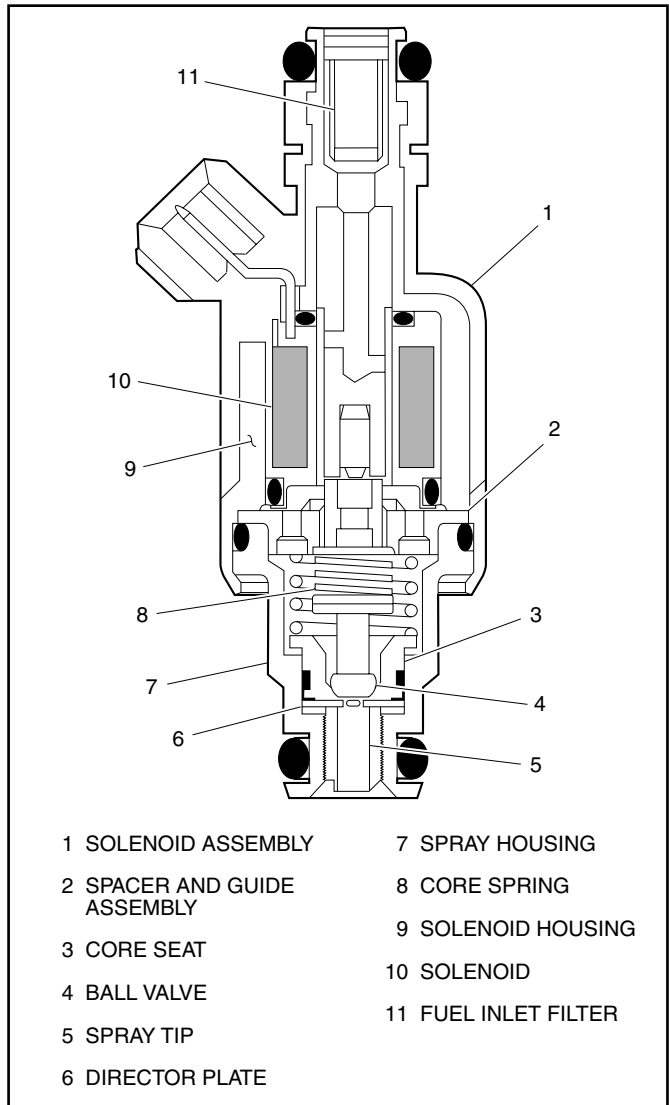


Figure 3-4 - PFI Injector Assembly (Typical)

### Throttle Body Assembly

The throttle body assembly is attached to the intake manifold air plenum, and is used to control air flow into the engine, thereby controlling engine output (Figure 3-5). The throttle plates within the throttle body are opened by the driver through the throttle controls. During engine idle, the throttle plates are controlled by the ECM.

The throttle body also provides the location for mounting the TP sensor and for sensing changes in engine vacuum due to throttle plates position.

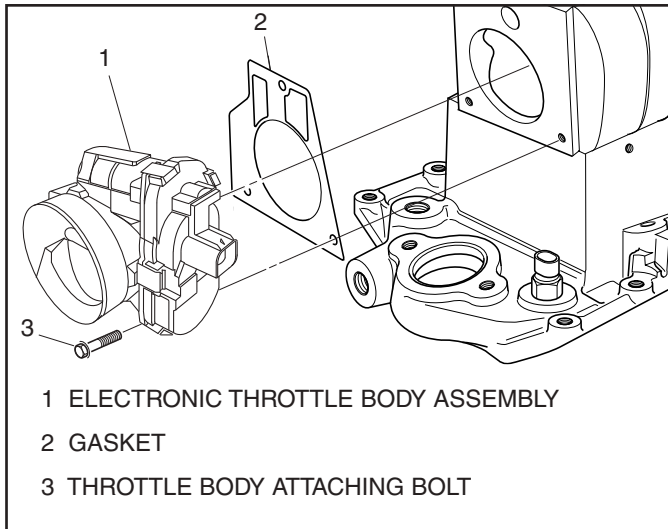


Figure 3-5 - Throttle Body Assembly, Cable Actuated

### On-Board Service

**Caution:**

**To reduce the risk of fire and personal injury, relieve fuel system pressure before servicing fuel system components.**

**After relieving fuel pressure, a small amount of fuel may be released when servicing fuel lines or connections. To reduce the chance of personal injury, cover fuel line fittings with a shop towel before disconnecting to catch any fuel that may leak out. Place the towel in an approved container when disconnection is completed.**

### Fuel Control On-Board Service

The following is general information required when working on the fuel system:

- Always keep a dry chemical fire extinguisher near the work area.
- Fuel pipe fittings require new O-rings when assembling.
- Do not replace fuel pipe with fuel hose.
- Always bleed off fuel pressure before servicing any fuel system components.
- Do not do any repairs on the fuel system until you have read the instructions and checked the figures relating the repair.
- Observe all notices and cautions.

### Fuel Pressure Relief Procedure

Tool Required:

J 34730-1, Fuel Pressure Gauge

### Important

- Refer to manufacturer's warnings and cautions before proceeding.
1. Disconnect negative battery cable to avoid possible fuel discharge if an accidental attempt is made to start the engine.

2. Loosen fuel filler cap to relieve any tank vapor pressure.
3. Connect fuel pressure gauge J 34730-1 to fuel pressure connector assembly. Wrap a shop towel around fitting while connecting the gauge to avoid any spillage.
4. Install bleed hose into an approved container and open valve to bleed system pressure. Fuel connections are now safe for servicing.
5. Drain any fuel remaining in the gauge into an approved container.

### Flame Arrestor

#### Remove or Disconnect

1. Flame arrestor retaining clamp.
2. Flame arrestor.

#### Inspect

- Flame arrestor element for dust, dirt or water. Replace if required.

#### Install or Connect

1. Flame arrestor to throttle body.
2. Flame arrestor retaining clamp to flame arrestor.

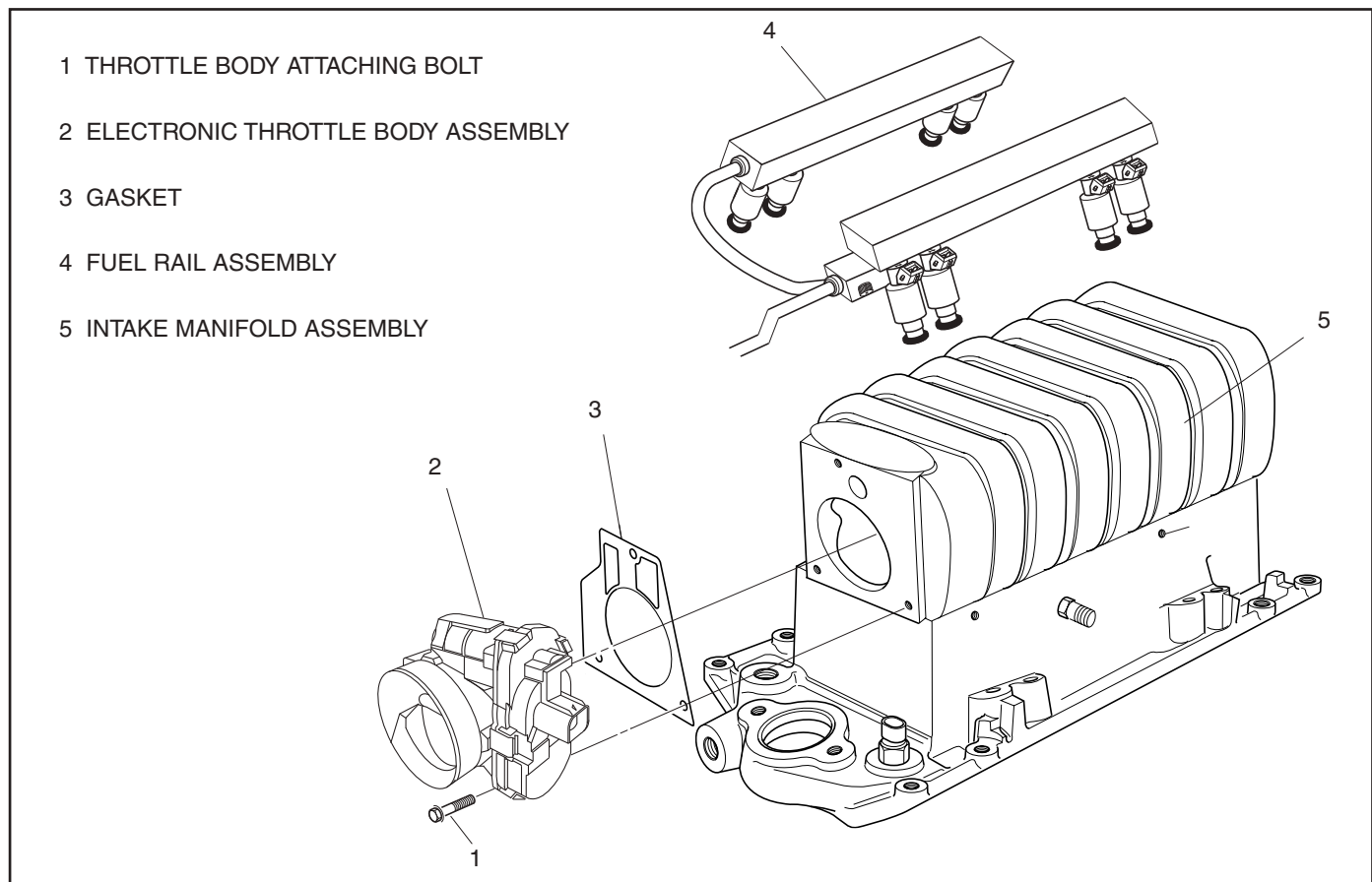


Figure 3-6 - Fuel Rail and Throttle Body Assemblies (Typical)

## Throttle Body Assembly

Figures 3-7 and 3-8

The throttle body assembly repair procedures cover component replacement with the unit on the vessel. However, throttle body replacement requires that the complete unit be removed from the engine.

### Clean

#### Important

- Do not soak the throttle body in cold immersion type cleaner. Some throttle valves have a factory applied sealing compound (DAG material is applied to outside edge of each valve and throttle bore) to prevent air bypass at closed throttle. Strong solvents or brushing will remove the material. To clean the throttle body following disassembly, use a spray type cleaner such as GM X66-A or GM 1052626. Use a shop towel to remove heavy deposits.
- When cleaning electronic throttle bodies, extreme care should be taken not to allow solvents of any kind in or near the actuator motor.

**Notice:** The TP sensors and the TAC Motor are electrical components and should NOT come in contact with solvent or cleaner as they may be damaged.

#### Remove or Disconnect

1. Negative battery cable.
2. Flame arrestor.
3. Electrical connector from Electronic Throttle Body.
4. Vacuum lines.
5. Throttle adjuster to throttle body cable.
6. Throttle body attaching bolts.
7. Throttle body assembly and flange gasket.
  - Discard gasket.

### Clean

**Notice:** Use care in cleaning old gasket material from machined aluminum surfaces as sharp tools may damage sealing surfaces.

- Gasket sealing surfaces.

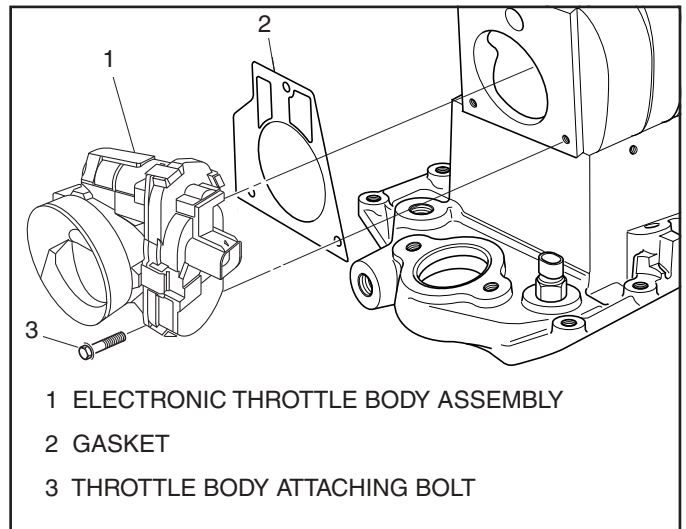


Figure 3-7 - Throttle Body Removal (Typical)

#### Install or Connect

1. Throttle body assembly with new flange gasket.
2. Throttle body attaching bolts. Torque to 15 N•m (11 lb.ft.).
3. Throttle adjuster to throttle body cable.
4. Vacuum lines.
5. Electrical connector to Electronic Throttle Body.
6. Flame arrestor.
7. Negative battery cable.

#### Inspect

- With the engine "OFF," check to see that the throttle lever is free.
  - Move the throttle lever to wide open throttle and release.

Reset proper idle speed:

- Move throttle lever slightly.
- Start and run engine for 5 seconds.
- Turn ignition "OFF" for 10 seconds.
- Restart engine and check for proper idle operation.

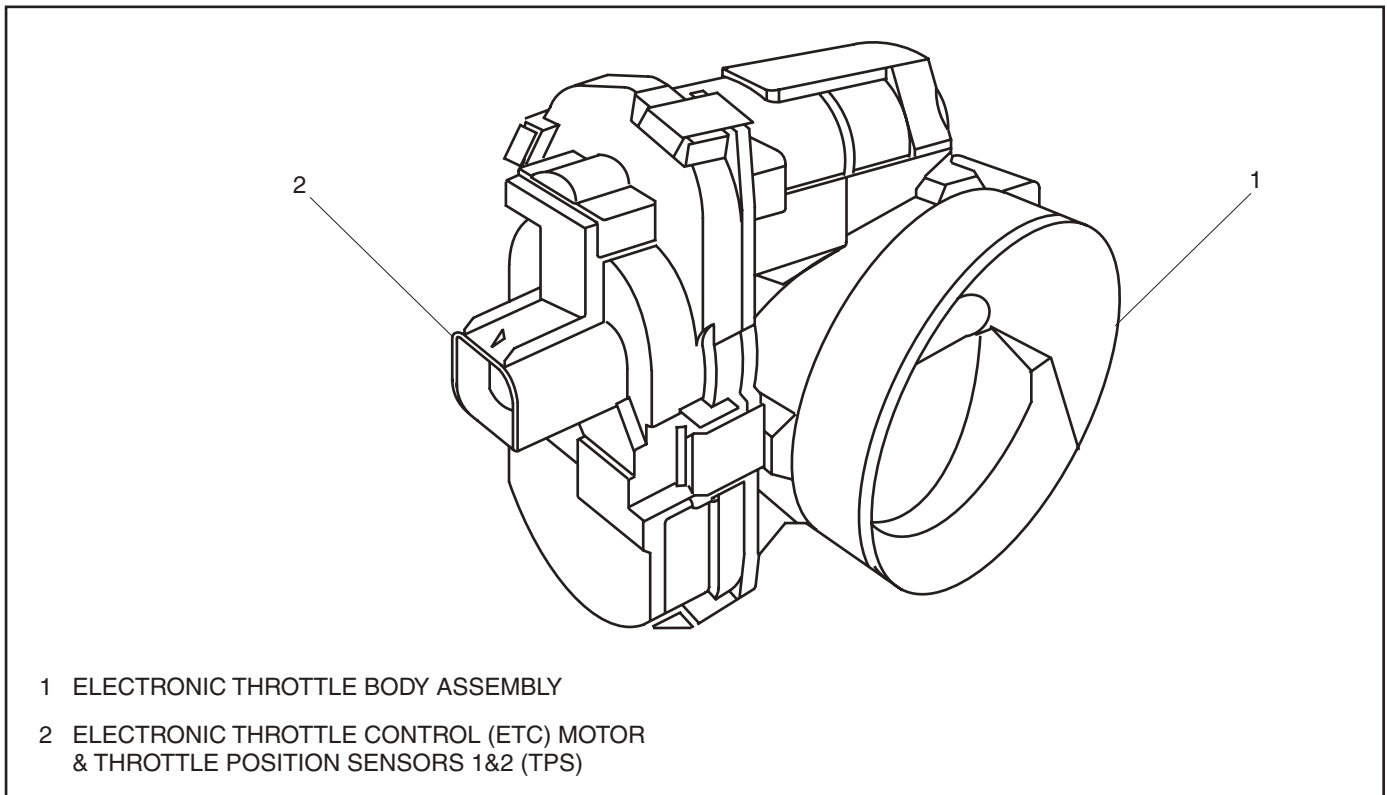


Figure 3-8 - Electronic Throttle Body Assembly (Typical)



## Fuel Rail Assembly

Figures 3-9 and 3-10

The fuel rails should be removed as an assembly with the injectors attached. Names of component parts will be found on the numbered list that accompanies the disassembled view (Figure 3-13).

### Notice:

- Use care in removing the fuel rail assembly to prevent damage to the injector electrical connector terminals and the injector spray tips.
- When removed, support the rail to avoid damaging its components.
- Prevent dirt and other contaminants from entering open lines and passages. Fittings should be capped and holes plugged during servicing.

### Clean

- Before removal, the fuel rail assembly may be cleaned with a spray type engine cleaner, following package instructions. Do Not soak fuel rails in liquid cleaning solvent.

**Caution: Safety glasses must be worn when using compressed air as flying dirt particles may cause eye injury.**

- Where injectors fit into intake manifold, use compressed air to blow out dirt from around injectors before removing.

### Remove or Disconnect

**Caution: To reduce the risk of fire and personal injury, relieve the fuel system pressure before servicing the fuel system components.**

1. Negative battery cable.
2. Relieve fuel pressure.
  - Refer to the “Fuel Pressure Relief Procedure.”
  - Fuel pressure connector assembly is located on right side rail in center of fuel rail.
3. Fuel inlet line, hold fitting in rail with a wrench to keep from turning.
4. Fuel outlet fitting at pressure regulator.
  - Hold pressure regulator with a wrench to keep from turning and damaging.
5. Vacuum line to fuel pressure regulator.
6. Retaining screw for pressure regulator and pressure regulator.
7. Electrical connectors from injectors.
  - To release electrical connector from injector, squeeze on metal loop with thumb and pull connector from injector.

8. Move wire harness out of way.
9. Four attaching screws for fuel rail.
10. Fuel rails as an assembly with injectors.
11. Injectors from rails, follow procedure for injector removal outlined in this section.
12. Retaining screws for fuel rail jumper line.
13. Twist and remove jumper line from rail.

### Clean and Inspect

**Notice:** If it is necessary to remove rust or burrs from the fuel rail pipes, use emery cloth in a radial motion with the tube end to prevent damage to the O-ring sealing surface.

- Use a clean shop towel to wipe off male pipe ends.
- Inspect all connectors for dirt and burrs. Clean or replace components/assemblies as required.

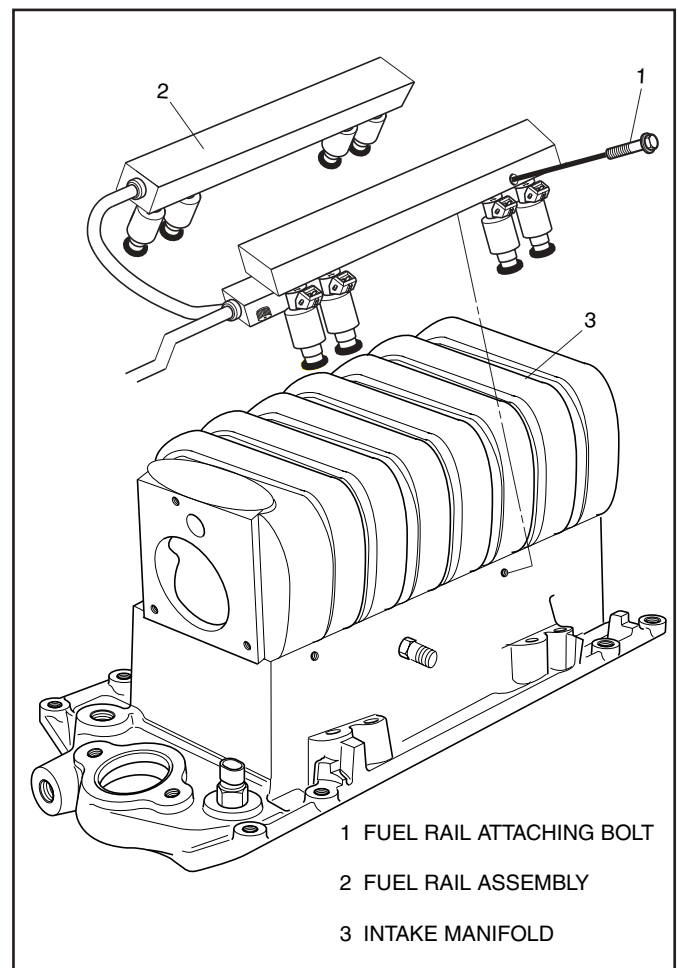


Figure 3-9 - Fuel Rail Removal and Installation (Typical)

**Disassemble**

- Injector O-ring seal from spray tip end of each injector. Discard O-ring seals.

**Assemble**

- Lubricate new injector O-ring seals with clean engine oil and install on spray tip end of each injector.

**Install or Connect**

1. Lubricate new O-ring seals and install on rail jumper line ends.
2. Rail jumper line in rails, long side of jumper to left rail.
3. Jumper line attaching screws. Torque to 7 N•m (62 lb.in.).
4. Lubricate injector O-ring seals and install injectors following injector installation procedure outlined in this section.
5. Fuel rails as an assembly with injectors onto intake manifold.
  - If injectors are lined up properly they will slide into place.
  - Push gently and evenly on rail to set injectors all the way into their bores

6. Fuel rail attaching screws. Torque to 10 N•m (88 lb.in.).
7. Injector electrical connectors and secure harness in place.
8. Lubricate new O-ring seal on pressure regulator and install pressure regulator.
9. Pressure regulator attaching screw. Torque to 9.5 N•m (84 lb.in.).
10. Vacuum line to fuel pressure regulator.
11. Lubricate new O-ring seal on pressure regulator outlet fitting and tighten fitting, careful not to twist regulator. Torque to 17.5 N•m (13 lb.ft.).
12. Inlet fuel line.
13. Negative battery cable.
14. Prime fuel system by cycling key “ON” and “OFF” a few times with engine “OFF”

**Inspect**

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

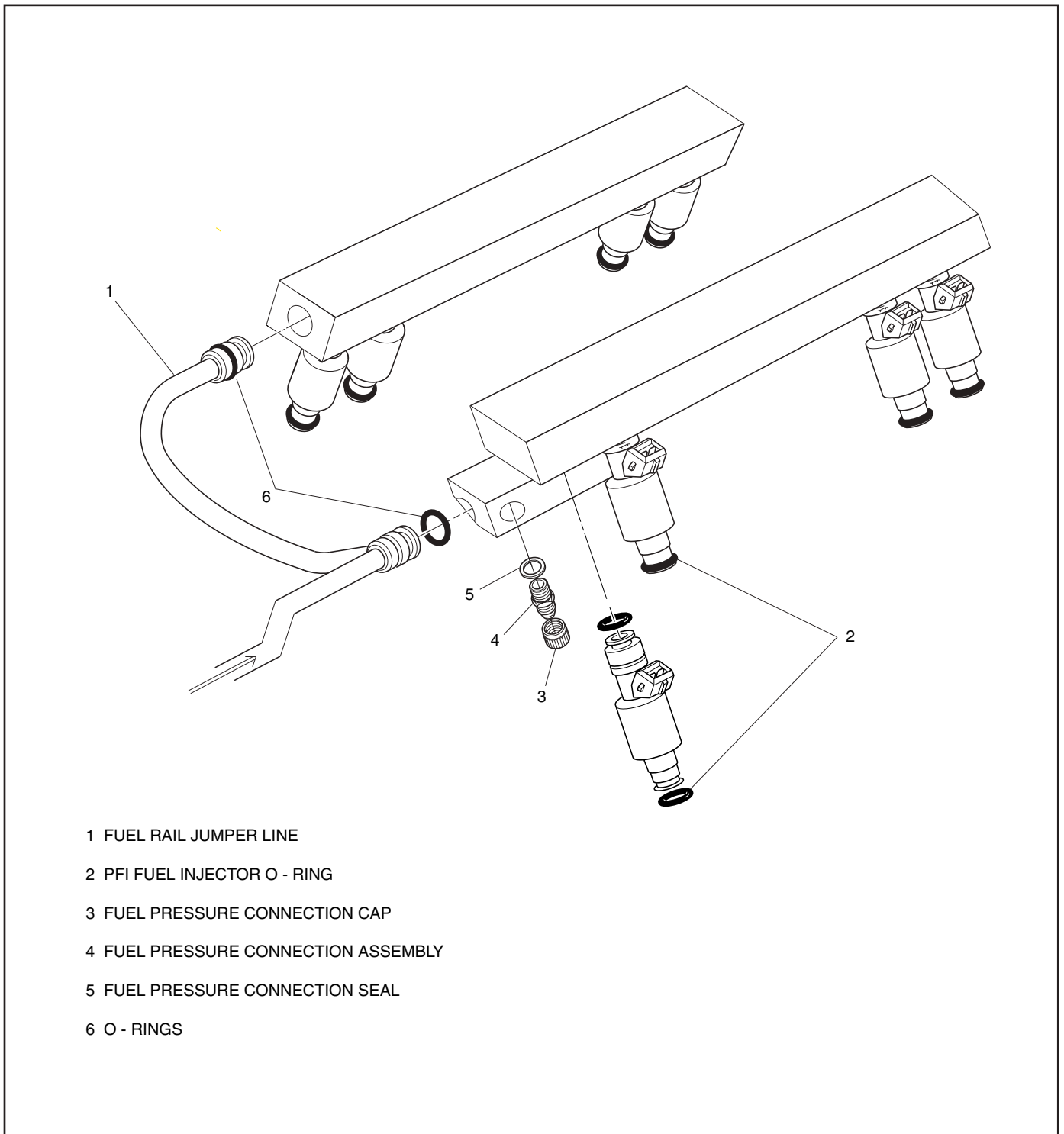


Figure 3-10 - Fuel Rail Assembly (Typical)

## Fuel Injectors

Figures 3-11

**Notice:** Use care in removing injectors to prevent damage to the injector electrical connector pins or the injector spray tips. The fuel injector is serviced as a complete assembly only. Since it is an electrical component, Do Not immerse it in any cleaner.

### Remove or Disconnect

1. Negative battery cable.
2. Relieve fuel pressure.
  - Refer to the “Fuel Pressure Relief Procedure.”
3. Fuel rail assembly following the procedures outlined in this section.

### Disassemble

1. Release injector clip by sliding off injector (Figure 3-14).
2. PFI injector from rail.
3. Injector O-ring seals from both ends of the injector and discard.
4. Injector retainer clip from rail.

### Clean and Inspect

- Injector bores in fuel rail and intake manifold for nicks, burrs or corrosion damage. If severe, replace. Clean lightly with emery cloth in a radial motion.
- Injector O-ring seal grooves for nicks, burrs or corrosion. Replace injector if damaged. Clean with spray cleaner and wipe groove clean with lint free cloth.
- Do Not use abrasive materials or wire brush on injectors. They are plated with an anti-corrosive material.

### Important

- When ordering individual replacement fuel injectors, be sure to order the identical part number that is inscribed on the old injector.

### Assemble

1. Lubricate new injector O-ring seals with clean engine oil and install on injector.
2. New retainer clip onto injector.
3. PFI fuel injector assembly into fuel rail injector socket with electrical connector facing outward.
4. Rotate injector retainer clip to locking position.

### Install or Connect

1. Fuel rail assembly following procedures outlined in this section.
2. Negative battery cable.

### Inspect

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

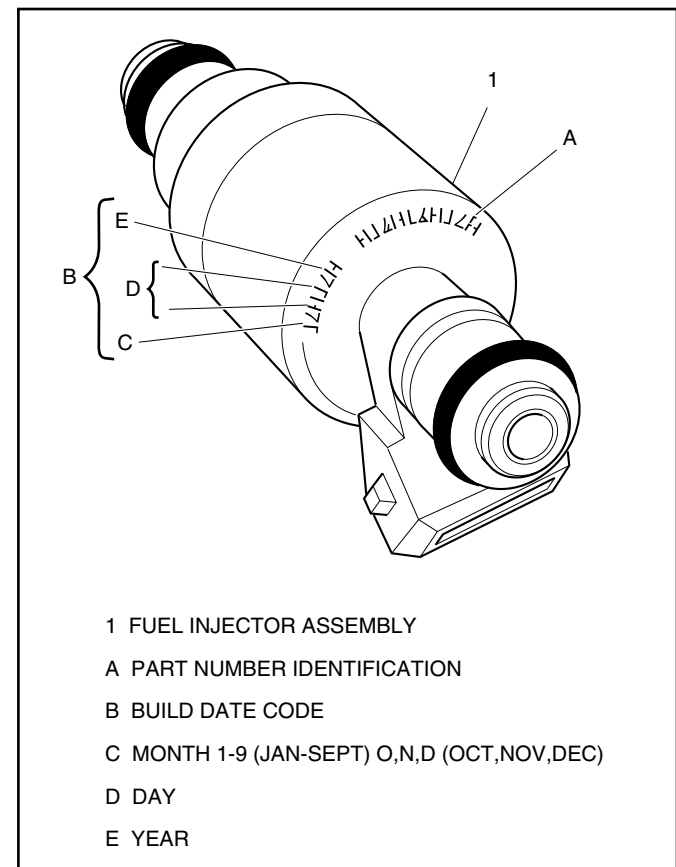


Figure 3-11 - Injector Part Number Location

## Fuel Pump

Figure 3-12

### Important

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

### Remove or Disconnect

1. Negative battery cable.
2. Fuel pump module electrical connector.
3. Supply and return fuel line fittings.
4. Fuel tank vent hose.
5. Fuel pump module.

**Notice:** Make sure to replace the fuel pump module with the identical part number.

### Install or Connect

1. Fuel pump module.
2. Fuel tank vent hose.
3. Supply and (return, if used) fuel line fittings.
4. Fuel pump module electrical connector.
5. Negative battery cable.

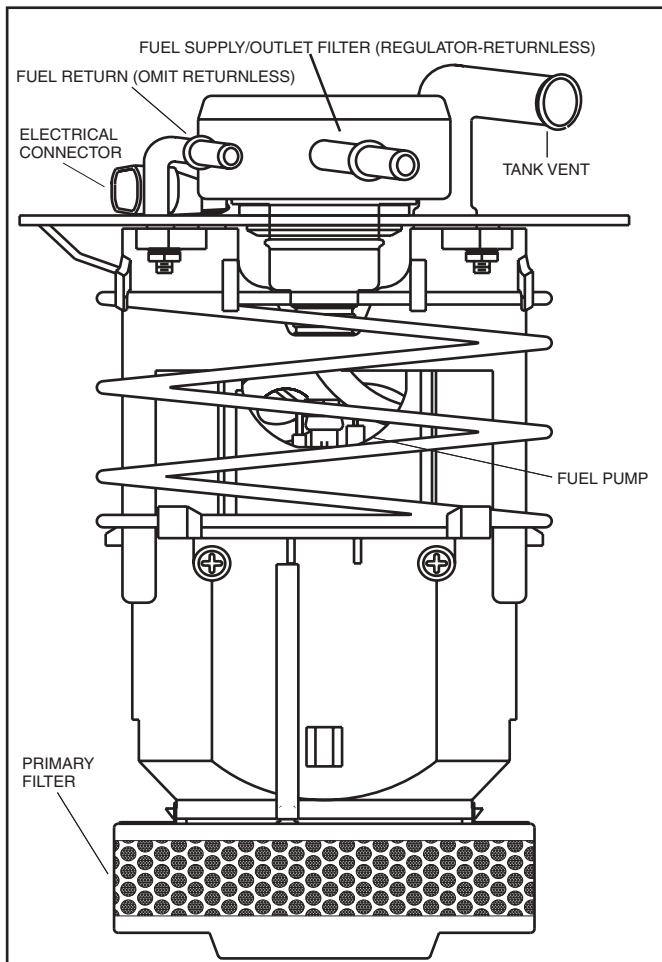


Figure 3-12 - Fuel Pump, In Tank (Typical)

### Inspect

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

## Fuel Pump Relay

Figure 3-13

### Remove or Disconnect

1. Retainer, if installed.
2. Fuel pump relay electrical connector.
3. Fuel pump relay.

### Important

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

### Install or Connect

1. Fuel pump relay.
2. Fuel pump relay electrical connector.
3. Retainer clip.

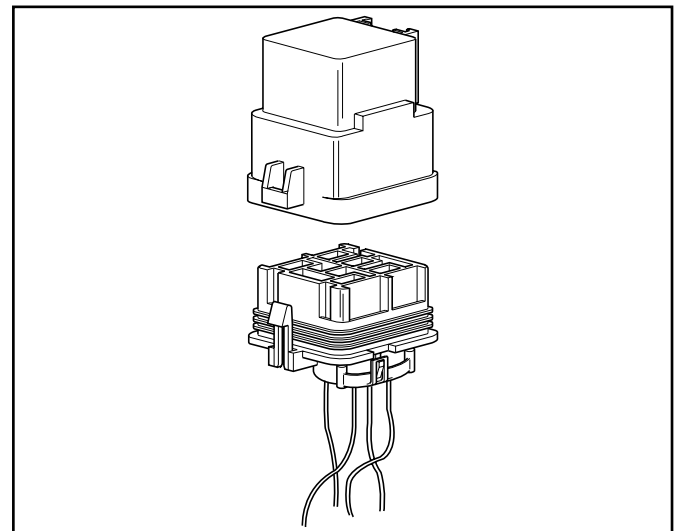


Figure 3-13- Fuel Pump Relay

**In-Line Fuel Filter (Pump-in-Tank)***Figure 3-14***Important**

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

**Remove or Disconnect**

1. Supply fuel line.
2. Filter from module mounting flange.
3. Fuel supply tube from fuel pump.

**Inspect**

- In-line fuel filter for being plugged or contaminated. Replace as necessary.

**Install or Connect**

1. Fuel supply tube from fuel pump.
2. Filter in module mounting flange.
3. Supply fuel line

**Inspect**

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

**Important**

- Fuel system needs to be primed and air bled out of the lines before the engine is started. Follow manufacturers recommendation for priming fuel system.

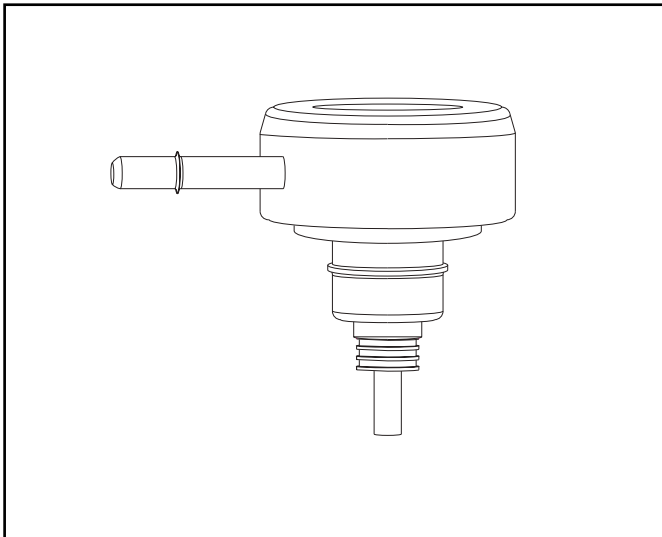


Figure 3-14 - In-Line Fuel Filter/Regulator (Typical)

**Primary Fuel Filter, In-Tank***Figure 3-15***Important**

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

**Remove or Disconnect**

1. Fuel pump module from tank.
2. Filter from module reservoir bottom.

**Inspect**

- Primary fuel filter for being plugged or contaminated. Replace as necessary.

**Install or Connect**

1. Filter on bottom of module reservoir.
2. Fuel pump module in the tank.

**Inspect**

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

**Important**

- Fuel system needs to be primed and air bled out of the lines before the engine is started. Follow manufacturers recommendation for priming fuel system.

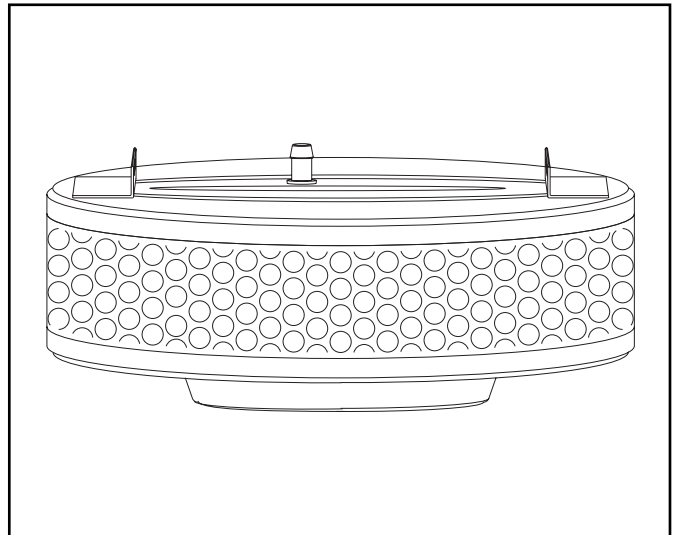


Figure 3-15 - Primary Inlet Fuel Filter (Typical)

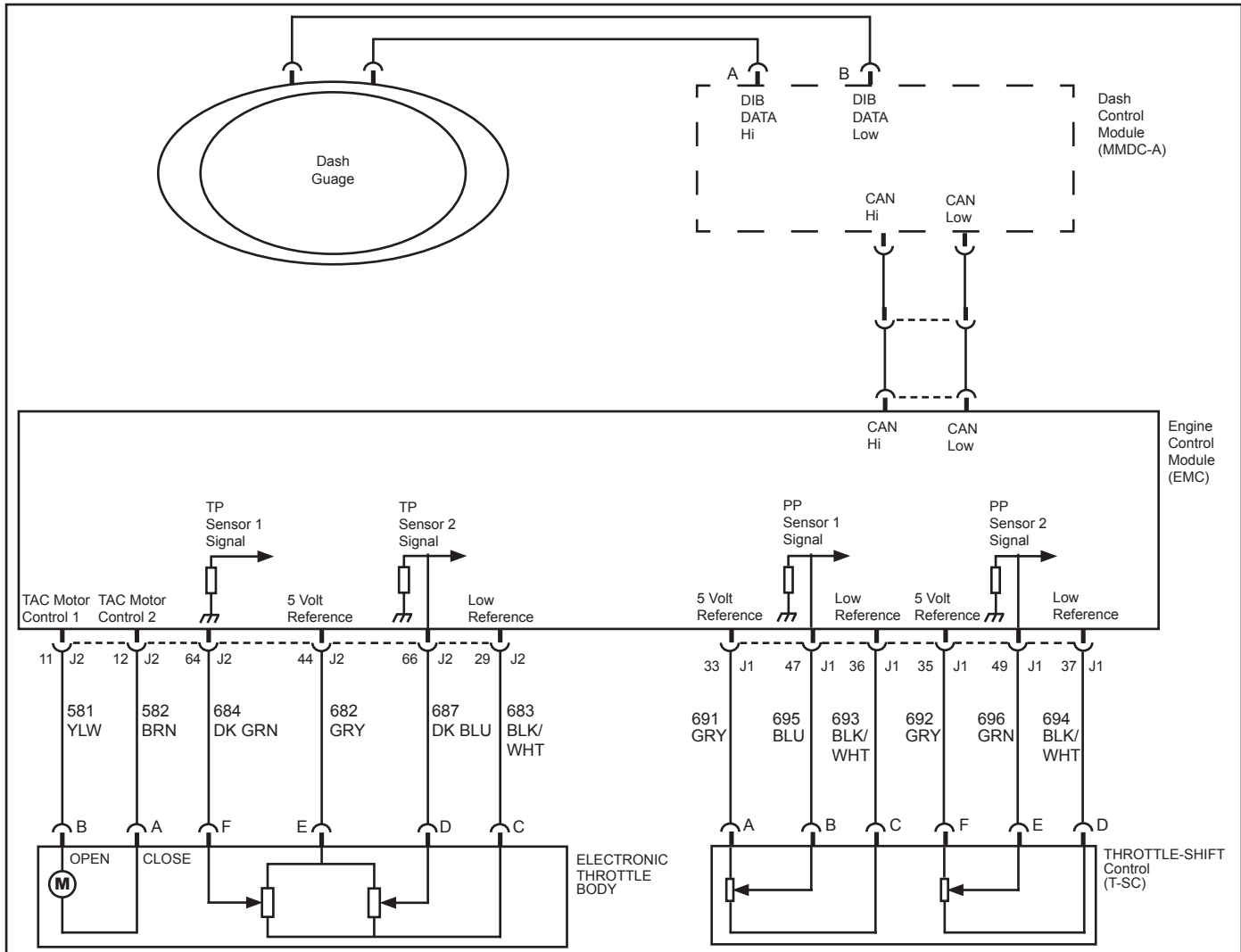
## Torque Specifications

### Fastener Tightening Specifications

Application	N•m	Lb Ft	Lb In
Throttle Body Attaching Screws	15	11	
IAC Valve Attaching Screws (If Used)	3.2		28
Fuel Pressure Connector	13		115
Fuel Pressure Regulator Attaching Screw	9.5		84
Fuel Pressure Regulator Outlet Line Nut	17.5	13	
Fuel Rail Jumper Line Attaching Screws	7		62
Fuel Rail Attaching Screws	10		88

## Fuel & Air Metering System - Port Fuel Injection (PFI) - 5.7L

### Electronic Throttle Control Description



### Electronic Throttle Control (ETC)

#### Components

The Electronic Throttle Control (ETC) system uses the boat electronics and components in order to calculate and control the position of the throttle blade. This system eliminates the need for a mechanical cable attachment from the Throttle-Shift Control (T-SC) to the electronic throttle body assembly.

The ETC system components include the following:

- The ECM
- The Throttle Position Sensor (TPS) is located in a sealed housing, which is mounted to the side of the electronic throttle body assembly.
- The Throttle Actuator Control (TAC) motor is located within the same sealed housing as the TPS.
- The Pedal Position Sensor (PPS) is located within a sealed housing mounted to the Throttle-Shift Control (T-SC).

Each of these components interface together in order to ensure accurate calculations, and in order to control the throttle position.

### Engine Control Module (ECM)

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

- Fuel metering system
- Ignition timing
- Idle speed
- On-board diagnostics for engine functions
- Boat speed
- Throttle position

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

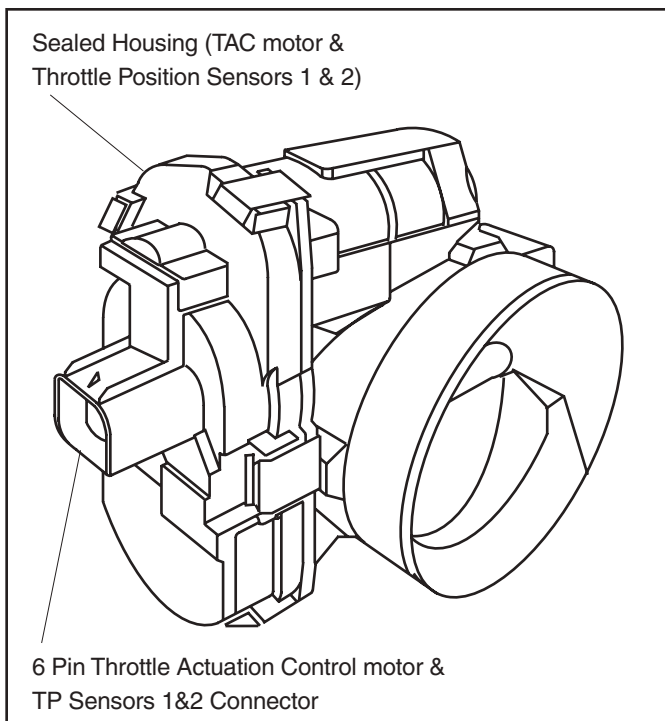


### ECM Function

The ECM supplies either 5 or 12 volts to power various sensors or switches. This is done through resistances in the ECM which are so high in value that a test light will not illuminate when connected to the circuit. In some cases, an ordinary voltmeter will not give an accurate reading because its resistance is too low. Therefore, a digital voltmeter with at least 10 megohms input impedance is required to ensure accurate voltage readings. Tool J 39978, Fluke 78 or Fluke 87 meets this requirement. The ECM controls output circuits such as the injectors, relays, etc. by controlling the ground or power feed circuit.

The ECM also controls the Electronic Throttle Control (ETC). The ECM monitors the commanded throttle position and compares the commanded position to the actual throttle position. This is accomplished by monitoring the Pedal Position Sensors (PPS) (located on the Throttle-Shift Control [T-SC]) and the Throttle Position Sensors (TPS). These two values must be within a calibrated value of each other. The ECM also monitors each individual circuit of the TPSs, and of the PPSs to verify proper operation (the Pedal Position Sensor reads the degree of movement of the Throttle-Shift Control from 0 degrees at locked neutral, to 120 degrees at Wide Open Throttle [WOT]).

### Electronic Throttle Body Assembly



The Electronic Throttle Body Assembly consists of the electronic throttle body, the Throttle Position Sensors (2), and the Throttle Actuation Control (TAC) motor. The throttle body has a sealed housing mounted to the side of it, which contains the two Throttle Position Sensors (TPS) and the Throttle Actuation Control (TAC) motor. The electronic throttle body assembly is connected to the ECM by a single 6 pin connector to the wiring harness.

### Throttle Position Sensor (TPS)

The Throttle Position Sensor (TPS) and the Throttle Actuation Control (TAC) motor are contained within a sealed housing mounted onto the side of the electronic throttle body assembly. If one of these components should become defective the electronic throttle body assembly must be replaced as a complete unit.

The TPS is actually two individual sensors within the above mentioned sealed housing. The TPSs use two separate signal circuits, however the two sensors share one low reference circuit and one, 5 volt reference circuit.

The TPS 1 signal voltage is pulled up to the reference voltage as the throttle opens, from ~0.6 volts at closed throttle to ~4.3 volts at wide open throttle (WOT). The TPS 2 signal voltage is pulled down to the reference voltage as the throttle opens, from ~4.3 volts at closed throttle to ~0.6 volts at WOT.

TPS 1 and Pedal Position Sensor (PPS) 1 share a 5 volt reference circuit that is connected within the ECM. TPS 2 and Pedal Position Sensor (PPS) 2 also share a 5 volt reference circuit that is connected within the ECM.

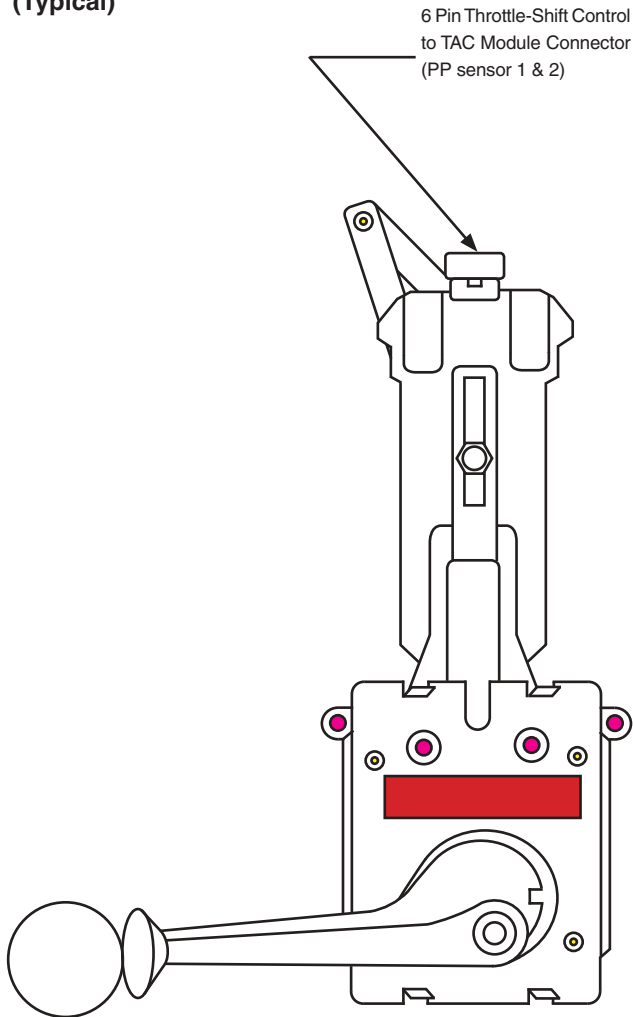
The PPS 1 signal voltage is pulled up to the reference voltage as the throttle opens, from ~0.45 volts at closed throttle to ~4.18 volts at wide open throttle (WOT). The PPS 2 signal voltage is pulled down to the reference voltage as the throttle opens, from ~4.55 volts at closed throttle to ~0.82 volts at WOT.

### Throttle Actuation Control (TAC) Motor

The Throttle Actuation Control (TAC) motor and the TPSs are located within one sealed housing mounted onto the side of the electronic throttle body. If one of these components should become defective, the electronic throttle body assembly must be replaced as a complete unit. The unit is connected to the ECM by one 6 pin connector.

The TAC motor is used to control the throttle position instead of a mechanical cable. This system eliminates the need for a mechanical cable attachment from the T-SC to the electronic throttle body assembly. The TAC motor also controls the throttle opening for idle and cold start/fast idle functions, thereby eliminating the need for an Idle Air Control (IAC) valve.

### Throttle-Shift Control (T-SC) (Typical)



The production Throttle-Shift Control (T-SC) unit is setup up for dual function in a single lever. It controls both shifting and throttle by a mechanical cable and by electronic throttle movement. Added features include a neutral interlock to help prevent accidental shifting and crisp positive detents. Also, the control has a push button clutch disengagement feature for warm-up and start-up adjustments for increased throttle. The throttle control is designed with neutral as the center location and is in gear when the lever is moved forward to crisp positive detent thirty degrees. The transmission cable is pulled with a one-to-one ratio as the lever rotates for the thirty degrees while the throttle blade is in the closed position. After the first thirty-five degrees, the throttle blade will begin to move and the transmission cable will stay at the thirty degree location. Maximum throttle is approximately one hundred twenty-five degrees. Reverse works in the same manner.

### Pedal Position Sensor

The Pedal Position Sensor (PPS) is mounted on the T-SC. The PPS is actually two individual position sensors within one housing. The PPSs use two separate signal circuits, two low references, and two 5 volt reference circuits to connect the PPSs to the ECM.

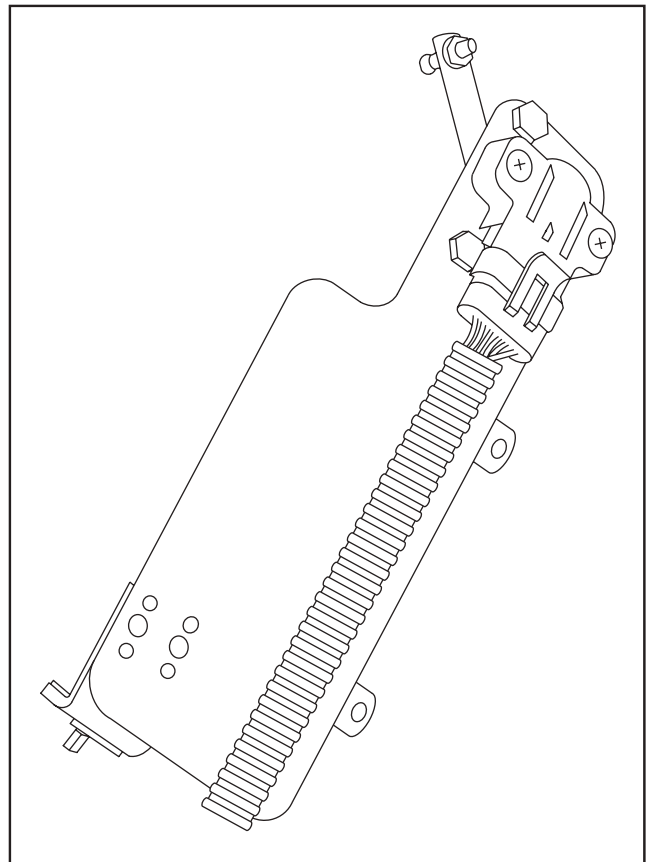
**Note:** The two PPSs operate in slightly different voltage ranges. Some variation in voltage above or below the normal calibration is acceptable, however more than approximately 0.15 volts will set a PPS 1-2 Correlation Fault.

The PPS 1 voltage should increase from below 1 volt at closed throttle to above 3.75 volts at WOT.

The PPS 2 voltage should decrease from below 5 volts at closed throttle to above 1 volt at WOT.

### Remote Mount Pedal Position Sensor (Typical)

#### Throttle Cable Interconnect



### Electronic Throttle Control (ETC) Basics

**Function:** Replaces the mechanical cable link from the Throttle-Shift Control (T-SC) to electronic throttle body assembly with a system of sensors and computer controlled throttle.

#### Components:

**Throttle Position Sensor (TPS 1 & 2):** These two individual sensors are housed together with one Throttle Actuation Control (TAC) motor within one sealed compartment. That sealed compartment is permanently mounted to the side of the electronic throttle body. There is one, 6 wire, connector plug leading from the electronic throttle body to the main wiring harness and eventually to the ECM.

**Pedal Position Sensor (PPS 1 & 2):** These two individual sensors, are housed together in one sealed compartment. That compartment is permanently attached to the aft end of the T-SC. There is one, six wire, connector plug leading directly from the T-SC to the ECM.

**ECM:** The ECM is the control center for the Electronic Throttle Control (ETC) system as well as the rest of the engine electronics. It communicates between the different sensors and the TAC motor. It constantly monitors the sensor readings.

The ECM continuously compares the voltage readings between TPS 1 and TPS 2. It looks for any variance from their normal operating voltage ranges. If variance is found a **TPS 1-2 Correlation** fault is set.

The ECM also monitors both TPS 1 and TPS 2 in case of a disconnected condition. If one of these sensors should become disconnected, then a **TPS 1 Out of Range or a TPS 2 Out of Range** fault will set. An **ETC Limited Authority** will also set (see Diagnosing the ETC system below for explanation). If this occurs the engine goes to idle.

Additionally, the ECM continuously compares the voltage readings between PPS 1 and PPS 2. It watches for any variance from their normal operating voltage ranges. If variance is found a **PPS 1-2 Correlation** fault will set.

The ECM also monitors both PPS 1 and PPS 2 in case of a disconnected condition. If one of these sensors becomes disconnected, then either a **PPS 1 Out of Range or a PPS 2 Out of Range** fault will set. An **ETC Limited Authority** will also set (see Diagnosing the ETC system below for explanation). If this occurs the engine goes into power reduction mode.

The ECM compares the predicted throttle position and the actual throttle position. The predicted throttle position is the amount of throttle called for by the pedal position sensor, which indicates how much throttle the driver wants. The actual throttle position is the current location (angle) of the throttle blade in the throttle body.

The ECM continuously compares the commanded throttle position and the actual throttle position. The commanded throttle position is the amount of throttle (degree of angle the throttle blade is set at) called for by the location of the Throttle-Shift Control (T-SC) from neutral to Wide Open Throttle (WOT). The actual throttle position is the current exact location or angle of the throttle blade.

The ECM continuously tests the integrity of the data within itself. If there is a loss of integrity in the ECM data, or an inability to write or read data to and from the RAM, or an inability to correctly read data from the flash memory, or an internal ECM processor fault, then an **ETC Process** fault sets.

**Optional Cruise Control System — General Operation (Typical)**

On boats equipped with a Cruise Control System, it is possible to review various functions by toggling to the cruise control read-outs on the multi-function gauge explained earlier in this section. Note also that the throttle position must always be greater than the speed set on the cruise control. For example, if the cruise was set at 35 mph but the throttle-shift position is equivalent to 25 mph, the boat will not reach 35. This is also true of the RPMs. Also, the cruise control cannot be engaged when the boat is at idle speed.

**System Start-Up:**

When the ignition is turned ON, the cruise control system starts in OFF mode. While it is in OFF mode, the LCD display will show the current time.

**RPM Set-Point Adjustment:**

In order to adjust the RPM Set Point in OFF Mode, first move the RPM/SPEED mode selection switch to the RPM position. Using the +/- switch, select the desired Set point. The RPM icon will illuminate and the LCD will display the current Set Point. Briefly pressing the +/- switch will increase or decrease the Set Point by 20 RPM. Holding the switch will increase or decrease by 100 RPM. The RPM Set Point is limited to a minimum of 1200 RPM and a maximum of 5000 RPM.

**Speed Set Point Adjustment:**

In order to adjust the Speed Set Point in OFF Mode, first move the RPM/SPEED Mode selection switch to the SPEED position. Use the +/- switch to select the desired Set Point. The SPEED icon will illuminate and the LCD will display the current Set Point. Briefly pressing the +/- switch will increase or decrease the Set Point by 0.2 MPH. Holding the switch increases or decreases the Set Point by 1.0 MPH. The Speed Set Point is limited to a minimum of 5.0 MPH and a maximum of 50 MPH.

**Activating RPM Cruise Control Mode:**

To activate the Cruise Control System in RPM Control mode, make sure that the RPM / SPEED mode selection switch is in the RPM position and that current engine speed is at least 400 RPM less than the Set Point. Press and hold the ON/OFF switch in the ON position for approximately one second. The LCD should now display the current engine speed, the RPM icon should be illuminated and the LOCK icon should be blinking.

**Turning On Speed Cruise Control Mode:**

To turn on the Cruise Control in Speed Control mode, make sure that the RPM/SPEED mode selection is at least 3.0 MPH less than the Set Point. Press and hold the ON/OFF switch in the ON position for approximately one second. The LCD should now display the current vessel speed, the SPEED icon should be illuminated and the LOCK icon should be blinking.

**Activating Manual Cruise Control Mode:**

To activate the Cruise Control in Manual Control mode, make sure that the RPM/SPEED mode selection switch is in the MANUAL (center) position and that current engine speed is at least 1200 RPM. Then press and hold the ON/OFF switch in the ON position for approximately one second. The LCD should display the current engine speed and the LOCK icon should be blinking.

**Manual Set Point Adjustment:**

The Manual Set Point can be adjusted using the +/- switch. The LOCK icon will disappear and the LCD will display the current Set Point. Short presses of the +/- switch will increase or decrease the Set Point by 20 RPM. Holding the switch increases or decreases the Set Point by 100 RPM. The Manual Set Point is limited to a minimum of 1200 RPM and a maximum of 5000 RPM.

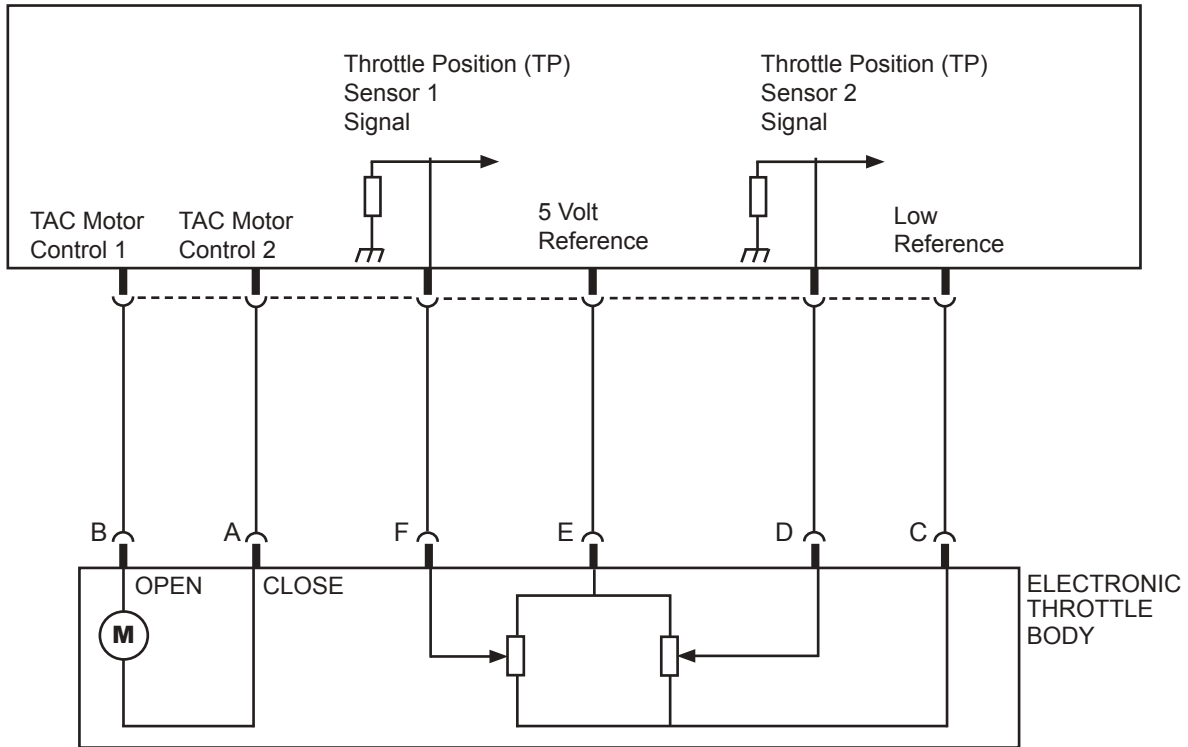
**Using Speed Control Mode:**

Manual Control works basically in the same way that RPM Control Mode does. The difference is that when the system is turned ON in manual mode the Set Point is set to the current engine speed. For example, if the Cruise Control is OFF and the engine speed is 2500 RPM, and the system is turned on, the engine will hold the engine speed at 2500 RPM.

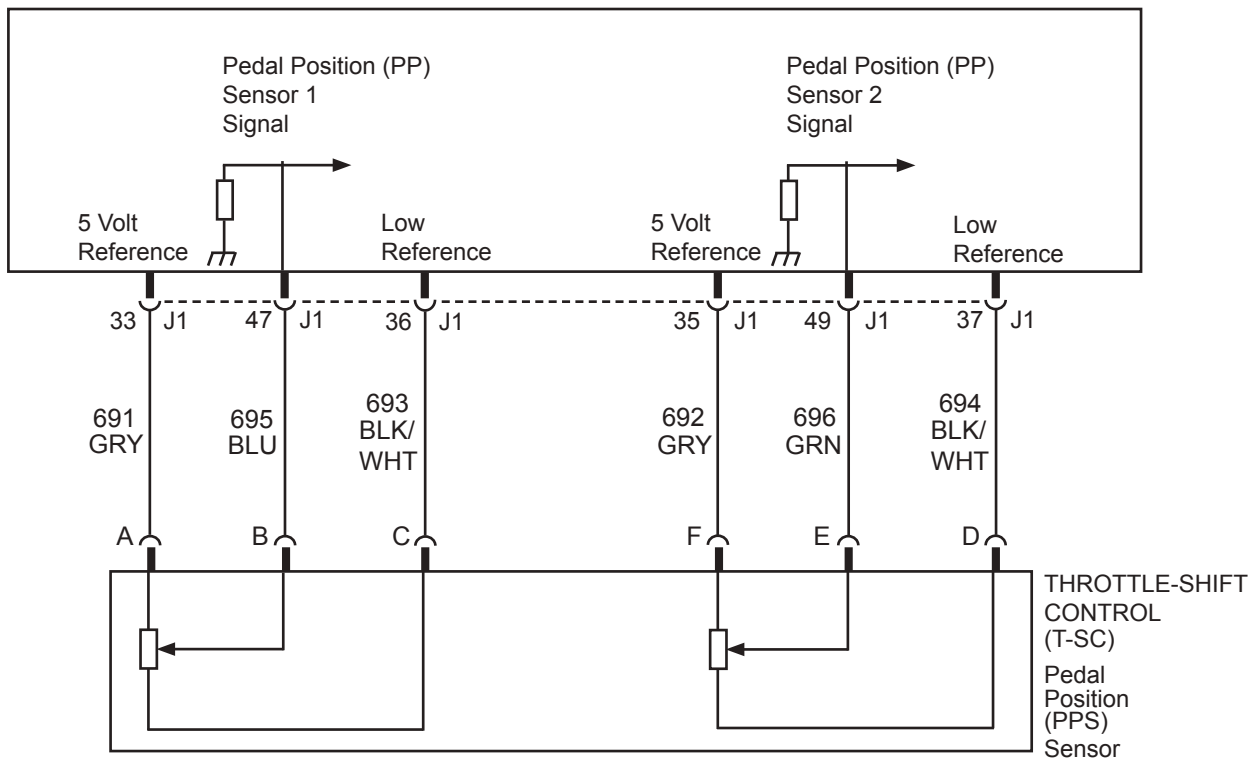
**Disengaging the Cruise Control System:**

There are two ways to disengage the system: Pulling back the throttle will disengage the system at any time. The system remains ON and can be re-engaged by accelerating the boat until the LOCK icon stays illuminated. Or by moving the ON/OFF switch to OFF. It is recommended that the throttle be pulled back before turning OFF the system.

Electronic Throttle Controls  
TAC Motor Controls & TPS 1 & 2



Electronic Throttle Controls  
Pedal Position Sensors 1 & 2



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## Section 4

### HVS Distributor System

This section will describe how the HVS Distributor System operates. It will also give a description and show how to repair each component used on the Electronic Fuel Injection equipped engines.

#### Contents

Cautions and Notices .....	Page 2	Cam Angle Verification Procedure .....	Page 10
<b>General Information</b> .....	Page 3	Installation Procedure 2.....	Page 11
MEFI 5 HVS Distributor .....	Page 3	Distributor Overhaul .....	Page 13
Ignition Coil Driver (ICD) Module .....	Page 4	Disassembly Procedure .....	Page 13
Ignition Coil .....	Page 4	Assembly Procedure .....	Page 16
Crankshaft Position (CKP) sensor .....	Page 5	Inspection .....	Page 19
Camshaft Position (CMP) sensor .....	Page 5	Ignition Coil and Ignition Coil Driver (ICD) Module	
Spark Plug Wires .....	Page 5	Replacement .....	Page 19
Engine Control Module (ECM) .....	Page 5	Crankshaft Position (CKP) Sensor	
Enhanced Ignition System Description .....	Page 6	Replacement .....	Page 20
System Operation .....	Page 6	Camshaft Position (CMP) Sensor	
Ignition Control (IC).....	Page 6	Replacement .....	Page 21
Knock Sensor System Description .....	Page 6	Spark Plug Replacement .....	Page 22
Purpose .....	Page 6	Spark Plug Wiring and Boots.....	Page 23
Operation .....	Page 6	Precautions.....	Page 23
Results of Incorrect Operation .....	Page 7	Replacement .....	Page 23
<b>On-Engine Service</b> .....	Page 7	<b>Torque Specifications</b> .....	Page 23
Distributor Replacement (HVS) .....	Page 7		
Removal Procedure.....	Page 7		
Installation Procedure 1.....	Page 8		

## Cautions and Notices

### Battery Disconnect Caution

*Caution: Before servicing any electrical component, the ignition key must be in the OFF or LOCK position and all electrical loads must be OFF, unless instructed otherwise in these procedures. If a tool or equipment could easily come in contact with a live exposed electrical terminal, also disconnect the negative battery cable. Failure to follow these precautions may cause personal injury and/or damage to the vehicle or its components.*



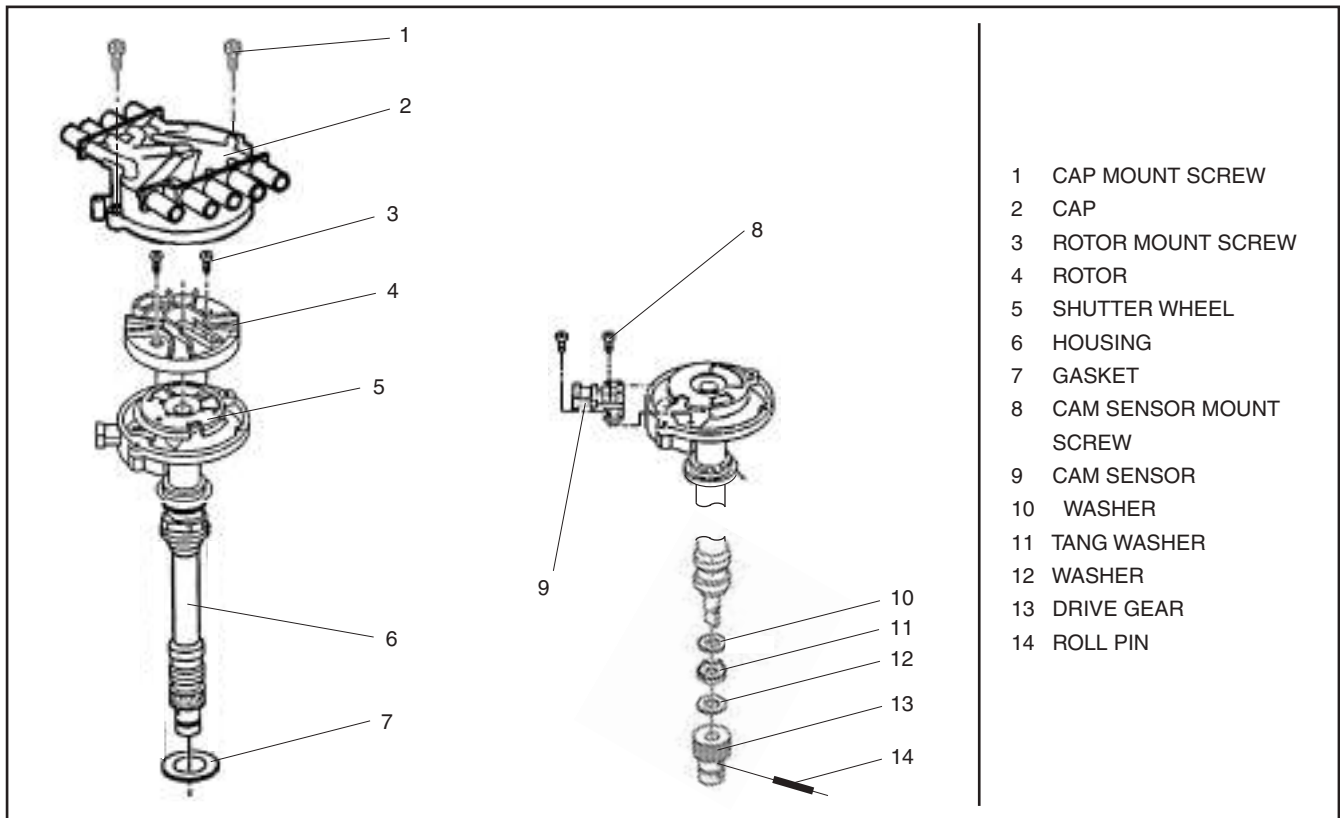


Figure 4-1 - MEFI 5 HVS Distributor

## General Information

The Distributor is actually an assembly that contains the Camshaft Position (CMP) Sensor, cap, rotor and shaft. The Distributor is splined by a helical gear to the camshaft and rotates providing a spark to each spark plug wire. When servicing the Distributor, it is critical to ensure proper cap sealing to the Distributor body and correct installation to the camshaft. If the Distributor is installed a tooth off in relation to the camshaft, a DTC sets. The Distributor is repairable, refer to the Distributor Overhaul Section.

The Camshaft Position (CMP) sensor is located within the Distributor. It's operation is very similar to the Crankshaft Position (CKP Sensor) however it provides one pulse per camshaft revolution (1x signal). This signal is not detrimental to the driveability of the vehicle. The ECM utilizes this signal in conjunction with the crankshaft position to determine which cylinders are misfiring.

The high voltage switch (HVS) type distributor is like the High Energy Ignition (HEI) distributor in the following ways:

1. It contains a distributor cap and rotor that are responsible for delivering spark to the spark plugs in each cylinder in a firing order sequence defined by the location of plug wires in the distributor cap towers.
2. It is adjustable in its location by loosening the distributor hold-down bolt and foot clamp.

The High Voltage Switch (HVS) distributor differs from the standard High Energy Ignition (HEI) distributor in the following ways.

1. The HVS distributor contains a cam sensor that is affixed to the base of the distributor housing with screws.
2. The HVS distributor does not output an RPM signal, does not have an internally mounted ignition control module, and does not have a pick-up coil.

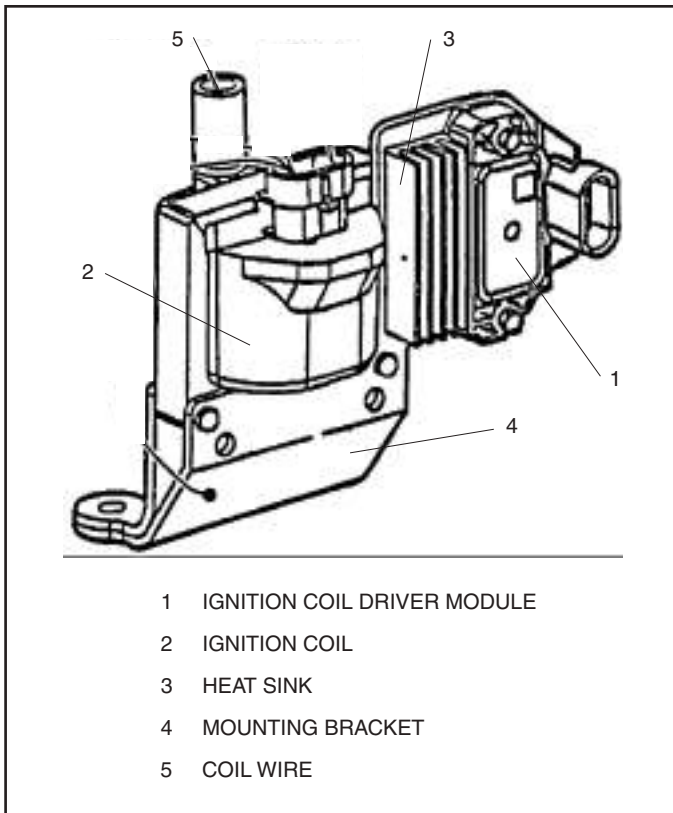


Figure 4-2 - Ignition Coil Driver Module With Separate Coil

### Ignition Coil Driver Module

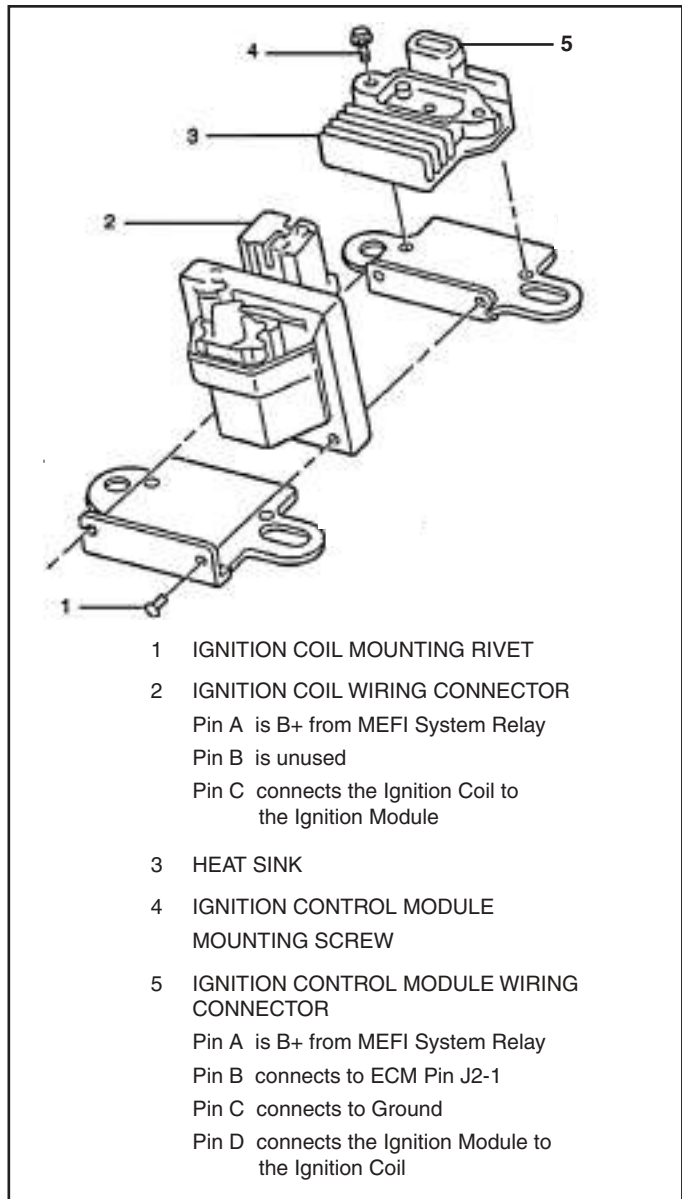
The Ignition Coil Driver Module is mounted on a bracket next to the coil. The ECM signals the ICDM to turn ON primary current to the ignition coil by pulling the IC line high (4 volts). The ICDM turns the primary current ON and OFF by applying and removing the ground to the primary winding at the appropriate time. This module is of minimum function. The module does not contain backup calibrations that allows the engine to continue to run if the IC signal is lost.

### Ignition Coil

The design construction of the ignition coil (Figure 4-2) affects its output. The ignition coil was designed to produce greater spark voltage, longer spark and operate at higher RPM. The coil has the secondary winding wrapped around the primary winding, and the primary winding is wrapped around the iron core. The coil is not oil filled, the windings are covered in an epoxy compound for protection against moisture and arc over.

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

The coil generates a high secondary voltage (up to 35,000 volts) when the primary circuit is broken. A secondary high tension wire connects from the top post of the coil to the center post of the distributor cap.



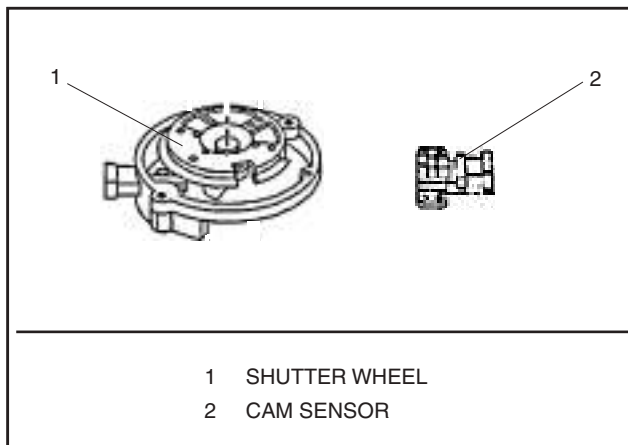
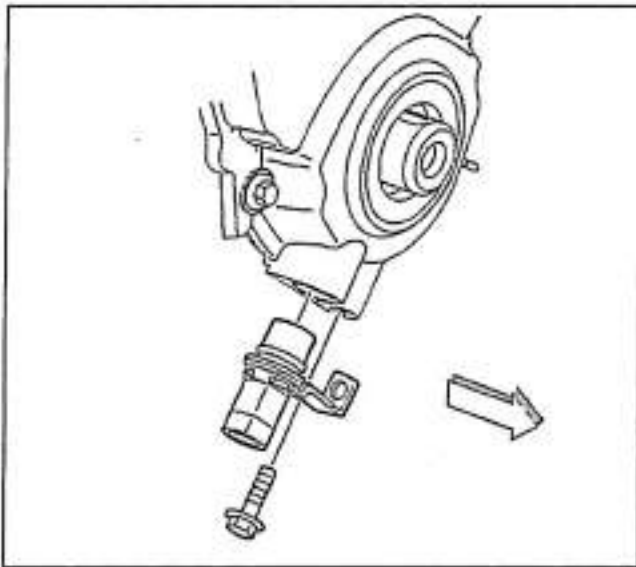


Figure 4-4 - Shutter Wheel &amp; CAM Sensor

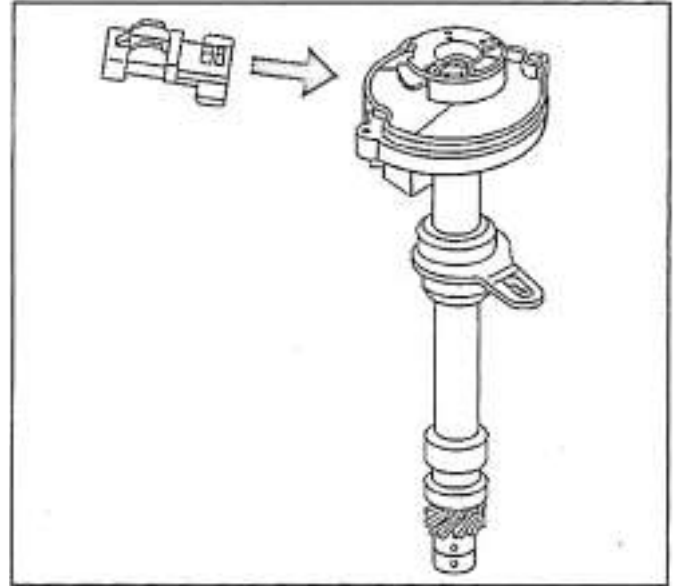
### Crankshaft Position (CKP) Sensor



The crankshaft position sensor provides the ECM with the crankshaft speed or engine RPM and the crankshaft position. The ECM utilizes the RPM information for the operation of the fuel, spark mapping tables and a number of other operations performed by the ECM. In conjunction with the cam position sensor (CMP) it also facilitates the determination of engine misfire. The ECM monitors the CKP sensor for a momentary drop in the crankshaft speed in order to determine if a misfire is occurring. When the ECM detects a misfire, a Fault Code will set.

The ECM also monitors the CKP sensor signal circuit for malfunctions. The ECM monitors CKP signal and the High and Low resolution signals. The ECM calculates these signals in order to determine a ratio. When the ECM detects that the ratio is out of normal operating range, the ECM will set a Fault Code.

### Camshaft Position (CMP) Sensor



The Camshaft Position (CMP) sensor is located within the distributor. The operation of the CMP sensor is very similar to the Crankshaft Position (CKP) sensor.

The CMP sensor will provide one pulse per camshaft revolution (1x signal). The loss of this signal may not affect the driveability of the vehicle, but will affect the type of control the ECM has on the fuel injection system. If this signal is lost the ECM will pulse the injectors bank to bank instead of each individual injector at a time. The ECM also utilizes this signal in conjunction with the crankshaft position in order to determine which cylinder(s) are misfiring.

### Spark Plug Wires

The spark plug wires are a carbon-impregnated cord conductor encased in a silicone rubber jacket. Silicone wiring will withstand very high temperature and is an excellent insulator for the higher voltages. The silicone spark plug boots provide a tight seal on the spark plug.

Silicone is soft, pliable and therefore, more susceptible to scuffing and cutting. It is extremely important that the spark plug cables be handled with care. They should be routed so as not to cross each other or to be in contact with other parts of the engine to prevent rubbing.

Do not force anything between the boot and wiring or through the silicone jacket. Connections should be made using an appropriate adapter.

### Engine Control Module (ECM)

The Engine Control Module (ECM) controls spark advance for all operating conditions. The ECM monitors input signals from the following components as part of its ignition control function to determine the required ignition timing:

- Crank Position (CKP) sensor.
- Engine Coolant Temperature (ECT) sensor.
- Manifold Absolute Pressure (MAP) sensor.
- Knock Sensor (KS).

### Enhanced Ignition System Description

The ignition system initiates combustion by providing a spark to ignite the compressed air and fuel mixture at the correct time. In order to provide an improved engine performance, fuel economy, and control of exhaust emissions, the ECM controls the distributor spark advance (timing) with the Ignition Control (IC) system.

The ignition system uses a primary and secondary sub system in order to accomplish the timed spark distribution. The primary system consists of a Crank Position (CKP) sensor. This signal travels to the ECM for base timing reference.

Another signal is sent back to the Ignition Control Driver (ICD) Module, which has been adjusted by the ECM (advanced or retarded) in order to trigger the coil, according to the requirements of the engine.

The secondary system consists of the ignition coil which has primary (low voltage) windings and secondary (high voltage) windings. The secondary side of the ignition coil generates a high voltage which high tension spark plug wires deliver to the spark plugs.

The ECM now controls the Ignition Control (IC) function.

In order to properly control the ignition/combustion timing, the Control Module needs to know the following things:

- The crankshaft position
- The engine speed (RPM)
- The engine load (manifold pressure or vacuum)
- The atmospheric (barometric) pressure
- The engine coolant temperature
- The camshaft position.

### System Operation

The Enhanced Ignition system used on all MEFI 5 engines somewhat resembles the Distributor Ignition (DI) system. However, the system has been greatly enhanced in order to make it compatible with the new regulations. The Enhanced Ignition system provides a spark at precisely the correct time in order to ignite the air and fuel mixture for optimum performance and fuel economy. The system consists of the following components:

- ECM
- HVS
- Ignition Coil Driver Module
- Ignition Coil
- Crankshaft Position Sensor

This system does not use the ignition module used on the DI systems in the past. The ECM now controls the Ignition Control (IC) and Bypass functions. The crankshaft sensor, located in the front engine cover, is perpendicular to a target wheel attached to the crankshaft. The target wheel is equipped with slots situated a specified number of degrees apart. As the crankshaft rotates, the target wheel rotates past the crankshaft position sensor. The rising and falling edges created by the

slots cause a signal to be sent back to the ECM. The signal occurs four times per crankshaft revolution and is referred to as the 4x signal for V8 applications.

The ECM then utilizes this 4x (V8) signal in order to provide the correct spark to the engine by way of the single coil driver module. The single coil driver module is basically an electronic switch that when commanded by the ECM, causes the primary coil voltage to breakdown, energizing the secondary coil and providing a spark via the coil wire to the Distributor cap. The Distributor consists of the following components:

- Cap and Rotor
- Camshaft Position Sensor
- Gear drive and shaft.

The camshaft drives the Distributor shaft which rotates providing a spark to the correct cylinder by way of the cap and rotor. The camshaft position sensor functions much like the crankshaft sensor previously described but provides only a 1x signal to the ECM. That is, for every 2 rotations of the crankshaft, there is 1 rotation of the camshaft. Note that any dysfunction relating to the camshaft position sensor will effect engine operation as this signal provides the timing input necessary to properly operate the sequential delivery of spark and fuel.

In many cases the engine will still operate without this sensor, but operation will be compromised. The camshaft position sensor is also used to detect misfire.

### Ignition Control (IC)

The ECM software controls all of the IC and Bypass functions. This reduces the number of circuits outside of the controller and ultimately reduces the possibility for shorts or opens in those circuits that could result in driveability complaints or DTCs.

### Knock Sensor System Description

#### Purpose

Varying octane levels in gasoline can cause a detonation in the engine. This detonation is sometimes called a spark knock. All of the engines use a Knock Sensor (KS) system with a knock sensor. The KS system reduces the spark knock in the engine. This allows the engine to have maximum spark advance for improved driveability and fuel economy.

#### Operation

An Engine Control Module (ECM) is used in conjunction with one or two knock sensors in order to control detonation. On a MEFI 5 ECM application no KS module will be found as it is internal to the control module. A 5 volt reference is applied to the knock sensor which has an internal resistance of about 100,000 ohms. This resistance will lower the applied voltage to about half or 2.5 volts. When a knock is present, a small AC voltage is produced by the knock sensor and transmitted to the control module riding on top of the already existing 2.5 volts. An AC voltage monitor inside the control module will detect the knock and trigger the control module to start retarding the spark incrementally.

### Results Of Incorrect Operation

An open or short to ground in the crank position sensor (CKP) circuit will cause the engine not to run. The ECM must have the crank position sensor signal to read engine RPM.

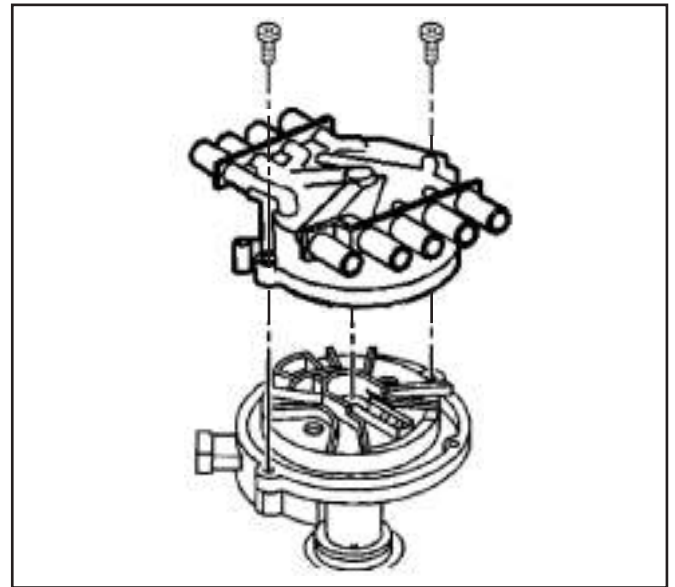
A crank position sensor signal fault will cause no RPM signal to be sent to the ECM. Therefore, your scan tool will not exhibit an RPM reading during a cranking event. If you are not reading an RPM signal during a cranking event, a possible failure mode could be the crank position sensor.

The cam position sensor is used to determine engine position and is mainly used during misfire detection. If the cam position sensor (CMP) open circuits or is shorted to ground, the engine will still run. It is likely that crank (starting) times may increase; however, the engine will still operate.

The following DTC's will be set for these sensors.

636-2 Crank signal fault

723-2 Cam signal fault



## On Engine Service

### Distributor Replacement (HVS)

#### Removal Procedure

**Notice:** There are two procedures available to install the distributor.

Use Installation Procedure 1 when the crankshaft has NOT been rotated from the original position.

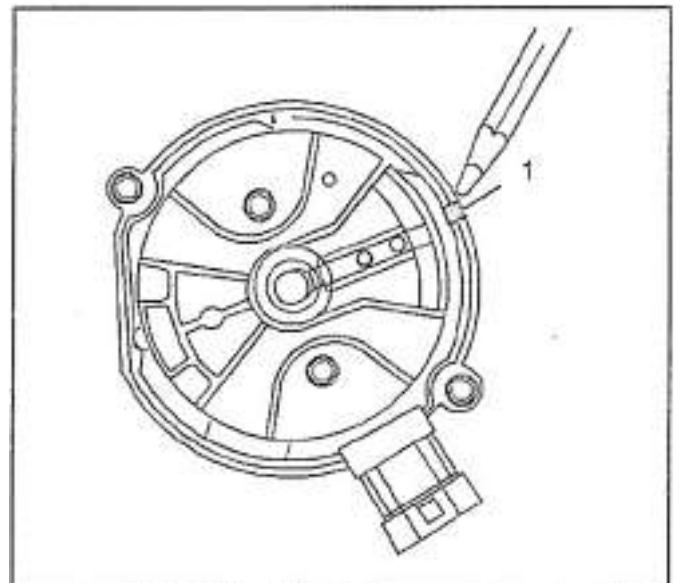
Use Installation Procedure 2 when any of the following components are removed:

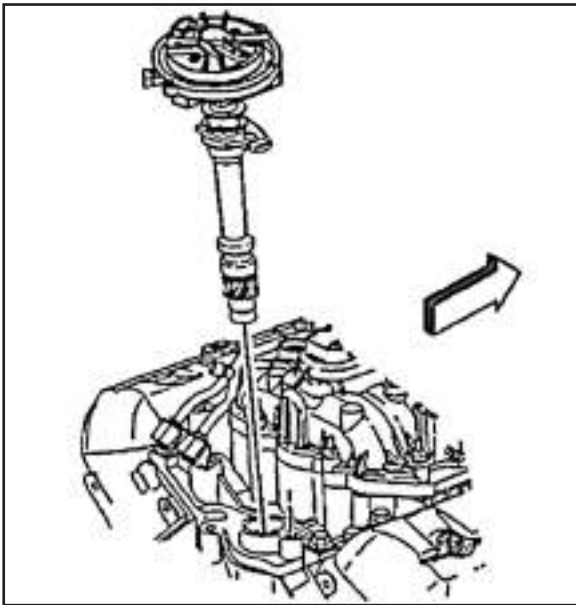
- The intake manifold.
- The cylinder head.
- The camshaft.
- The timing chain or sprockets.
- The complete engine.

If the Malfunction Indicator Lamp turns on, and a Fault Code sets after installing the distributor, this indicates an incorrectly installed distributor.

Engine damage or distributor damage may occur. Use Procedure 2 in order to install the distributor.

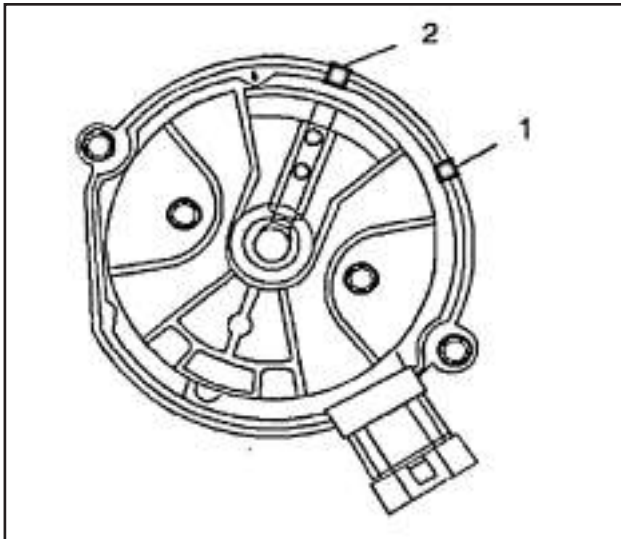
1. Turn OFF the ignition switch.
2. Remove the spark plug wires from the distributor cap.
3. Remove the electrical connector from the base of the distributor.
4. Remove the two screws that hold the distributor cap to the housing.
5. Replace these screws with new ones upon re-installation.
6. Remove the distributor cap from the housing.
7. Use a grease pencil in order to note the position of the rotor in relation to the distributor housing. The mark is identified in the graphic with the number 1.
8. Mark the distributor housing and the intake manifold with a grease pencil.





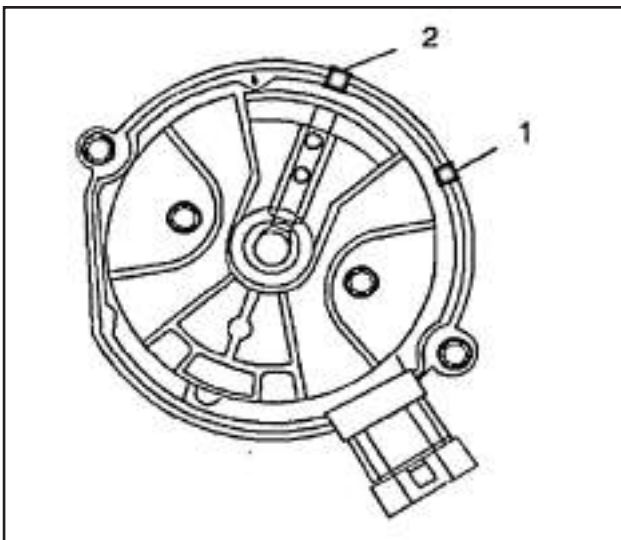
### Distributor Replacement (HVS) (Cont...)

9. Remove the mounting clamp hold down bolt.
10. Remove the distributor.



11. As the distributor is being removed from the engine, watch the rotor move in a counter-clockwise direction about 42 degrees. This will appear as slightly more than one clock position.
12. Note the position of the rotor segment.
  - 12.1 Place a second mark on the base of the distributor.
 

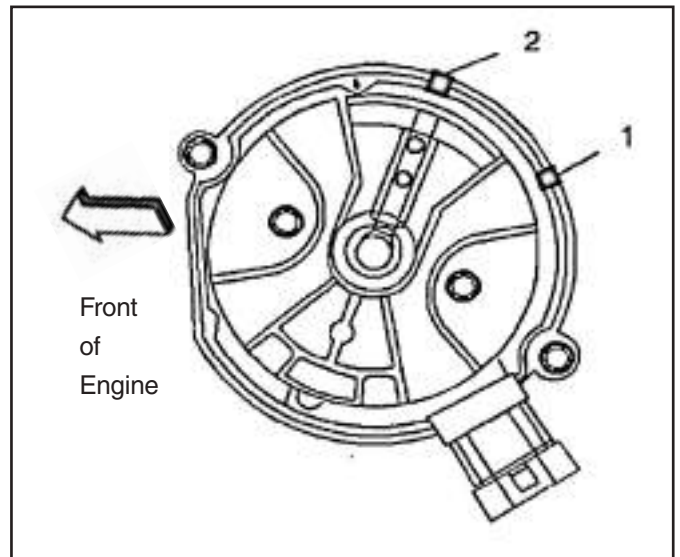
This will aid in achieving proper rotor alignment during the distributor installation.
  - 12.2 The second mark on the distributor housing is identified in the graphic as number 2.



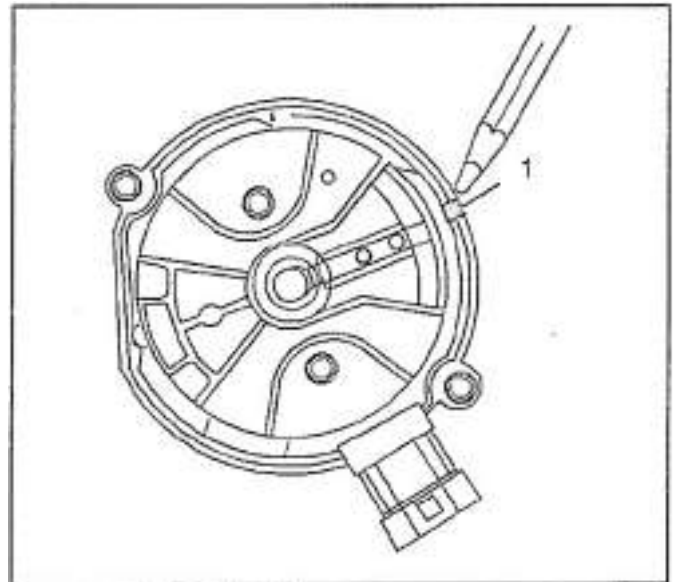
### Installation Procedure 1

1. If installing a new distributor assembly, place two marks on the new distributor housing in the same location as the two marks on the original housing.
2. Remove the new distributor cap, if necessary.
3. Align the rotor with the mark made at location 2.

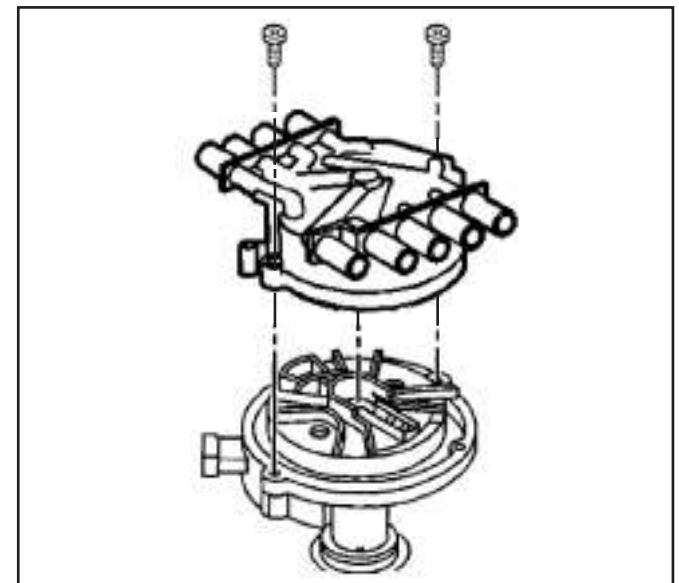
4. Guide the distributor into the engine.  
Make sure that the flat part on the distributor is facing to the front of the engine.



5. As the distributor is being installed, observe the rotor moving in a clockwise direction about 42 degrees.
6. Once the distributor is completely seated, the rotor segment should be aligned with the mark on the distributor base in location number 1.
- If the rotor segment is not aligned with the number 1 mark, the driven gear teeth and the camshaft have meshed one or more teeth out of alignment.
  - In order to correct this condition, remove the distributor and reinstall it.



7. Install the distributor mounting clamp.  
Install the distributor hold down clamp and bolt and tighten the bolt to a snug, but not fully tightened position.  
Install the distributor cap.
8. Install two NEW distributor cap screws.  
Tighten  
Tighten the screws to 2.4 N·m (21 lb. in).
9. Install the electrical connector to the distributor.



10. Install the spark plug wires to the distributor cap.  
*Refer to Spark Plug Wire Harness Replacement or Spark Plug Wire Harness Replacement.*

**Important:** If the Malfunction Indicator lamp is turned on after installing the distributor, and a Fault Code is found, the distributor has been installed incorrectly. Refer to Installation Procedure 2 for proper distributor installation.

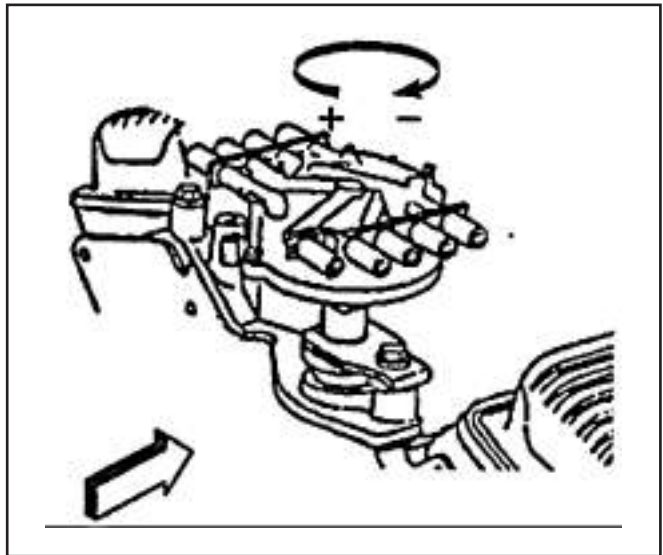
### 11. Cam Angle Verification Procedure

The ignition timing cannot be adjusted. The distributor may need adjusting to prevent crossfire. To insure proper alignment of the distributor, perform the following:

1. With the ignition OFF, install the scan tool.
  2. Start the engine. Allow the engine to idle until the engine reaches normal operating temperature.
- Important:** Cam Retard Offset reading will not be accurate below 1,000 RPM.
3. Increase engine speed to ~1200 RPM while performing the following steps.
  4. Using the scan tool, monitor the Cam Angle Offset.
  5. If the Cam Angle indicates a value of 705 degrees, the distributor is properly adjusted.
  6. If the Cam Angle does not indicate 705 degrees, the distributor must be adjusted.

### Adjusting Procedure

1. With the engine OFF, slightly loosen the distributor hold down bolt.
- Important:** Cam Angle reading will not be accurate below 1,000 RPM.
2. Start the engine, and raise engine speed to ~1200 RPM.
  3. Using a scan tool, monitor Cam Angle.
  4. Rotate the distributor as follows:
    - To compensate for a negative reading, rotate the distributor in the counterclockwise direction.
    - To compensate for a positive reading, rotate the distributor in the clockwise direction.



5. Repeat step 4 until 705 degrees is obtained.
6. Turn OFF the ignition.

**Notice:** Refer to Fastener Notice in Cautions and Notices.

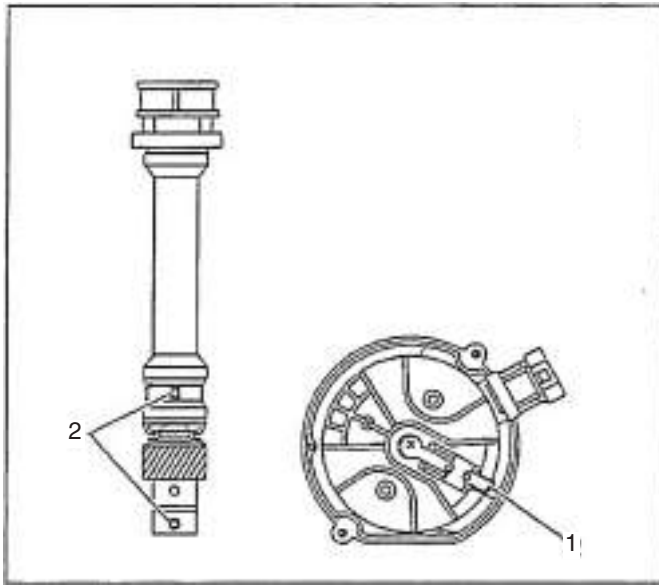
7. Tighten the distributor hold-down bolt.

### Tighten

Tighten the bolt to 3 N•m (25 lb ft)

8. Start the engine.
9. Raise the engine speed to 1,000 RPM and recheck Camshaft Retard Offset.





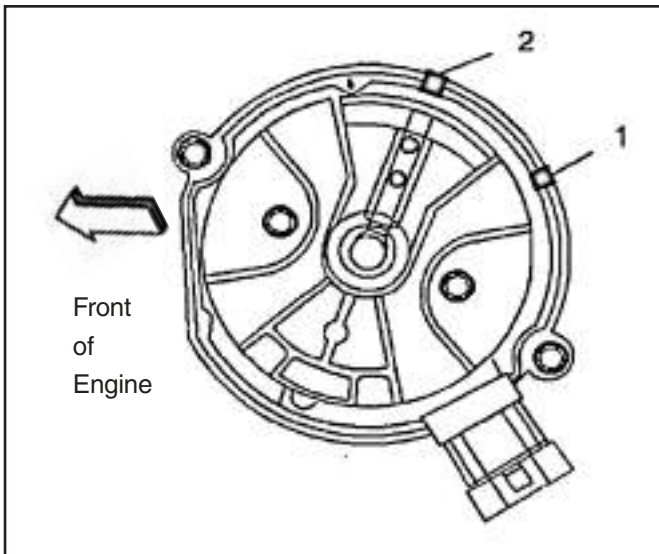
### Installation Procedure 2

1. Rotate the number 1 cylinder to Top Dead Center (TDC) of the compression stroke.
2. Align white paint mark on the bottom stem of the distributor, and the pre-drilled indent hole in the bottom of the gear (2).
3. With the gear in this position, the rotor segment should be positioned as shown for a V8 engine.(1)
  - The alignment will not be exact.
  - If the driven gear is installed incorrectly, the dimple will be approximately 180 degrees opposite of the rotor segment when it is installed in the distributor.

**Notice:** The OBD II ignition system distributor driven gear and rotor can be installed in multiple positions. In order to avoid mistakes, make sure to mark the distributor in the following positions:

- The distributor driven gear.
- The distributor shaft.
- The rotor holes for the same mounting position upon reassembly.

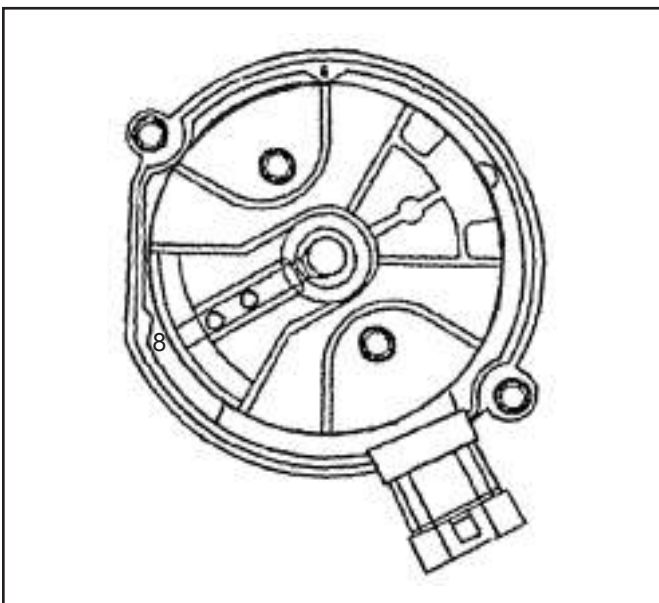
**Notice:** Installing the driven gear 180 degrees out of alignment, or locating the distributor rotor in the wrong holes, may cause a no-start condition. Premature engine wear and damage may result.



4. Using a long screw driver, align the oil pump drive shaft to the drive tab of the distributor.
5. Guide the distributor into the engine.

Make sure that the flat part on the distributor is facing to the front of the engine.

6. Once the distributor is fully seated, the rotor segment should be aligned with the pointer cast into the distributor base.
  - This pointer should have number 8 cast into it, indicating that the distributor is to be used on a 8 cylinder engine.
  - If the rotor segment does not come within a few degrees of the pointer, the gear mesh between the distributor and the camshaft may be off a tooth or more.
  - If this is the case, repeat the procedure again in order to achieve proper alignment.



7. Install the distributor mounting clamp.  
Install the distributor hold down clamp and bolt and tighten the bolt to a snug, but not fully tightened position.  
Install the distributor cap.
8. Install two NEW distributor cap screws.  
Tighten  
Tighten the screws to 2.4 N·m (21 lb in).
9. Install the electrical connector to the distributor.
10. Install the spark plug wires to the distributor cap.  
*Refer to Spark Plug Wire Harness Replacement or Spark Plug Wire Harness Replacement.*

**Important:** If the Malfunction Indicator lamp is turned on after installing the distributor, and a Fault Code is found, the distributor has been installed incorrectly. Repeat Installation Procedure 2 for proper distributor installation.

### 11. Cam Angle Verification Procedure

The ignition timing cannot be adjusted. The distributor may need adjusting to prevent crossfire. To insure proper alignment of the distributor, perform the following:

1. With the ignition OFF, install the scan tool.
2. Start the engine. Allow the engine to idle until the engine reaches normal operating temperature.

**Important:** Cam Retard Offset reading will not be accurate below 1,000 RPM.

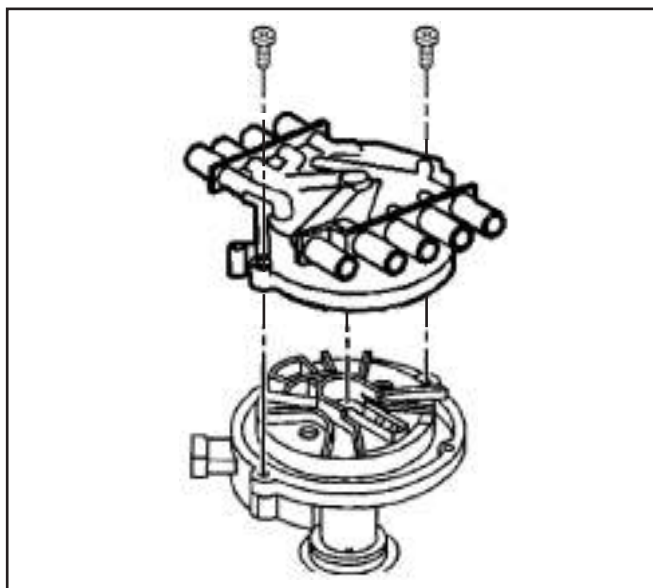
3. Increase engine speed to ~1200 RPM while performing the following steps.
4. Using the scan tool, monitor the Cam Angle Offset.
5. If the Cam Angle indicates a value of 705 degrees, the distributor is properly adjusted.
6. If the Cam Angle does not indicate 705 degrees, the distributor must be adjusted.

### Adjusting Procedure

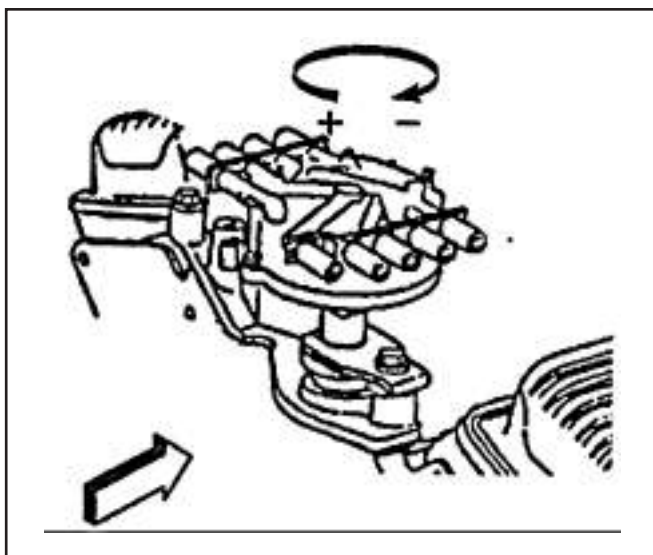
1. With the engine OFF, slightly loosen the distributor hold down bolt.

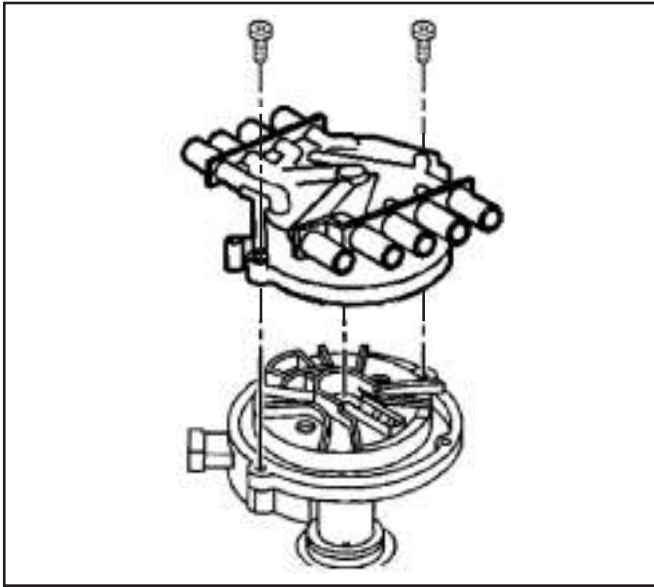
**Important:** Cam Angle reading will not be accurate below 1,000 RPM.

2. Start the engine, and raise engine speed to ~1200 RPM.
3. Using a scan tool, monitor Cam Angle.



4. Rotate the distributor as follows:
    - To compensate for a negative reading, rotate the distributor in the counterclockwise direction.
    - To compensate for a positive reading, rotate the distributor in the clockwise direction.
  5. Repeat step 4 until 705 degrees is obtained.
  6. Turn OFF the ignition.
- Notice:** Refer to Fastener Notice in Cautions and Notices.
7. Tighten the distributor hold-down bolt.  
**Tighten**  
Tighten the bolt to 3 N·m (25 lb ft)
  8. Start the engine.
  9. Raise the engine speed to 1,000 RPM and recheck Camshaft Retard Offset.



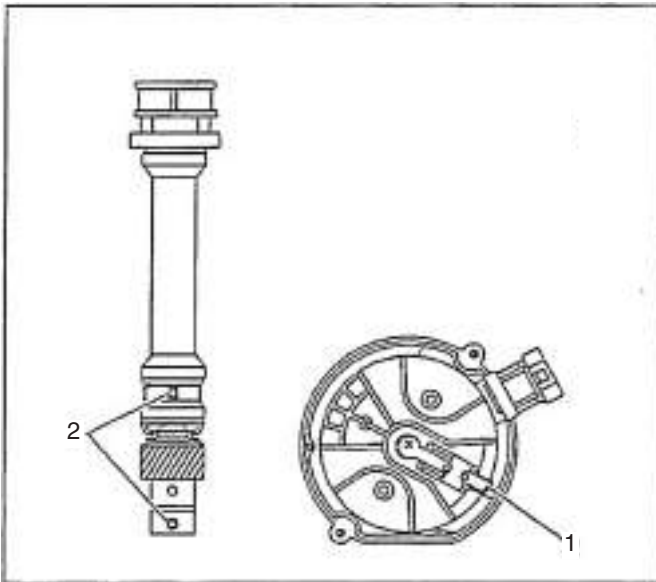


### Distributor Overhaul

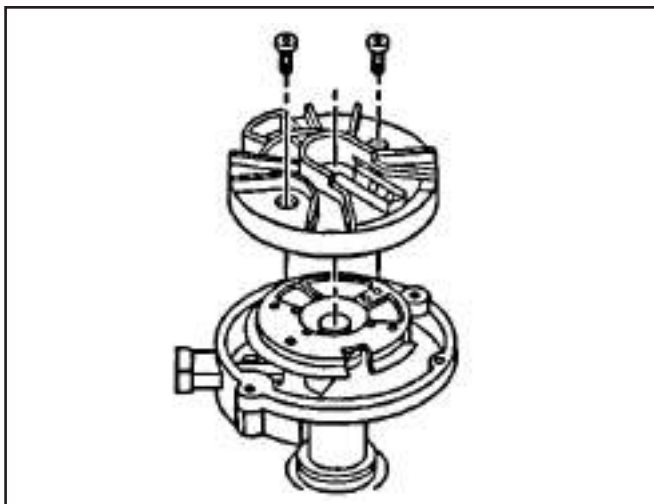
#### Disassembly Procedure

**Notice:** Refer to Distributor Driven Gear Can Be Installed in Multiple Positions in Cautions and Notices.

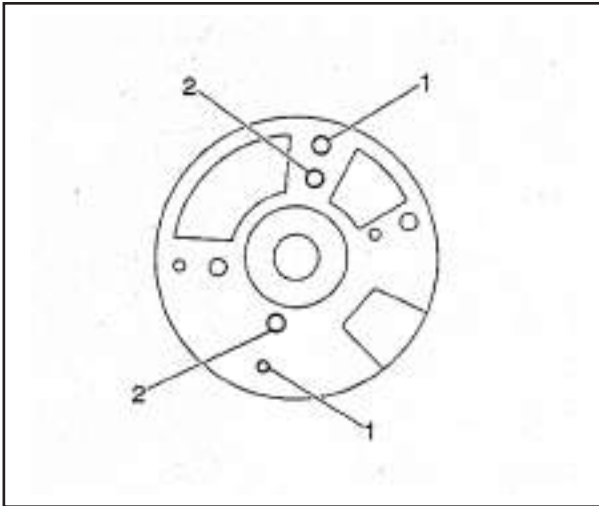
1. Remove the two screws that hold the distributor cap to the housing.
2. Do not discard the screws.
3. Remove the distributor cap from the housing.



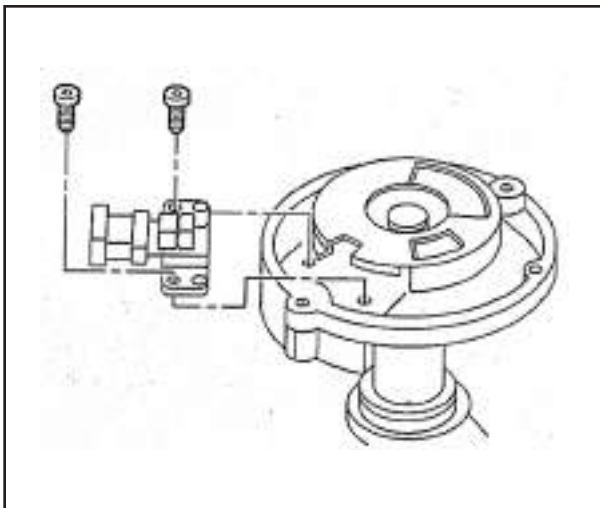
4. Align white paint mark on the bottom stem of the distributor, and the pre-drilled indent hole in the bottom of the gear (2).
5. With the gear in this position, the rotor segment should be positioned as shown for a V8 engine (1). If not, replace the distributor.



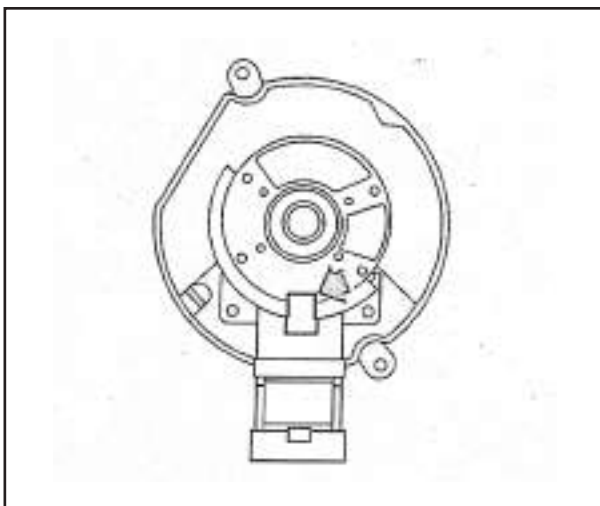
6. Remove the two screws from the rotor.
7. Remove the rotor.



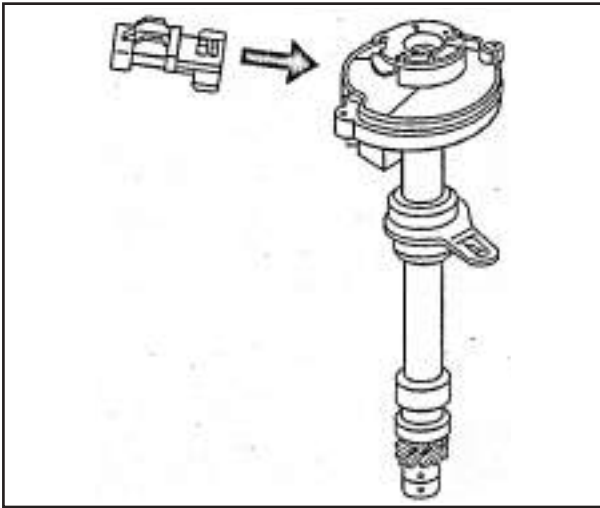
8. Note the locating holes that the rotor was removed from:  
(1) is the rotor screw holes.  
(2) is the rotor locator pin holes.



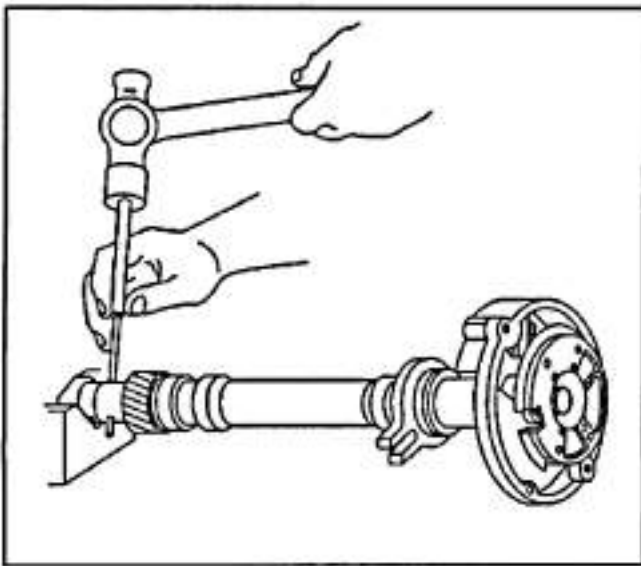
9. Remove the two screws that hold the camshaft position (CMP) sensor.  
10. Do not discard the screws.



11. Line up the square-cut hole in the vane wheel with the CMP sensor.

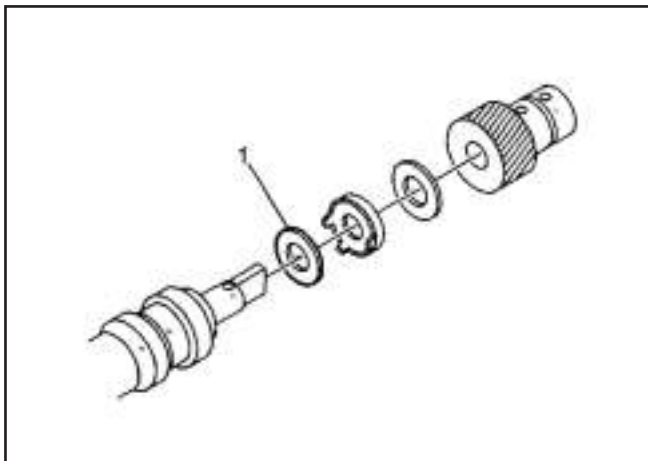


12. Remove the CMP sensor.
13. Note the dimple located below the roll pin hole on one side of the gear. The dimple will be used to properly orient the gear onto the shaft during reassembly.

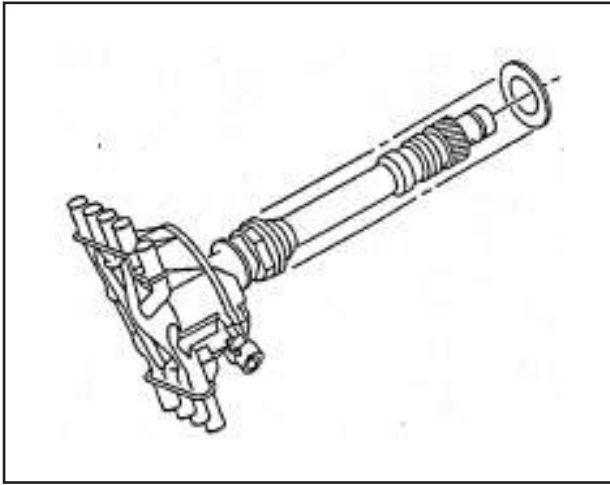


**Caution: Refer to Safety Glasses Caution in Cautions and Notices.**

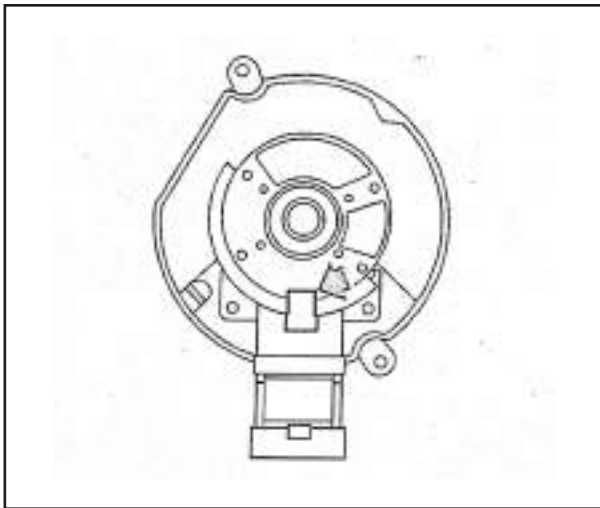
14. Support the distributor drive gear in a V-block or similar fixture.
15. Drive out the roll pin with a suitable punch.



16. Remove the driven gear from the distributor shaft.
17. Remove the round washer.
18. Remove the tang washer.
19. Remove the round washer, if equipped (1).

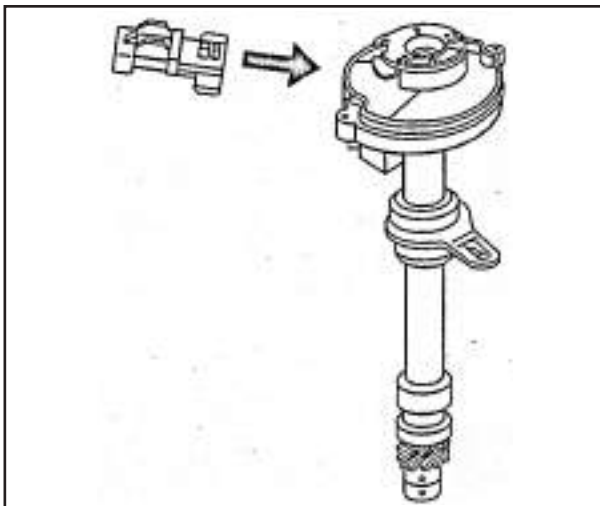


20. Remove the old oil seal.

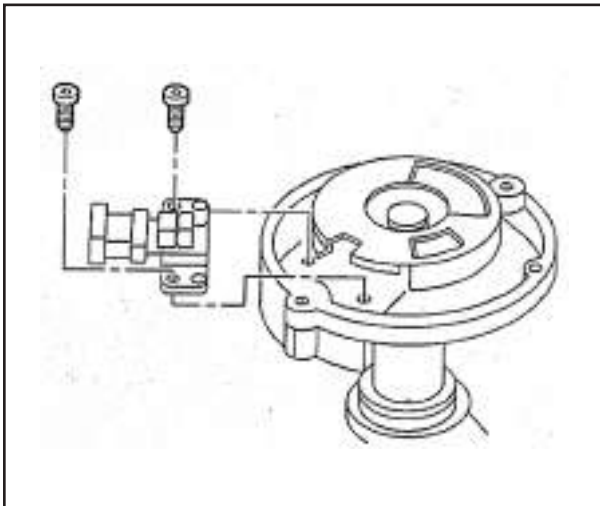


#### Assembly Procedure

1. Line up the square-cut hole in the vane wheel for the camshaft position (CMP) sensor.



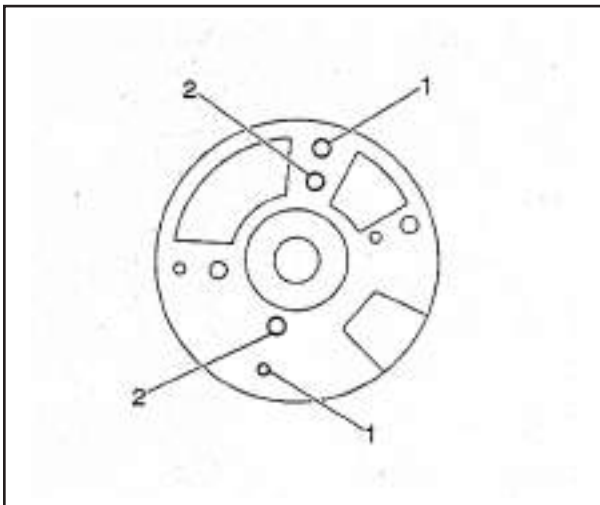
2. Insert the sensor into the housing.



3. Install two screws for the camshaft position (CMP) sensor.

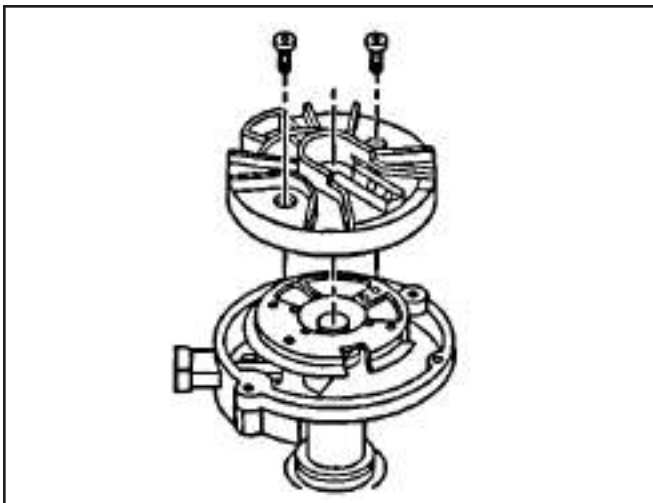
**Tighten**

Tighten the screws to 2.2 N·m (20 lb in).



4. Identify the correct rotor mounting position.

- (1) is the rotor screw holes.
- (2) is the rotor locator pin holes.

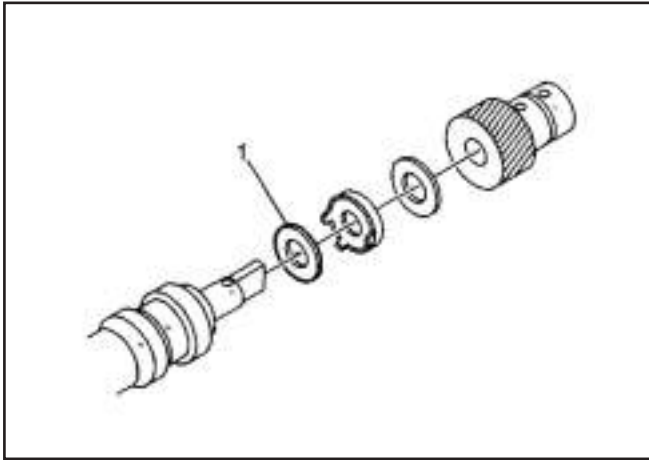


5. Install the distributor rotor according to the index marks.

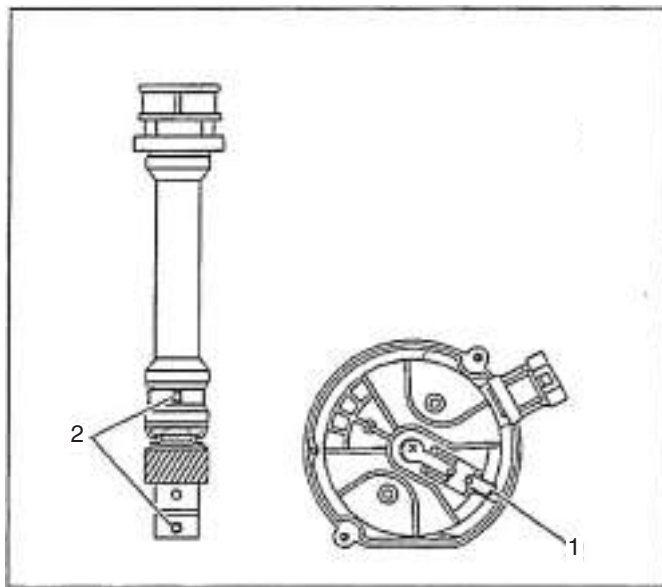
6. Install two rotor hold down screws.

**Tighten**

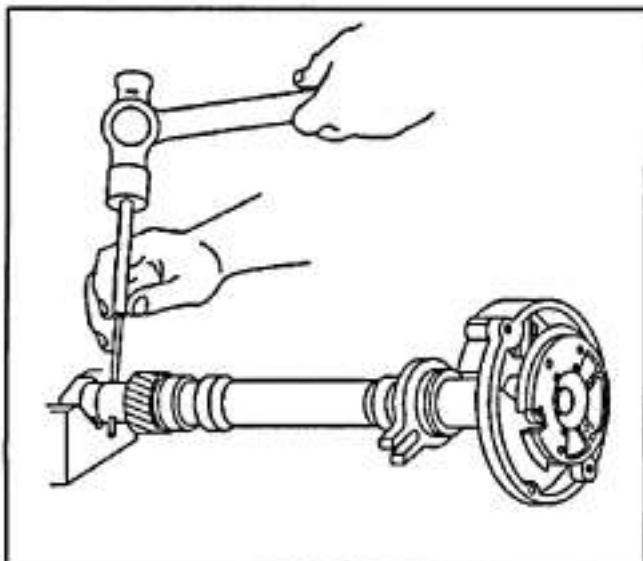
Tighten the screws to 1.9 N·m (17 lb in).



7. Install the round washer, if equipped (1).
8. Install the tang washer over the bottom of the distributor shaft.
9. Install the round washer.
10. Install the driven gear according to the index marks.



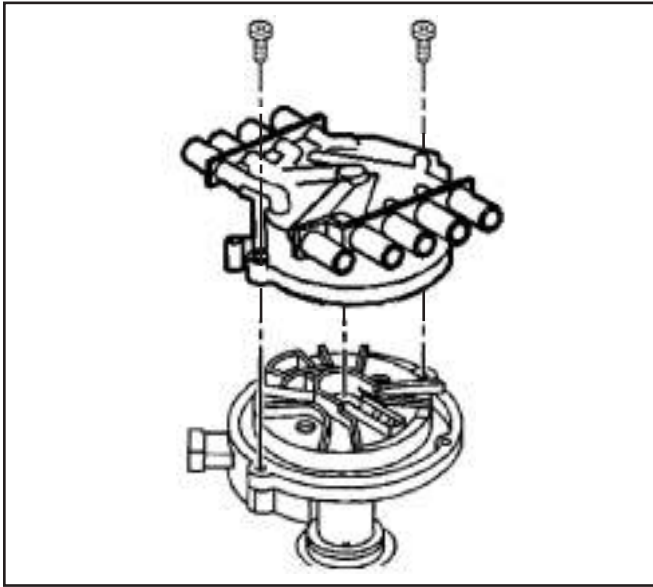
11. Align the rotor segment as shown for a V8 engine. (1)
12. Install the gear and align white paint mark on the bottom stem of the distributor, and the pre-drilled indent hole in the bottom of the gear (2).
13. Check to see if the driven gear is installed incorrectly, the dimple will be approximately 180 degrees opposite the rotor segment when it is installed in the distributor.



*Caution: Refer to Safety Glasses Caution in Cautions and Notices.*

14. Support the distributor drive gear in a V-block or similar fixture.
15. Install the roll pin with a suitable punch and hammer in order to hold the driven gear in the correct position.

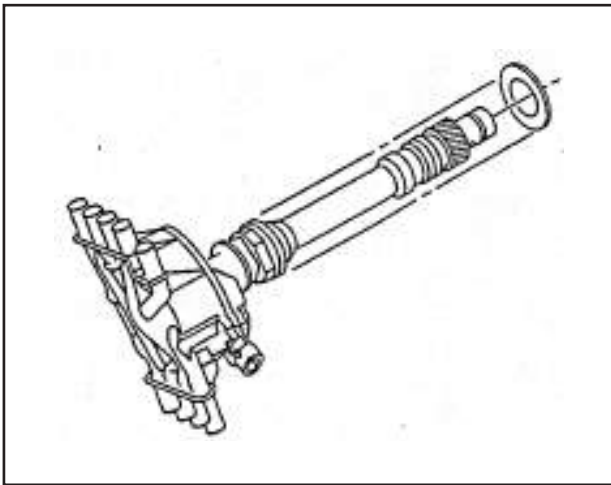




16. Install the distributor cap.
17. Install two NEW distributor cap screws.

#### Tighten

Tighten the screws to 2.4 N·m (21 lb in).



18. Install the new oil seal under the mounting flange of the distributor base.

#### Distributor Inspection

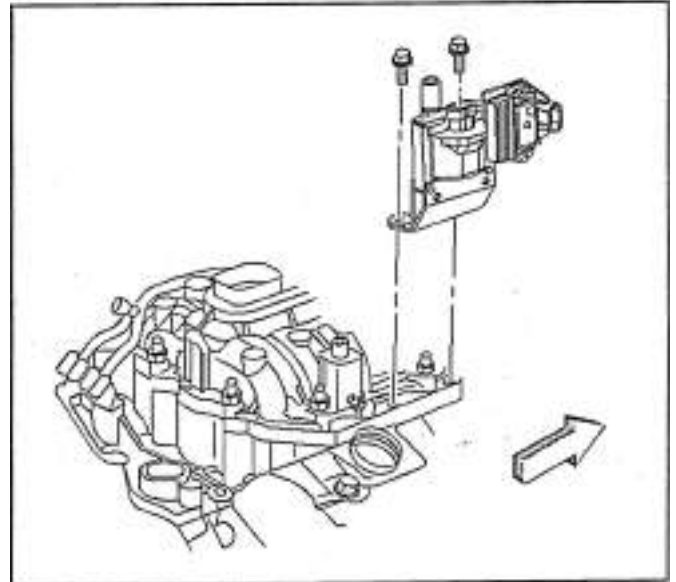
**Important:** Discoloration of the cap and some whitish build up around the cap terminals is normal. Yellowing of the rotor cap, darkening and some carbon build up under the rotor segment is normal. Replacement of the cap and rotor is not necessary unless there is a driveability concern.

1. Inspect the cap for cracks, tiny holes or carbon tracks between the cap terminal traces. If the inside of the cap contains moisture or a filmy residue, wipe clean with a cloth lightly dampened

with alcohol and allow to dry thoroughly. If the residue is hardened and cannot be removed, replace the cap.

2. Inspect the cap for excessive build-up of corrosion on the terminals. Scrape clean the terminals or replace the cap if the corrosion is excessive. Some build-up is normal.

#### Ignition Coil and ICD Module Replacement (HVS)



#### Removal Procedure

1. Remove the air cleaner assembly.
2. Disconnect the electrical connectors.
3. Remove the ignition coil wire to the distributor.
4. Remove the studs holding the bracket and the ignition coil to the intake manifold.
5. Remove the bracket and the ignition coil.
6. Drill and punch out the two rivets holding the ignition coil to the bracket.
7. Remove the ignition coil from the bracket.

#### Installation Procedure

**NOTICE:** Be sure to thoroughly coat the bottom of the ignition control module with silicone grease. Failure to do so could result in heat damage to the module.

- Lubricate bottom of the ignition control module and the module rest pad on the housing with silicone grease or an equivalent heat transfer substance.
1. Ignition control module to the housing with two screws.
  2. Pick-up coil.
    - Fit the tab on the bottom of the coil into the anchor hole in the housing.

A replacement ignition coil kit comes with two screws in order to attach the ignition coil to the bracket.

1. Install the ignition coil to the bracket with the two screws.

**Notice:** Refer to Fastener Notice in Cautions and Notices.

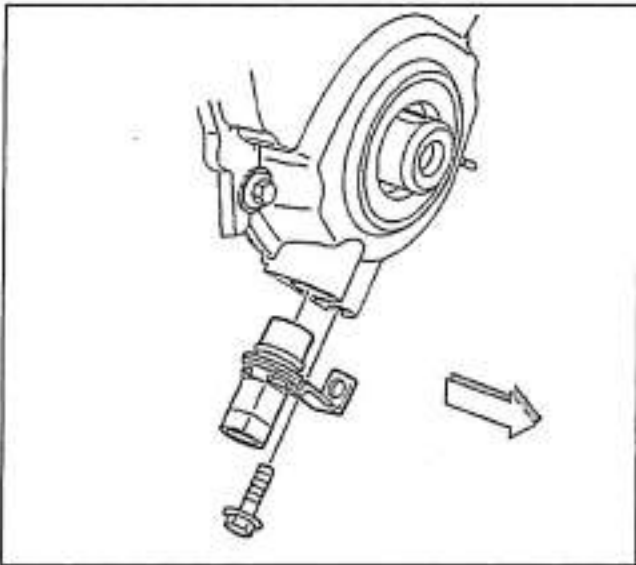
2. Install the ignition coil and the bracket to the intake manifold with studs.

**Tighten**

Tighten the studs to 11 N·m (8 lb ft).

3. Install the ignition coil wire.
4. Install the electrical connectors.
5. Install the air cleaner assembly.

### Crankshaft Position Sensor Replacement



### Removal Procedure

**Important:** The CKP System Variation Learn Procedure will need to be performed whenever the Crankshaft Position (CKP) sensor is removed or replaced. *Refer to CKP System Variation Learn Procedure.*

**Caution:** Refer to **Battery Disconnect Caution in Cautions and Notices Page 4-2.**

1. Disconnect the negative battery cable.
2. Remove the CKP sensor harness connector.
3. Remove the sensor hold down bolt.
4. Remove the sensor from the timing cover.
5. Inspect the sensor O-ring for wear, cracks or leakage.

Replace if necessary. Lube the new O-ring with clean engine oil before installing.

### Installation Procedure

**Important:** Make certain that the Crankshaft Position (CKP) sensor mounting surfaces are clean and free of burrs before installing the CKP sensor.

When installing a crankshaft position (CKP) sensor make sure the sensor is fully seated and held stationary in the front cover before torquing the hold down bolt into the front cover. A sensor which is not seated may result in erratic operation and lead to the setting of false codes.

1. Install the sensor into the timing cover. Lube the O-ring with clean engine oil before installing.

**Notice:** Refer to Fastener Notice in Cautions and Notices.

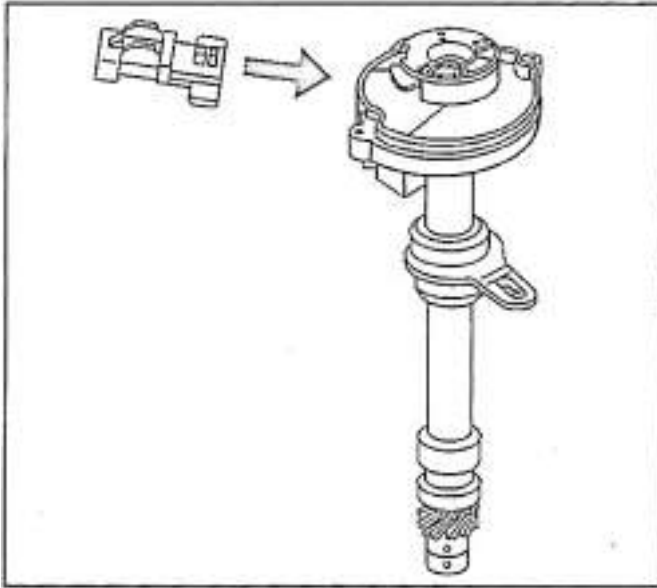
2. Install the sensor hold down bolt.

**Tighten**

Tighten the hold down bolt to 8 N·m (71 lb in).

3. Install the CKP sensor harness connector.
4. Connect the negative battery cable.
5. Perform the CKP System Variation Learn Procedure. *Refer to CKP System Variation Learn Procedure.*

## Camshaft Position Sensor Replacement



## Removal Procedure

**Caution:** Refer to *Battery Disconnect Caution in Cautions and Notices Page 4-2*

1. Disconnect the negative battery cable.
2. Disconnect the spark plug wires and ignition coil wire from the distributor.
3. Disconnect the CMP sensor harness connector from the distributor.
4. Remove the distributor cap screws.
5. Remove the distributor cap.
6. Remove the rotor screws.
7. Remove the rotor.
8. Align the square slot in the reluctor wheel with the CMP sensor.
9. Remove the CMP sensor fasteners.
10. Remove the CMP sensor.

## Installation Procedure

**Important:** Do not use the old cap screws, CMP sensor screws, or rotor screws. Use replacement screws that have been coated with a thread locking compound. Precoated replacement distributor cap and CMP sensor screws can be acquired using P/N 10475922 (pkg of 10 screws). Precoated replacement rotor screws can be acquired using P/N 10475924 (pkg of 10 screws).

1. Align the square slot in the reluctor wheel with the CMP sensor.
2. Insert the CMP sensor through the reluctor wheel slot.

**Notice:** Refer to Fastener Notice in Cautions and Notices.

3. Install the new CMP sensor mounting screws.

**Tighten**

Tighten the screws to 1.6–2.8 N·m (14–25 lb in).

**Important:** The locating tabs on the rotor are necessary for correct alignment of the rotor. If the tabs are missing or damaged, replace the rotor.

4. Install the rotor onto the reluctor wheel.
5. Install the new rotor screws.

**Tighten**

Tighten the screws to 1.5–2.4 N·m (13–22 lb in).

6. Install the distributor cap.
7. Install new distributor cap screws.

**Tighten**

Tighten the screws to 1.8–3.0 N·m (16–26 lb in).

8. Connect the CMP sensor harness connector.
9. Connect the spark plug wires and ignition coil wire.
10. Connect the negative battery cable.

## Spark Plug Replacement

### Tools Required

J 39358 Spark Plug Socket

### Service Precautions

- Allow the engine to cool before removing the spark plugs. Attempting to remove the plugs from a hot engine may cause the plug to seize, causing damage to the cylinder head threads.
- Clean the spark plug recess area before removing the plug.  
Failure to do so can result in engine damage due to dirt or foreign material entering the cylinder head or contamination of the cylinder head threads.  
Contaminated threads may prevent proper seating of a new plug.
- Do not install the plugs that are either hotter or colder than the heat range specified.  
Using plugs of the wrong heat range may damage the engine.

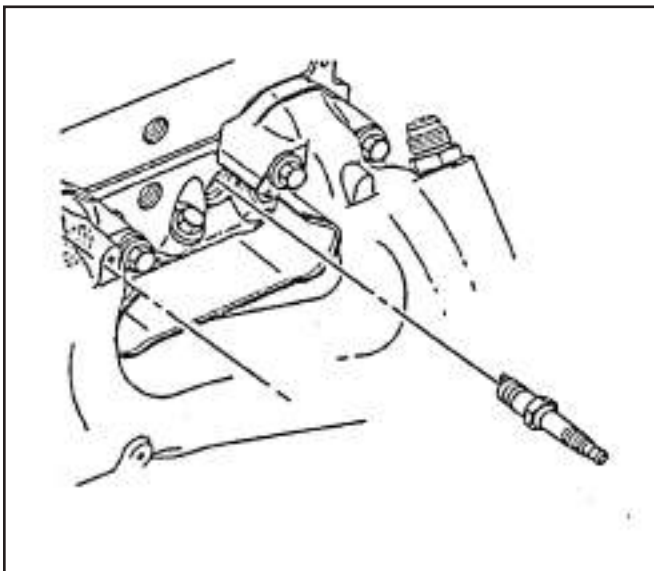
### Removal Procedure

1. Turn OFF the ignition switch.

**Notice:** Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

2. Remove the spark plug wires using a twisting motion in order to release the boot from the spark plug. The spark plug wires are numbered to assist in re-assembly.

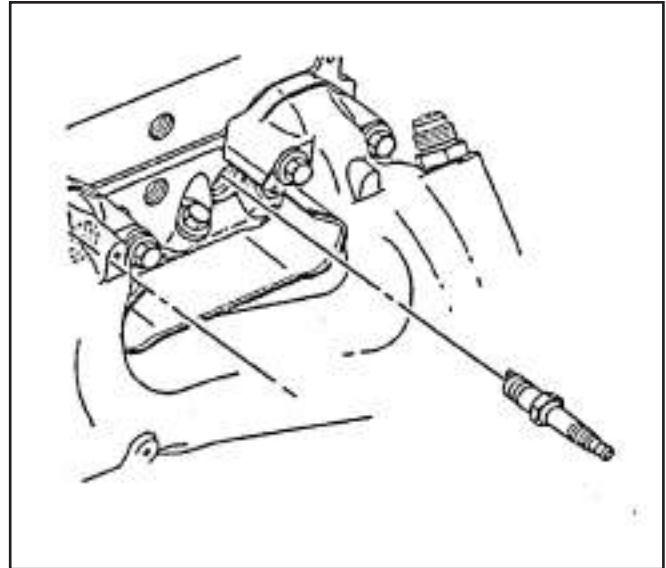
**Notice:** Use the J 39358 or the equivalent. Failure to do so could cause cracking of the insulator and arcing inside the plug, resulting in engine misfire.



3. Remove the spark plugs using the J 39358.
4. Inspect each plug for wear.  
Refer to Spark Plug Visual Diagnosis.

### Installation Procedure

**Notice:** Be sure plug threads smoothly into cylinder head and is fully seated. Use a thread chaser if necessary to clean threads in cylinder head. Cross-threading or failing to fully seat spark plug can cause overheating of plug, exhaust blow-by, or thread damage. Follow the recommended torque specifications carefully. Over or under-tightening can also cause severe damage to engine or spark plug.



1. Install the spark plugs.

### Tighten

Tighten the spark plugs to 15 N·m (11 lb ft).

2. Install the spark plug wires in their original locations.  
Refer to Spark Plug Wire Harness Replacement.

## Spark Plug Replacement

### Remove or Disconnect

1. Negative battery cable.
2. Spark plug wires and boots.
  - Turn each boot one-half turn before removing it.
  - Label the plug wires if the identification numbers have worn off.
3. Spark plugs.

### Inspect

- Each plug for wear and gap.

### Install or Connect

1. Spark plugs. Torque to 15 N•m (11 lb.ft.).
2. Wire and boot assemblies. Refer to “Spark Plug Wiring and Boots” below for precautions.
3. Negative battery cable.

## Spark Plug Wiring And Boots

### Precautions

1. Twist boots one-half turn before removing.
2. When removing the boot, do not use pliers or other tools that may tear the boot.
3. Do not force anything between the wire and the boot, or through the silicone jacket of the wiring.
4. Do not pull on the wires to remove the boot. Pull on the boot, or use a tool designed for this purpose.

5. Special care should be used when installing spark plug boots to make sure the metal terminal within the boot is fully seated on the spark plug terminal and the boot has not moved on the wire. If boot to wire movement has occurred, the boot will give a fast visual impression of being fully seated. A good check to make sure the boots have been properly installed is to push sideways on them. If they have been correctly installed, a stiff boot with only slight looseness will be noted. If the terminal has not been properly seated on the spark plug, only the resistance of the rubber boot will be felt when pushing sideways.

### Replacement

Wire routings must be kept intact during service and followed exactly. If wires have been disconnected, or replacement of the wires is necessary, route the wires in their original positions. Failure to route the wires properly may result in driveability problems.

## Torque Specifications

### Fastener Tightening Specifications

Application	N•m	Lb Ft	Lb In
Distributor Hold Down	40	30	
Coil Bracket Screws	22	16	
Spark Plugs	15	11	

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## Section 5

**Diagnostics, Wiring Diagrams, Pin-Outs, Fault Descriptors & Diagnostic “Trees”**

This section will be used to perform diagnostic procedures on the System 5 equipped engines. The section describes system circuits and diagnostic tables used to diagnose the circuits. It will be used to correct Diagnostic Trouble Codes (DTCs) by following tables for scan tool use. This section contains the On-Board Diagnostic (OBD) System Check that is the first step to perform before any further diagnostics or repairs are made to this system. The assumption is made that on all diagnostic tables, the engine is equipped with a System 5 ECM, wiring harness, fuel components and GM sensors and ignition components. The wiring schematics and circuit identifications are for the System 5 originally equipped wiring harness.

The diagnostic tables and voltages shown are prepared with the requirement that the system functioned correctly at the time of assembly and that there are no multiple failures.

**Contents**

Cautions & Notices.....	Page 2-3	ETC TPS 2 Range	
ECM Wiring .....	Page 4-11	SPN 65601 FMI 2.....	132-135
ECM Connector Identification .....	Page 12-21	ETC TPS 1 Range	
Scan Tool Data List .....	22-25	SPN 65602 FMI 2.....	136-139
Scan Tool Data Definitions .....	26-27	ETC PPS 2 Range	
Scan Tool Output Controls .....	28-29	SPN 65604 FMI 2.....	140-143
Harness Connector Identification .....	30-35	ETC PPS 1 Range	
<b>Diagnostic Trouble Codes</b>		SPN 65605 FMI 2.....	144-147
<b>Repair Procedures.....</b>	<b>Pages 36 - 189</b>	ETC TPS 1-2 Correlation	
Engine Oil Pressure		SPN 65610 FMI 2.....	148-151
SPN 100 FMI 3 & 4 .....	78-85	ETC PPS 1-2 Correlation	
MAP Sensor		SPN 65613 FMI 2.....	152-155
SPN 106 FMI 3 & 4 .....	86-93	PPS Re-Alignment Procedure.....	156-157
Engine Coolant Temperature		ETC Actuation	
SPN 110 FMI 3 & 4 .....	94-101	SPN 65615 FMI 7.....	158-161
CAL Memory Failure		ETC Process	
SPN 630 FMI 13 .....	102-103	SPN 65616 FMI 12.....	162-165
Crankshaft Position Sensor		ETC Return Fault	
SPN 636 FMI 2 .....	104-107	SPN 65618 FMI 7.....	166-169
Fuel Injectors		MEFI System Relay (/Powertrain Relay according to SAE J1939)	
SPN 651 - 658 .....	108-111	Short Low SPN 66013 FMI 5	
Camshaft Position Sensor		Short High SPN 66013 FMI 6	
SPN 723 FMI 2.....	112-115	Open SPN 66013 FMI 7	
EST 1 Short High		Contact Low SPN 66014 FMI 4 .....	170-173
SPN 65541 FMI 3		Fuel Pump Relay	
EST 1 Short Low		SPN 66017 FMI 5,6,7.....	174-177
SPN 65541 FMI 4		O2 Sensor A&B Rich	
EST 1 Open		SPN 65561, 65563 FMI 0.....	178-181
SPN 65541 FMI 5 .....	116-119	O2 Sensor A&B Lean	
Knock Sensor		SPN 65561, 65563 FMI 1.....	182-185
SPN 65551 FMI 2		O2 Sensor A&B Heater Short Low	
Knock Sensor		O2 Sensor A&B Heater Short High	
SPN 65552 FMI 2 .....	120-123	O2 Sensor A&B Heater Open	
Can Bus Hardware		SPN 66019 FMI 5,6,7	
SPN 65559 FMI 11 .....	124-125	SPN 66020 FMI 5,6,7.....	186-189
CPU Failure		Misfire DTC	
SPN 65580 FMI 12 .....	126-127	SPN 65590 FMI 7 .....	190-193
MHC Failure		<b>Complete Fault Code List .....</b>	<b>194-196</b>
SPN 65581 FMI 12 .....	128-129		
NV RAM Failure			
SPN 65582 FMI 12 .....	130-131		

## Cautions and Notices and Special Testing Procedures

### Battery Disconnect Caution

*Caution:* Before servicing any electrical component, the ignition key must be in the OFF or LOCK position and all electrical loads must be OFF, unless instructed otherwise in the procedures. If a tool or equipment could easily come in contact with a live exposed electrical terminal, also disconnect the negative battery cable. Failure to follow these precautions may cause personal injury and/or damage to the vehicle or its components.

### Using Fused Jumper Wires

#### Tools Required

*J 36169-A* Fused Jumper Wire

**Important:** A fused jumper may not protect solid state components from being damaged. The *J 36169-A* includes small clamp connectors that provide adaptation to most connectors without damage. This fused jumper wire is supplied with a 20-A fuse which may not be suitable for some circuits. Do not use a fuse with a higher rating than the fuse that protects the circuit being tested.

### Electrostatic Discharge Damage

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

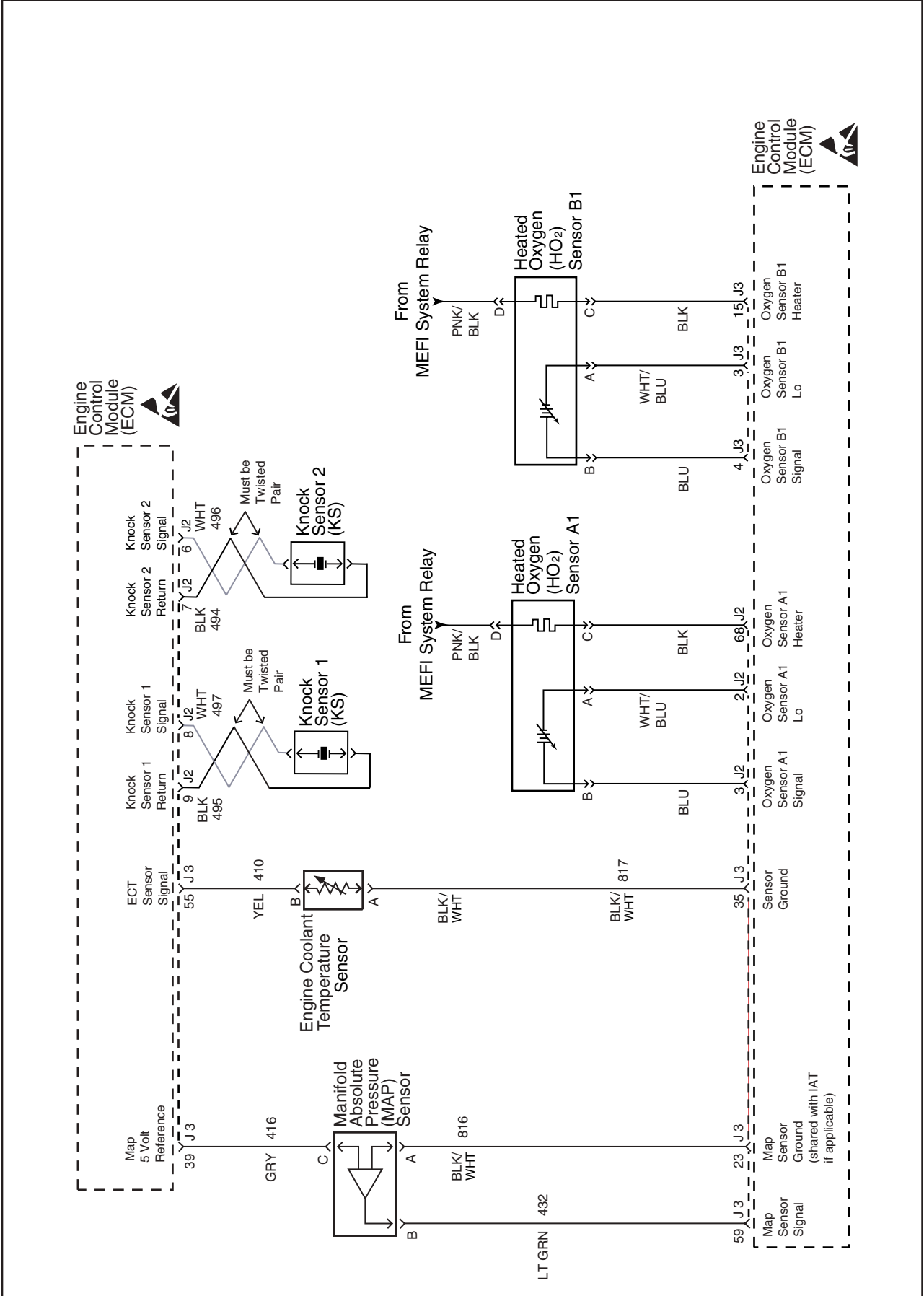
There are several ways a person can become statically charged. The most common methods of charging are by friction and by induction. An example of charging by friction is a person sliding across a seat, in which a charge of as much as 25,000 volts can build up. Charging by induction occurs when a person with well insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off, leaving the person highly charged with the opposite polarity. Static charges of either type can cause damage. Therefore, it is important to use care when handling and testing electronic components.



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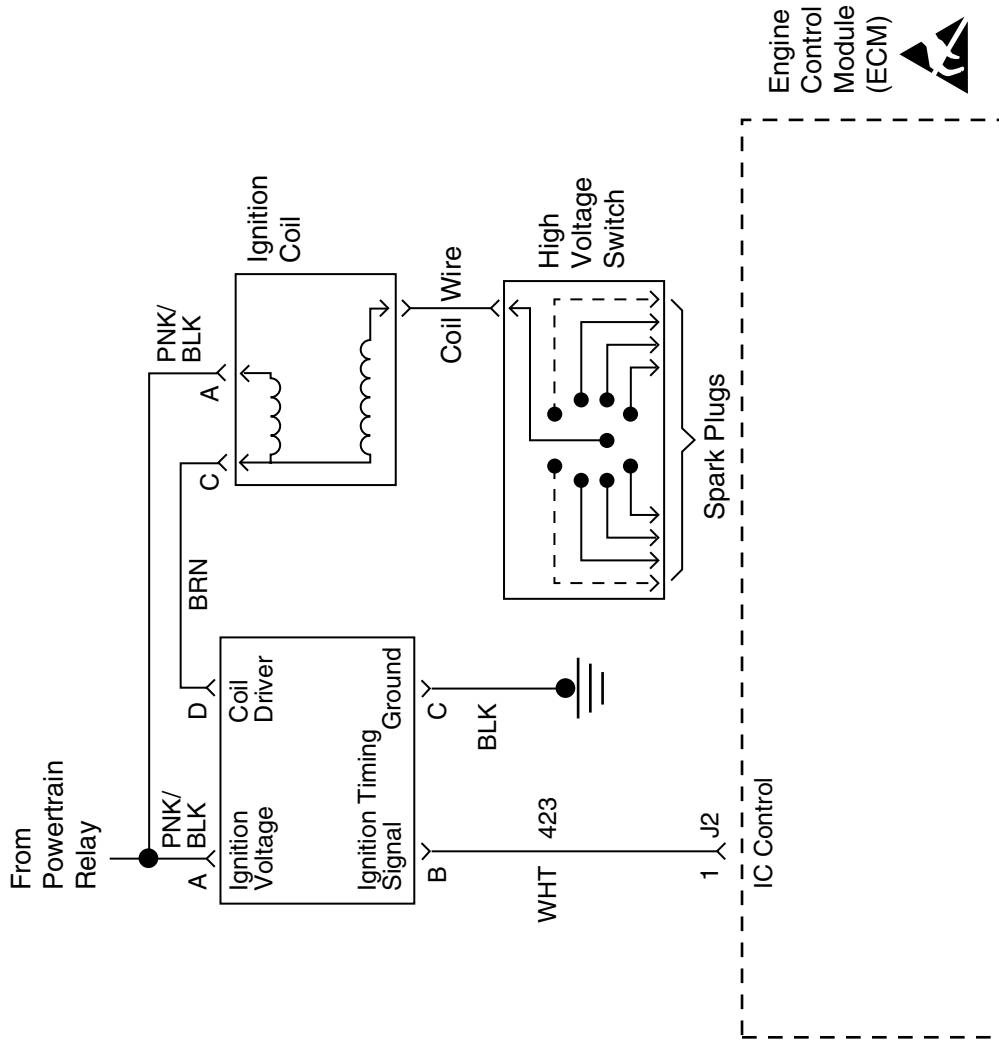
ECM Wiring (1 of 5)

Engine Controls Schematics (5.7L - Sensors)

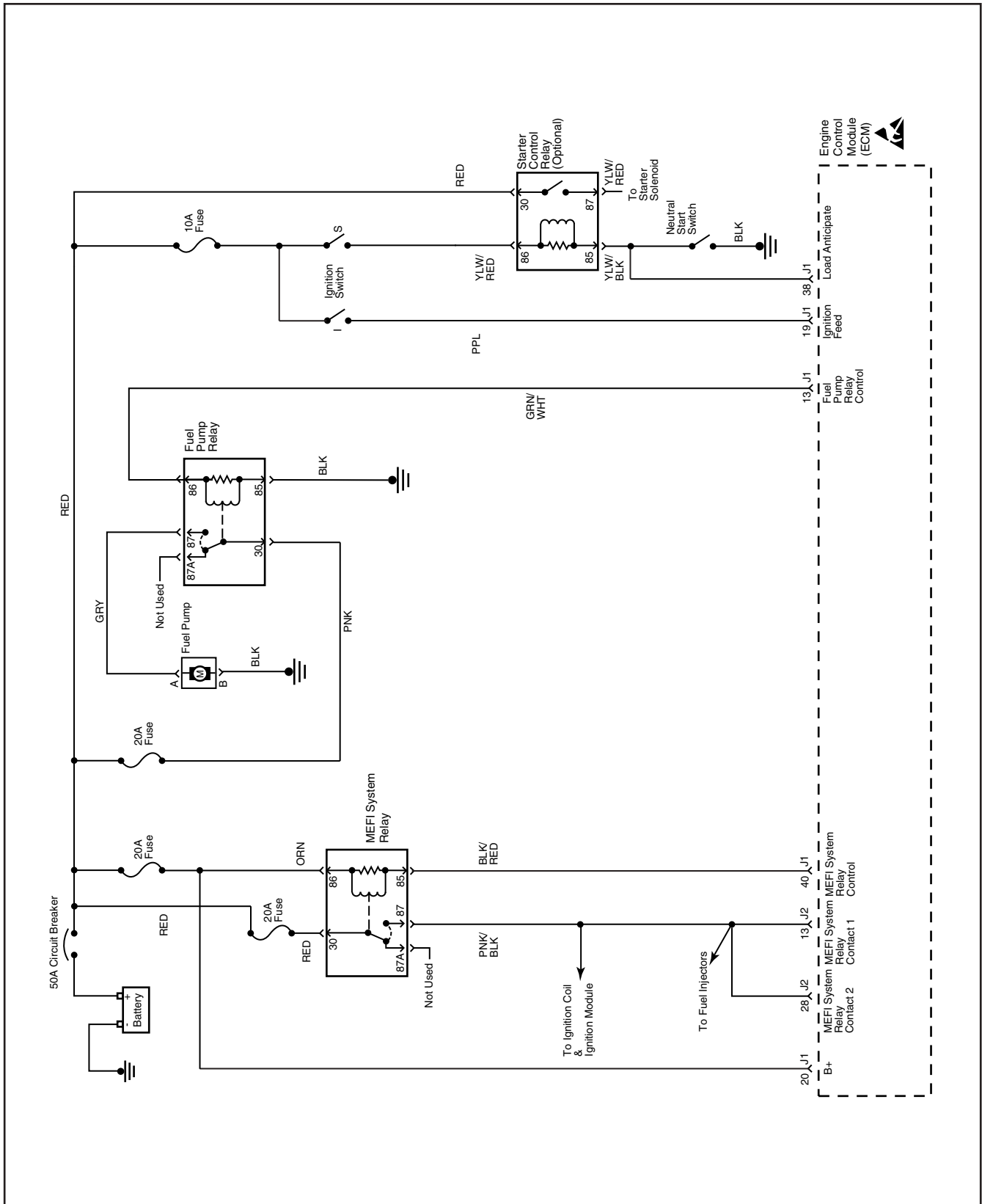




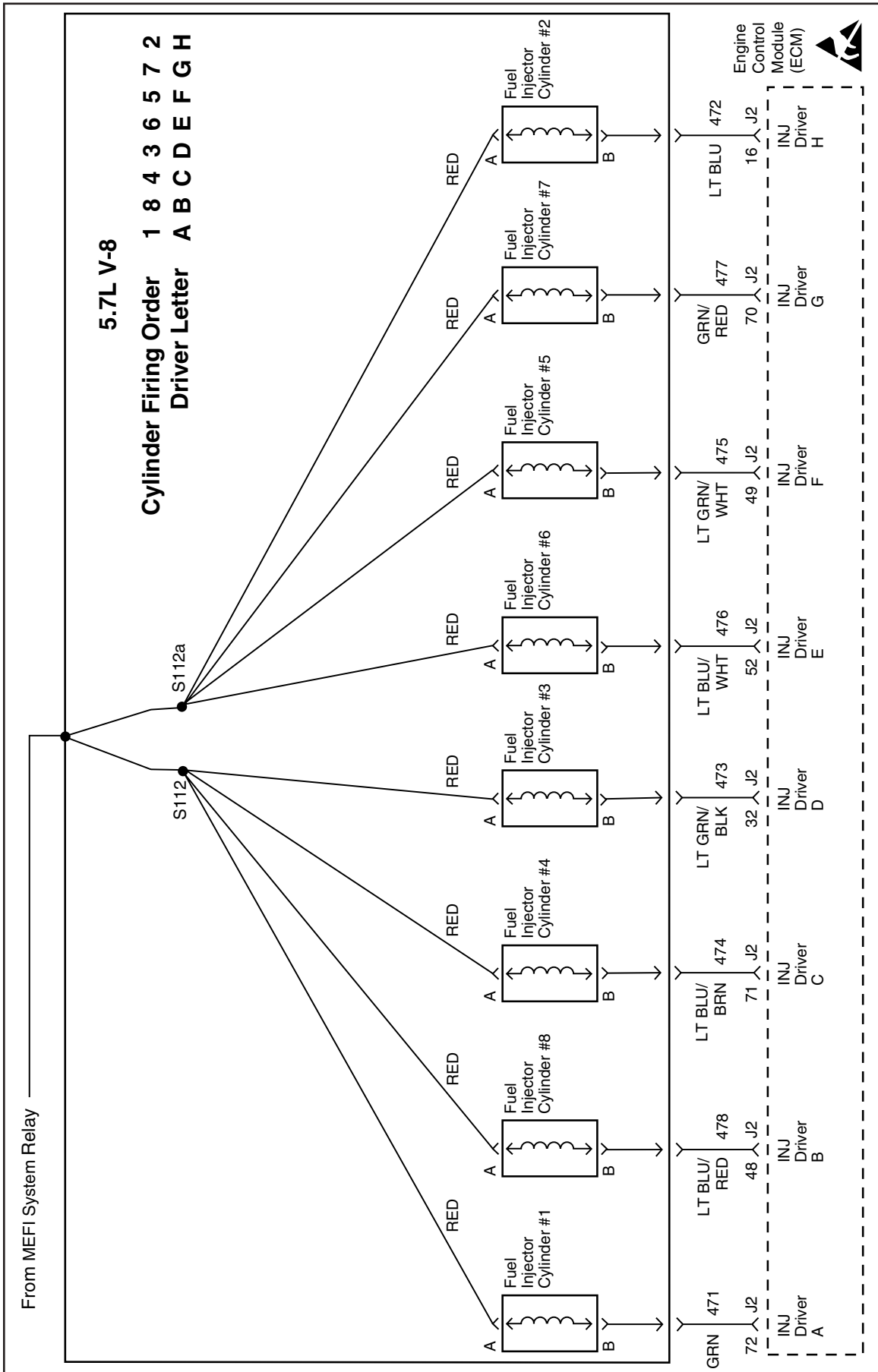
ECM Wiring (3 of 5)



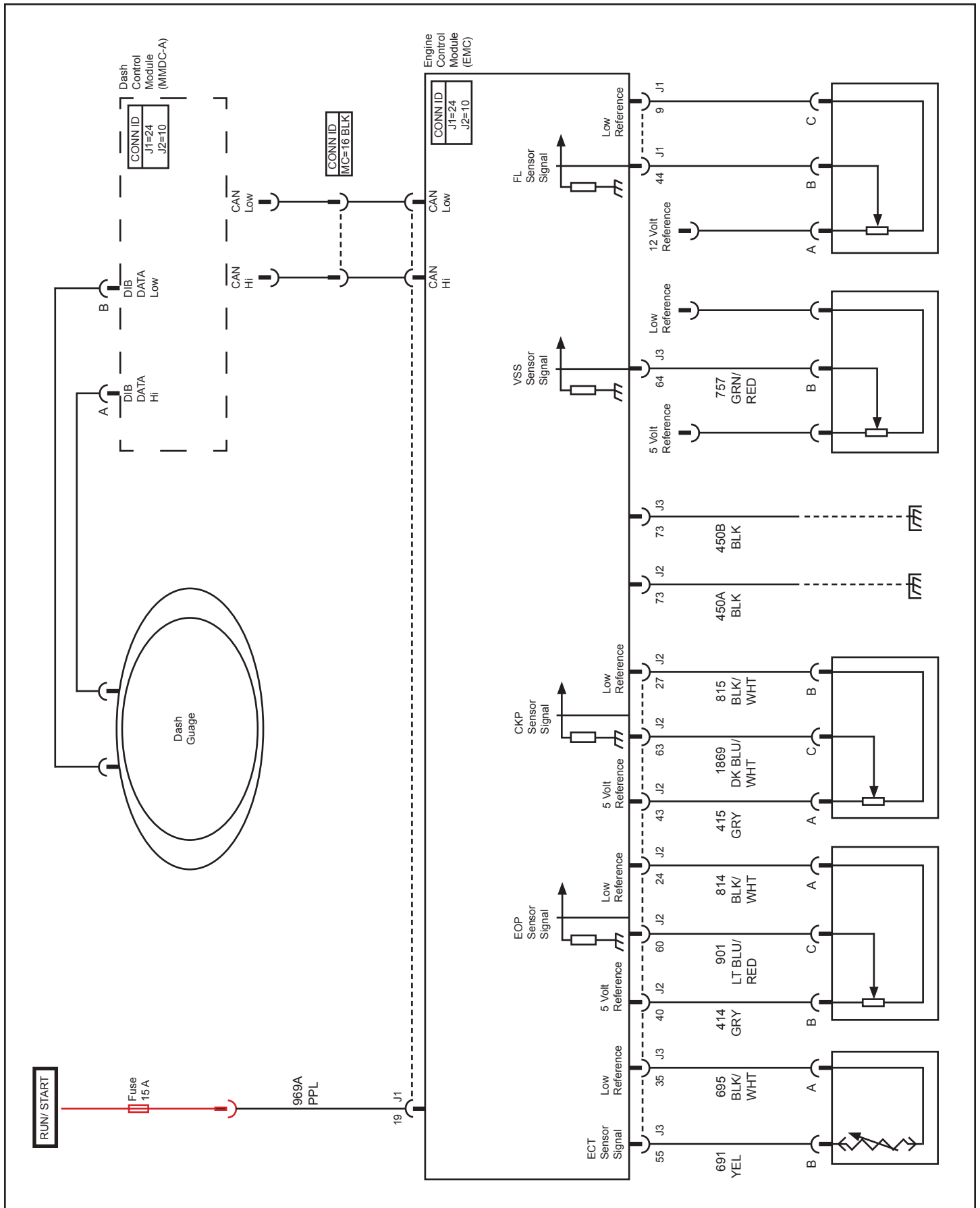
ECM Wiring (4 of 5)



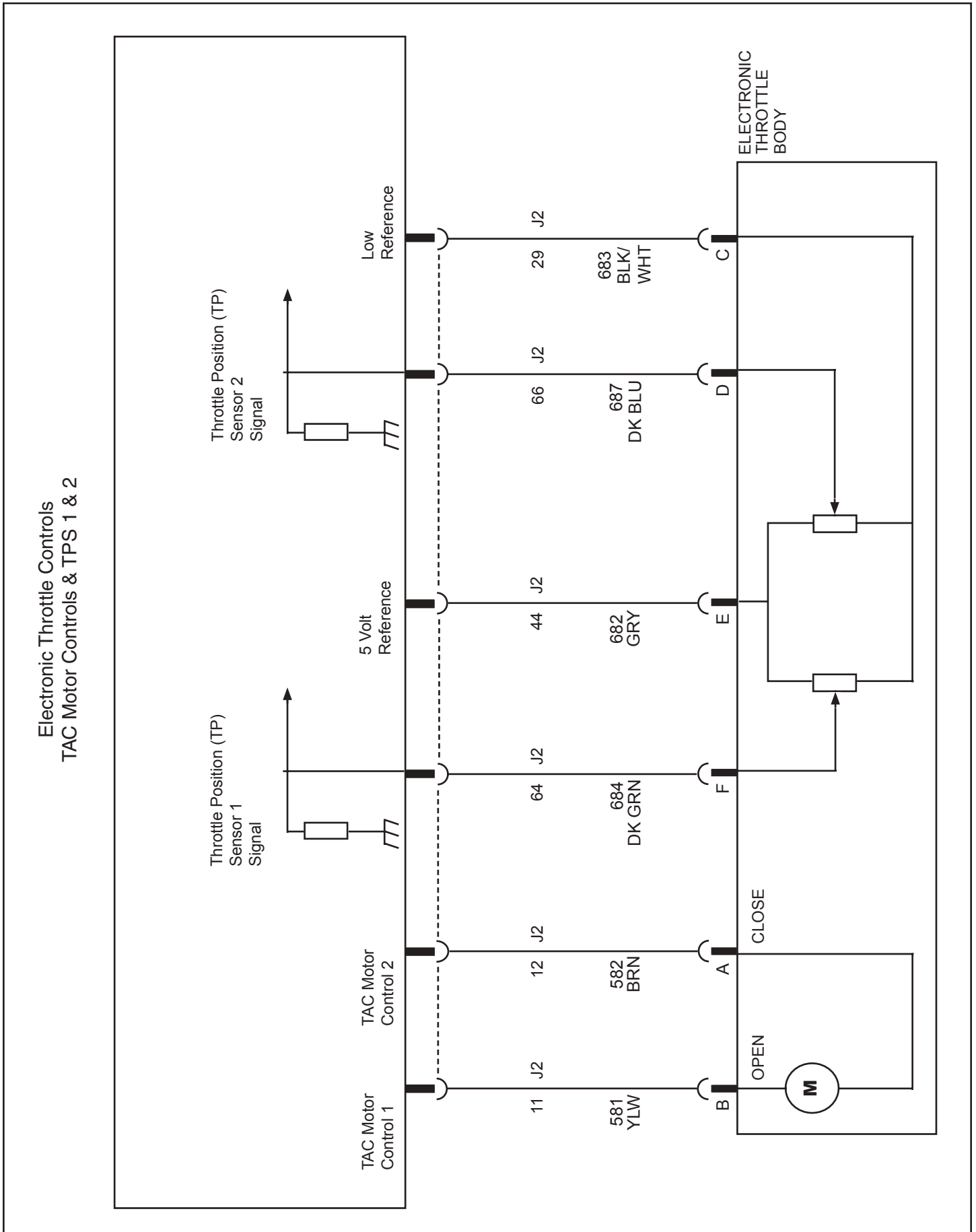
ECM Wiring (5 of 5)



Dash Wiring Schematics (ECT, EOP, CKP, VSS, & FL)

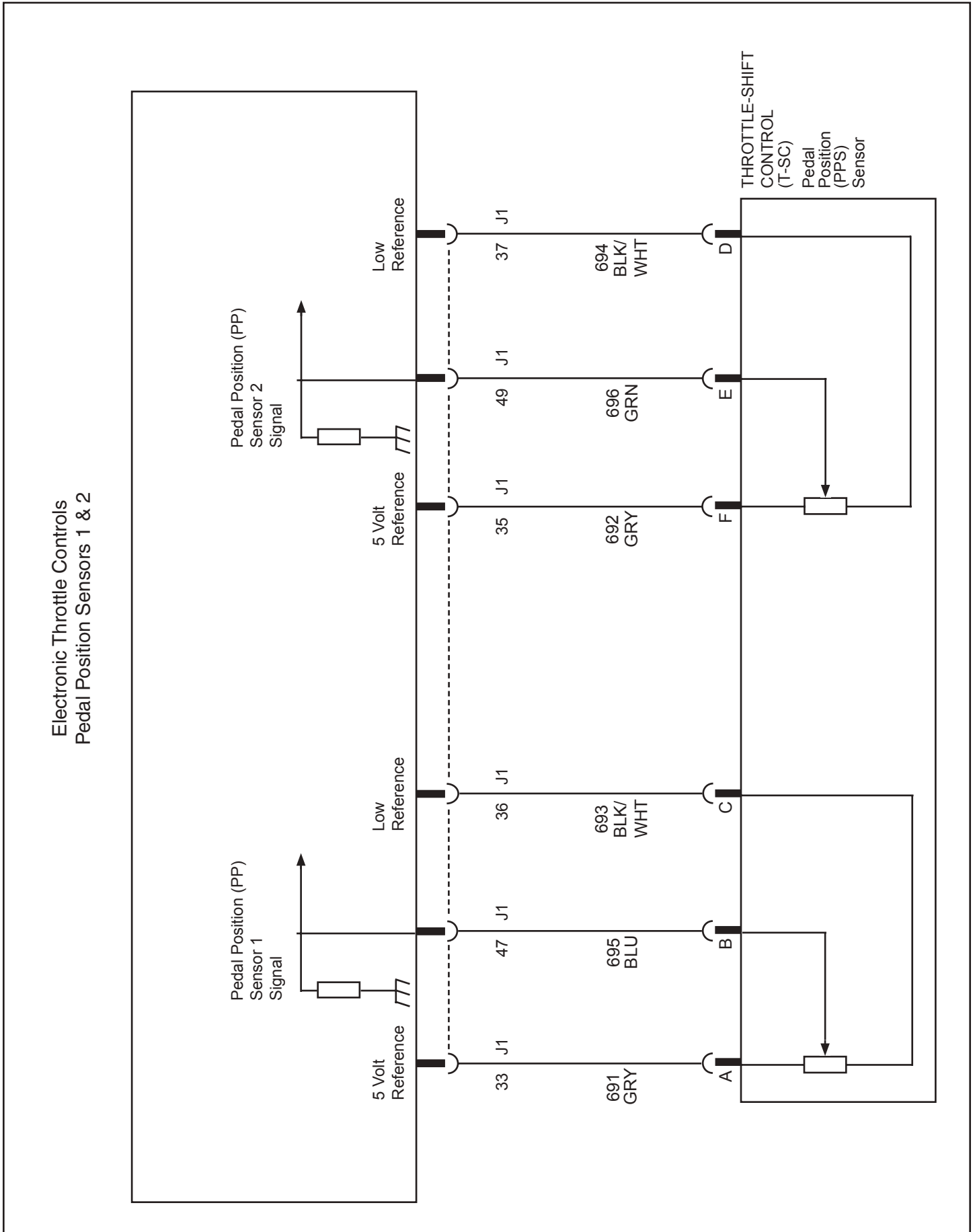


Electronic Throttle Control (ETC) Wiring (TAC Motor & TPS 1 & 2)

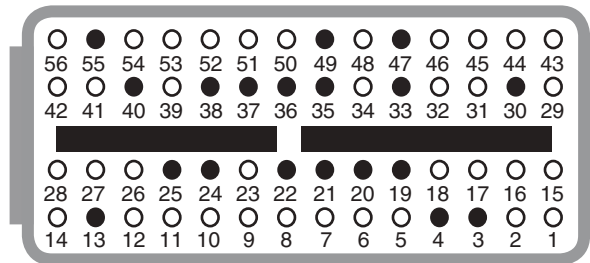




Electronic Throttle Control (ETC) Wiring (PPS 1 & 2)



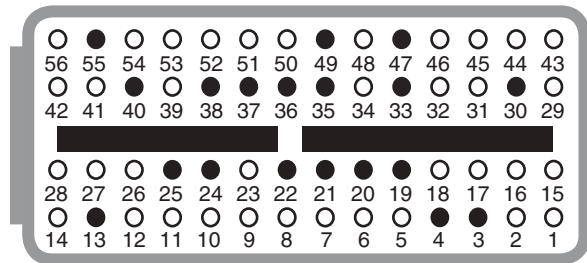
## J-1 ECM Connector Identification (1 of 2 J-1)



## ECM 56 WAY OUTPUT CONNECTOR

ECM PIN NUMBER	CKT(WIRE) NUMBER	CKT (WIRE) COLOR	CIRCUIT DESCRIPTION
J1-1			CRANK REQUEST
J1-2			N/A
J1-3	759	TAN/WHT	PERFECT PASS ENABLE
J1-4	941	YEL	SLAVE ENGINE SELECT
J1-5			N/A
J1-6			N/A
J1-7			EMERGENCY STOP
J1-8			N/A
J1-9			LOW REFERENCE - FUEL LEVEL SENSOR
J1-10			N/A
J1-11			TROLL MODE
J1-12			MALFUNCTION INDICATOR LAMP
J1-13	465	GRN/WHT	FUEL PUMP ENABLE
J1-14			N/A
J1-15			N/A
J1-16			N/A
J1-17			GOVERNOR MODE
J1-18			BOOT MODE
J1-19	969A	PURPLE	IGNITION FEED
J1-20	440C	ORN	BATTERY FEED
J1-21	751	PNK/BLU	CRUISE INCREMENT UP / ACCELERATE
J1-22	752	PNK/WHT	CRUISE SET
J1-23			N/A
J1-24	921B	GRY	PULLUP FOR TACH
J1-25	921A	GRY	TACHOMETER
J1-26		TAN	STARTER CONTROL HS
J1-27			N/A
J1-28			N/A
J1-29			N/A
J1-30	753A	LT GRN	CRUISE/SYNC ON/OFF
J1-31			SENSOR RETURN - VSS ANALOG
J1-32			5V REFERENCE - VSS ANALOG

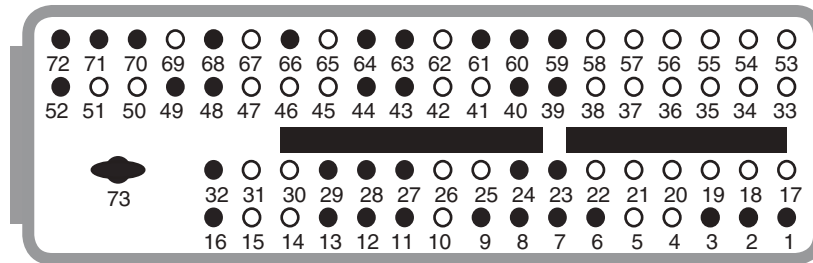
## J-1 ECM Connector Identification (2 of 2 J-1)



## ECM 56 WAY OUTPUT CONNECTOR

ECM PIN NUMBER	CKT(WIRE) NUMBER	CKT (WIRE) COLOR	CIRCUIT DESCRIPTION
J1-33	691	GRY	5V REFERENCE - PEDAL POSITION #1
J1-34			5V REFERENCE - FUEL PRESSURE SENSOR
J1-35	692	GRY	5V REFERENCE - PEDAL POSITION #2
J1-36	693	BLK/WHT	LOW REFERENCE - PEDAL POSITION #1
J1-37	694	BLK/WHT	LOW REFERENCE - PEDAL POSITION #2
J1-38	906A	YLW/BLK	LOAD ANTICIPATE 1 (IN GEAR)
J1-39			N/A
J1-40	441	BLK/RED	MEFI SYSTEM RELAY ENABLE
J1-41			CHECK GAUGE LAMP
J1-42			N/A
J1-43			N/A
J1-44			FUEL LEVEL SENSOR
J1-45	753B		FUEL LEVEL SENSOR #2
J1-46			VSS ANALOG
J1-47	695	BLU	PEDAL POSITION SENSOR 1
J1-48			FUEL PRESSURE SENSOR
J1-49	696	GRN	PEDAL POSITION SENSOR 2
J1-50			FUEL TEMPERATURE SENSOR
J1-51			GENERAL WARNING 1 LAMP
J1-52			GENERAL WARNING 2 LAMP
J1-53			SPEED BASED OUTPUT
J1-54			BUZZER
J1-55	754	LT GRN/BLK	CRUISE STATUS LAMP
J1-56			STARTER CONTROL LS

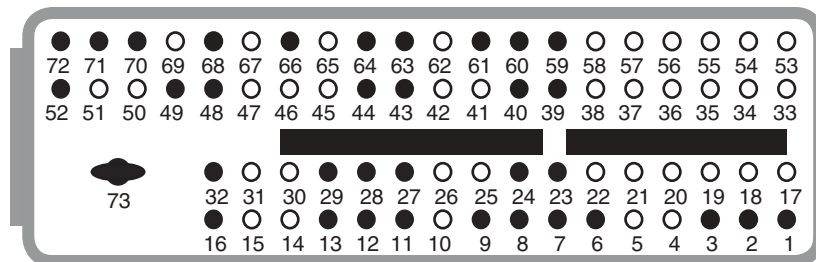
## J-2 ECM Connector Identification (1 of 3 J-2)



## ECM 73 WAY OUTPUT CONNECTOR

ECM PIN NUMBER	CKT(WIRE) NUMBER	CKT (WIRE) COLOR	CIRCUIT DESCRIPTION
J2-1	423	PPL	EST A - IGNITION COIL G - CYLINDER 1
J2-2		WHT/BLU	OXYGEN SENSOR A1 LO
J2-3		BLU	OXYGEN SENSOR A1 HI
J2-4			OXYGEN SENSOR A2 HI
J2-5			OXYGEN SENSOR A2 LO
J2-6	496	WHT	KNOCK SENSOR FLAT RESPONSE#2
J2-7	494	BLK	KNOCK SENSOR RETURN #2
J2-8	497	WHT	KNOCK SENSOR-FLAT RESPONSE
J2-9	495	BLK	KNOCK SENSOR RETURN
J2-10			KNOCK SENSOR SHIELD
J2-11	581	YLW	ETC MOTOR OPEN: IAC1 PWM
J2-12	582	BRN	ETC MOTOR CLOSE: IAC2 PWM
J2-13	439B	PNK/BLK	IGNITION 1 VOLTAGE - PINS H IGNITION COILS EVEN & ODD BANKS
J2-14		RED/BLK	CAM PHASE CONTROL W PIN D
J2-15			CAM PHASE CONTROL Y
J2-16	472	LT BLU	FUEL INJECTOR H (CYLINDER 2)
J2-17		PPL/WHT	EST B - IGNITION COIL G - CYLINDER 8
J2-18		GRN/WHT	EST G - IGNITION COIL C - CYLINDER 4
J2-19		BRN	EST RETURN #2 - IGNITION COIL EVEN BANK
J2-20			SENSOR RETURN - CAMX
J2-21			SENSOR RETURN - CAMY
J2-22			SENSOR RETURN - CAMZ
J2-23	813	BLK/WHT	LOW REFERENCE - CAM SENSOR (DISTRIBUTOR)
J2-24	814	BLK/WHT	LOW REFERENCE - ENGINE OIL PRESSURE
J2-25			LOW REFERENCE - LEGR SENSOR
J2-26			KNOCK SENSOR SHIELD #2
J2-27	815	BLK/WHT	LOW REFERENCE - CRANK SENSOR
J2-28	439C	PNK/BLK	IGNITION 1 VOLTAGE
J2-29	683	BLK/WHT	LOW REFERENCE - THROTTLE POSITION SENSOR
J2-30			CAM PHASE RETURN X
J2-31			LEGR / CAM PHASE RETURN Z
J2-32	473	LT GRN/BLK	FUEL INJECTOR D (CYLINDER 3)

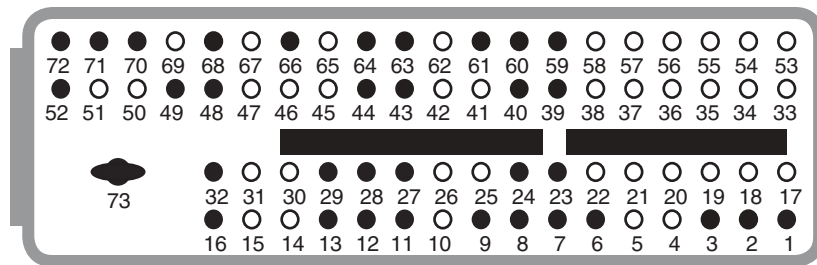
## J-2 ECM Connector Identification (2 of 3 J-2)



## ECM 73 WAY OUTPUT CONNECTOR

ECM PIN NUMBER	CKT(WIRE) NUMBER	CKT (WIRE) COLOR	CIRCUIT DESCRIPTION
J2-33		RED	EST C - IGNITION COIL B - CYLINDER 7
J2-34		GRN	EST F - IGNITION COIL C - CYLINDER 5
J2-35		BRN	EST RETURN - IGNITION COIL E - ODD BANK
J2-36			5V REFERENCE - CAMX (CAMB, CAM 4X)
J2-37			5V REFERENCE - CAMY (CAMC, CAM 4X2)
J2-38			5V REFERENCE - CAMZ (CAMD, CAM 4X3)
J2-39	413	GRY	5V REFERENCE - CAM SENSOR
J2-40	414	GRY	5V REFERENCE - ENGINE OIL PRESSURE
J2-41			5V REFERENCE - LINEAR EGR POSITION
J2-42			SENSOR RETURN - INDUCTION AIR
J2-43	415	GRY	5V REFERENCE - CRANK SENSOR
J2-44	682	GRY	5V REFERENCE - THROTTLE POSITION SENSOR
J2-45			SENSOR RETURN - ENGINE OIL TEMP
J2-46		YLW/BLK	CAM PHASE RETURN W - PIN E
J2-47			CAM PHASE RETURN Y
J2-48	478	LT BLU/RED	FUEL INJECTOR B (CYLINDER 8)
J2-49	475	LT GRN/WHT	FUEL INJECTOR F (CYLINDER 5)
J2-50			CAM PHASE CONTROL X
J2-51			LEGR: CAM PHASE CONTROL Z
J2-52	476	LT BLU/WHT	FUEL INJECTOR E (CYLINDER 6)
J2-53			EST D
J2-54			EST E
J2-55			EST H
J2-56			CAMX SENSOR (CAMB, CAM 4X)
J2-57			CAMY SENSOR (CAMC, CAM 4X2)
J2-58			CAMZ SENSOR (CAMD, CAM 4X3)
J2-59	633	BRN/WHT	CAM SENSOR SIGNAL (CAMA, CAM 8XPWP)
J2-60	901	LT BLU/RED	ENGINE OIL PRESSURE SENSOR SIGNAL
J2-61	756	PNK	DASH
J2-62			INDUCTION AIR TEMPERATURE (OR MAT) SENSOR
J2-63	1869	DK BLU/WHT	CRANK SENSOR
J2-64	684	DK GRN	THROTTLE POSITION SENSOR #1

**J-2 ECM Connector Identification (3 of 3 J-2)**

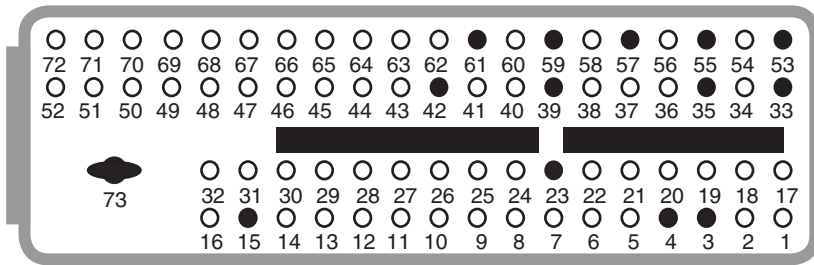


**J-2 (Continued)  
ECM 73 WAY OUTPUT CONNECTOR**

ECM PIN NUMBER	CKT(WIRE) NUMBER	CKT (WIRE) COLOR	CIRCUIT DESCRIPTION
J2-65			ENGINE OIL TEMPERATURE SENSOR
J2-66	687	DK BLU	THROTTLE POSITION SENSOR #2
J2-67			HIGH SPEED MASS AIR FLOW
J2-68		BLK	OXYGEN SENSOR A1 HEATER
J2-69			OXYGEN SENSOR A2 HEATER
J2-70	477	GRN/RED	FUEL INJECTOR G
J2-71	474	LT BLU/BRN	FUEL INJECTOR C
J2-72	471	GRN	FUEL INJECTOR A
J2-73	450A	BLK	POWER GROUND

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**J-3 ECM Connector Identification (1 of 3 J-3)**

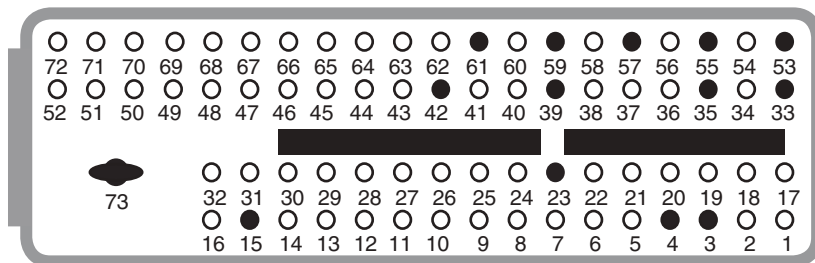


**ECM 73 WAY OUTPUT CONNECTOR**

ECM PIN NUMBER	CKT(WIRE) NUMBER	CKT (WIRE) COLOR	CIRCUIT DESCRIPTION
J3-1			CAT TEMPERATURE SENSOR A
J3-2			CAT TEMPERATURE SENSOR B
J3-3		WHT/BLU	OXYGEN SENSOR B1 LO
J3-4		BLU	OXYGEN SENSOR B1 HI
J3-5			OXYGEN SENSOR B2 HI
J3-6			OXYGEN SENSOR B2 LO
J3-7			N/A
J3-8			LOW OIL LEVEL LAMP
J3-9			N/A
J3-10			CYLINDER DEACTIVATE C
J3-11			CYLINDER DEACTIVATE A
J3-12			GOVENOR PWM OUTPUT (NON-ETC GOVENOR)
J3-13			TRANSMISSION UP-SHIFT
J3-14			N/A
J3-15		BLK	OXYGEN SENSOR B1 HEATER
J3-16			TROLL MODE LAMP
J3-17			N/A
J3-18			ENGINE OIL LEVEL LOW SENSOR
J3-19			SENSOR RETURN - CAT TEMP SENSOR A
J3-20			SENSOR RETURN - CAT TEMP SENSOR B
J3-21			SENSOR RETURN - VARIABLE GOVENOR
J3-22			N/A
J3-23	816	BLK/WHT	LOW REFERENCE - MANIFOLD ABSOLUTE PRESSURE
J3-24			AUX ANALOG RETURN
J3-25			SENSOR RETURN - GENERAL WARNING 2
J3-26			SENSOR RETURN - GENERAL WARNING 1
J3-27			N/A
J3-28			SENSOR RETURN - DIGITAL VSS
J3-29			N/A
J3-30			N/A
J3-31			N/A
J3-32			N/A



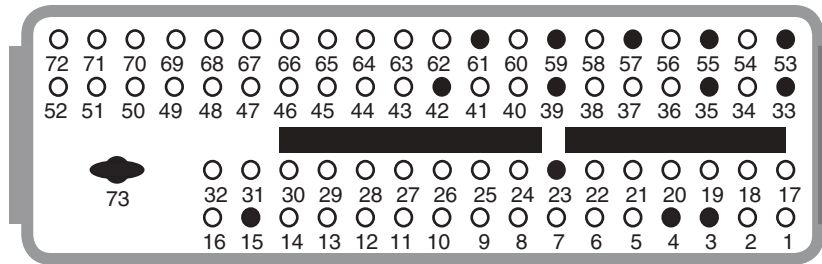
## J-3 ECM Connector Identification (2 of 3 J-3)



## ECM 73 WAY OUTPUT CONNECTOR

ECM PIN NUMBER	CKT(WIRE) NUMBER	CKT (WIRE) COLOR	CIRCUIT DESCRIPTION
J3-33	804A	WHT/BLK	CAN BUS LO TERMINATED (TO DASH & DLC)
J3-34			N/A
J3-35	817	BLK/WHT	LOW REFERENCE - ENGINE COOLANT TEMP SENSOR
J3-36			N/A
J3-37			5V REFERENCE - VARIABLE GOVERNOR
J3-38			N/A
J3-39	416	GRY	5V REFERENCE - MANIFOLD ABOSOLUTE PRESSURE
J3-40			5V REFERENCE - AUX ANALOG
J3-41			5V REFERENCE - GENERAL WARNING 2
J3-42	417	GRY	5V REFERENCE - GENERAL WARNING 1 (TRANSMISSION OVER TEMP SENSOR)
J3-43			N/A
J3-44			5V REFERENCE - DIGITAL VSS
J3-45			LOAD ANTICIPATE 2
J3-46			SHIFT INTERRUPT / TRANSMISSION LOCK LOW
J3-47			N/A
J3-48			CONTROL CANISTER PURGE
J3-49			N/A
J3-50			OXYGEN SENSOR B2 HEATER
J3-51			N/A
J3-52			N/A
J3-53	803A	WHT/RED	CAN BUS HI TERMINATED (GOES TO DLC-C & DASH K)
J3-54			N/A
J3-55	410	YLW	ENGINE COOLANT TEMPERATURE SENSOR SIGNAL
J3-56			N/A
J3-57	755	LT GRN/WHT	VARIABLE GOVERNOR (TO DASH-E)
J3-58			N/A
J3-59	432	LT GRN	MANIFOLD ABSOLUTE PRESSURE SENSOR SIGNAL
J3-60			AUX ANALOG INPUT
J3-61	933	TAN/BLK	GENERAL WARNING 1 (TO TRANS TEMP SENSOR SIGNAL)
J3-62			GENERAL WARNING 2
J3-63			N/A
J3-64	757	GRN/RED	DIGITAL VSS (TO DASH-N)

**J-3 ECM Connector Identification (3 of 3 J-3)**



**ECM 73 WAY OUTPUT CONNECTOR**

ECM PIN NUMBER	CKT(WIRE) NUMBER	CKT (WIRE) COLOR	CIRCUIT DESCRIPTION
J3-65			ENGINE OIL PRESSURE SWITCH
J3-66			VR VSS FREQ HI
J3-67			VR VSS FREQ LO
J3-68			CYLINDER DEACTIVATE B
J3-69			CYLINDER DEACTIVATE D
J3-70			N/A
J3-71			N/A
J3-72			N/A
J3-73	450B	BLK	POWER GROUND #2

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## Scan Tool Data List

### Scan Tool Data List: Engine Controls – MEFI5

The Engine Scan Tool Data List contains all engine related parameters that are available on the scan tool. The list is arranged in alphabetical order. A given parameter may appear in any one of the data lists, and in some cases may appear more than once, or in more than one data list in order to group certain related parameters together.

Use the Engine Scan Tool Data List only after the following is determined:

- The Diagnostic System Check – Vehicle is completed.
- No diagnostic trouble codes (DTCs)
- On-board diagnostics are functioning properly.

Scan tool values from a properly running engine may be used for comparison with the engine you are diagnosing. The Engine Scan Tool Data List represents values that would be seen on a normal running engine.

**Important:** A scan tool that displays faulty data should not be used. The scan tool problem should be reported to the manufacturer. Use of a faulty scan tool can result in misdiagnosis and unnecessary parts replacement.

Only the parameters listed below are referenced in this service manual for use in diagnosis. If all values are within the typical range described below, refer to *Symptoms - Engine Controls* for diagnosis.

The column labeled Data List indicates where a parameter can be located on the scan tool. Refer to the scan tool operating manual for the exact locations of the data lists. The following is a description of each term listed:

**All:** The Parameter is in all of the data lists indicated below.

**Eng:** Engine Data List

**EE:** Enhanced Evaporative Emission (EVAP) Data

**FT:** Fuel Trim Data List

**H2:** Heated Oxygen Sensor (HO2S) Data List

**HO2S:** Heated Oxygen Sensor (HO2S)

**IG:** Ignition System Data List

**MF:** Misfire Data List

**OD:** Output Driver Data List

**TAC:** Throttle Actuator Control (TAC) Data List

Scan Tool Parameter	Data List	Parameter Range/Units	Typical Data Values
<b>Engine Idling/Radiator Hose Hot/Closed Throttle/Park/Closed Loop/Accessories OFF</b>			
5-Volt Reference 1 Circuit Status	EE, Eng, Ign, TAC	OK/Fault	OK
5-Volt Reference 2 Circuit Status	EE, Eng, Ign, TAC	OK/Fault	OK
5-Volt Reference 1	EE, Eng, Ign, TAC	Volts	4.5 V
5-Volt Reference 2	EE, Eng, Ign, TAC	Volts	4.5 V
Ambient Air Temperature	Eng	°C/°F	Varies
PPS Indicated Angle	EE, Eng, FT, HO2S, Ign, MF, TAC	0–100%	0
PP Sensor 1	TAC	0–5.0 Volts	0.4–1.0 Volt
PP Sensor 2	TAC	5.0–0 Volts	4.5–4.1 Volts
PP Sensor 1	TAC	0–100%	0%
PP Sensor 2	TAC	0–100%	0%
PP Sensor 1 and 2	TAC	Agree/Disagree	Agree
PP Sensor 1 Indicated Position	TAC	%	0%
PP Sensor 2 Indicated Position	TAC	%	—
PP Sensors	TAC	%	0%
BARO	EE, Eng, FT, HO2S, Ign	kPa	50–104 kPa/ Varies w/ Altitude
CKP Active Counter	Ign	0–250 Counts	Varies
CKP Resync Counter	Ign	Counts	0
CKP Sensor	Eng, Ign	RPM	500–700 RPM
CMP Active Counter	Ign	0–250 Counts	Varies

CMP Sensor	Eng, Ign, MF	RPM	1,000–1,400 RPM
Cold Start-Up	Eng, EE	Yes/No	Varies
Cruise Control Active	Eng, TAC	Active/Inactive	Inactive
Cycles of Misfire Data	MF	0–100 Counts	Varies
Cylinder 1–8 IC Circuit Status	OD	OK, Incomplete, Short B+, Short Gnd/Open	OK
Cylinder 1–8 Injector Circuit Status	OD	OK, Incomplete, Short B+, Short Gnd/Open	OK
Decel Fuel Cutoff	Eng, FT, HO2S	Active/Inactive	Inactive
Desired Idle Speed	EE, Eng, TAC	RPM	ECM Controlled
EC Ignition Relay Circuit Status	OD	OK, Incomplete, Short B+, Short Gnd/Open	OK/Incomplete
EC Ignition Relay Command	Eng, TAC	On/Off	On
EC Ignition Relay Feedback	Eng, TAC	Volts	2.25–2.95 Volts
ECM Reset	EE, Eng, Ign	Yes/No	No
ECT Sensor	All	-39 to +140°C (-38 to +284°F)	88–105°C (190–221°F)
Engine Load	All	0–100%	18% @ Idle 21% @ 2500 RPM
Engine Oil Pressure Sensor	Eng, MF	PSI	30
Engine Oil Pressure Sensor	EVAP	Volts	1.5
Engine Run Time	All	Hrs, Min, Sec	Varies
Engine Speed	All	0–10,000 RPM	500–700 RPM
Engine Speed Circuit Status	OD	OK, Incomplete, Short B+, Short Gnd/Open	OK
FC Circuit Status	OD	OK, Incomplete, Short B+, Short Gnd/Open	OK/Incomplete
Fuel Level Sensor	EE	0–5 Volts	0.7–2.5 Volts
Fuel Pump Relay Circuit Status	OD	OK, Incomplete, Short B+, Short Gnd/Open	OK/Incomplete
Fuel Pump Relay Command	Eng, FT	On/Off	ON
Fuel Tank Level Remaining	Eng, MF	0–100%	Varies
HO2S Bank 1 Sensor 1	EE, Eng, FT, HO2S	Millivolts	10–1,000 mV and Varying
HO2S Bank 2 Sensor 1	EE, Eng, FT, HO2S	Millivolts	10–1,000 mV and Varying
HO2S BN 1 Sensor 1 Heater	HO2S	Amps	0.7–0.9Amps
HO2S BN 2 Sensor 1 Heater	HO2S	Amps	0.7–0.9Amps
HO2S BNK 1 Sen 1 Heater Circuit Status	OD	OK, Incomplete, Short B+, Short Gnd/Open	OK/Incomplete
HO2S BNK 2 Sen 1 Heater Circuit Status	OD	OK, Incomplete, Short B+, Short Gnd/Open	OK/Incomplete
HO2S Bnk 1 Sensor 1 Heater Command	HO2S	On/Off	ON
HO2S Bnk 1 Sensor 1 Heater Command	HO2S	%	100%
HO2S Bnk 2 Sensor 1 Heater Command	HO2S	On/Off	ON
HO2S Bnk 2 Sensor 1 Heater Command	HO2S	%	100%
Hot Open Loop	CD, FT, HO2S	Active/Inactive	Inactive
KS Module Status	Ign	OK/Fault/Incomplete	OK/Incomplete
MAP Sensor	EE, Eng, FT, HO2S, Ign, MF, TAC,	kPa	20–48 kPa
MAP Sensor	Eng, FT, HO2S, MF, TAC	Volts	1.0–2.0 Volts Varies with Altitude
MIL Circuit Status	OD	OK, Incomplete, Short B+, Short Gnd/Open	OK/Incomplete
MIL Command	EE, Eng, Ign	Off/On	Off
MIL Requested by DTC	EE, Eng, Ign	Yes/No	No

Misfire Current Cyl. 1–8	MF	0–200 Counts	0
Misfire History Cyl. 1–8	MF	0–65,535 Counts	0
Power Enrichment	Eng, FT, HO2S, MF	Active/Inactive	Inactive
Reduced Engine Power	TAC	Active/Inactive	Inactive
Spark	Eng, FT, HO2S, Ign, MF	Degrees	10–17°
Starter Relay Circuit Status	OD	OK, Incomplete, Short B+, Short Gnd/Open	OK/Incomplete
TAC Forced Engine Shutdown	TAC	Yes/No	No
TAC Motor	TAC	Enabled/Disabled	Enabled
TAC Motor Command	TAC	0–100%	15–35%
Total Knock Retard	Ign	Degrees	0°
Total Misfire	MF	Counts	Varies
TP Desired Angle	TAC	0–100%	5.5%
TP Indicated Angle	EE, Eng, FT, HO2S, Ign, MF, TAC	0–100%	5.5%
TP Sensor 1	TAC	0–5.0 Volts	4.1–4.95 Volts
TP Sensor 1	TAC	0–100%	Varies near 5%
TP Sensor 1 Learned Minimum	TAC	Volts	.55
TP Sensor 2	TAC	5.0–0 Volts	0.4–0.85 V
TP Sensor 2	TAC	100–0%	Varies near 5%
TP Sensor 2 Learned minimum	TAC	Volts	.55
TP Sensors 1 and 2	TAC	Agree/Disagree	Agree
TP Sensor 1 Indicated Position	TAC	%	5%
TP Sensor 2 Indicated Position	TAC	%	5%
Vacuum Calculated	EE, Eng, FT, HO2S	kPa/in Hg	59 kPa/16 in Hg
Vehicle Speed Circuit Status	OD	OK, Incomplete, Short B+, Short Gnd/Open	OK/Incomplete
Vehicle Speed Circuit 2 Status	OD	OK, Incomplete, Short B+, Short Gnd/Open	OK/Incomplete
Vehicle Speed Sensor	EE, Eng, FT, HO2S, Ign, MF, TAC	km/h mph	0
Wide Open Throttle	TAC	Yes/No	No

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## Scan Tool Data Definitions

### *Scan Tool Data Definitions: Engine Controls - 6.0L*

The Engine Scan Tool Data Definitions contains a brief description of all engine related parameters available on the scan tool. The list is in alphabetical order. A given parameter may appear in any one of the data lists. In some cases, the parameter may appear more than once or in more than one data list in order to group certain related parameters together.

**BARO (Gasoline):** This parameter displays the barometric pressure as calculated by the control module using the signal from the manifold absolute pressure (MAP) sensor measured when the ignition is turned on with the engine not running. The control module will update the barometric pressure during wide-open throttle (WOT) conditions. The scan tool will display a low value when the barometric pressure is low, and a high value when the barometric pressure is high.

**BARO (Gasoline):** This parameter displays the voltage signal received by the control module from the manifold absolute pressure (MAP) sensor measured when the ignition is turned on with the engine not running. The control module will update the barometric pressure during wide-open throttle (WOT) conditions. The scan tool will display a low value when the barometric pressure is low, and a high value when the barometric pressure is high.

**CMP Sensor - High To Low:** This parameter displays the number of times the signal voltage from the camshaft position (CMP) sensor changes from high to low. The scan tool will display these transitions as counts.

**CMP Sensor - Low To High:** This parameter displays the number of times the signal voltage from the camshaft position (CMP) sensor changes from low to high. The scan tool will display these transitions as counts.

**Cycles Of Misfire Data:** This parameter displays the number of cylinder firing events that were recorded as misfires as determined by the control module.

**Desired IAC Airflow:** This parameter displays the desired airflow in the idle air control (IAC) passage as calculated by the control module.

**Desired Idle Speed:** This parameter displays the engine idle speed in RPM commanded by the control module. The control module compensates for various engine loads in order to maintain the desired engine RPM at idle. This parameter is not valid unless the engine is running.

**DTC Set This Ignition:** This parameter displays if a diagnostic trouble code (DTC) set during the current ignition cycle. The scan tool will display YES if a DTC is stored this ignition cycle.

**ECT Sensor:** This parameter displays the temperature of the engine coolant based on a voltage input from the engine coolant temperature (ECT) sensor to the control module. The scan tool will display a low value when the coolant temperature is low and a high value when the coolant temperature is high.

**Engine Load:** This parameter displays the engine load in percent based on inputs to the control module from various engine sensors. The scan tool will display a low percentage when the engine is at idle with little or no load. The scan tool will display a high percentage when the engine is running at a high RPM under a heavy load.

**Engine Run Time:** This parameter displays the time elapsed since the engine was started. The scan tool will display the time in hours, minutes and seconds. The engine run time will reset to zero as soon as the engine stops running.

**Engine Speed:** This parameter displays the speed of the crankshaft as calculated by the control module based on inputs from the Crankshaft Position (CKP) Sensor. The scan tool will display the engine speed in revolutions per minute (RPM).

**Fuel Level Sensor:** This parameter displays the voltage from the signal produced by the sensor used to monitor the fuel level inside the fuel tank. The scan tool will display a low voltage reading when the fuel level in the tank is low or near empty. The scan tool will display a high voltage reading when the fuel level in the tank is high or near full.

**Generator F-Terminal Signal :** This parameter displays the commanded state of the generator by the control module. A High value indicates a high charging command, and a low value indicates a low charging command.

**Generator L-Terminal Signal Command:** This parameter displays if the control module is allowing the generator to operate. The scan tool displays ON if the generator is allowed to operate. The scan tool displays OFF if the control module is disabling the generator.

**HO2S Bank 1 Sensor 1:** This parameter displays the voltage from the signal produced by the heated oxygen sensor used to monitor fuel trim for cylinder bank 1. The scan tool will display a low voltage reading when that cylinder bank is running lean. The scan tool will display a high voltage reading when that cylinder bank is running rich.

**HO2S Bank 1 Sensor 1 Heater Command:** This parameter displays the commanded state of the bank 1 sensor 1 heater by the control module. The scan tool will display a higher value as the heater command is increased, and a lower value if the heater is not commanded ON.

**HO2S Bank 1 Sensor 1 Heater Command:** This parameter displays the commanded state of the bank 1 sensor 1 heater by the control module. The scan tool will display ON when the heater is commanded ON. The scan tool will display OFF when the heater is commanded OFF.

**HO2S Bank 2 Sensor 1:** This parameter displays the voltage from the signal produced by the heated oxygen sensor used to monitor fuel trim for cylinder bank 2. The scan tool will display a low voltage reading when that cylinder bank is running lean. The scan tool will display a high voltage reading when that cylinder bank is running rich.



**HO2S Bank 2 Sensor 1 Heater Command:** This parameter displays the commanded state of the bank 2 sensor 1 heater by the control module. The scan tool will display a higher value as the heater command is increased, and a lower value if the heater is not commanded ON.

**HO2S Bank 2 Sensor 1 Heater Command:** This parameter displays the commanded state of the bank 2 sensor 1 heater by the control module. The scan tool will display ON when the heater is commanded ON. The scan tool will display OFF when the heater is commanded OFF.

**HO2S Heater Bn 1 Sen. 1:** This parameter displays the current through the control module when the bank 1 sensor 1 HO2S heater is commanded ON by the control module. HO2S Heater Bn 1 Sen. 1 is a range of values indicating a low current when the heater circuit resistance is high to a high current when the heater circuit resistance is low.

**HO2S Heater Bn 1 Sen. 1 Circuit Status:** This parameter displays the status of the output driver for the HO2S Heater Bn 1 Sen 1. The scan tool will display OK, Incomplete, Short B+, Short Gnd/Open. The scan tool will display OK/Incomplete if the circuit is operating correctly. The scan tool will display a fault if there is an open, short to ground, or a short to voltage on the circuit.

**HO2S Heater Bn 2 Sen. 1:** This parameter displays the current through the control module when the bank 2 sensor 1 HO2S heater is commanded ON by the control module. HO2S Heater Bn 2 Sen. 1 is a range of values indicating a low current when the heater circuit resistance is high to a high current when the heater circuit resistance is low.

**HO2S Heater Bn 2 Sen. 1 Circuit Status:** This parameter displays the status of the output driver for the HO2S Heater Bn 2 Sen 1. The scan tool will display OK, Incomplete, Short B+, Short Gnd/Open. The scan tool will display OK/Incomplete if the circuit is operating correctly. The scan tool will display a fault if there is an open, short to ground, or a short to voltage on the circuit.

**Hot Open Loop:** This parameter indicates the status of the fuel delivery system. The scan tool will display Active if the fuel system is running in Open Loop due to a temperature concern. The scan tool will display Inactive if the fuel system is operating normally.

**IAC Position:** This parameter displays the position of the Idle Air Control (IAC) motor pintle as commanded by the control module. The scan tool will display a high count for a higher idle speed command, and a low count for a lower idle speed command.

**IAT Sensor:** This parameter displays the temperature of the intake air calculated by the control module based on the input from the intake air temperature (IAT). The scan tool will display a low value for a low intake air temperature, and a high value for a high intake air temperature.

**Ignition 1 Signal:** This parameter displays the voltage measured at the ignition 1 circuit of the control module. Voltage is applied to the control module when the ignition switch is in the ignition 1 position. The scan tool will display a higher value with a higher system voltage, and a lower value with a lower system voltage.

**Injector PWM Bank 1 Average:** The scan tool displays in milliseconds. This parameter is the average time the control module turns on each fuel injector on that bank. The scan tool will display a higher value with a longer pulse width, or a lower value with a shorter pulse width.

**Injector PWM Bank 2 Average:** The scan tool displays in milliseconds. This parameter is the average time the control module turns on each fuel injector on that bank. The scan tool will display a higher value with a longer pulse width, or a lower value with a shorter pulse width.

**Knock Retard:** The scan tool displays in  $^{\circ}$ . This parameter indicates the amount of timing retard commanded by the control module. The scan tool will display a lower value if no knock is detected and a higher value as more knock is detected and the control module retards the ignition timing.

**MAP Sensor:** The scan tool displays kPa. This parameter displays the pressure inside of the intake manifold as calculated by the control module based on the input from the MAP sensor. The scan tool will display a high value at cruising speed or wide open throttle (WOT). The scan tool will display a low value at idle speed.

**MAP Sensor:** This parameter displays the voltage signal from the MAP sensor to the control module. The scan tool will display a high value at cruising speed or wide open throttle (WOT). The scan tool will display a low value at idle speed.

**MIL Command:** This parameter displays the commanded state of the malfunction indicator lamp (MIL) control circuit. The malfunction indicator lamp should be on when the scan tool indicates the MIL Command is On. The malfunction indicator lamp should be off when the scan tool indicates the MIL Command is Off. The control module will command the MIL On when the ignition is ON with the engine OFF in order to perform a bulb check.

**Misfire Current Cyl. #1-8:** The scan tool will display in counts. This parameter indicates the number of cylinder firing events detected as possible misfires on each cylinder during the last 200 crankshaft revolutions as calculated by the control module. The scan tool will display a low number for a low number of cylinder misfire events. The scan tool will display a high number for a high number of cylinder misfire events.

**Misfire History Cyl. #1-8:** The scan tool displays in counts. This parameter displays the total level of cylinder misfires that have been calculated for each cylinder by the control module. This parameter will not update or show activity until a misfire DTC has become active. The misfire history counters will update every 200 cylinder firing events.

**Not Run Counter:** The scan tool displays the number of times a DTC diagnostic has not reached the predetermined

criteria in order to run since the first DTC run failure.

**Pass Counter:** The scan tool displays the number of times a DTC has run and passed.

**Reduced Engine Power:** The scan tool displays Active or Inactive. The scan tool displays Active when the control module receives a signal from the throttle actuator control (TAC) module that a TAC system fault is occurring. The scan tool displays inactive when the engine is operating normally.

**Spark:** This parameter is the desired spark advance calculated by the control module based on many sensor inputs. The scan tool will display a lower value at idle speed, and a higher value under heavy acceleration and load conditions.

**Start Up ECT:** This parameter indicates the engine coolant temperature at startup, as calculated by the control module based on the input from the engine coolant temperature sensor. The scan tool will display a higher value at higher engine startup temperatures, and a lower value at lower startup temperatures.

**TP Sensor:** This parameter displays the voltage signal sent to the control module from the sensor used to monitor the position of the throttle plates. The scan tool will display a low voltage when the throttle plates are at rest. The scan tool will display a high voltage when the throttle plates are fully open.

**TP Sensor:** This parameter displays the angle of the throttle position (TP) sensor in percent. This information is calculated by the control module using the signal from the throttle position sensor. The scan tool will display a low percentage when the throttle plates are closed. The scan tool will display a high percentage when the throttle plates are fully open.

**Vehicle Speed Sensor:** This parameter indicates the vehicle speed calculated by the control module based on an input from the vehicle speed sensor (VSS). The scan tool will display a high value at higher vehicle speeds, and a low value at lower vehicle speeds.

## Scan Tool Output Controls

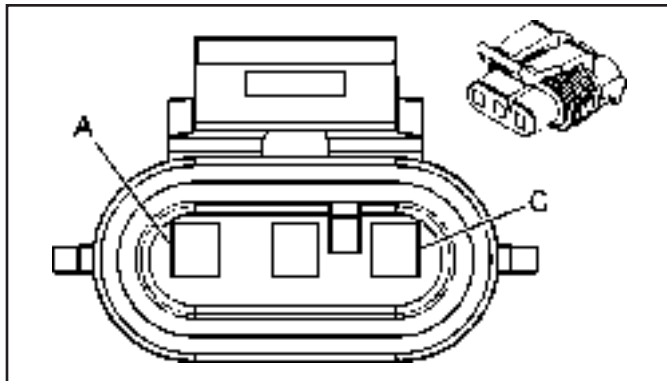
### Scan Tool Output Controls: Engine Controls – MEFI 5

Scan Tool Output Control	Additional Menu Selection(s)	Description
Crankshaft Position Variation Learn	—	Enables the engine control module (ECM) to learn the variations in the crankshaft position (CKP) system. The ECM will learn the variations once the following conditions are met: <ul style="list-style-type: none"> <li>• Engine coolant temperature (ECT) is more than a specified value.</li> <li>• All instructions on the scan tool have been completed.</li> <li>• The accelerator pedal is smoothly applied until the fuel cut-OFF, as specified on the scan tool, is achieved, and then immediately released.</li> </ul> The ECM learns the variation values on the deceleration from fuel cut-OFF.
Cylinder Power Balance	Fuel System	Enables/Disables a cylinder by turning OFF the fuel injector to the cylinder. The fuel injector is normally enabled. The ECM disables the fuel injector when the following conditions are met: <ul style="list-style-type: none"> <li>• All instruction on the scan tool are completed</li> <li>• Stabilized engine speed</li> <li>• The fuel injector is selected</li> </ul> When Disable is selected the PCM turns the injector OFF for 30 seconds. During this period, the engine operates with a misfire.
Engine Controls Ignition Relay	Engine Output Controls	Enables or disables the Engine Controls Ignition Relay. The scan tool will command the engine controller to turn the relay ON or OFF. The normal commanded state is ON.
Engine Speed Control	TAC System	Activates the throttle activation control (TAC) system to change engine RPM. The normal commanded state is None. To enable the RPM control, all instruction on the scan tool must be completed. The system will increase or decrease the RPM within a range of 350–2000 RPM. The set step value changes the RPM by increments of 25 RPM, 100 RPM, and 500 RPM. The system remains in the commanded state until cancelled by the scan tool.
Fuel Injector Balance	Fuel System	Enables the fuel injector in order to verify proper fuel injector flow. The ECM will pulse the selected injector when the following conditions are met: <ul style="list-style-type: none"> <li>• All instruction on the scan tool completed</li> <li>• Fuel injector selected</li> <li>• Key ON, engine OFF</li> </ul> The selected fuel injector can only be flowed/pulsed once per ignition cycle.

Fuel Pump	Engine Output Controls/ Fuel Pump	Controls the fuel pump relay. The normal commanded state is None. When commanded ON/OFF, the ECM turns the fuel pump ON/OFF. If the engine is running, and the fuel pump is commanded OFF, the engine will stall. The system remains in the commanded state until cancelled by the scan tool.
HO2S Bnk 1 Sensor 1 Heater	Engine Output Controls/ Heated Oxygen Sensors	Commands HO2S heater ON, 0–100 percent in 10-percent increments while the engine is running.
HO2S Bnk 2 Sensor 1 Heater	Engine Output Controls/ Heated Oxygen Sensors	Commands HO2S heater ON, 0–100 percent in 10-percent increments while the engine is running
Malfunction Indicator Lamp	Engine Output Controls	Controls the malfunction indicator lamp (MIL). The commanded states include None, ON, and OFF. When commanded ON or OFF, the system remains in the commanded state until cancelled by the scan tool.
Misfire Graphic	—	Graphs the accumulated misfires occurring in each cylinder. The scan tool allows for a reset of the misfire graph.
Spark Retard	Engine Output Controls/ Spark Control	Controls the amount of spark retard. The scan tool will command an increase or decrease in the amount of spark retard in 1-degree increments, within a range of 1–10 degrees. The degrees of spark retard will remain in the commanded state until cancelled by the scan tool. The normal commanded states is NONE.
Throttle Position	TAC System/Throttle Blade Control	Operates TAC motor in 10-percent increments to open or close the throttle blade. The test operates during key ON, engine OFF.

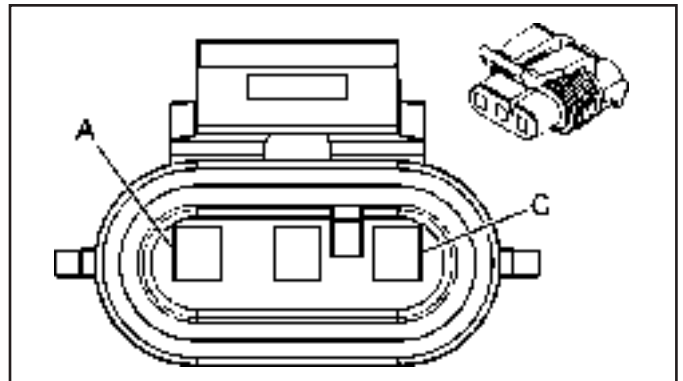
### Small Connector Pin Outs

#### Camshaft Position (CMP) Sensor



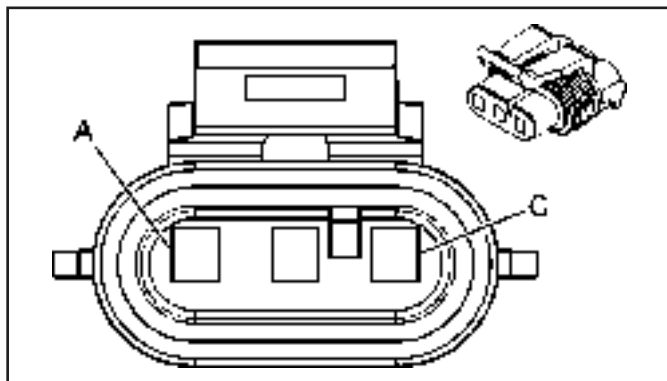
<b>Connector Part Information</b>		<ul style="list-style-type: none"> <li>• 12110293</li> <li>• 3-Way F Metri-Pack 150 Series Sealed</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	BLK/WHT	813	5 V Return
B	BRN/WHT	633	CMP Sensor Signal
C	GRY	413	Sensor 5 V Reference

#### Crankshaft Position (CKP) Sensor



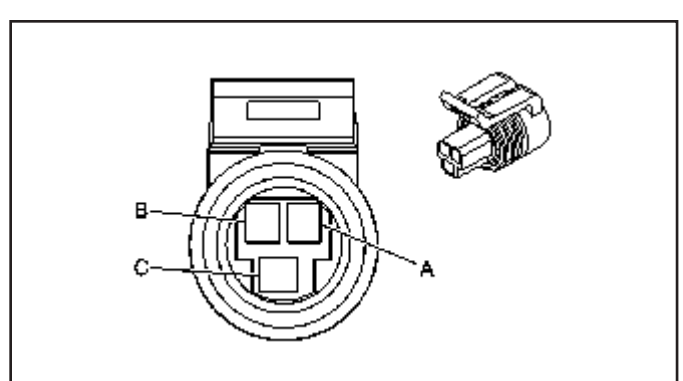
<b>Connector Part Information</b>		<ul style="list-style-type: none"> <li>• 12129946</li> <li>• 3-Way F Metri-Pack 150 Series Sealed</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	GRY	415	Sensor 5 V Reference
B	BLK/WHT	815	Sensor 5 V Return
C	DK BLU	1869	CKP Sensor Signal

#### Ignition Coil Connector



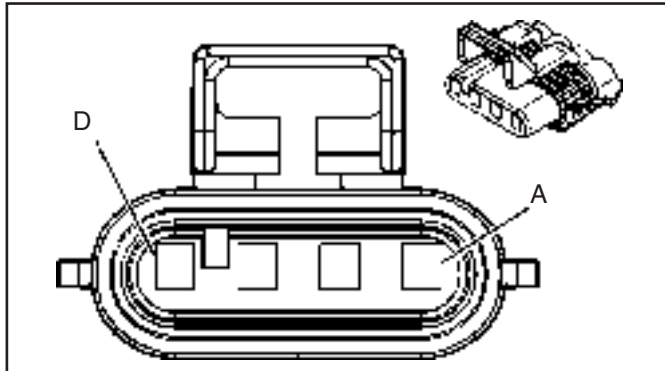
<b>Connector Part Information</b>		<ul style="list-style-type: none"> <li>• —</li> <li>• 3-Way F Metri-Pack 150 Series Sealed</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	PNK/BLK	439B & C	Low Reference
B	—	—	Unused
C	BRN	N/A	To Ign. Control Mod. Term. D Coil Driver

#### Engine Oil Pressure (EOP) Sensor



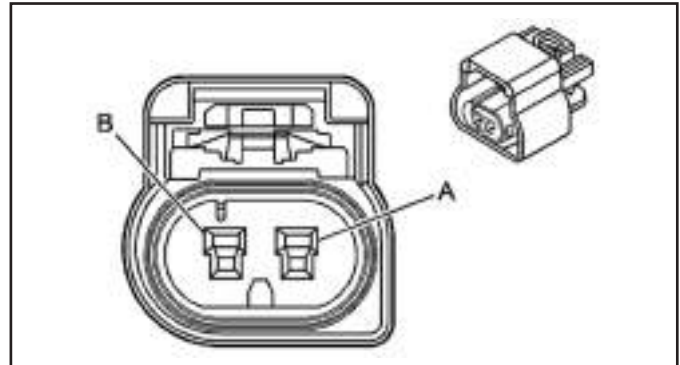
<b>Connector Part Information</b>		<ul style="list-style-type: none"> <li>• 12078090</li> <li>• 3-Way F Metri-Pack 150 Series Sealed</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	BLK/WHT	814	Low Reference
B	GRY	414	Sensor 5 V Return
C	LT BLU/RED	901	EOP Sensor Signal

**Ignition Coil Driver Module Connector**



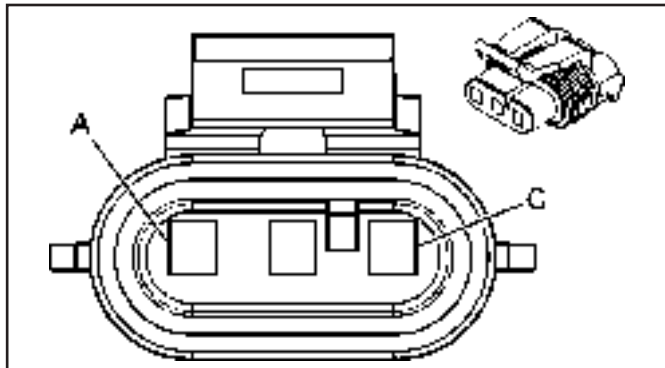
<b>Connector Part Information</b>		<ul style="list-style-type: none"> <li>• 12162144</li> <li>• 4-Way F Metri-Pack</li> <li>150 Series Sealed (BLK)</li> </ul>	
Pin	Wire Color	Circuit No.	Function From ECM Relay
A	PNK/BLK	439B & C	Ignition Voltage
B	WHT	423	Ignition Timing Signal
C	BLK	N/A	IC Module Ground
D	BRN	N/A	Coil Driver

**Knock Sensor, - Odd**



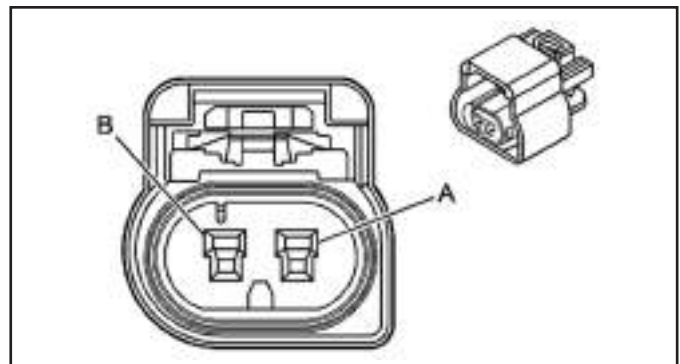
<b>Connector Part Information</b>		<ul style="list-style-type: none"> <li>• 15355362</li> <li>• 1-Way F Metri-Pack</li> <li>150 Series Sealed (NAT)</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	WHT	497	KS 2 Signal
B	BLK	495	KS 2 Ground

**Manifold Absolute Pressure (MAP) Sensor**



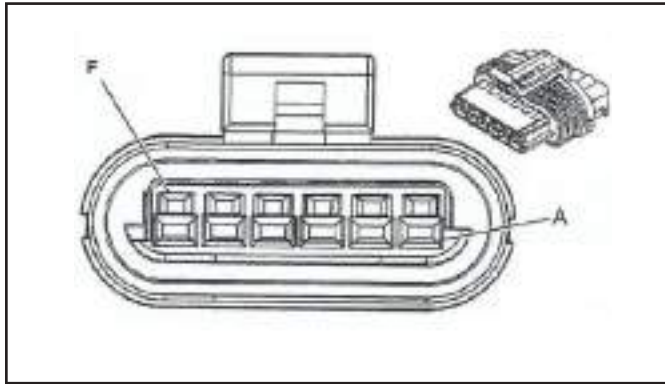
<b>Connector Part Information</b>		<ul style="list-style-type: none"> <li>• 12129946</li> <li>• 3-Way F Metri-Pack</li> <li>150 Series Sealed (GRY)</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	BLK	816	Low Reference
B	LT GRN	432	MAP Sensor Signal
C	GRY	416	5 Volt Reference

**Knock Sensor, - Even**



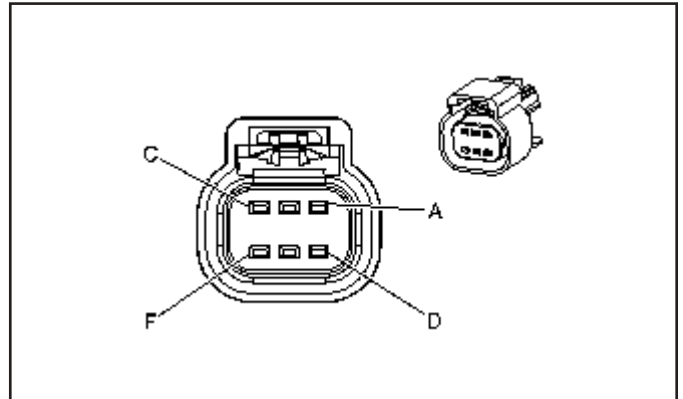
<b>Connector Part Information</b>		<ul style="list-style-type: none"> <li>• 15355362</li> <li>• 1-Way F Metri-Pack</li> <li>150 Series Sealed (NAT)</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	WHT	496	KS 2 Signal
B	BLK	494	KS 2 Ground

**Throttle-Shift Control to ECM**



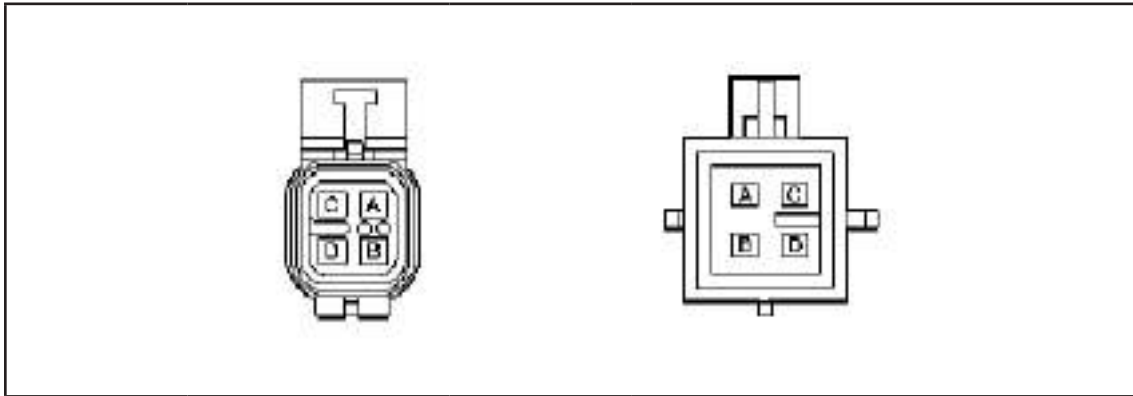
<b>Connector Part Information</b>		<ul style="list-style-type: none"> <li>• 12162261</li> <li>• 6 - Way F Metri-Pack 150.2 Series Pull to Seat (BLK)</li> </ul>	
Pin	Wire Color	Circuit No.	Function
B	BLK/WHT	694	Low Reference-PPS 2
C	GRN	696	Signal-PPS 2
D	GRY	692	5V Reference-PPS 2
F	BLU	695	Signal-PPS 1
G	GRY	691	5V Reference-PPS 1
J	BLK/WHT	693	Low Reference-PPS 1

**Electronic Throttle Body (TAC Motor & TPS 1 & 2)**



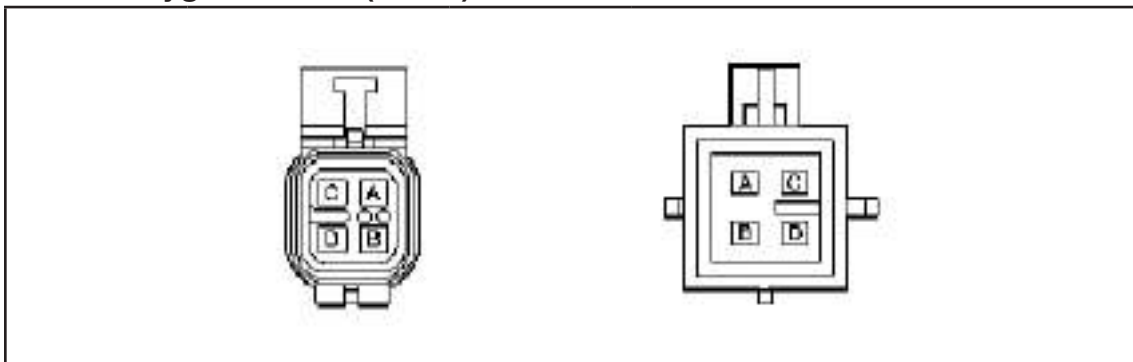
<b>Connector Part Information</b>		<ul style="list-style-type: none"> <li>• 15355297</li> <li>• 6-Way F GT 150 Series Sealed (BLK)</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	BRN	582	ETC Motor Close
B	YLW	581	ETC Motor Open
C	BLK/WHT	683	Low Reference-TPS
D	DK BLU	687	Signal-TPS 2
E	DK GRN	682	5V Reference-TPS
F	BLK/WHT	684	Signal-TPS 1

## Heated Oxygen Sensor (HO2S) Bank 1 Sensor 1



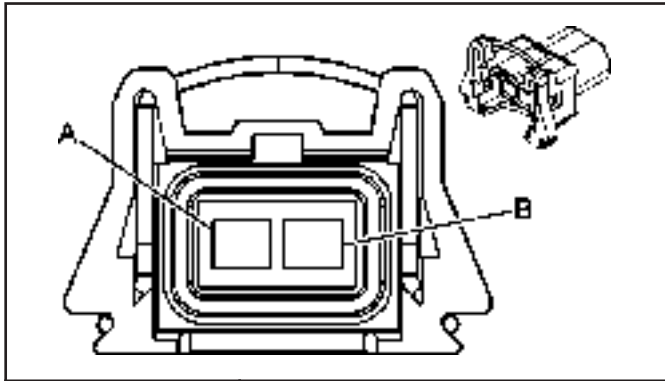
Connector Part Information		<ul style="list-style-type: none"> <li>12160825</li> <li>4-Way F Metri-Pack 150 Series Sealed (BK)</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	WHT/BLU	1664	HO2S Heater Low Control – Bank 1 Sensor 1
B	BLU	1665	HO2S High Signal – Bank 1 Sensor 1
C	BLK	3113	HO2S Heater Low Control – Bank 1 Sensor 1
D	PNK/BLK	5293	Ignition - 1 Voltage

## Heated Oxygen Sensor (HO2S) Bank 2 Sensor 1



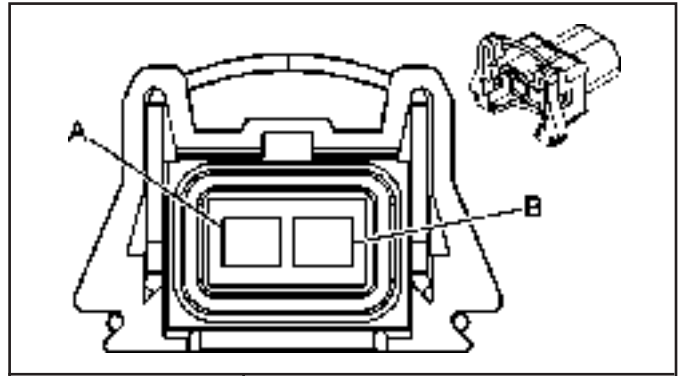
Connector Part Information		<ul style="list-style-type: none"> <li>12160825</li> <li>4-Way F Metri-Pack 150 Series Sealed (BK)</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	WHT/BLU	1667	HO2S Low Signal – Bank 2 Sensor 1
B	BLU	1666	HO2S High Signal – Bank 2 Sensor 1
C	BLK	3212	HO2S Heater Low Control – Bank 2 Sensor 1
D	PNK/BLK	5293	Ignition 1 Voltage

Fuel Injector #1



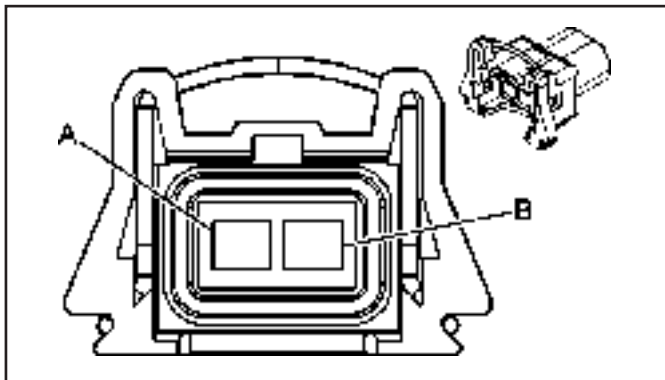
<b>Connector Part Information</b>		<ul style="list-style-type: none"> <li>• 12129140</li> <li>• 2-Way F Metri-Pack 280.1 P2S (BLK)</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	RED	N/A	Ignition Voltage
B	GRN	471	Fuel Injector 1 Control

Fuel Injector #2



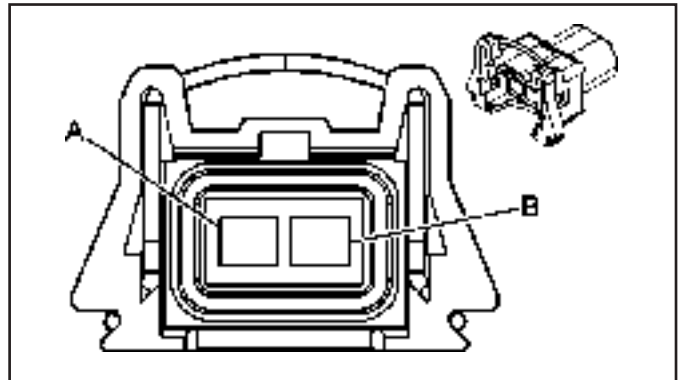
<b>Connector Part Information</b>		<ul style="list-style-type: none"> <li>• 12129140</li> <li>• 2-Way F Metri-Pack 280.1 P2S (BLK)</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	RED	N/A	Ignition Voltage
B	LT BLU	472	Fuel Injector 2 Control

Fuel Injector #3



<b>Connector Part Information</b>		<ul style="list-style-type: none"> <li>• 12129140</li> <li>• 2-Way F Metri-Pack 280.1 P2S (BLK)</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	RED	N/A	Ignition Voltage
B	LT GRN/BLK	473	Fuel Injector 3 Control

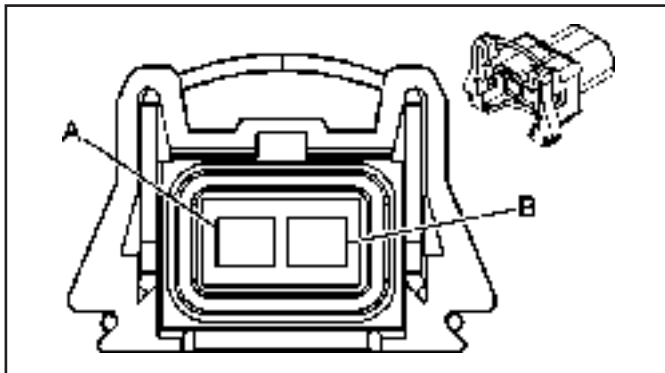
Fuel Injector #4



<b>Connector Part Information</b>		<ul style="list-style-type: none"> <li>• 12129140</li> <li>• 2-Way F Metri-Pack 280.1 P2S (BLK)</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	RED	N/A	Ignition Voltage
B	LT BLU/BRN	474	Fuel Injector 4 Control

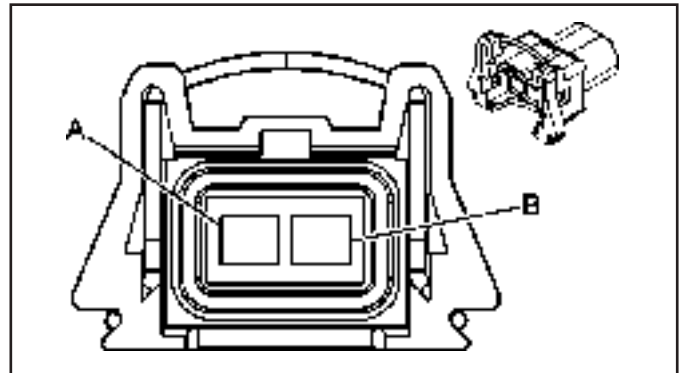


Fuel Injector #5



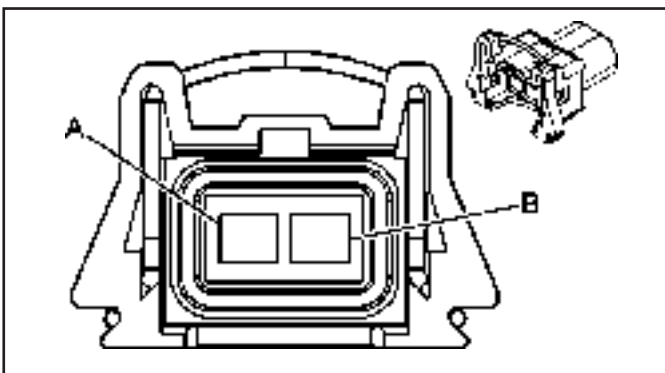
Connector Part Information		<ul style="list-style-type: none"> <li>• 12129140</li> <li>• 2-Way F Metri-Pack 280.1 P2S (BLK)</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	RED	N/A	Ignition Voltage
B	LT GRN/WHT	475	Fuel Injector 5 Control

Fuel Injector #6



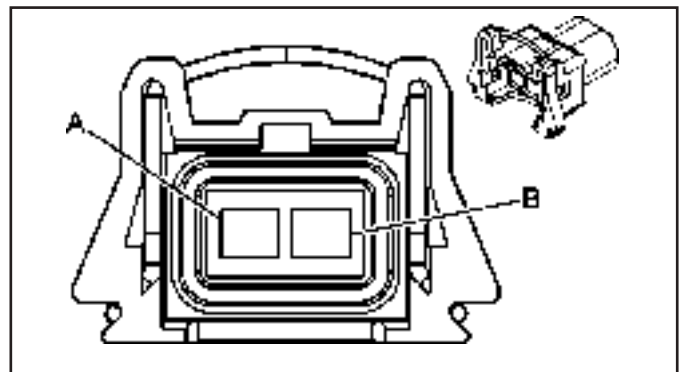
Connector Part Information		<ul style="list-style-type: none"> <li>• 12129140</li> <li>• 2-Way F Metri-Pack 280.1 P2S (BLK)</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	RED	N/A	Ignition Voltage
B	LT BLU/WHT	476	Fuel Injector 6 Control

Fuel Injector #7



Connector Part Information		<ul style="list-style-type: none"> <li>• 12129140</li> <li>• 2-Way F Metri-Pack 280.1 P2S (BLK)</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	RED	N/A	Ignition Voltage
B	GRN/RED	477	Fuel Injector 7 Control

Fuel Injector #8



Connector Part Information		<ul style="list-style-type: none"> <li>• 12129140</li> <li>• 2-Way F Metri-Pack 280.1 P2S (BLK)</li> </ul>	
Pin	Wire Color	Circuit No.	Function
A	RED	N/A	Ignition Voltage
B	LT BLU/RED	478	Fuel Injector 8 Control

### Logged Warnings

These warnings will be displayed following the Diagnostic Trouble Codes. They can be cleared the same as the trouble codes. Unlike other trouble codes, these warnings cannot distinguish the specific DTC based on flash counts through the MIL light.

Description
Overheat
Low Oil Pressure / Catalyst Temperature
Low System Voltage
Low Oil Level
General Warning 1 (J1-19)
General Warning 2 (J1-4)
Low Fuel Pressure
Stop Engine Warning

### Clearing Diagnostic Trouble Codes - Non Scan

1. Install Diagnostic Trouble Code (DTC) tool.
2. Ignition "ON," engine "OFF"
3. Switch DTC tool to "service mode" or "ON."
4. Move the throttle from 0% (idle) to 100% (WOT) and back to 0%.
5. Switch DTC tool to "normal mode" or "OFF." (If this step is not performed, the engine may not start and run).
6. Turn ignition "OFF" for at least 20 seconds.
7. Ignition "ON," engine "OFF"
8. Switch DTC tool to "service mode" or "ON" and verify DTC 12 only. Remove DTC tool.
9. If original DTC's are still present, check "Notice" below and repeat the DTC clearing procedure.
10. If new DTC's are displayed, perform the "On-Board Diagnostic" (OBD) system check.

### Clearing Diagnostic Trouble Codes - Scan

1. Install scan tool.
2. Start engine.
3. Select "Clear DTC's" function.
4. Clear DTC's.
5. Turn ignition "OFF" for at least 20 seconds.
6. Turn ignition "ON" and read DTC's. If DTC's are still present, check "Notice" below and repeat procedure following from step 2.

**NOTICE:** In order to clear DTC's, with or without the use of a scan tool, the ignition must be cycled to the "OFF" position.

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## Diagnostic Information and Procedures

### A Diagnostic Starting Point - Engine Controls

Begin the system diagnosis with *A Diagnostic System Check-Engine Controls*. The Diagnostic System Check will provide the following information:

- The ability of the control module to communicate through the serial data circuit.
- The identification of any stored Diagnostic Trouble Codes (DTCs) and Logged Warnings.

The use of the Diagnostic System Check will identify the correct procedure for diagnosing the system.

### A Diagnostic System Check - Engine Controls

#### Description

The Diagnostic System Check is an organized approach to identifying a condition that is created by a malfunction in the electronic engine control system. The Diagnostic System Check must be the starting point for any driveability concern. This procedure directs the service technician to the next logical step in order to diagnose the concern. Understanding and correctly using the diagnostic table reduces diagnostic time and prevents unnecessary replacement of parts.

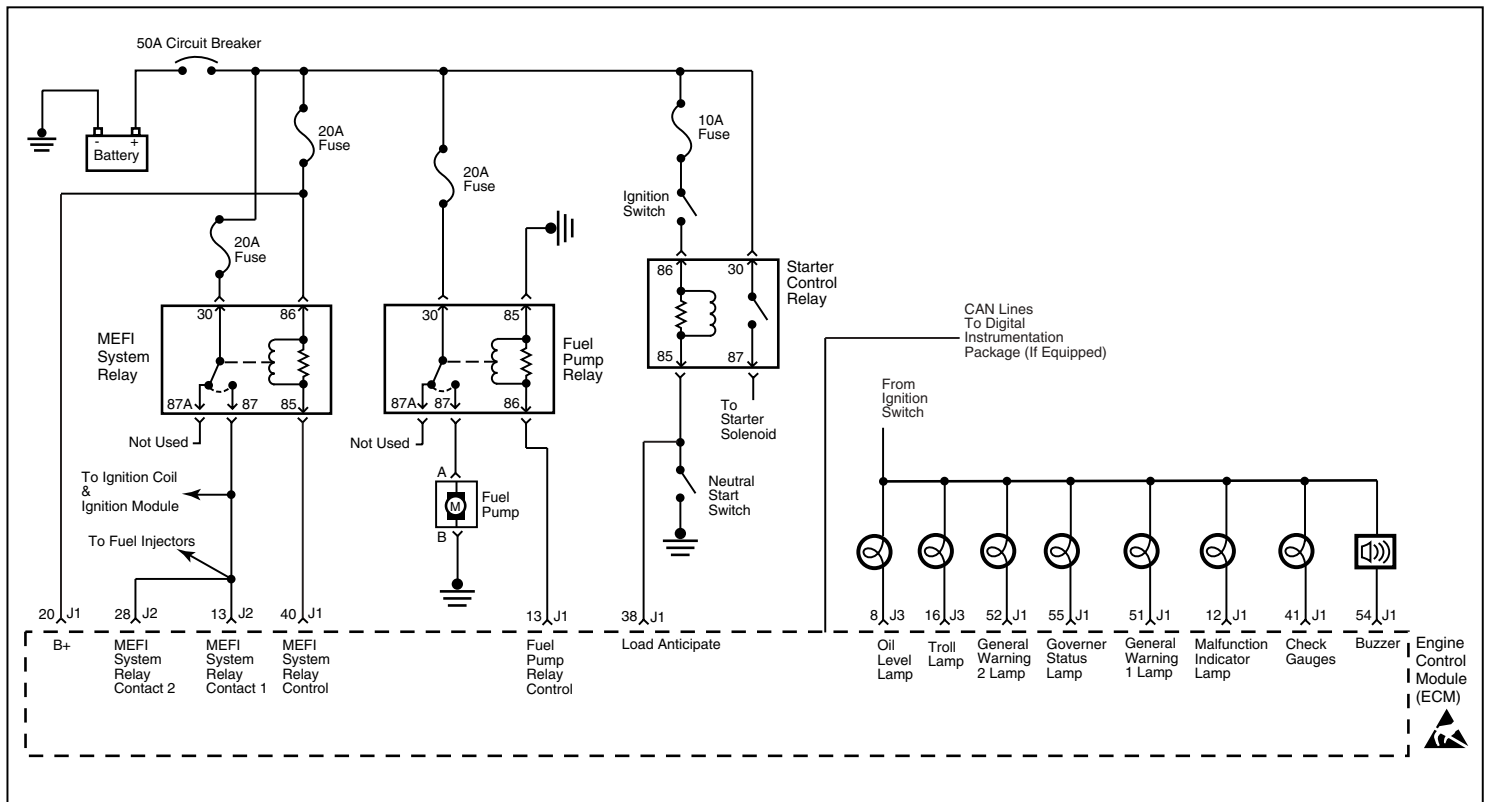
### Test Description

Number(s) below refer to the Step number(s) on the Diagnostic Table:

1. The MIL should be ON steady with the ignition ON, engine OFF. If not, the **No Malfunction Indicator Lamp Test Procedure** should be used to isolate the malfunction.
3. Checks the serial data circuit and ensures that the ECM is able to transmit serial data.
5. If the engine will not start, the **Engine Cranks But Will Not Run** diagnostic procedure should be used to diagnose the condition.
8. A scan tool parameter which is not within the typical range may help to isolate the area which is causing the problem.

## On-Board Diagnostic (OBD) System Check - Scan

Step	Action	Value	Yes	No
1	<p><b>Important:</b></p> <ul style="list-style-type: none"> <li>Only perform this diagnostic if there is a driveability concern, unless another procedure directs you to this diagnostic.</li> <li>Before you proceed with diagnosis, search for applicable service bulletins.</li> <li>Unless a diagnostic procedure instructs you, DO NOT clear the DTC's.</li> <li>If there is a condition with the starting system, repair that first.</li> <li>Ensure the battery has a full charge.</li> <li>Ensure the battery cables are clean and tight.</li> <li>Ensure the ECM grounds are clean, tight and in the correct location.</li> </ul> <p>Install a scan tool. Does the scan tool turn ON?</p>	—	Go to Step 2	Go to Data Link Connector Diagnosis
2	<p>Attempt to start the engine. Does the engine start and idle?</p>	—	Go to Step 3	Go to Engine Cranks but Does Not Run
3	<p>Select the DTC display function on the scan tool. Does the scan tool display DTCs?</p>	—	Go to Applicable DTC Table	Go to Step 4
4	<ol style="list-style-type: none"> <li>Review the following symptoms.</li> <li>Refer to the applicable symptom diagnostic table. <ul style="list-style-type: none"> <li><i>Hard Start</i></li> <li><i>Surges/Chuggles</i></li> <li><i>Lack of Power, Sluggishness or Sponginess</i></li> <li><i>Detonation/Spark Knock</i></li> <li><i>Hesitation, Sag or Stumble</i></li> <li><i>Cuts Out, Misses</i></li> <li><i>Poor Fuel Economy</i></li> <li><i>Rough, Unstable or Incorrect Idle and Stalling</i></li> <li><i>Dieseling, Run-On</i></li> <li><i>Backfire</i></li> </ul> </li> </ol> <p>Did you find and correct the condition?</p>	—	Verify Repair	Go to Intermittent Conditions Section 7



## Malfunction Indicator Lamp (MIL) Diagnosis

### Circuit Description

Use a properly functioning scan tool with the diagnostic tables in this section. DO NOT clear the DTC's unless directed by a diagnostic procedure. Clearing the DTC's may also clear valuable diagnostic information.

### Test Description

Number(s) below refer to the step number(s) on the diagnostic table:

3. An engine that just cranks and does not attempt to start indicates that the ECM is not powered-up.
5. This step is checking for a B+ supply to the Data Link Connector (DLC).
6. A ground must be available for the scan tool to function properly.
9. A no start condition occurs when the fuse(s) for the battery or ignition feed circuits is open. The MIL is inoperative when the battery and ignition feed circuit fuses open. Inspect the circuits for being grounded when either of these fuses open.
12. The scan tool does not communicate when the serial data circuit from the ECM to the DLC is open.
14. If the test lamp does not illuminate for a circuit, inspect the fuse for being open. If the fuse is open, inspect the circuit for a short to ground.
15. Inspect for an open ground circuit.
16. Inspect for an open fuse that supplies the DLC. If the fuse is open, repair the grounded circuit.

## Malfunction Indicator Lamp (MIL) Diagnosis

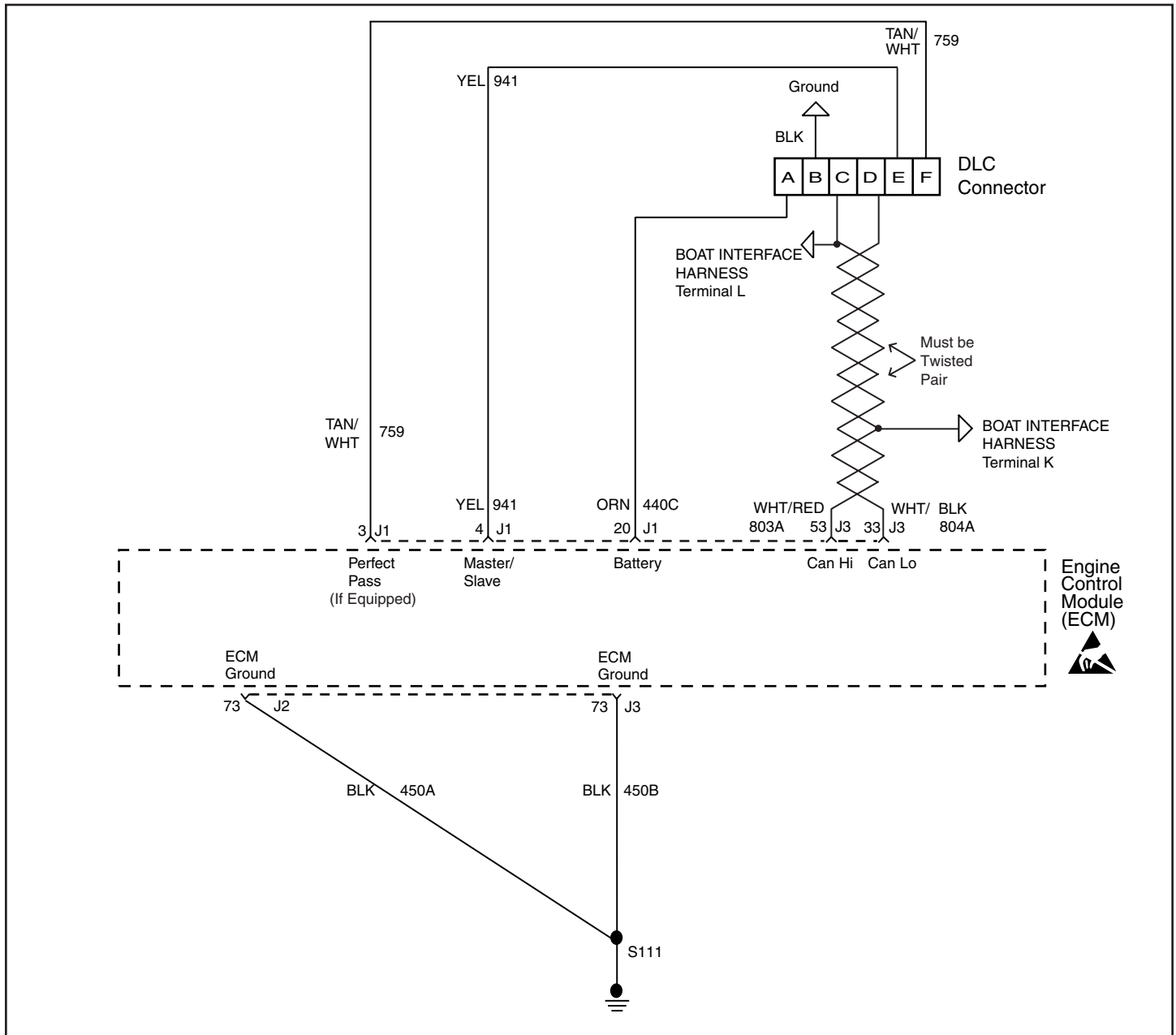
Step	Action	Value	Yes	No
1	Did you perform the On-Board Diagnostic (OBD) System Check?	—	Go to Step 2	Go to OBD System Check
2	<b>Important:</b> This table assumes that the scan tool you are using is functional. 1. Turn ON the ignition leaving the engine OFF. 2. Connect the scan tool to the Data Link Connector (DLC). Does the scan tool power-up?	—	Go to Step 3	Go to Step 5
3	Does the engine start and continue to operate?	—	Go to Step 6	Go to Step 4
4	Does the engine start and stall?	—	Go to Step 12	Go to Step 9
5	1. Disconnect the scan tool from the DLC. 2. Turn ON the ignition leaving the engine OFF. 3. Probe the DLC terminal A using a test lamp J 34142-B connected to the battery ground. Is the test lamp illuminated?	—	Go to Step 6	Go to Step 16
6	Probe the DLC terminal B using a test lamp J 34142-B connected to B+. Is the test lamp illuminated?	—	Go to Step 7	Go to Step 8
7	Inspect the scan tool connections at the DLC. Also inspect the terminals for proper terminal tension at the DLC. Did you find and repair the condition?	—	Go to OBD System Check	Go to Step 12
8	Repair the open ground circuit to the DLC terminal B. Is the action complete?	—	Go to OBD System Check	—
9	1. Turn OFF the ignition. 2. Disconnect the ECM connector J1. 3. Turn ON the ignition leaving the engine OFF. 4. Probe the ECM battery and the ECM ignition feed circuits (J1-20 and J1-19) in the ECM harness connector using a test lamp J 34142-B connected to a battery ground. Does the test lamp illuminate for each circuit?	—	Go to Step 10	Go to Step 14
10	1. Turn OFF the ignition. 2. Disconnect the ECM connectors J2 & J3. 3. Measure the resistance between the battery ground and the ECM ground circuits (J2-73 and J3-73) in the ECM harness connectors using a DMM J 39200. Does the DMM display between the specified range on each circuit?	0-2 ohms	Go to Step 11	Go to Step 15
11	Inspect the ECM for proper connections. Did you find and correct the condition?	—	Go to OBD System Check	Go to Step 13
12	Inspect the serial data circuit for being open, shorted or a poor connection at the ECM. Did you find and repair the condition?	—	Go to OBD System Check	Go to Step 13

## Malfunction Indicator Lamp (MIL) Diagnosis

Step	Action	Value	Yes	No
13	Check?	—	Go to Step	Go to OBD System Check
14	1. Turn ON the ignition leaving the engine OFF. 2. Connect the scan tool to the Data Link Connector (DLC). Does the scan tool power-up?	—	Go to Step	Go to Step
15	Does the engine start and continue to operate?	—	Go to Step	Go to Step
16	Inspect the Battery fuse. Is the fuse good?	—	Go to Step	Go to Step
5	1. Disconnect the scan tool from the DLC. 2. Turn ON the ignition leaving the engine OFF. 3. Probe the DLC terminal A using a test lamp J 34142-B connected to the battery ground. Is the test lamp illuminated?	—	Go to Step	Go to Step
6	Probe the DLC terminal B using a test lamp J 34142-B connected to B+. Is the test lamp illuminated?	—	Go to Step	Go to Step
7	Inspect the scan tool connections at the DLC. Also inspect the terminals for proper terminal tension at the DLC. Did you find and repair the condition?	—	Go to OBD System Check	Go to Step
8	Repair the open ground circuit to the DLC terminal B. Is the action complete?	—	Go to OBD System Check	—
9	1. Turn OFF the ignition. 2. Disconnect the ECM connector J1. 3. Turn ON the ignition leaving the engine OFF. 4. Probe the ECM battery and the ECM ignition feed circuits (J1-20 and J1-19) in the ECM harness connector using a test lamp J 34142-B connected to a battery ground. Does the test lamp illuminate for each circuit?	—	Go to Step 10	Go to Step 14
10	1. Turn OFF the ignition. 2. Disconnect the ECM connectors J2 & J3. 3. Measure the resistance between the battery ground and the ECM ground circuits (J2-73 and J3-73) in the ECM harness connectors using a DMM J 39200. Does the DMM display between the specified range on each circuit?	0-2 ohms	Go to Step 11	Go to Step 15
11	Inspect the ECM for proper connections. Did you find and correct the condition?	—	Go to OBD System Check	Go to Step 13
12	Inspect the serial data circuit for being open, shorted or a poor connection at the ECM. Did you find and repair the condition?	—	Go to OBD System Check	Go to Step 13



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### Data Link Connector Diagnosis

#### Circuit Description

Use a properly functioning scan tool with the diagnostic tables in this section. DO NOT clear the DTC's unless directed by a diagnostic procedure. Clearing the DTC's may also clear valuable diagnostic information.

#### Test Description

Number(s) below refer to the step number(s) on the diagnostic table:

3. An engine that just cranks and does not attempt to start indicates that the ECM is not powered-up.
5. This step is checking for a B+ supply to the Data Link Connector (DLC).
6. A ground must be available for the scan tool to function properly.
9. A no start condition occurs when the fuse(s) for the battery or ignition feed circuits is open. The MIL is inoperative when the battery and ignition feed circuit fuses open. Inspect the circuits for being grounded when either of these fuses open.
12. The scan tool does not communicate when the serial data circuit from the ECM to the DLC is open.
14. If the test lamp does not illuminate for a circuit, inspect the fuse for being open. If the fuse is open, inspect the circuit for a short to ground.
15. Inspect for an open ground circuit.
16. Inspect for an open fuse that supplies the DLC. If the fuse is open, repair the grounded circuit.

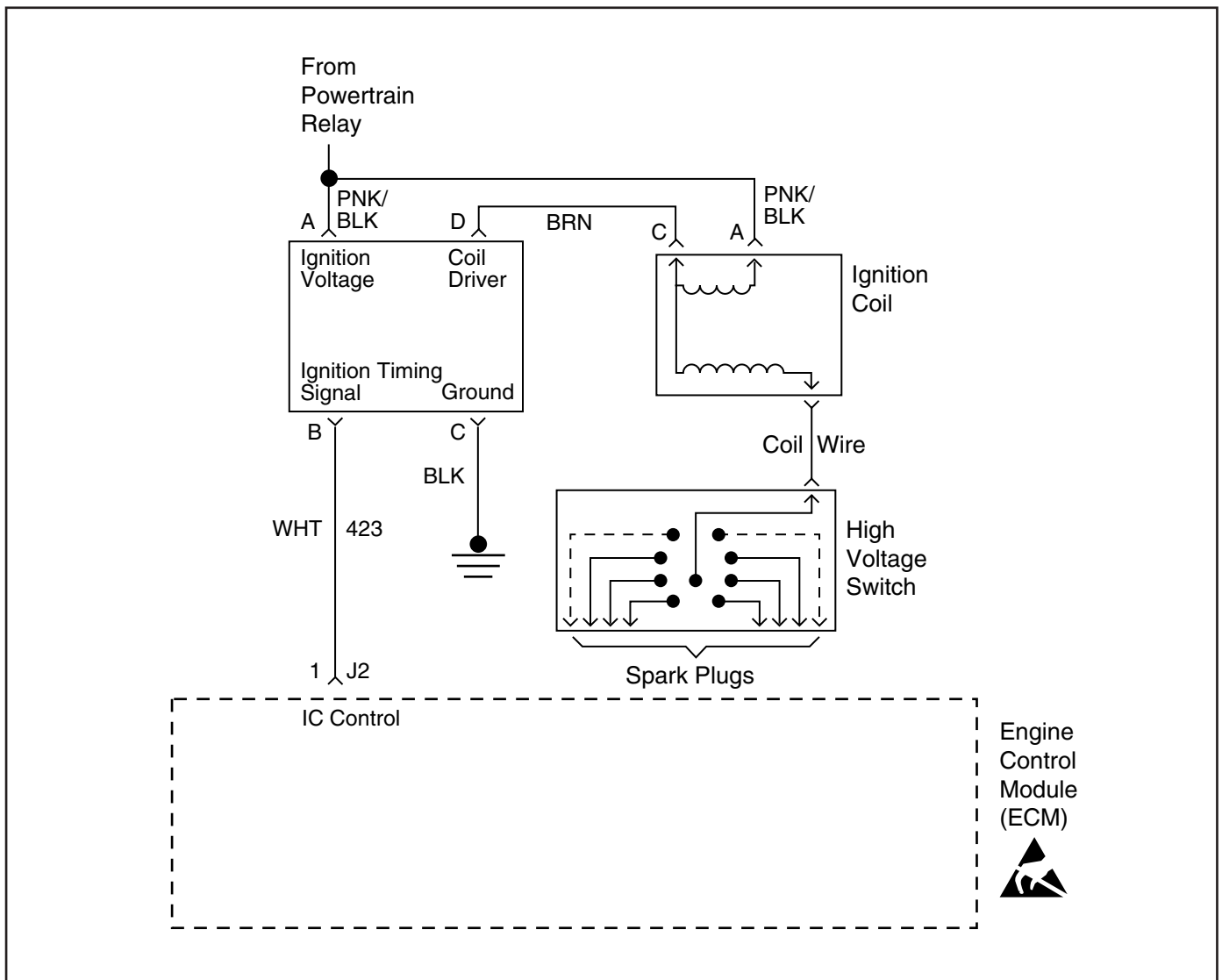
## Data Link Connector Diagnosis

Step	Action	Value	Yes	No
1	Did you perform the On-Board Diagnostic (OBD) System Check?	—	Go to Step 2	Go to OBD System Check
2	<b>Important:</b> This table assumes that the scan tool you are using is functional. 1. Turn ON the ignition leaving the engine OFF. 2. Connect the scan tool to the Data Link Connector (DLC). Does the scan tool power-up?	—	Go to Step 3	Go to Step 5
3	Does the engine start and continue to operate?	—	Go to Step 6	Go to Step 4
4	Does the engine start and stall?	—	Go to Step 12	Go to Step 9
5	1. Disconnect the scan tool from the DLC. 2. Turn ON the ignition leaving the engine OFF. 3. Probe the DLC terminal A using a test lamp J 34142-B connected to the battery ground. Is the test lamp illuminated?	—	Go to Step 6	Go to Step 16
6	Probe the DLC terminal B using a test lamp J 34142-B connected to B+. Is the test lamp illuminated?	—	Go to Step 7	Go to Step 8
7	Inspect the scan tool connections at the DLC. Also inspect the terminals for proper terminal tension at the DLC. Did you find and repair the condition?	—	Go to OBD System Check	Go to Step 12
8	Repair the open ground circuit to the DLC terminal B. Is the action complete?	—	Go to OBD System Check	—
9	1. Turn OFF the ignition. 2. Disconnect the ECM connector J1. 3. Turn ON the ignition leaving the engine OFF. 4. Probe the ECM battery and the ECM ignition feed circuits (J1-20 and J1-19) in the ECM harness connector using a test lamp J 34142-B connected to a battery ground. Does the test lamp illuminate for each circuit?	—	Go to Step 10	Go to Step 14
10	1. Turn OFF the ignition. 2. Disconnect the ECM connectors J2 and J3. 3. Measure the resistance between the battery ground and the ECM ground circuits (J2-73 and J3-73) in the ECM harness connectors using a DMM J 39200. Does the DMM display between the specified range on each circuit?	0-2 ohms	Go to Step 11	Go to Step 15
11	Inspect the ECM for proper connections. Did you find and correct the condition?	—	Go to OBD System Check	Go to Step 13
12	Inspect the serial data circuit for being open, shorted or a poor connection at the ECM. Did you find and repair the condition?	—	Go to OBD System Check	Go to Step 13

**Data Link Connector Diagnosis (cont'd)**

<b>Step</b>	<b>Action</b>	<b>Value</b>	<b>Yes</b>	<b>No</b>
<b>13</b>	Replace the ECM. Is action complete?	—	<i>Go to OBD System Check</i>	—
<b>14</b>	Repair the circuit that did not illuminate the test lamp. Is action complete?	—	<i>Go to OBD System Check</i>	—
<b>15</b>	Repair the faulty ECM ground circuit(s). Is action complete?	—	<i>Go to OBD System Check</i>	—
<b>16</b>	Repair the faulty B+ supply circuit. Is action complete?	—	<i>Go to OBD System Check</i>	—

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### Engine Cranks But Does Not Run

#### Circuit Description

The Engine Cranks but Does Not Run diagnostic table assumes that battery condition and engine cranking speed are OK. If the battery condition and the cranking speed are not OK, refer to those conditions first. Make sure that there is adequate fuel in the fuel tank(s).

#### Test Description

Number(s) below refer to the step number(s) on the diagnostic table:

4. It may be necessary to connect a battery charger to the battery for this step. If the battery state of charge is low, the scan tool may reset during the cranking test.
5. This step tests the system relay for proper operation. The system relay supplies voltage to the injectors and the ignition coils. When the system relay is not operating properly, a no start condition occurs. If the test lamp does not illuminate, this indicates the system relay is not supplying a voltage to the fuses.
6. The Crankshaft Position sensor is located on the front of the engine, behind the harmonic balancer, mounted on the timing cover.
7. The Camshaft Position sensor is located in the High Voltage Switch (HVS) distributor assembly.
8. The ignition feed circuit for the Camshaft and Crankshaft Position sensors is internally connected within the ECM. A short to ground on either circuit will cause a no start condition.
10. You may need to get close to the fuel pump in order to hear if the fuel pump is operating.
12. At this point, the engine should start. Refer to *Hard Start Symptom* for further diagnosis.

## Engine Cranks but Does Not Run

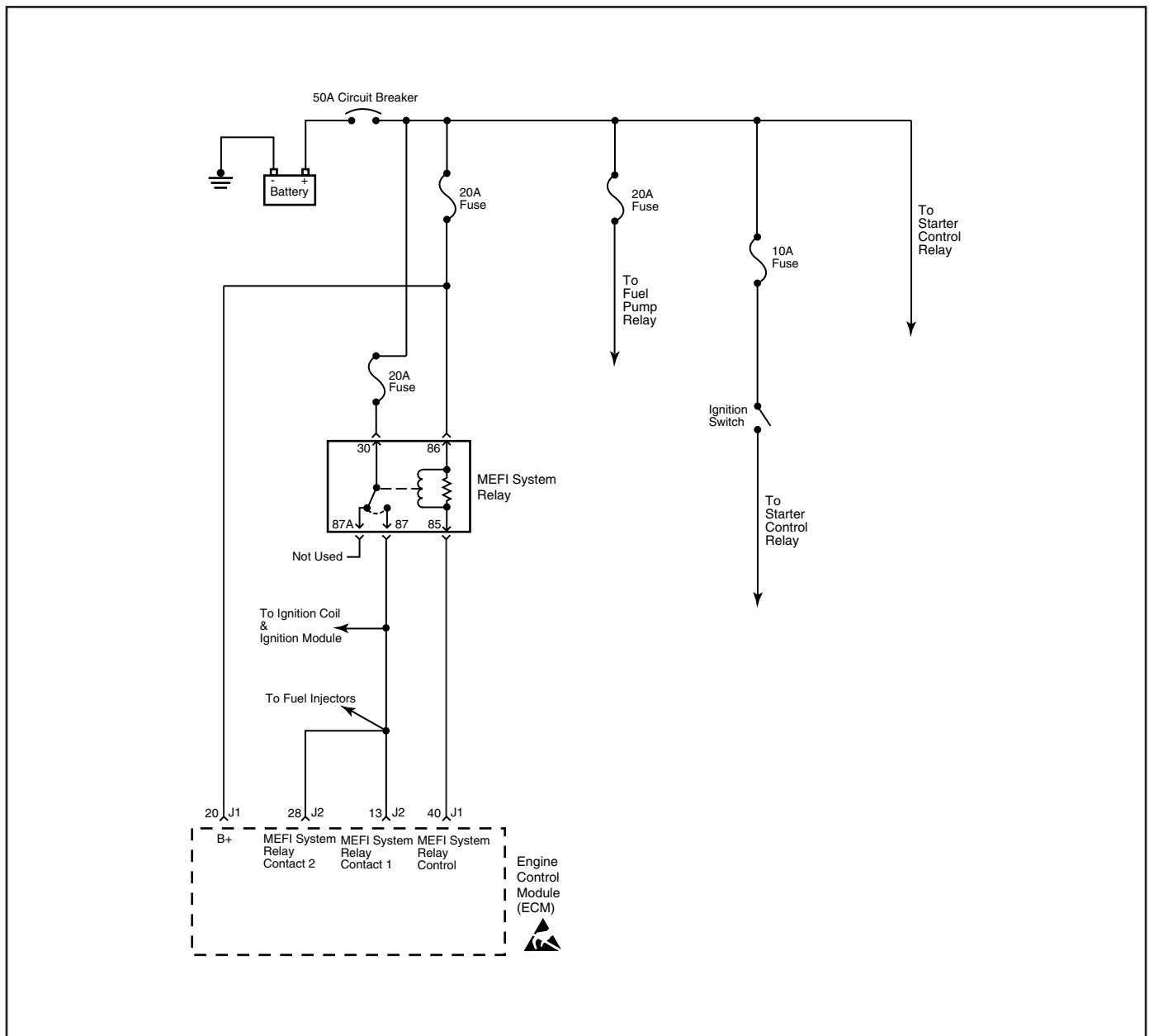
Step	Action	Value	Yes	No
1	Did you perform the On-Board Diagnostic (OBD) System Check?	—	Go to Step 2	Go to OBD System Check
2	<b>Important:</b> Refer to the applicable DTC table if any of the following DTC's are set: SPN 65541 FMI 5. Monitor the engine speed while cranking the engine. Is engine RPM indicated on the scan tool?	—	Go to Step 3	Go to Step 4
3	1. Turn ON the ignition leaving the engine OFF. 2. Probe both sides of the fuse listed below using a test lamp J 34142-B connected to ground. • Powertrain or MEFI System Fuse (C & D) Does the test lamp illuminate on both sides of the fuses?	—	Go to Step 7	Go to System Relay Diagnosis
4	1. Disconnect the Crankshaft Position (CKP) sensor electrical connector. 2. Measure the voltage at the ignition feed circuit at the CKP electrical connector using a DMM J 39200. Does the DMM display near the specified voltage?	B+	Go to Step 11	Go to Step 5
5	1. Disconnect the Camshaft Position (CMP) sensor electrical connector. 2. Measure the voltage at the ignition feed circuit at the CMP electrical connector using a DMM J 39200. Does the DMM display near the specified voltage?	B+	Go to Step 12	Go to Step 6
6	Inspect the Camshaft and Crankshaft Position sensor ignition feed circuits for a short to ground. Did you find and correct the condition?	—	Go to Step 14	Go to Step 13
7	Monitor the engine coolant temperature using the scan tool. Is the engine coolant temperature on the scan tool close to the actual engine temperature?	—	Go to Step 8	Go to SPN 110, FMI 3 Engine Coolant Temperature (ECT) Sensor Circuit High Voltage
8	Enable the fuel pump using the scan tool. Does the fuel pump operate?	—	Go to Step 9	Go to Fuel Pump Relay Diagnosis
9	1. Turn OFF the ignition. 2. Install a fuel pressure gauge. <b>Important:</b> The fuel pump operates for about 2 seconds when the ignition is turned ON. The fuel pressure must be observed when the fuel pump is operating. 3. Turn ON the ignition leaving the engine OFF. 4. Observe the fuel pressure while the fuel pump is operating. Is the fuel pressure within the specified range?	379-427 kPa (55-62 psi)	Go to Step 10	Go to Fuel System Diagnosis

## Engine Cranks but Does Not Run (cont'd)

Step	Action	Value	Yes	No
10	Perform the following additional inspections: <ul style="list-style-type: none"> <li>Inspect that the throttle angle is at 0% at a closed throttle. If the throttle angle is not at 0%, refer to SPN 65601, FMI 2 <i>Throttle Position Sensor (TPS) 2 Range</i> SPN 65602, FMI 2 <i>Throttle Position Sensor (TPS) 1 Range</i> SPN 65610, FMI 2 <i>TPS 1- 2 Correlation</i>.</li> <li>Inspect the spark plugs for being gas fouled. If the spark plugs are gas fouled, determine what caused the rich condition.</li> <li>Inspect for an engine mechanical failure that causes an engine not to start (i.e. timing chain, low compression).</li> <li>Compare MAP/BARO parameters to another vessel. The parameter values should be close to each other.</li> </ul>	—	Go to Step 14	Go to Hard Start for diagnosis
11	Replace the CKP sensor. Refer to <i>Crankshaft Position Sensor Replacement</i> . Is the action complete?	—	Go to Step 14	—
12	Replace the CMP sensor. Refer to <i>Camshaft Position Sensor Replacement</i> . Is the action complete?	—	Go to Step 14	—
13	Replace the ECM. Is the action complete?	—	Go to Step 14	—
14	1. Select the Diagnostic Trouble Codes (DTC) option and the Clear DTC option using the scan tool. 2. Attempt to start the engine. Does the engine start and continue to run?	—	Go to Step 15	Go to Step 2
15	1. Idle the engine at the normal operating temperature. 2. Select the Diagnostic Trouble Codes (DTC) option using the scan tool. Are any DTCs displayed?	—	Go to the applicable DTC table	System OK



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### System Relay Diagnosis

#### Circuit Description

The system relay powers the following components:

- Injectors
- Ignition Coils

#### Diagnostic Aids

The following may cause an intermittent:

- Poor connections. Check for adequate terminal tension.
- Corrosion
- Mis-routed harness
- Rubbed through wire insulation
- Broken wire inside the insulation

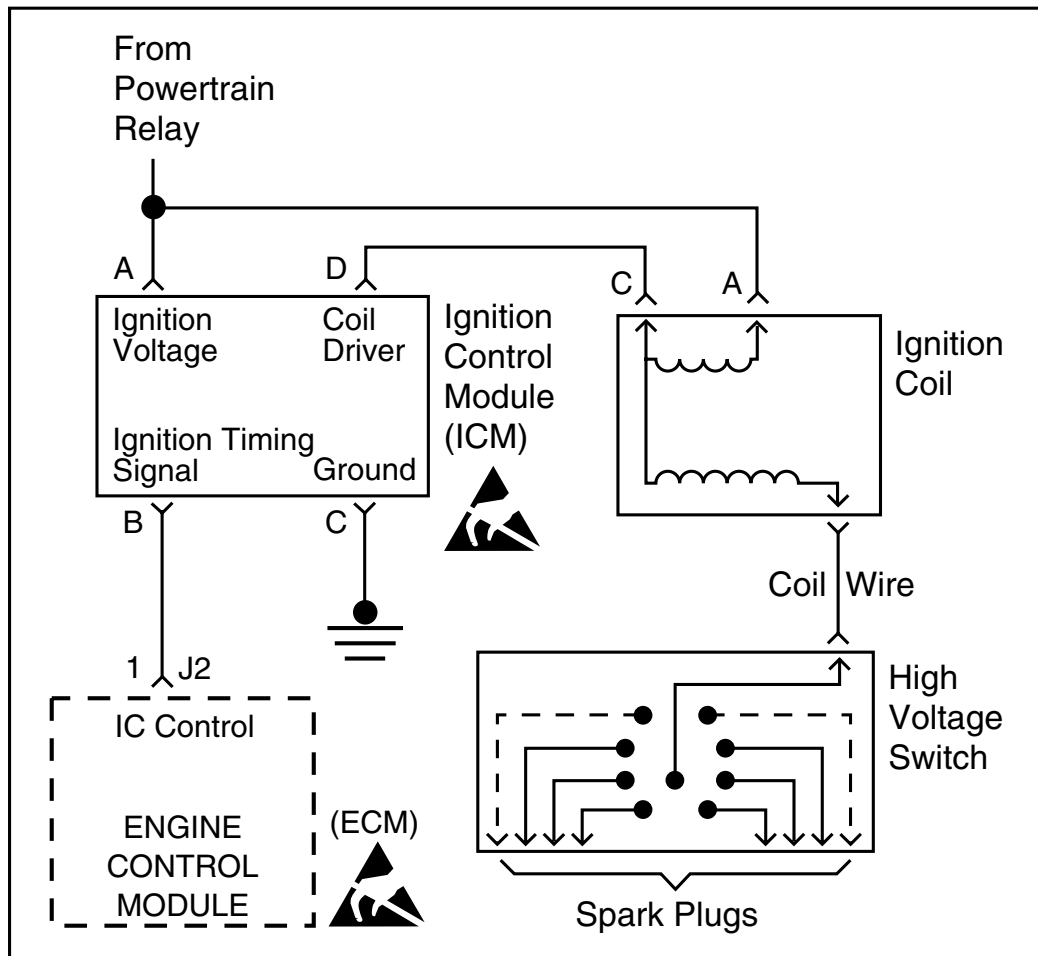
#### Test Description

Number(s) below refer to the step number(s) on the diagnostic table:

2. Refer to Thumbnail Schematic for proper relay terminal identification.
4. This step is testing the relay ground circuit.
5. This step isolates the circuit from the system relay. All of the circuits are good if the test lamp illuminates.
9. The open circuit will be between the splice and the system relay.

## System Relay Diagnosis

Step	Action	Value	Yes	No
1	Did you perform the On-Board Diagnostic (OBD) System Check?	—	Go to Step 2	Go to OBD System Check
2	1. Turn OFF the ignition. 2. Disconnect the system relay electrical connector. 3. Probe the system relay B+ feed circuit (switch side of the relay) using a test lamp J 34142-B connected to a ground. Does the test lamp illuminate?	—	Go to Step 3	Go to Step 8
3	1. Turn ON the ignition leaving the engine OFF. 2. Probe the system relay ignition feed circuit using a test lamp J 34142-B connected to a ground. Does the test lamp illuminate?	—	Go to Step 4	Go to Step 9
4	1. Turn OFF the ignition. 2. Measure the resistance of the system relay ground circuit using a DMM J 39200 connected to the battery ground. Is the resistance less than the specified value?	0-5 ohms	Go to Step 5	Go to Step 10
5	1. Turn OFF the ignition. 2. Jumper the system relay B+ feed circuit and the system relay load circuit together using a fused jumper wire. 3. Probe the fuses for the following components with a test lamp J 34142-B connected to a ground. <ul style="list-style-type: none"> <li>• Injectors</li> <li>• Ignition coils</li> </ul> Does the test lamp illuminate?	—	Go to Step 6	Go to Step 11
6	Inspect for poor terminal contact at the system relay connector. Did you find and correct the condition?	—	System OK	Go to Step 7
7	Replace the system relay. Is the action complete?	—	System OK	—
8	Repair the open B+ supply to the system relay. Is the action complete?	—	System OK	—
9	Repair the ignition feed circuit to the system relay. Is the action complete?	—	System OK	—
10	Repair the system relay ground circuit. Is the action complete?	—	System OK	—
11	Repair the system relay load circuit. Is the action complete?	—	System OK	—



### High Voltage Switch (replaces distributor) System Check

#### Circuit Description

The ignition system on this engine uses an ignition control module to drive the ignition coil. The engine control module (ECM) controls the spark event for each cylinder through an ignition control (IC) circuit. When the ECM commands the IC circuit ON, electrical current will flow through the primary winding of the ignition coil, creating a magnetic field. When a spark event is requested, the ECM will command the IC circuit OFF, interrupting current flow through the primary winding. The magnetic field created by the primary winding will collapse across the secondary coil winding, producing a high voltage across the spark plug electrodes. The ECM uses information from the crankshaft position (CKP) and the camshaft position (CMP) sensor for sequencing and timing of the spark events. The ignition coil module has the following circuits:

- An ignition voltage circuit
- A ground circuit
- An IC circuit
- A low reference circuit

#### Diagnostic Aids

An intermittent may be caused by a poor connection, rubbed through wire insulation or a wire broken inside the insulation. Check for the following items:

- Poor connection or damaged harness. Inspect the ECM harness and connectors for improper mating, broken locks, improperly formed or damaged terminals, poor terminal to wire connection and damaged harness.
- The “tach” needs to be disconnected while testing the ignition system. You will also need a place to check coil trigger voltage. By disconnecting the “2-wire boat harness” (gray and purple wires), this will give you a test terminal to check coil trigger voltage as needed in several steps. After “tach” is disconnected, try starting the engine. If the engine starts, check for a short to ground in the boat “tach” circuit.

**Test Description**

Number(s) below refer to the Step number(s) on the Diagnostic Table:

2. Two wires are checked to ensure that an open is not present in a spark plug wire.
4. A spark indicates the problem must be in the distributor cap, rotor or coil output wire.
6. Normally, there should be battery voltage at the "C" and "+" terminals. Low voltage would indicate an open or a high resistance circuit from the distributor to the coil or ignition switch. If "C" terminal voltage was low, but "+" terminal voltage is 10 volts or more, circuit from "C" terminal to ignition coil is open or primary winding of the ignition coil is open.
8. Checks for a shorted module or grounded circuit from the ignition coil to the module. The distributor module should be turned "OFF," so normal voltage should be about 12 volts. If the module is turned "ON," the voltage would be low, but above 1 volt. This could cause the ignition coil to fail from excessive heat. With an open ignition coil primary winding, a small amount of voltage will leak through the module from the "batt" to the "tach" terminal.
11. Applying a voltage (1.35-1.50 volts) to the module terminal "P" should turn the module "ON" and the tach voltage should drop to about 7-9 volts. This test will determine whether the module or coil is faulty or if the pick-up coil is not generating the proper signal to turn the module "ON." This test can be performed by using a DC test battery with a rating of 1.5 volts (Such as AA, C, or D cell). The battery must be a known good battery with a voltage of over 1.35 volts.
12. This should turn the module "OFF" and cause a spark. If no spark occurs, the fault is most likely in the ignition coil because most module problems would have been found before this point in the procedure.

**High Voltage Switch (replaces distributor) System Check**

Step	Action	Value	Yes	No
1	Was the "On-Board Diagnostics" (OBD) System Check performed?	—	Go to Step 2	Go to OBD System Check
2	1. Check spark plug wires for open circuits, cracks in insulation, or improper seating of terminals at spark plugs, distributor, and ignition coil before proceeding with the test. 2. Check spark at the plug with the J 26792 spark tester or equivalent while cranking. (If there is no spark on one wire, check a second wire). A few sparks then nothing is considered "no spark." Is adequate spark present?	—	Refer to Symptoms Section	Go to Step 3
3	1. Remove the coil wire from the distributor cap. 2. Insert J 26792 spark tester into the coil wire and clamp the tester onto a ground. 3. Crank the engine. Is adequate spark present?	—	Go to Step 13	Go to Step 4
4	Measure the coil wire resistance using a J 39200 DMM. The resistance should be approximately the specified value. Is the resistance within the specified value?	1000 $\Omega$ /inch	Go to Step 5	Go to Step 32
5	1. Disconnect the ignition coil harness connector. 2. Probe the ignition coil connector terminal C with a test lamp connected to B+. 3. Crank the engine. Is the test lamp flashing while cranking the engine?	—	Go to Step 8	Go to Step 6

### High Voltage Switch (replaces distributor) System Check

Step	Action	Value	Yes	No
6	1. Turn OFF the ignition. 2. Probe the ignition coil harness connector terminal C with a test lamp connected to B+. good coil wire. Is the test lamp ON?	—	<i>Go to Step 28</i>	<i>Go to Step 9</i>
7	1. Turn the Ignition "ON," leaving the engine "OFF" 2. Measure the terminal A voltage with a J 39200 DMM connected to a ground. Does the voltage measure above the specified value?	10 volts	<i>Go to Step 21</i>	<i>Go to Step 18</i>
8	1. Turn OFF the ignition. 2. Disconnect the ignition control module harness connector. 3. Check for an open circuit between the ignition coil harness connector terminal C and the ignition control module harness connector terminal D. Is the circuit open?	—	<i>Go to Step 27</i>	<i>Go to Step 10</i>
9	1. Disconnect the ignition control module harness connector. 2. Turn ON the ignition leaving the engine OFF. 3. Measure the voltage on terminal A at the ignition control module harness connector with J 39200 DMM connected to a ground. Does the voltage measure above the specified value?	10 volts	<i>Go to Step 11</i>	<i>Go to Step 19</i>
10	Probe the ignition control module harness connector terminal C with a test lamp connected to B+. Is the test lamp ON?	—	<i>Go to Step 12</i>	<i>Go to Step 23</i>
11	1. Disconnect the ignition control module harness connector. 2. Probe the ignition control module harness connector terminal B with a J 39200 DMM set to the AC Hertz scale connected to ground. 3. Crank the engine. 4. Observe the frequency while the engine is being cranked. Is the frequency between the specified values?	3-20 HZ	<i>Go to Step 20</i>	<i>Go to Step 15</i>
12	1. Remove distributor cap. 2. Check the cap for the following conditions: <ul style="list-style-type: none"> <li>• Cracks</li> <li>• Moisture</li> <li>• Carbon tracks</li> <li>• Physical damage</li> </ul> Are any of these conditions present?	—	<i>Go to Step 34</i>	<i>Go to Step 14</i>
13	1. Crank the engine. 2. Observe the distributor rotor while the engine is being cranked. Did the distributor rotor turn?	—	<i>Go to Step 33</i>	<i>Go to Symptoms</i>

## High Voltage Switch (replaces distributor) System Check

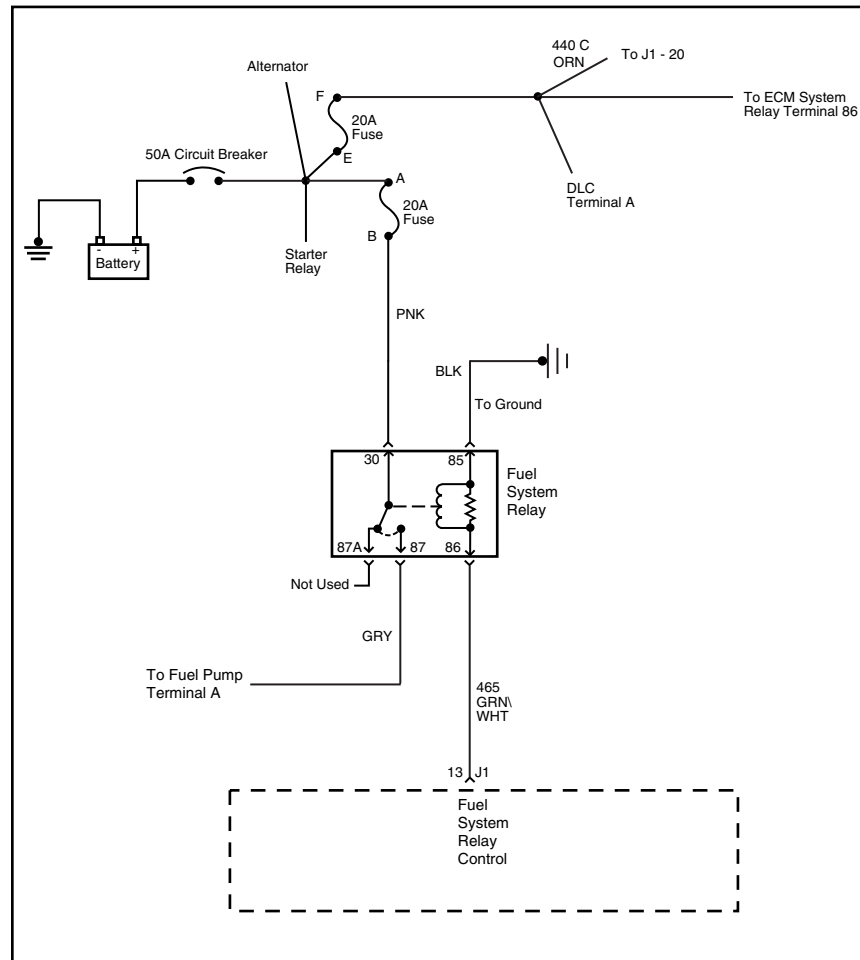
Step	Action	Value	Yes	No
14	1. Turn OFF the ignition. 2. Disconnect Pin J2 - 1. 3. Check the ignition timing signal circuit for an open between the J2 - 1 Pin harness connector and the ignition control module harness connector terminal B. Is the circuit open?	—	Go to Step 24	Go to Step 16
15	Probe the ignition control (IC) circuit at the Pin J2-1 connector with a test lamp connected to B+. Is the test lamp ON?	—	Go to Step 25	Go to Step 17
16	1. Turn ON the ignition leaving the engine OFF. 2. Probe the ignition control (IC) circuit at the J2-1 Pin connector with a test lamp connected to a ground. Is the test lamp ON?	—	Go to Step 26	Go to Step 22
17	Check for an open or shorted to ground ignition positive voltage circuit at terminal A of the ignition coil. Repair as necessary. Is action complete?	—	Go to Step 37	—
18	Check for an open or shorted to ground ignition positive voltage circuit at terminal A of the ignition control module. Repair as necessary. Is action complete?	—	Go to Step 37	—
19	Check for a poor ignition control module connection. Did you find the problem?	—	Go to Step 30	Go to Step 35
20	Check for a poor coil connection. Did you find the problem?	—	Go to Step 30	Go to Step 31
21	Check for a poor connection at Pin J2-1. Did you find the problem?	—	Go to Step 30	Go to Step 36
22	Repair the open ignition control module ground circuit. Is action complete?	—	Go to Step 37	—
23	Repair the open IC circuit between the Pin J2-1 and the ignition control module. Is action complete?	—	Go to Step 37	—
24	Repair the grounded IC circuit between the Pin J2-1 and the ignition control module. Is action complete?	—	Go to Step 37	—
25	Repair short to voltage in the IC circuit between the Pin J2-1 and the ignition control module. Is action complete?	—	Go to Step 37	—
26	Repair the open in the circuit between the ignition coil and the ignition control module. Is action complete?	—	Go to Step 37	—

### High Voltage Switch (replaces distributor) System Check

Step	Action	Value	Yes	No
27	Repair the short to ground in between the ignition coil and the ignition control module. Is action complete?	—	<i>Go to Step 37</i>	—
28	Repair the circuit as necessary. Is the action complete?	—	<i>Go to Step 37</i>	—
29	Replace the ignition coil. Refer to <i>Ignition Coil and ICM Replacement (HVS)</i> in Engine Mechanical. Is the action complete?	—	<i>Go to Step 37</i>	—
30	Replace the coil wire. Refer to <i>Ignition Coil and ICM Replacement (HVS)</i> in Engine Mechanical. Is the action complete?	—	<i>Go to Step 37</i>	—
31	Replace the distributor rotor. Refer to <i>Camshaft Position Sensor Replacement</i> for distributor rotor replacement. Is action complete?	—	<i>Go to Step 37</i>	—
32	Replace the distributor cap. Refer to <i>Camshaft Position Sensor Replacement</i> for distributor cap replacement. Is action complete?	—	<i>Go to Step 37</i>	—
33	Replace ignition control module. Refer to <i>Ignition Coil and ICM Replacement (HVS)</i> . Is action complete?	—	<i>Go to Step 37</i>	—
34	Replace ECM. Is action complete?	—	<i>Go to Step 37</i>	—
35	Operate the vessel within the conditions under which the original symptom was noted. Does the system now operate properly?	—	System OK	<i>Go to Step 1</i>



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### Fuel Pump Relay Circuit Diagnosis

#### Circuit Description

When the ignition switch is ON, the ECM activates the electric fuel pump. The fuel pump remains ON as long as the ECM receives reference pulses from the ignition system. If there are no reference pulses, the ECM turns the fuel pump OFF after about 2 seconds. The pump delivers fuel to the fuel rail and injectors, then to the pressure regulator, where the system pressure remains at 379-427 kPa (55-62 psi) while the fuel pump is running. Excess fuel returns to the fuel tank. When the engine is stopped, a scan tool in the output controls function can turn ON the fuel pump.

Improper fuel system pressure results in one or many of the following symptoms:

- Cranks but will not run
- Cuts out, may feel like an ignition problem
- Poor fuel economy
- Loss of power
- Hesitation
- DTCs

#### Diagnostic Aids

The following conditions may have caused the fuel pump fuse to open:

- The fuse is faulty
- There is an intermittent short in the fuel pump power feed circuit.
- The fuel pump has an intermittent internal problem.

For an intermittent condition, refer to *Symptoms*.

#### Test Description

Number(s) below refer to the step number(s) on the diagnostic table:

3. Refer to Thumbnail Schematic for proper terminal identification.
5. The test lamp only illuminates for two seconds even through the scan tool commanded position is ON. You will have to command the fuel pump OFF then ON to re-enable the ECM fuel pump control.
12. Inspect the fuel pump fuse for an open. If the fuse is open, inspect the circuit for a short to ground.
20. Inspect the fuel pump fuse for an open. If the fuse is open, inspect the circuit for a short to ground.

## Fuel Pump Relay Circuit Diagnosis

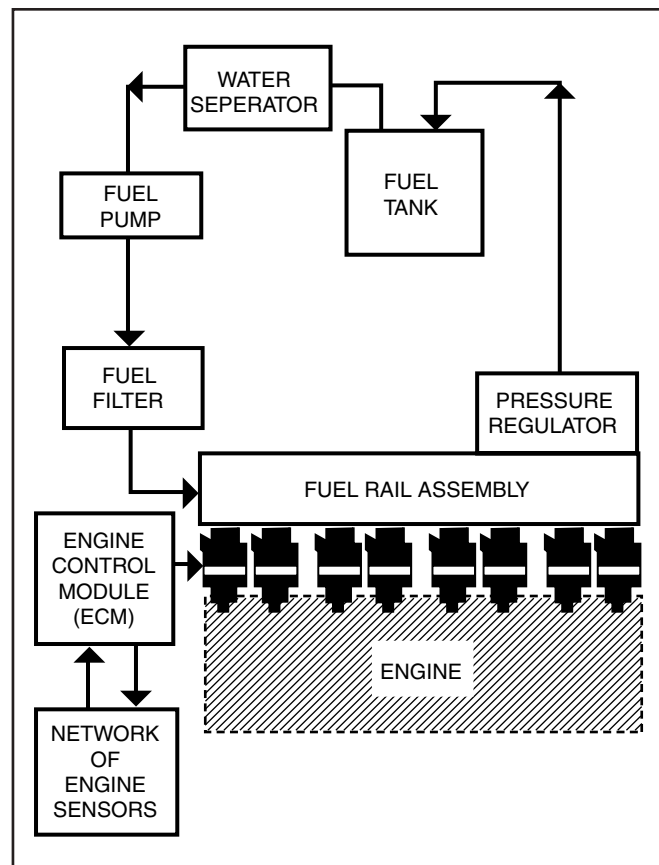
Step	Action	Value	Yes	No
1	Did you perform the On-Board Diagnostic (OBD) System Check?	—	Go to Step 2	Go to OBD System Check
2	Check the fuel pump fuse. Is the fuse open?	—	Go to Step 9	Go to Step 3
3	1. Install a scan tool. 2. Disconnect the fuel pump relay harness connector. 3. Turn ON the ignition leaving the engine OFF. 4. Probe the fuel pump relay battery feed circuit at the harness connector with a test lamp J 34142-B connected to ground. Does the test lamp illuminate?	—	Go to Step 4	Go to Step 12
4	Probe the fuel pump relay ground circuit at the harness connector with a test lamp J 34142-B connected to B+. Refer to the thumbnail wiring schematic for the proper terminal identification. Does the test lamp illuminate?	—	Go to Step 5	Go to Step 13
5	1. Probe the fuel pump control circuit at the harness connector with a test lamp J 34142-B connected to ground. Refer to the thumbnail wiring schematic for the proper terminal identification. 2. Enable the fuel pump using the scan tool. Does the test lamp illuminate?	—	Go to Step 6	Go to Step 11
6	<b>Important:</b> Ignition must be ON before performing this step. Jumper the fuel pump relay battery feed circuit to the fuel pump load circuit at the harness connector using a fused jumper wire. Does the fuel pump operate?	—	Go to Step 18	Go to Step 7
7	1. Leave the fused jumper wire connected. 2. Disconnect the fuel pump harness connector at the fuel pump. 3. Probe the power feed circuit in the fuel pump harness connector with a test lamp J 34142-B connected to ground. Does the test lamp illuminate?	—	Go to Step 8	Go to Step 14
8	1. Leave the fused jumper wire connected. 2. Connect the test lamp J 34142-B between the battery feed circuit and the ground circuit in the fuel pump harness connector. Does the test lamp illuminate?	—	Go to Step 25	Go to Step 15

## Fuel Pump Relay Circuit Diagnosis (cont'd)

Step	Action	Value	Yes	No
9	1. Turn OFF the ignition. 2. Remove the fuel pump fuse. 3. Disconnect the fuel pump harness connector at the fuel pump. 4. Probe the load circuit for the fuel pump relay at the harness connector with a test lamp J 34142-B connected to B+. Does the test lamp illuminate?	—	Go to Step 16	Go to Step 10
10	Probe the battery feed circuit for the fuel pump relay at the harness connector with a test lamp J 34142-B connected to B+. Does the test lamp illuminate?	—	Go to Step 20	Go to Step 21
11	1. Turn OFF the ignition. 2. Disconnect the ECM connector J1. 3. Measure the continuity of the fuel pump relay control circuit from the fuel pump relay harness connector to the ECM connector using the DMM J 39200. Does the DMM display the specified value or lower?	5 ohms	Go to Step 22	Go to Step 17
12	Repair the open or grounded battery feed circuit to the relay. Replace the fuel pump fuse if the fuse is open. Is the action complete?	—	Go to Step 26	—
13	Repair the open fuel pump relay ground circuit. Is the action complete?	—	Go to Step 26	—
14	Repair the open circuit between the fuel pump relay and the fuel pump. Is the action complete?	—	Go to Step 26	—
15	Repair the open fuel pump ground circuit. Is the action complete?	—	Go to Step 26	—
16	Repair the short to ground in the fuel pump relay load circuit between the relay and the fuel pump. Is the action complete?	—	Go to Step 26	—
17	Repair the fuel pump relay control circuit. Is the action complete?	—	Go to Step 26	—
18	Inspect for poor connections at the relay harness connector. Did you find and correct the condition?	—	Go to Step 26	Go to Step 19
19	Replace the relay. Refer to <i>Fuel Pump Relay Replacement</i> . Is the action complete?	—	Go to Step 26	—
20	Repair the short to ground in the battery feed circuit to the fuel pump relay. Is the action complete?	—	Go to Step 26	—

## Fuel Pump Relay Circuit Diagnosis (cont'd)

Step	Action	Value	Yes	No
21	<ol style="list-style-type: none"> <li>Turn OFF the ignition.</li> <li>Re-install the fuel pump relay.</li> <li>Install a new fuse.</li> <li>Connect the fuel pump harness to the fuel pump.</li> <li>Turn ON the ignition leaving the engine OFF.</li> <li>Command the fuel pump relay ON using a scan tool.</li> </ol> Is the fuel pump fuse open?	—	Go to Step 24	Go to Diagnostic Aids
22	Inspect for a poor connection at the ECM. Did you find and correct the condition?	—	Go to Step 26	Go to Step 23
23	Replace the ECM. Is the action complete?	—	Go to Step 26	—
24	<ol style="list-style-type: none"> <li>Inspect the fuel pump harness for a short to ground.</li> <li>If you find a short, repair the circuit as necessary.</li> </ol> Did you find and correct the condition?	—	Go to Step 26	Go to Step 25
25	<b>Important:</b> Inspect for poor electrical connections at the fuel pump harness before replacing the fuel pump. Replace the fuel pump. Is the action complete?	—	Go to Step 26	—
26	<ol style="list-style-type: none"> <li>Select the Diagnostic Trouble Code (DTC) option and the Clear DTC Information option using the scan tool.</li> <li>Attempt to start the engine.</li> </ol> Does the engine start and continue to operate?	—	Go to Step 27	Go to Step 2
27	<ol style="list-style-type: none"> <li>Idle the engine until the normal operating temperature is reached.</li> <li>Select the Diagnostic Trouble Code (DTC) option.</li> </ol> Are any DTCs displayed?	—	Go to the applicable DTC table	System OK



### Fuel System Diagnosis

#### Circuit Description

When the ignition switch is ON, the ECM activates the electric fuel pump. The fuel pump remains ON as long as the ECM receives reference pulses from the ignition system. If there are no reference pulses, the ECM turns the fuel pump OFF after about 2 seconds.

The electric pump delivers fuel through an in-pipe fuel filter to the fuel rail assembly. The fuel pump provides fuel at a pressure above the pressure needed by the fuel injectors. A fuel pressure regulator, attached to the fuel rail, keeps the fuel available to the fuel injectors at a regulated pressure. Unused fuel returns to the fuel tank by a separate fuel return pipe.

#### Test Description

Number(s) below refer to the step number(s) on the diagnostic table:

2. When the ignition switch is ON and the fuel pump is running, the fuel pressure indicated by the fuel pressure gauge should read 379-427 kPa (55-62 psi). The spring pressure inside the fuel pressure regulator controls the fuel pressure.
3. A fuel system that drops more than 14 kPa (2 psi) in 10 minutes has a leak in one or more of the following areas:

- The fuel pump check valve.
  - The fuel pump flex pipe.
  - The valve or valve seat within the fuel pressure regulator.
  - The fuel injector(s).
4. A fuel system that drops more than 14 kPa (2 psi) in 10 minutes after being relieved to 69 kPa (10 psi) indicates a leaking fuel pump check valve.
  5. Fuel pressure that drops off during acceleration, cruise or hard cornering may cause a lean condition. A lean condition can cause a loss of power, surging or misfire.
  8. When the engine is at idle, the manifold pressure is low (high vacuum). This low pressure (high vacuum) is applied to the fuel pressure regulator diaphragm. The low pressure (high vacuum) will offset the pressure being applied to the fuel pressure regulator diaphragm by the spring inside the fuel pressure regulator. When this happens, the result is lower fuel pressure. The fuel pressure at idle will vary slightly as the barometric pressure changes, but the fuel pressure at idle should always be less than the fuel pressure noted in step 2 with the engine OFF.

### Fuel System Diagnosis

12. A rich condition may result from the fuel pressure being above 427 kPa (62 psi). Driveability conditions associated with rich conditions can include hard starting followed by black smoke and a strong sulfur smell in the exhaust.
  13. This test determines if the high fuel pressure is due to a restricted fuel return pipe or if the high fuel pressure is due to a faulty fuel pressure regulator.
  15. A lean condition may result from the fuel pressure being below 379 kPa (55 psi). Driveability conditions associated with lean conditions can include hard starting (when the engine is cold), hesitation, poor driveability, lack of power, surging and misfiring.
- Notice:** Do not allow the fuel pressure to exceed 517 kPa (75 psi). Excessive pressure may damage the fuel pressure regulator.
16. Restricting the fuel return pipe with the J 37287 fuel pipe shut-off adapter causes the fuel pressure to rise above the regulated pressure. Using a scan tool to pressurize the fuel system, the fuel pressure should rise above 427 kPa (62 psi) as the valve on the fuel pipe shut-off adapter connected to the fuel return pipe becomes partially closed.
  22. Check the spark plug associated with a particular fuel injector for fouling or saturation in order to determine if that particular fuel injector is leaking. If

checking the spark plug associated with a particular fuel injector for fouling or saturation does not determine that a particular fuel injector is leaking, use the following procedure.

1. Remove the fuel rail. Refer to *Fuel Rail Assembly Replacement*.
2. Reinstall the crossover pipe to the right fuel rail. Refer to *Fuel Rail Assembly Replacement*.
3. Connect the fuel feed pipe and the fuel return pipe to the fuel rail. Refer to *Fuel Rail Assembly Replacement*.
4. Lift the fuel rail just enough to leave the fuel injector nozzles in the fuel injector ports.

**Caution:** In order to reduce the risk of fire and personal injury that may result from fuel spraying on the engine, verify that the fuel rail is positioned over the fuel injector ports. Also verify that the fuel injector retaining clips are intact.

5. Pressurize the fuel system by using the scan tool fuel pump enable.
6. Visually and physically inspect the fuel injector nozzles for leaks.

### Fuel System Diagnosis

Step	Action	Value	Yes	No
1	Did you perform the On-Board Diagnostic (OBD) System Check?	—	Go to Step 2	Go to OBD System Check
2	<ol style="list-style-type: none"> <li>1. Turn OFF the ignition.</li> </ol> <p><b>Caution:</b> Wrap a shop towel around the fuel pressure connection in order to reduce the risk of fire and personal injury. The towel will absorb any fuel leakage that occurs during the connection of the fuel pressure gauge. Place the towel in an approved container when the connection of the fuel pressure gauge is complete.</p> <ol style="list-style-type: none"> <li>2. Install the J 34730-1A fuel pressure gauge.</li> <li>3. Place the bleed hose of the fuel pressure gauge into an approved gasoline container.</li> <li>4. Turn the ignition ON leaving the engine OFF.</li> <li>5. Bleed the air out of the fuel pressure gauge.</li> <li>6. Turn the ignition OFF for 10 seconds.</li> <li>7. Turn the ignition ON leaving the engine OFF.</li> </ol> <p><b>Important:</b> The fuel pump will run for approximately 2 seconds. Cycle the ignition as necessary in order to achieve the highest possible fuel pressure.</p> <ol style="list-style-type: none"> <li>8. Observe the fuel pressure with the fuel pump running. Is the fuel pressure within the specified limits?</li> </ol>	379-427 kPa (55-62 psi)	Go to Step 3	Go to Step 12

## Fuel System Diagnosis (cont'd)

Step	Action	Value	Yes	No
3	<b>Important:</b> The fuel pressure may vary slightly when the fuel pump stops running. After the fuel pump stops running, the fuel pressure should stabilize and remain constant. Does the fuel pressure drop more than the specified value in 10 minutes?	—	Go to Step 10	Go to Step 4
4	Relieve the fuel pressure to the first specified value. Does the fuel pressure drop more than the second specified value in 10 minutes?	69 kPa (10 psi) 14 kPa (2 psi)	Go to Step 19	Go to Step 5
5	Do you suspect the fuel pressure of dropping-off during acceleration, cruise or hard cornering?	—	Go to Step 6	Go to Step 8
6	Visually and physically inspect the following items for a restriction: <ul style="list-style-type: none"> <li>The fuel filter</li> <li>The fuel feed pipe</li> </ul> Did you find a restriction?	—	Go to Step 24	Go to Step 7
7	1. Remove the fuel sender assembly. 2. Visually and physically inspect the following items: <ul style="list-style-type: none"> <li>The fuel strainer/check valve for a restriction.</li> <li>The fuel pump pipe for leaks.</li> <li>Verify the fuel pump is the correct fuel pump for this vehicle.</li> </ul> Did you find a problem in any of these areas?	—	Go to Step 24	Go to Step 19
8	1. Start the engine. 2. Allow the engine to idle at normal operating temperature. Does the fuel pressure drop by the amount specified?	21-69 kPa (3-10 psi)	Go to Symptoms	Go to Step 9
9	1. Disconnect the vacuum hose from the fuel pressure regulator. 2. With the engine idling, apply 12-14 inches of vacuum to the fuel pressure regulator. Does the fuel pressure drop by the amount specified?	21-69 kPa (3-10 psi)	Go to Step 20	Go to Step 21
10	1. Relieve the fuel pressure. Refer to <i>Fuel Pressure Relief Procedure</i> . 2. Disconnect the fuel feed pipe and the fuel return pipe from the fuel rail. 3. Install the J 37287 fuel pipe shut-off adapters between the fuel feed pipe and the fuel return pipe and the fuel rail. 4. Open the valves on the fuel pipe shut-off adapters. 5. Turn the ignition ON. 6. Pressurize the fuel system using a scan tool. 7. Place the bleed hose of the fuel pressure gauge into			



## Fuel System Diagnosis (cont'd)

Step	Action	Value	Yes	No
10	<p>an approved gasoline container.</p> <p>8. Bleed the air out of the fuel pressure gauge.</p> <p>9. Wait for the fuel pressure to build.</p> <p>10. Close the valve in the fuel pipe shut-off adapter that is connected to the fuel return pipe.</p> <p>Does the fuel pressure remain constant?</p>	—	Go to Step 19	Go to Step 11
11	<p>1. Open the valve in the fuel pipe shut-off adapter that is connected to the fuel feed pipe.</p> <p>2. Pressurize the fuel system using a scan tool.</p> <p>3. Wait for the fuel pressure to build.</p> <p>4. Close the valve in the fuel pipe shut-off adapter that is connected to the fuel return pipe.</p> <p>Does the fuel pressure remain constant?</p>	—	Go to Step 21	Go to Step 22
12	Is the fuel pressure above the specified limit?	427 kPa (62 psi)	Go to Step 13	Go to Step 15
13	<p>1. Relieve the fuel pressure. Refer to the <i>Fuel Pressure Relief Procedure</i>.</p> <p>2. Disconnect the fuel return pipe from the fuel rail.</p> <p>3. Attach a length of flexible fuel hose to the fuel rail outlet passage.</p> <p>4. Place the open end of the flexible fuel hose into an approved gasoline container.</p> <p>5. Turn the ignition OFF for 10 seconds.</p> <p>6. Turn the ignition ON.</p> <p>7. Observe the fuel pressure with the fuel pump running.</p> <p>Is the fuel pressure within the specified limits?</p>	379-427 kPa (55-62 psi)	Go to Step 23	Go to Step 14
14	<p>Visually and physically inspect the fuel rail outlet passages for a restriction.</p> <p>Was a restriction found?</p>	—	Go to Step 24	Go to Step 21
15	Is the fuel pressure above the specified value?	0 kPa (0 psi)	Go to Step 16	Go to Step 17
16	<p>1. Relieve the fuel pressure. Refer to <i>Fuel Pressure Relief Procedure</i>.</p> <p>2. Disconnect the fuel return pipe from the fuel rail.</p> <p>3. Install the J 37287 fuel pipe shut-off adapter between the fuel return pipe and the fuel rail.</p> <p>4. Open the valve on the fuel pipe shut-off adapter.</p> <p>5. Turn the ignition ON.</p> <p>6. Pressurize the fuel system using a scan tool.</p> <p>7. Place the bleed hose of the fuel pressure gauge into an approved gasoline container.</p> <p>8. Bleed the air out of the fuel pressure gauge.</p> <p><b>Notice:</b> Do not allow the fuel pressure to exceed 517 kPa (75 psi). Excessive pressure may damage the fuel</p>			

## Fuel System Diagnosis (cont'd)

Step	Action	Value	Yes	No
16	pressure regulator. 9. Slowly close the valve in the fuel pipe shut-off adapter that is connected to the fuel return pipe. Does the fuel pressure rise above the specified value?	427 kPa (62 psi)	Go to Step 21	Go to Step 7
17	Turn ON the fuel pump using a scan tool. Does the fuel pump run?	—	Go to Step 18	Go to Fuel Pump Relay Circuit Diagnosis
18	Visually and physically inspect the following items: <ul style="list-style-type: none"> <li>• The fuel filter for obstructions.</li> <li>• The fuel feed pipe for a restriction.</li> <li>• The fuel strainer for obstructions.</li> <li>• The fuel pump pipe for leaks.</li> </ul> Did you find a problem in any of these areas?	—	Go to Step 24	Go to Step 19
19	Replace the fuel pump. Is the action complete?	—	System OK	—
20	Locate and repair the loss of vacuum to the fuel pressure regulator. Is the action complete?	—	System OK	—
21	Replace the fuel pressure regulator. Is the action complete?	—	System OK	—
22	Locate and replace any leaking fuel injector(s). Is the action complete?	—	System OK	—
23	Locate and repair the restriction in the fuel return pipe. Is the action complete?	—	System OK	—
24	Repair the problem as necessary. Is the action complete?	—	System OK	—

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### Fuel Injector Coil Test - Engine Coolant Temperature (ECT) Between 10-35 Degrees C (50-95 Degrees F)

#### Test Description

2. The engine coolant temperature affects the ability of the fuel injector tester to detect a faulty fuel injector. If the engine coolant temperature is NOT between 10-35 degrees C (50-95 degrees F), use *Fuel Injector Test - Engine Coolant Temperature (ECT) Outside 10-35 Degrees C (50-95 Degrees F)* table.
3. The first second of the voltage displayed by the DMM may be inaccurate due to the initial current surge. Therefore, record the lowest voltage displayed by the DMM after the first second of the test. The voltage displayed by the DMM should be within the specified range. Refer to the Example. The voltage displayed by the DMM may increase throughout the test as the fuel injector windings warm and the resistance of the fuel injector windings changes. An erratic voltage reading with large fluctuations in voltage that do not stabilize, indicates an intermittent connection with the fuel injector.

Resistance Ohms	Voltage Specification at 10-35 Degrees C (50-95 Degrees F)	
11.8-12.6	5.7-6.6 V	
Fuel Injector Number	Voltage Reading	Pass/Fail
1	6.3	P
2	5.9	P
3	6.2	P
4	6.1	P
5	4.8	F
6	6.0	P
7	5.0	P
8	5.3	P

### Fuel Injector Coil Test - Engine Coolant Temperature (ECT) Between 10-35 Degrees C (50-95 Degrees F)

Step	Action	Value	Yes	No
1	Was the "On-Board Diagnostic" (OBD) system check performed?	—	Go to Step 2	Go to OBD System Check
2	1. Connect the scan tool. 2. Check the engine coolant temperature. Is the engine coolant temperature within the specified limits?	10°C-35°C (50°F-95°F)	Go to Step 3	Go to Fuel Injector Coil Test-ECT Outside 10-35°C (50-95°F)
3	1. Turn the ignition OFF. <b>Notice:</b> Be careful not to flood a single cylinder. 2. Relieve the fuel pressure per manufacturers recommendation. 3. Access the fuel injector electrical connectors as required. 4. Connect the J 39021 fuel injector tester to B+ and ground. 5. Set the amperage supply selector switch on the fuel injector tester to the Coil Test 0.5 amp position. 6. Connect the leads from the DMM to the fuel injector tester. 7. Set the DMM to the tenths scale (0.0). 8. Connect the fuel injector tester to a fuel injector using the J 39021-380 injector test adapter. <b>Important:</b> Check the engine coolant temperature again in order to ensure that the correct chart is being used.			

### Fuel Injector Coil Test - Engine Coolant Temperature (ECT) Between 10-35 Degrees C (50-95 Degrees F) (cont'd)

Step	Action	Value	Yes	No
3	9. Press the Push to Start Test button on the fuel injector tester. <b>Important:</b> The voltage reading may rise during the test. 10. Observe the voltage reading on the DMM. 11. Record the lowest voltage observed after the first second of the test. 12. Repeat steps 8 through 11 for each fuel injector. Did any fuel injector have an erratic voltage reading with large fluctuations in voltage that do not stabilize, or a voltage reading outside the specified limits?	5.7-6.6 V	Go to Step 4	Go to Fuel Injector Balance Test with Special Tool
4	Replace the faulty fuel injectors. Refer to <i>Fuel Injector Replacement</i> . Is the action complete?	—	Go to Fuel Injector Balance Test with Special Tool	—

### Fuel Injector Coil Test - Engine Coolant Temperature (ECT) Outside 10-35 Degrees C (50-95 Degrees F)

#### Test Description

- The engine coolant temperature affects the ability of the fuel injector tester to detect a faulty fuel injector. If the engine coolant temperature is between 10-35 degrees C (50-95 degrees F), use *Fuel Injector Test - Engine Coolant Temperature (ECT) Between 10-35 Degrees C (50-95 Degrees F)* table.
- The first second of the voltage displayed by the DMM may be inaccurate due to the initial current surge. Therefore, record the lowest voltage displayed by the DMM after the first second of the test. The voltage displayed by the DMM may increase throughout the test as the fuel injector windings warm and the resistance of the fuel injector windings changes. An erratic voltage reading with large fluctuations in voltage that do not stabilize, indicates an intermittent connection with the fuel injector. From the voltages recorded, identify the highest voltage, excluding any voltages above 9.5 volts. Subtract each voltage that is not above 9.5 volts from the highest voltage. Record each subtracted value. Refer to the Example. The subtracted value that is more than 0.6 volt is faulty. Replace the fuel injector. A fuel injector with a recorded voltage above 9.5 volts is also faulty. Replace the fuel injector.

Highest Voltage Reading		Acceptable Subtracted Value Above/Below 10-35°C (50-95°F)	
7.1 V		0.6 V	
Injector Number	Voltage	Subtracted Value	Pass/Fail
1	9.8	—	F
2	6.6	0.5	P
3	6.9	0.2	P
4	5.8	1.3	F
5	7.0	0.1	P
6	7.1	0.0	P
7	9.6	—	F
8	6.0	1.1	F

### Fuel Injector Coil Test - Engine Coolant Temperature (ECT) Outside 10-35 Degrees C (50-95 Degrees F)

Step	Action	Value	Yes	No
1	Was the "On-Board Diagnostic" (OBD) system check performed?	—	Go to Step 2	Go to OBD System Check
2	1. Connect the scan tool. 2. Check the engine coolant temperature. Is the engine coolant temperature within the specified limits?	10°C-35°C (50°F-95°F)	Go to Step 3	Go to Fuel Injector Coil Test-ECT Between 10-35°C (50-95°F)
3	1. Turn the ignition OFF. <b>Notice:</b> Be careful not to flood a single cylinder. 2. Relieve the fuel pressure per manufacturers recommendation. 3. Access the fuel injector electrical connectors as required. 4. Connect the J 39021 fuel injector tester to B+ and ground. 5. Set the amperage supply selector switch on the fuel injector tester to the Coil Test 0.5 amp position. 6. Connect the leads from the DMM to the fuel injector tester. 7. Set the DMM to the tenths scale (0.0). 8. Connect the fuel injector tester to a fuel injector using the J 39021-380 injector test adapter. <b>Important:</b> Check the engine coolant temperature again in order to ensure that the correct chart is being used. 9. Press the Push to Start Test button on the fuel injector tester. <b>Important:</b> The voltage reading may rise during the test. 10. Observe the voltage reading on the DMM. 11. Record the lowest voltage observed after the first second of the test. 12. Repeat steps 8 through 11 for each fuel injector. 13. Identify the highest voltage reading recorded other than those above 9.5 volts. 14. Subtract any other voltage readings recorded from the highest voltage reading recorded. 15. Repeat step 14 for all the remaining fuel injectors. Is any value that resulted from subtraction more than the specified value?	0.6 V	Go to Step 4	Go to Fuel Injector Balance Test with Special Tool
4	Replace any fuel injector that had any of the following: <ul style="list-style-type: none"> <li>• A subtracted value exceeding 0.6 volts</li> <li>• An initial reading above 9.5 volts</li> <li>• An erratic reading</li> </ul> Refer to <i>Fuel Injector Replacement</i> . Is the action complete?	—	Go to Fuel Injector Balance Test with Special Tool	—

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### Fuel Injector Balance Test with Special Tool

#### Test Description

4. The engine coolant temperature must be below the operating temperature in order to avoid irregular fuel pressure readings due to Hot Soak fuel boiling.
5. The fuel pressure should be within the specified range.
6. The fuel pressure should reach a steady value.
7. If the fuel pressure drop value for each injector is within 10 Kpa (1.5 psi) of the average pressure drop value, the fuel injectors are flowing properly. Calculate the pressure drop value for each fuel injector by subtracting the second pressure reading from the first pressure reading.

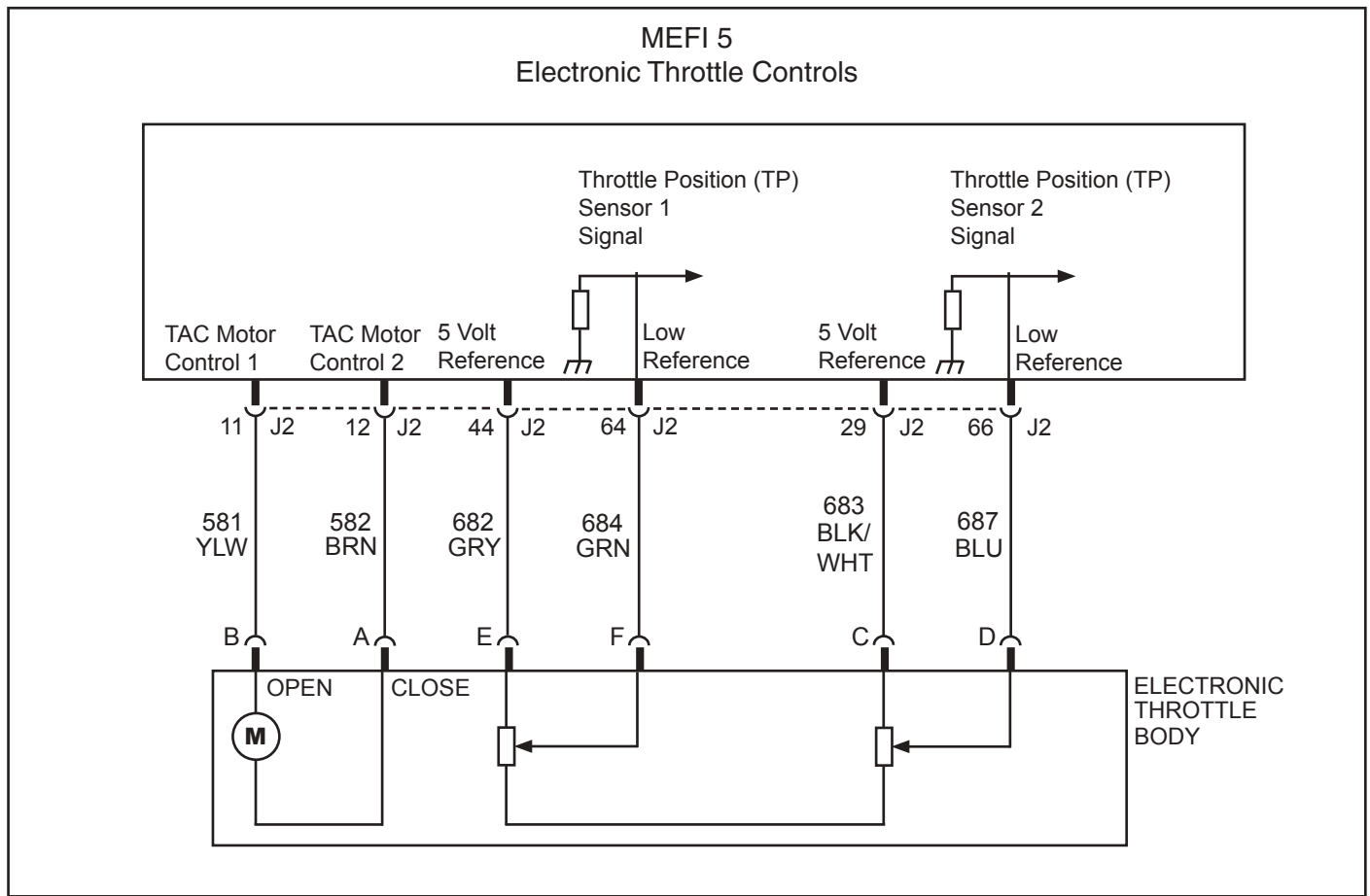
### Fuel Injector Balance Test with Special Tool

Step	Action	Value	Yes	No
1	Was the "On-Board Diagnostic" (OBD) system check performed?	—	Go to Step 2	Go to OBD System Check
2	Did you perform the Fuel Injector Coil Test Procedure?	—	Go to Step 3	Go to Fuel Injector Coil Test-ECT Between 10-35°C (50-95°F)
3	Is the engine coolant temperature above the specified value?	94°C(201°F)	Go to Step 4	Go to Step 5
4	Allow the engine to cool below the specified value. Is the engine coolant temperature below the specified value?	94°C(201°F)	Go to Step 5	—
5	<ol style="list-style-type: none"> <li>1. Turn the ignition OFF.</li> <li>2. Connect the J 34730-1A fuel pressure gauge to the fuel pressure test port.</li> <li>3. Turn ON the ignition leaving the engine OFF.</li> <li>4. Install the scan tool.</li> <li>5. Energize the fuel pump using the scan tool.</li> <li>6. Place the bleed hose of the fuel pressure gauge into an approved gasoline container.</li> <li>7. Bleed the air out of the fuel pressure gauge.</li> <li>8. Again energize the fuel pump using the scan tool.</li> </ol> <p><b>Important:</b> The fuel pump will run for approximately 2 seconds. Repeat step 8 as necessary in order to achieve the highest possible fuel pressure.</p> <ol style="list-style-type: none"> <li>9. Wait for the fuel pressure to build.</li> <li>10. Observe the reading on the fuel pressure gauge while the fuel pump is running.</li> </ol> Is the fuel pressure within the specified limits?	379-427 kPa (55-62 psi)	Go to Step 6	Go to Fuel System Diagnosis
6	After the fuel pump stops, the fuel pressure may vary slightly, then should hold steady. Does the fuel pressure remain constant within the specified value?	379-427 kPa (55-62 psi)	Go to Step 7	Go to Fuel System Diagnosis



## Fuel Injector Balance Test with Special Tool (cont'd)

Step	Action	Value	Yes	No
7	<ol style="list-style-type: none"> <li>1. Connect the J 39021 fuel injector tester to a fuel injector using the J 39021-380 injector test adapter.</li> <li>2. Set the amperage supply selector switch on the fuel injector tester to the balance test 0.5-2.5 amp position.</li> <li>3. Energize the fuel pump using the scan tool in order to pressurize the fuel system.</li> <li>4. Record the fuel pressure indicated by the fuel pressure gauge after the fuel pressure stabilizes. This is the 1st pressure reading.</li> <li>5. Energize the fuel injector by depressing the Push to Start Test button on the fuel injector tester.</li> <li>6. Record the fuel pressure indicated by the fuel pressure gauge after the fuel pressure gauge needle has stopped moving. This is the 2nd pressure reading.</li> <li>7. Repeat steps 1 through 6 for each fuel injector.</li> <li>8. Subtract the 2nd pressure reading from the 1st pressure reading for one fuel injector. The result is the pressure drop value.</li> <li>9. Obtain a pressure drop value for each fuel injector.</li> <li>10. Add all of the individual pressure drop values. This is the total pressure drop.</li> <li>11. Divide the total pressure drop by the number of fuel injectors. This is the average pressure drop.</li> </ol> <p>Does any fuel injector have a pressure drop value that is either higher than the average pressure drop or lower than the average pressure drop by the specified value?</p>	10 kPa (1.5 psi)	Go to Step 8	Go to Symptoms
8	<p><b>Notice:</b> Do Not repeat any portion of this test before running the engine in order to prevent the engine from flooding.</p> <p>Retest any fuel injector that does not meet the specification. Refer to the procedure in step 7.</p> <p>Does any fuel injector still have a pressure drop value that is either higher than the average pressure drop or lower than the average pressure drop by the specified value?</p>	10 kPa (1.5 psi)	Go to Step 9	Go to Symptoms
9	<p>Replace the faulty fuel injectors. Refer to <i>Fuel Injector Replacement</i>.</p> <p>Is the action complete?</p>	—	System OK	—



### Idle Air Control Functional Test

#### Circuit Description

The ECM controls idle speed to a calibrated “desired” RPM based on sensor inputs and actual engine RPM. The ECM uses two circuits to move the throttle blade in the electronic throttle body in order to command Idle Air Control (IAC) function. The movement of the throttle blade varies the amount of air flow bypassing the throttle plates. The ECM controls idle speed by determining the position of the throttle blade.

#### Diagnostic Aids

An intermittent may be caused by a poor connection, rubbed through wire insulation or a wire broken inside the insulation. Check for the following items:

- Poor connection or damaged harness. Inspect the ECM harness and connectors for improper mating, broken locks, improperly formed or damaged terminals, poor terminal to wire connection and damaged harness.
- Check for vacuum leaks, disconnected or brittle vacuum hoses, cuts, etc. Examine manifold and throttle body gaskets for proper seal. Check for cracked intake manifold.

- Check for poor connections, opens or short to grounds in CKT's 581, 582, 682, 683, 684, and 687. This may result in improper idle control.
- A throttle blade which is “frozen” and will not respond to the ECM, a throttle stop screw which has been tampered with, or a damaged throttle body or linkage may cause improper idle.

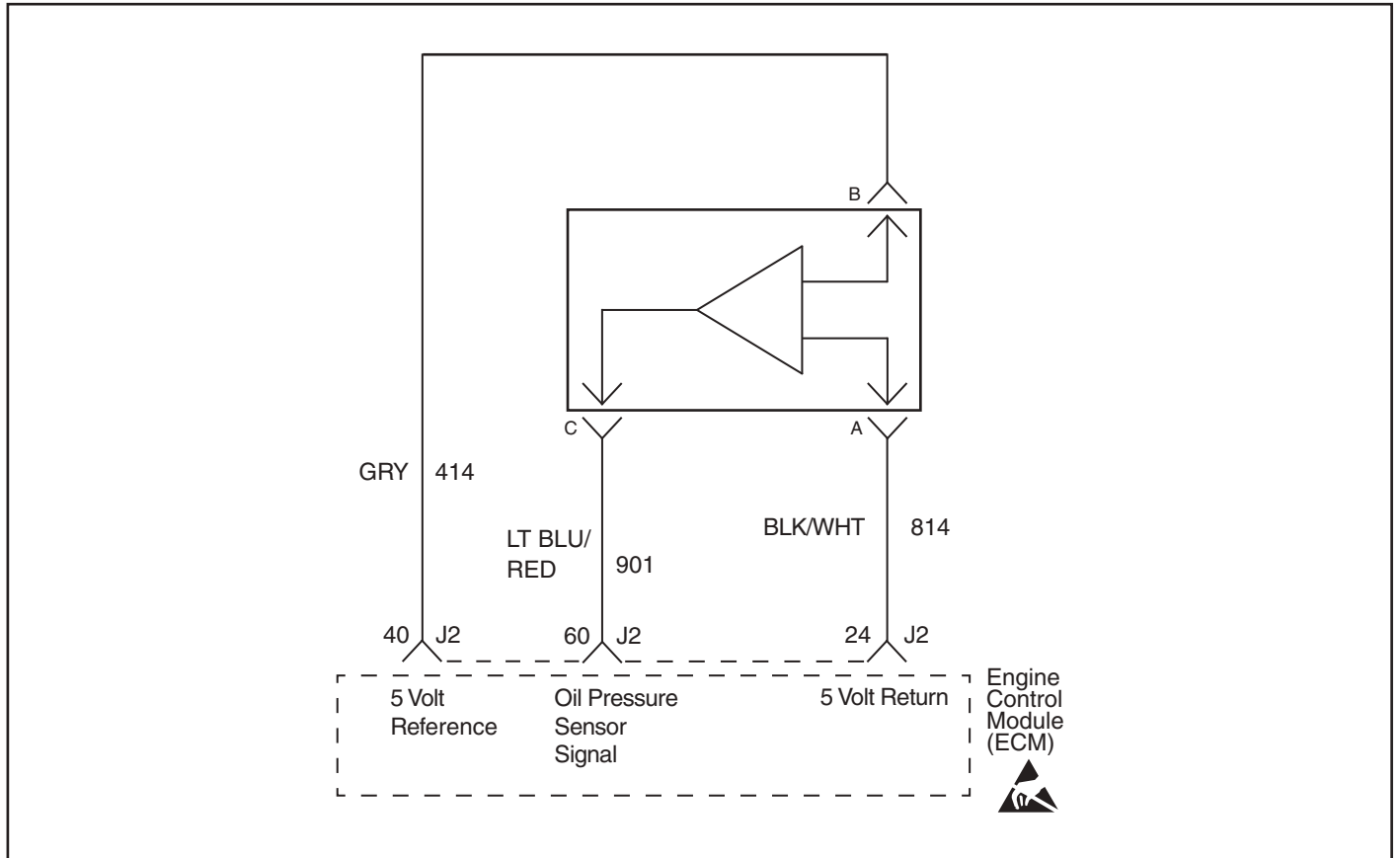
#### Test Description

2. This step determines if the Throttle Actuator Control (TAC) motor is functioning properly.
4. This step determines if the circuitry or the TAC motor is faulty.

## Idle Air Control Functional Test

Step	Action	Value	Yes	No
1	Was the "On-Board Diagnostic" (OBD) system check performed?	—	Go to Step 2	Go to OBD System Check
2	<ol style="list-style-type: none"> <li>1. Engine should be at normal operating temperature.</li> <li>2. Start engine and allow idle to stabilize.</li> <li>3. Record RPM.</li> <li>4. Ignition "OFF" for 10 seconds.</li> <li>5. Disconnect Electronic Throttle Body harness connector.</li> <li>6. Restart engine and record RPM.</li> </ol> Is RPM higher than the first recorded RPM by more than the specified value?	200 RPM	Go to Step 3	Go to Step 4
3	<ol style="list-style-type: none"> <li>1. Reinstall Electronic Throttle Body harness connector.</li> <li>2. Idle speed should gradually return within 75 RPM of the original recorded RPM within 30 seconds.</li> </ol> Does RPM return to original recorded RPM?	—	Go to Step 5	Go to Step 4
4	<ol style="list-style-type: none"> <li>1. Ignition "OFF" for 10 seconds.</li> <li>2. Disconnect Electronic Throttle Body harness connector.</li> <li>3. Restart engine.</li> <li>4. Using a test lamp J 34142-B connected to ground, probe each one of the six Electronic Throttle Body harness terminals.</li> </ol> Does the test lamp blink on all four terminals?	—	Go to Step 7	Go to Step 6
5	Electronic Throttle Body circuit is functioning properly.	—	—	—
6	Locate and repair poor connection, open, or short to ground in the Electronic Throttle Body circuit that did not blink. If a problem was found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 8
7	Check for poor Electronic Throttle Body connections or replace the faulty Electronic Throttle Body. Is action complete?	—	Go to OBD System Check	—
8	Repair faulty ECM connections or replace faulty ECM. Is action complete?	—	Go to OBD System Check	—

## Engine Oil Pressure Sensor



## SPN 100 FMI 3 - Oil Pressure Voltage High

## Circuit Description

The engine oil pressure (EOP) sensor changes resistance based on engine oil pressure. The ECM monitors the signal circuit of the EOP sensor. The EOP sensor has the following circuits:

- 5-volt reference circuit
- Low reference circuit
- EOP sensor signal circuit

The engine control module (ECM) supplies 5 volts to the EOP sensor on the 5-volt reference circuit. The ECM also provides a ground on the low reference circuit. The EOP sensor provides a signal to the ECM on the EOP sensor signal circuit which is relative to the pressure changes in the engine oil pressure. When the oil pressure is high, the sensor resistance is high, and the ECM senses a high voltage. When the oil pressure is low, the sensor voltage is low, and the ECM senses a low signal voltage. The ECM monitors the EOP sensor signal for voltage outside of the normal range. If the ECM detects an EOP sensor signal voltage that is excessively high, SPN 100 FMI 3 sets.

The ECM sends the engine oil pressure information to the IPC (Dash) via the CAN BUS J1939 data circuit. An EOP fault code will cause RPM reduction to occur on some engine packages.

## DTC Descriptor

This diagnostic procedure supports the following DTC:  
SPN 100 FMI 3 Oil Pressure Voltage High

## Conditions for Running the DTC

- The engine is running.

## Conditions for Setting the DTC

The ECM detects that the EOP sensor voltage is greater than 4.5 volt for more than 9 seconds.

## Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the DTC at the time the diagnostic fails.

## Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after consecutive ignition cycle that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

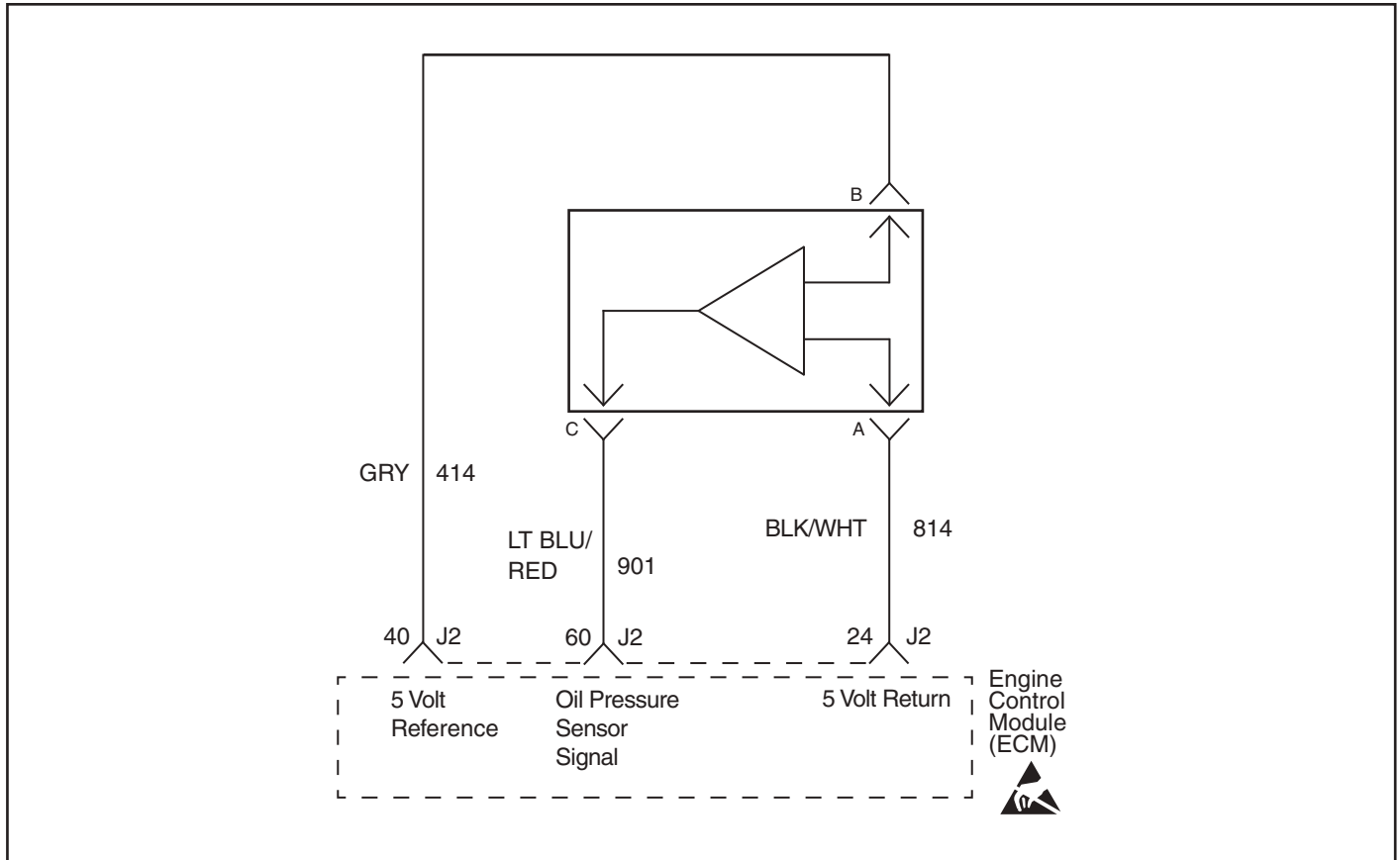
## Diagnostic Aids

Step	Action	Value	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views</i> or <i>Engine Controls Connector End Views</i>				
1	Was the "On-Board Diagnostic" (OBD) system check performed?	—	Go to Step 2	Go to OBD System Check Page 2-12
2	1. Install a scan tool. 2. Turn the ignition ON, with the engine OFF. 3. With the scan tool, observe the Engine Oil Pressure Sensor parameter in the Scan Tool Data list. Does the Engine Oil Pressure Sensor parameter display less than the specified value?	0.48 V	Go to Step 3	Go to Diagnostic Aids
3	1. Turn the ignition OFF. 2. Disconnect the engine oil pressure (EOP) sensor. 3. Connect a 3-ampere fused jumper between the EOP sensor original circuit and the 5 volt reference circuit of the EOP sensor. 4. With the scan tool, observe the Engine Oil Pressure Sensor parameter. Does the Engine Oil Pressure Sensor parameter display greater than the specified value?	4.6 V	Go to Step 7	Go to Step 4
4	1. Disconnect the fused jumper. 2. Measure the voltage between the 5 volt reference circuit of the EOP sensor and the low reference circuit of the EOP sensor. Does the voltage measure greater than the specified value?	4.6 V	Go to Step 6	Go to Step 5
5	Test the 5 volt reference circuit of the EOP sensor for an open or for high resistance. Did you find and correct the condition?		Verify Repair	Go to Step 8
6	Test the EOP sensor signal circuit for an open, for a short to ground, or for high resistance. Did you find and correct the condition?		Verify Repair	Go to Step 8

Step	Action	Value	Yes	No
7	Inspect for poor connections at the harness connector of the EOP sensor. Did you find and correct the condition?	—	Verify Repair	Go to Step 9
8	Inspect for poor connections at the harness connector of the ECM. Did you find and correct the condition?		Verify Repair	Go to Step 10
9	Replace the EOP sensor. Did you complete the replacement?		Verify Repair	
10	<b>Important:</b> Program the replacement ECM. Replace the ECM. Did you complete the replacement?		Verify Repair	

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## Engine Oil Pressure Sensor

**SPN 100 FMI 4 - Oil Pressure Voltage Low****Circuit Description**

The engine oil pressure (EOP) sensor changes resistance based on engine oil pressure. The ECM monitors the signal circuit of the EOP sensor. The EOP sensor has the following circuits:

- 5-volt reference circuit
- Low reference circuit
- EOP sensor signal circuit

The engine control module (ECM) supplies 5 volts to the EOP sensor on the 5-volt reference circuit. The ECM also provides a ground on the low reference circuit. The EOP sensor provides a signal to the ECM on the EOP sensor signal circuit which is relative to the pressure changes in the engine oil pressure. When the oil pressure is high, the sensor resistance is high, and the ECM senses a high voltage. When the oil pressure is low, the sensor voltage is low, and the ECM senses a low signal voltage. The ECM monitors the EOP sensor signal for voltage outside of the normal range. If the ECM detects an EOP sensor signal voltage that is excessively low, SPN 100 FMI 4 sets.

The ECM sends the engine oil pressure information to the instrument panel (Dash) via the CAN BUS J1939 data circuit.

**DTC Descriptor**

This diagnostic procedure supports the following DTC:  
SPN 100 FMI 4 Oil Pressure Voltage Low

**Conditions for Running the DTC**

- The engine is running.

**Conditions for Setting the DTC**

The ECM detects that the EOP sensor voltage is less than 0.48 volt for more than 9 seconds.



## Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the DTC at the time the diagnostic fails.

## Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after consecutive ignition cycle that the diagnostic runs and does not fail.
  - A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
  - A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

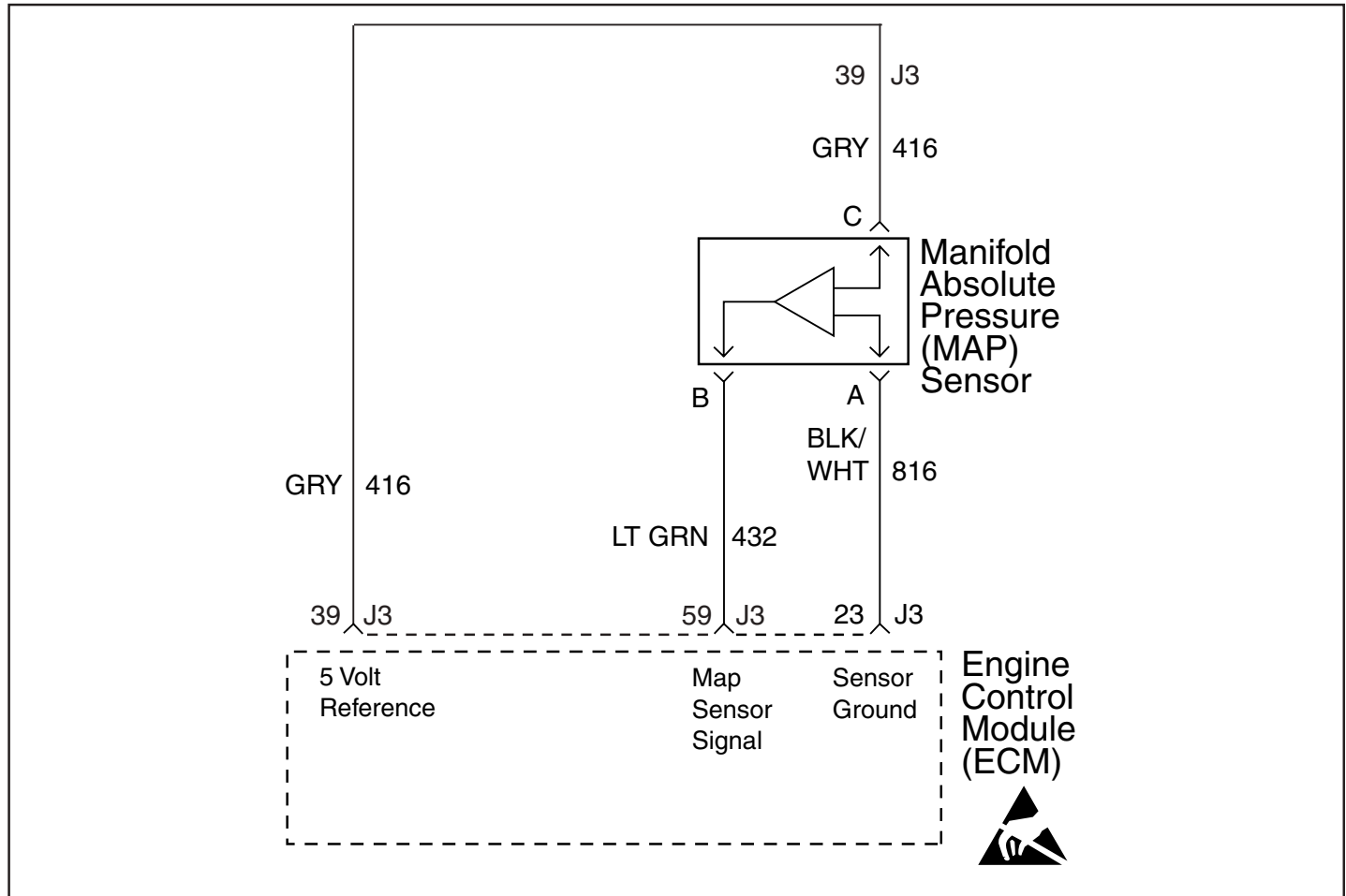
## Diagnostic Aids

Step	Action	Value	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> Pages 5-2 to 5-6` <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views</i> or <i>Engine Controls Connector End Views</i>				
1	Was the "On-Board Diagnostic" (OBD) system check performed?	—	Go to Step 2	Go to OBD System Check Page 2-12
2	1. Install a scan tool. 2. Turn ON the ignition, with the engine OFF. 3. With the scan tool, observe the Engine Oil Pressure Sensor parameter in the Scan Tool Data list. Does the Engine Oil Pressure Sensor parameter display greater than the specified value?	4.5 V	Go to Step 3 on Facing Page	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect the engine oil pressure (EOP) sensor. 3. With the scan tool, observe the Engine Oil Pressure Sensor parameter. Does the Engine Oil Pressure Sensor parameter display less than the specified value?	0.4 V	Go to Step 7	Go to Step 4
4	1. Turn OFF the ignition. 2. Disconnect the negative battery cable. 3. Measure the resistance from the low reference circuit of the EOP sensor to a good ground. Is the resistance less than the specified value?	5 ohms	Go to Step 6	Go to Step 5
5	Test the EOP sensor signal circuit for a short to voltage. Did you find and correct the condition?		Verify Repair	Go to Step 8
6	1. Disconnect the ECM. 2. Test the low reference circuit of the EOP sensor for an open or for a high resistance. Did you find and correct the condition?	-	Verify Repair	Go to Step 8

Step	Action	Value	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views</i> or <i>Engine Controls Connector End Views</i>				
7	Inspect for poor connections at the harness connector of the EOP sensor. Did you find and correct the condition?	-	Verify Repair	Go to Step 9
8	Inspect for poor connections at the harness connector of the ECM. Did you find and correct the condition?	-	Verify Repair	Go to Step 10
9	Replace the EOP sensor. Did you complete the replacement?		Verify Repair	
10	<b>Important:</b> Program the replacement ECM. Replace the ECM. Did you complete the replacement?		Verify Repair	

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## Manifold Absolute Pressure Sensor



## Diagnostic Information and Procedures

## SPN 106, FMI 3 MAP Sensor High

## Circuit Description

The manifold absolute pressure (MAP) sensor responds to pressure changes in the intake manifold (Vacuum). The pressure changes occur based on the engine load. The MAP sensor has the following circuits:

- 5-volt reference circuit
- Low reference circuit
- MAP sensor signal circuit

The engine control module (ECM) supplies 5 volts to the MAP sensor on the 5-volt reference circuit. The ECM also provides a ground on the low reference circuit. The MAP sensor provides a signal to the ECM on the MAP sensor signal circuit which is relative to the pressure changes in the manifold. The ECM should detect a low signal voltage about 1.0-1.5 volts at a low MAP, such as during an idle or a deceleration. The ECM should detect a high signal voltage about 4.0-4.5 volts at a high MAP, such as the ignition is ON, with the engine OFF, or at a wide open throttle (WOT). The MAP sensor is also used in order to determine the barometric pressure (BARO). This occurs when the ignition switch is turned ON, with the engine OFF. The BARO reading may also be updated whenever the engine is operated at WOT. The ECM monitors the MAP sensor signal for voltage outside of the normal range.

If the ECM detects a MAP sensor signal voltage that is excessively high, this DTC will set.

## DTC Descriptor

This diagnostic procedure supports the following DTC:

*SPN 106 FMI 3 MAP Sensor High*

## Conditions for Running the DTC

- The throttle angle is less than 20 percent when the engine speed is more than 600 RPM.
- The above conditions are present for 5 seconds.
- SPN 106 FMI 3 runs continuously when the above conditions are met.

## Conditions for Setting the DTC

The ECM detects that the MAP sensor voltage is more than 4.9 volts for more than 4 seconds.

## Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the DTC at the time the diagnostic fails.
- The ECM operates with a default MAP reading, which varies based on throttle angle.

## Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after consecutive ignition cycle that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

## Diagnostic Aids

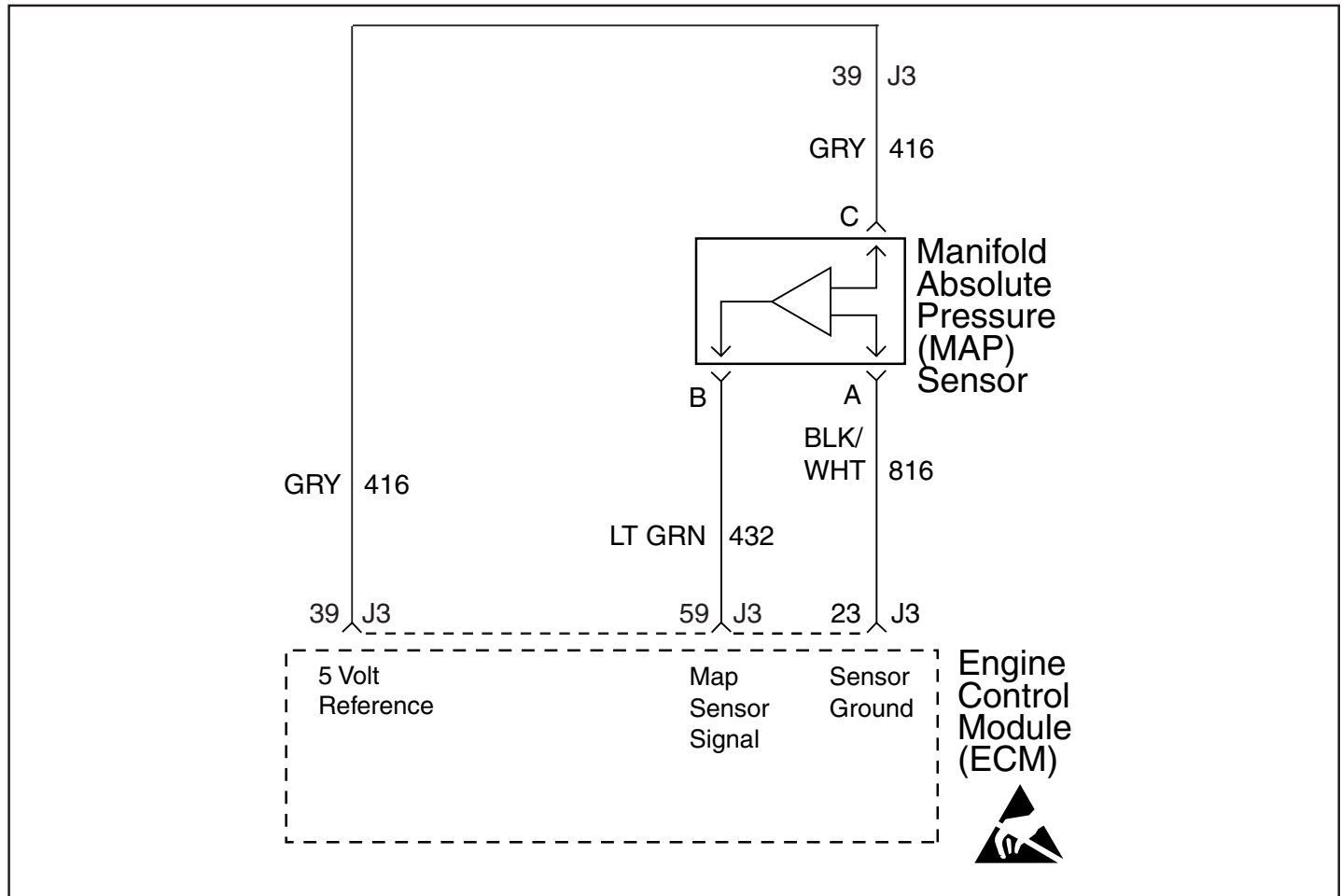
- Inspect for any vacuum leaks.
- This DTC may set as the result of a misfire.
- This DTC may set as the result of improper tension or alignment of the timing chain.
- If this DTC is determined to be intermittent, refer to *Testing for Intermittent Conditions and Poor Connections*.

Step	Action	Values	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views</i> or <i>Engine Controls Connector End Views</i>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to Diagnostic System Check
2	Attempt to start the engine. Does the engine start and run?	—	Go to Step 3	Go to Step 4
3	1. Install a vacuum gauge to a manifold vacuum source. 2. Start the engine and increase engine speed to about 1000 RPM in neutral. 3. Vacuum reading should be steady. Is the vacuum gauge reading steady and above the specified value	14" Hg (45.5 kPa)	Go to Step 6	Go to Step 5
4	1. Turn OFF the ignition. 2. Remove the MAP sensor from the intake manifold. Refer to <i>Manifold Absolute Pressure (MAP) Sensor Replacement</i> . Leave the electrical harness connected. 3. Connect a J 23738-A Mityvac to the MAP sensor. 4. Apply vacuum until 5 inch Hg is reached. 5. Observe the MAP Sensor parameter with the scan tool. Is the voltage more than the specified value?	4.9 V	Go to Step 6	Go to Diagnostic Aids
5	1. Start the engine and increase engine speed to about 1000 RPM in neutral. 2. Observe the manifold absolute pressure (MAP) sensor parameter with a scan tool. Is the voltage more than the specified value?	4 V	Go to Step 6	Go to Diagnostic Aids

6	<p>Inspect for the following conditions:</p> <ul style="list-style-type: none"> <li>• Disconnected, damaged, or incorrectly routed vacuum hoses</li> <li>• The MAP sensor disconnected from the vacuum source</li> <li>• Restrictions in the MAP sensor vacuum source</li> <li>• Intake manifold vacuum leaks</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 17	Go to Step 7
7	<ol style="list-style-type: none"> <li>1. Turn OFF the ignition.</li> <li>2. Turn ON the ignition, with the engine OFF.</li> <li>3. Monitor the Diagnostic Trouble Code (DTC) Information with the scan tool.</li> </ol> <p>Are there any other sensor high or out of range codes also set?</p>	—	Go to Step 9	Go to Step 8
8	<ol style="list-style-type: none"> <li>1. Disconnect the MAP sensor electrical connector.</li> <li>2. Observe the MAP sensor parameter with the scan tool.</li> </ol> <p>Is the voltage less than the specified value?</p>	0.1 V	Go to Step 10	Go to Step 11
9	<ol style="list-style-type: none"> <li>1. Disconnect the MAP sensor electrical connector.</li> <li>2. Observe the MAP sensor parameter with the scan tool.</li> </ol> <p>Is the voltage less than the specified value?</p>	0.1 V	Go to Step 10 <i>Focus on low ref. which DTC is effecting the circuit</i>	Go to Step 11
10	<ol style="list-style-type: none"> <li>1. Unless already done, remove the MAP sensor from the intake manifold. Refer to <i>Manifold Absolute Pressure (MAP) Sensor Replacement</i>.</li> <li>2. Connect a jumper wire between each of the terminals in the MAP sensor harness connector and the corresponding terminal at the MAP sensor. Refer to <i>Using Connector Test Adapters</i>.</li> <li>3. Measure the voltage from the low reference circuit of the MAP sensor at the jumper wire terminal to a good ground with the DMM. Refer to <i>Measuring Voltage Drop</i>.</li> </ol> <p>Is the voltage more than the specified value?</p>	0.2 V	Go to Step 12	Go to Step 13
11	<p>Test the MAP sensor signal circuit between the engine control module (ECM) and the MAP sensor for a short to voltage. Refer to <i>Circuit Testing and Wiring Repairs</i>.</p> <p>Did you find and correct the condition?</p>	—	Go to Step 17	Go to Step 16
12	<p>Test the low reference circuit between the ECM and the MAP sensor for high resistance or for an open. Refer to <i>Circuit Testing and Wiring Repairs</i>.</p> <p>Did you find and correct the condition?</p>	—	Go to Step 17	Go to Step 14
13	<p>Inspect for an intermittent and for a poor connection at the MAP sensor. Refer to <i>Testing for Intermittent Conditions and Poor Connections and Connector Repairs</i>.</p> <p>Did you find and correct the condition?</p>	—	Go to Step 17	Go to Step 15
14	<p>Inspect for an intermittent and for a poor connection at the ECM. Refer to <i>Testing for Intermittent Conditions and Poor Connections and Connector Repairs</i>.</p> <p>Did you find and correct the condition?</p>	—	Go to Step 17	Go to Step 16
15	<p>Replace the MAP sensor. Refer to <i>Manifold Absolute Pressure (MAP) Sensor Replacement</i>.</p> <p>Did you complete the replacement?</p>	—	Go to Step 17	—
16	<p>Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming.</p> <p>Did you complete the replacement?</p>	—	Go to Step 17	—
17	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> <li>4. Operate the vehicle within the Conditions for Running the DTC.</li> </ol> <p>Did the DTC fail this ignition?</p>	—	Go to Step 2	Go to Step 18
18	<p>Observe the Capture Info with a scan tool.</p> <p>Are there any DTCs that have not been diagnosed?</p>	—	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK

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## Manifold Absolute Pressure Sensor



## Diagnostic Information and Procedures

## SPN 106, FMI 4 MAP Sensor Low

## Circuit Description

The manifold absolute pressure (MAP) sensor responds to pressure changes in the intake manifold (Vacuum). The pressure changes occur based on the engine load. The MAP sensor has the following circuits:

- 5-volt reference circuit
- Low reference circuit
- MAP sensor signal circuit

The engine control module (ECM) supplies 5 volts to the MAP sensor on the 5-volt reference circuit. The ECM also provides a ground on the low reference circuit. The MAP sensor provides a signal to the ECM on the MAP sensor signal circuit which is relative to the pressure changes in the manifold. The ECM should detect a low signal voltage about 1.0-1.5 volts at a low MAP, such as during an idle or a deceleration. The ECM should detect a high signal voltage about 4.0-4.5 volts at a high MAP, such as the ignition is ON, with the engine OFF, or at a wide open throttle (WOT). The MAP sensor is also used in order to determine the barometric pressure (BARO). This occurs when the ignition switch is turned ON, with the engine OFF. The BARO reading may also be updated whenever the engine is operated at WOT. The ECM monitors the MAP sensor signal for voltage outside of the normal range.

If the ECM detects a MAP sensor signal voltage that is excessively low, this DTC will set.

## DTC Descriptor

This diagnostic procedure supports the following DTC:

*SPN 106 FMI 4 MAP Sensor Low*



### Conditions for Running the DTC

- The engine is running.
- When the engine speed is less than 300 RPM.

OR

- The throttle angle is more than 50 percent
- The above conditions are present for 0.5 seconds.
- SPN 106 FMI 4 runs continuously when the above conditions are met.

### Conditions for Setting the DTC

The ECM detects that the MAP sensor voltage is less than 0.06 volt for more than 4 seconds.

### Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the DTC at the time the diagnostic fails.
- The ECM operates with a default MAP reading, which varies based on throttle angle.

### Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after consecutive ignition cycle that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

### Diagnostic Aids

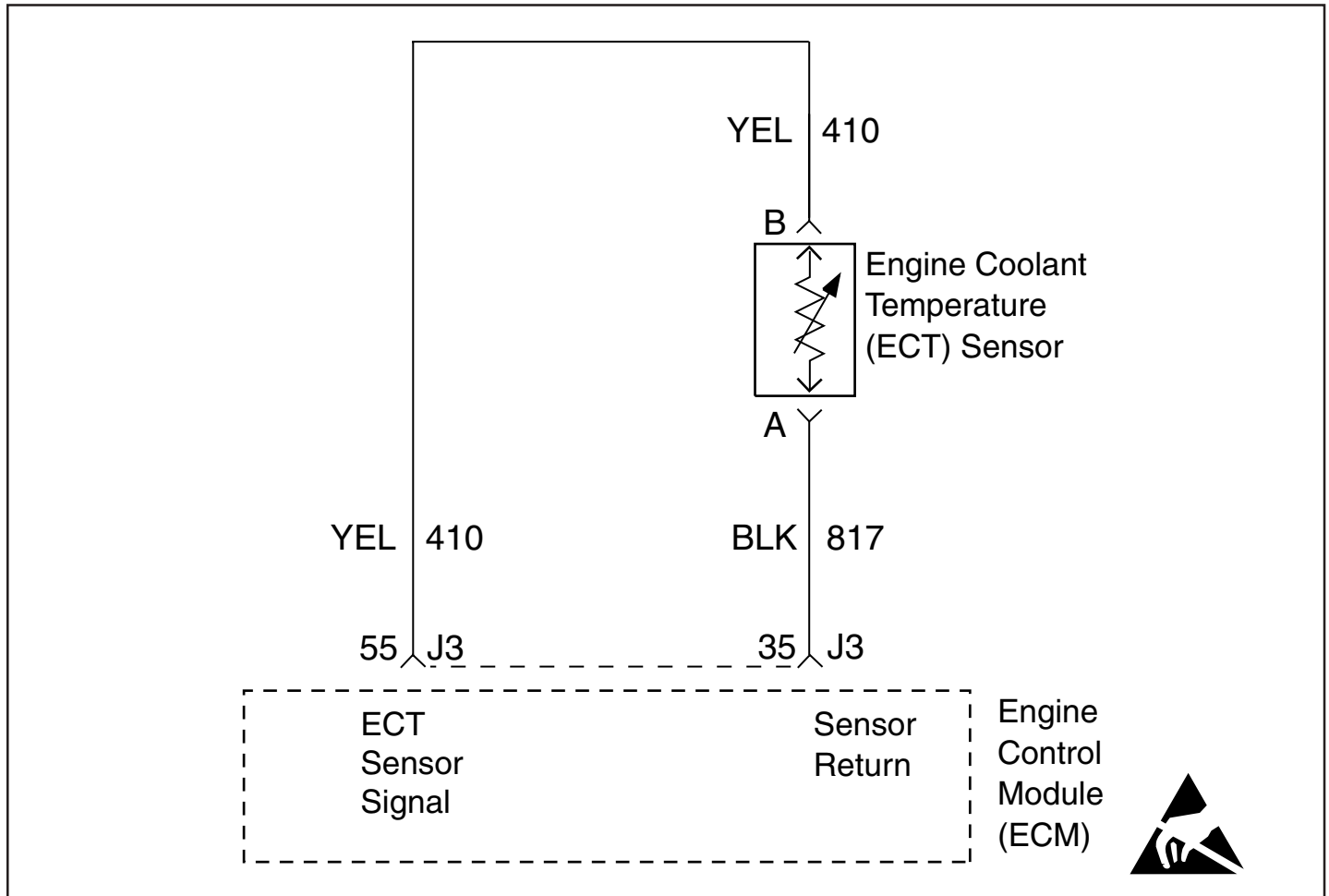
- If this DTC is determined to be intermittent, refer to *Testing for Intermittent Conditions and Poor Connections*.

Step	Action	Values	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views</i> or <i>Engine Controls Connector End Views</i>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to <i>Diagnostic System Check</i>
2	1. Turn ON the ignition, with the engine OFF. 2. Monitor the Diagnostic Trouble Code (DTC) Information with the scan tool. Are there any other sensor low or out of range codes also set?	—	Go to Step 3 or <i>Focus on 5 volt ref. which DTC is effecting 5 v circuit.</i>	Go to Step 3
3	Observe the manifold absolute pressure (MAP) sensor parameter with the scan tool. Is the voltage less than the specified value?	0.1 V	Go to Step 5	Go to Step 4
4	1. Install a vacuum gauge to a manifold vacuum source. 2. Start the engine and increase engine speed to about 1000 RPM in neutral. 3. Vacuum reading should be steady. Is the vacuum gauge reading steady and above the specified value?	14" Hg (45.5 kPa)	Go to Step 5	<i>Repair low or unsteady vacuum problem</i>

5	<ol style="list-style-type: none"> <li>1. Turn OFF the ignition.</li> <li>2. Disconnect the MAP sensor electrical connector.</li> <li>3. Turn ON the ignition, with the engine OFF.</li> </ol> <p><b>Important:</b> Certain resistances will not be detectable if a test lamp is not connected to provide a circuit load.</p> <ol style="list-style-type: none"> <li>4. Connect a test lamp between the MAP sensor 5-volt reference circuit and a good ground.</li> <li>5. Measure the voltage from the 5-volt reference circuit of the MAP sensor to a good ground, with a DMM, at the MAP sensor connector. Refer to <i>Circuit Testing</i>.</li> </ol> <p>Is the voltage more than the specified value?</p>	4.8 V	Go to Step 6	Go to Step 7
6	<ol style="list-style-type: none"> <li>1. Connect a 3-amp fused jumper wire between the 5-volt reference circuit of the MAP sensor and the signal circuit of the MAP sensor.</li> <li>2. Observe the MAP sensor parameter with the scan tool.</li> </ol> <p>Is the voltage more than the specified value?</p>	4.9 V	Go to Step 9	Go to Step 8
7	<p>Test the 5-volt reference circuit between the engine control module (ECM) and the MAP sensor for an open or high resistance. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i>.</p> <p>Did you find and correct the condition?</p>	—	Go to Step 13	Go to Step 10
8	<p>Test the MAP sensor signal circuit between the ECM and the MAP sensor for a short to ground or an open. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i>.</p> <p>Did you find and correct the condition?</p>	—	Go to Step 13	Go to Step 10
9	<p>Test for an intermittent and for a poor connection at the MAP sensor. Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Connector Repairs</i>.</p> <p>Did you find and correct the condition?</p>	—	Go to Step 13	Go to Step 11
10	<p>Test for an intermittent and for a poor connection at the ECM. Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Connector Repairs</i>.</p> <p>Did you find and correct the condition?</p>	—	Go to Step 13	Go to Step 12
11	<p>Replace the MAP sensor. Refer to <i>Manifold Absolute Pressure (MAP) Sensor Replacement</i>.</p> <p>Did you complete the replacement?</p>	—	Go to Step 13	—
12	<p>Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming.</p> <p>Did you complete the replacement?</p>	—	Go to Step 13	—
13	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> <li>4. Operate the vehicle within the Conditions for Running the DTC.</li> </ol> <p>Did the DTC fail this ignition?</p>	—	Go to Step 2	Go to Step 14
14	<p>Observe the Capture Info with a scan tool.</p> <p>Are there any DTCs that have not been diagnosed?</p>	—	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK

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## Engine Coolant Temperature Sensor



## Diagnostic Information and Procedures

**SPN 110, FMI 3 Coolant Sensor High (ECT Sensor Circuit High Voltage / Low Temperature) Circuit Description**

The engine coolant temperature (ECT) sensor is a variable resistor that measures the temperature of the engine coolant. The ECT sensor has a signal circuit and a low reference circuit. The engine control module (ECM) supplies 5 volts to the ECT signal circuit and a ground for the ECT low reference circuit. When the ECT is cold, the sensor resistance is high. When the ECT increases, the sensor resistance decreases. With high sensor resistance, the ECM detects a high voltage on the ECT signal circuit. With lower sensor resistance, the ECM detects a lower voltage on the ECT signal circuit. If the ECM detects an excessively high ECT signal voltage, which is a low temperature indication, SPN 110, FMI 3 sets.

**DTC Descriptor**

This diagnostic procedure supports the following DTC:  
SPN 110, FMI 3 Coolant Sensor High

**Conditions for Running the DTC**

- The engine has been running for more than 10 seconds.
- SPN 110, FMI 3 runs continuously when the above condition is met.

**Conditions for Setting the DTC**

The ECM detects that the ECT sensor parameter is less than  $-31^{\circ}\text{C}$  ( $-24^{\circ}\text{F}$ ) for approximately 3 seconds. Note: Exact temperature and duration may vary depending on ECM calibration.

## Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.

## Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) when the diagnostic runs and does not fail. After the diagnostic runs and passes, there may be a timed delay before the malfunction indicator lamp (MIL) turns OFF.
- An active DTC clears when the diagnostic runs and passes.
- A history DTC clears after 20 to 50 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic. Each warm-up cycle must last a minimum of 10 seconds.
- Clear the MIL and the DTC with a scan tool.

## Diagnostic Aids

- If a short to a separate 5-volt source occurs, this DTC may set.
- After starting the engine, the ECT should rise steadily, then stabilize near the thermostat opening temperature.
- Use the Temperature vs. Resistance table to test the ECT sensor. A skewed sensor could result in poor driveability conditions. Refer to *Temperature vs Resistance* .

Step	Action	Values	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views</i> or <i>Engine Controls Connector End Views</i>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to Diagnostic System Check
2	Observe the ECT sensor parameter with a scan tool. Is the ECT sensor parameter less than the specified value? (Sensor resistance greater than the specified value?) If the indicated temperature is set at a default value, use the sensor resistance value for this step.	-31°C (-24°F)  57,300 Ohms	Go to Step 4	Go to Step 3
3	1. Observe the Conditions for Running this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the engine within the Conditions for Running the DTC. Did the DTC fail this ignition?	—	Go to Step 4	Go to Diagnostic Aids
4	1. Disconnect the ECT sensor. 2. Measure the voltage from the signal circuit of the ECT sensor to a good ground with a DMM. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Is the voltage more than the specified value?	5.2 V	Go to Step 5	Go to Step 6
5	<b>Important:</b> If a short to voltage occurs, the ECT sensor may be damaged. Test the ECT signal circuit for a short to voltage. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 15	Go to Step 12
6	1. Connect a 3-amp fused jumper between the signal circuit of the ECT sensor and the low reference circuit. Refer to <i>Using Fused Jumper Wires</i> . 2. Observe the ECT sensor parameter with the scan tool. Is the ECT sensor parameter more than the specified value? (Sensor resistance less than the specified value?) If the indicated temperature is set at a default value, use the sensor resistance value for this step.	150°C (302°F)  47 Ohms	Go to Step 10	Go to Step 7
7	1. Connect a 3-amp fused jumper between the signal circuit of the ECT sensor and a good ground. 2. Observe the ECT sensor parameter with a scan tool. Is the ECT sensor parameter more than the specified value? (Sensor resistance less than the specified value?) If the indicated temperature is set at a default value, use the sensor resistance value for this step.	150°C (302°F)  47 Ohms	Go to Step 9	Go to Step 8

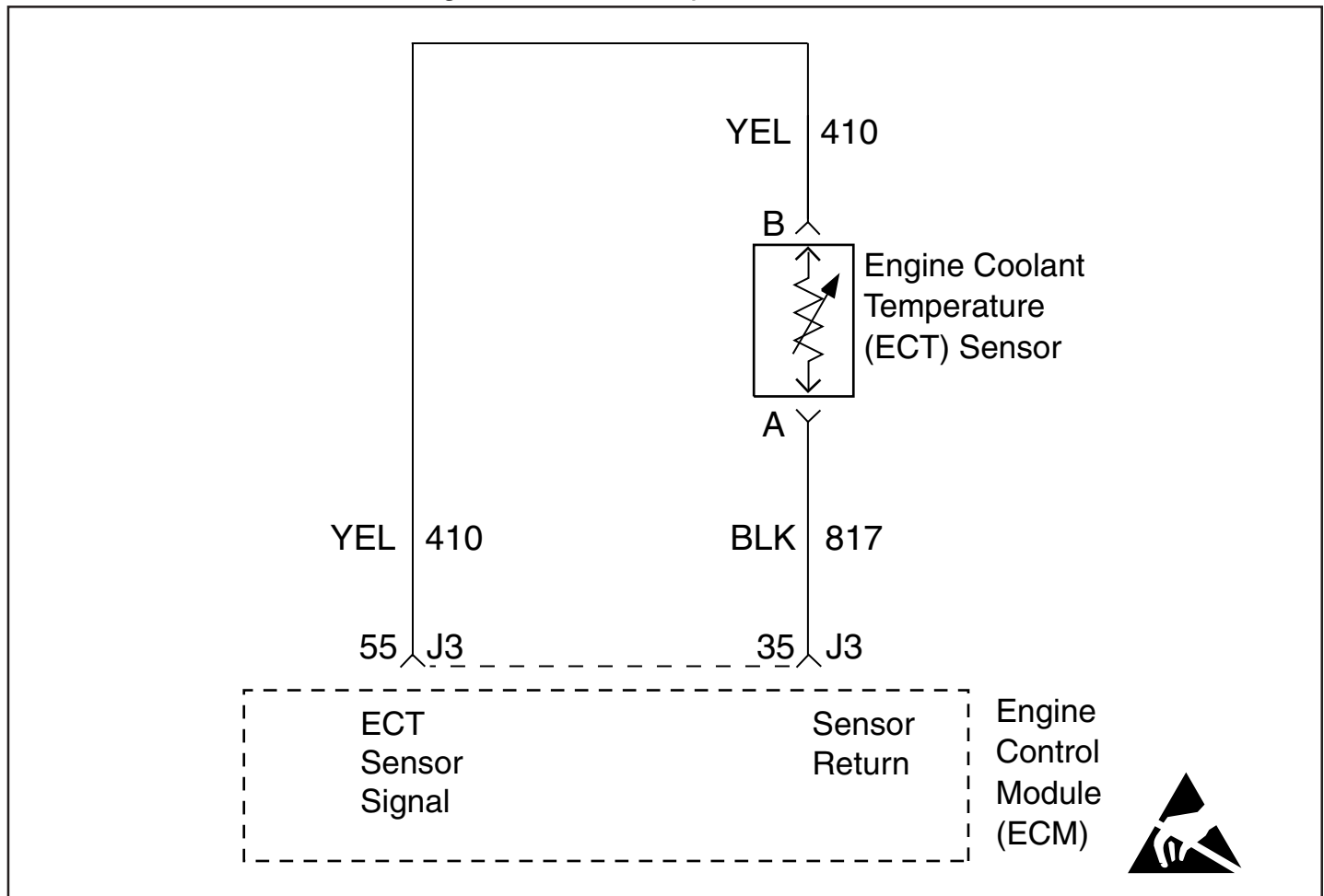
8	Test the signal circuit of the ECT sensor for a high resistance or an open. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 15	Go to Step 12
9	Test the low reference circuit of the ECT sensor for a high resistance or an open. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 15	Go to Step 12

### Temperature vs Resistance Reference Chart

C	F	OHMS
Temperature vs Resistance Values (Approximate)		
150	302	47
140	284	60
130	266	77
120	248	100
110	230	132
100	212	177
90	194	241
80	176	332
70	158	467
60	140	667
50	122	973
45	113	1188
40	104	1459
35	95	1802
30	86	2238
25	77	2796
20	68	3520
15	59	4450
10	50	5670
5	41	7280
0	32	9420
-5	23	12300
-10	14	16180
-15	5	21450
-20	-4	28680
-30	-22	52700
-40	-40	100700

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## Engine Coolant Temperature Sensor



## Diagnostic Information and Procedures

**SPN 110, FMI 4 Coolant Sensor Low (ECT Sensor Circuit Low Voltage / High Temperature) Circuit Description**

The engine coolant temperature (ECT) sensor is a variable resistor that measures the temperature of the engine coolant. The engine control module (ECM) supplies 5 volts to the ECT signal circuit and a ground for the ECT low reference circuit. When the ECT is cold, the sensor resistance is high. When the ECT increases, the sensor resistance decreases. With high sensor resistance, the ECM detects a high voltage on the ECT signal circuit. With lower sensor resistance, the ECM detects a lower voltage on the ECT signal circuit. If the ECM detects an excessively low ECT signal voltage, which is a high temperature indication, SPN 110, FMI 4 sets.

**DTC Descriptor**

This diagnostic procedure supports the following DTC:  
SPN 110, FMI 4 Coolant Sensor Low

**Conditions for Running the DTC**

- The engine run time is more than 10 seconds.
- SPN 110, FMI 4 runs continuously when the above condition is met.

**Conditions for Setting the DTC**

The ECT sensor temperature is more than 150°C (302°F) for more than approximately 3 seconds. Note: Exact temperature and duration may vary depending on ECM calibration.

**Action Taken When the DTC Sets**

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.



## Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) when the diagnostic runs and does not fail. After the diagnostic runs and passes, there may be a timed delay before the malfunction indicator lamp (MIL) turns OFF.
- An active DTC clears when the diagnostic runs and passes.
- A history DTC clears after 20 to 50 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic. Each warm-up cycle must last a minimum of 10 seconds.
- Clear the MIL and the DTC with a scan tool.

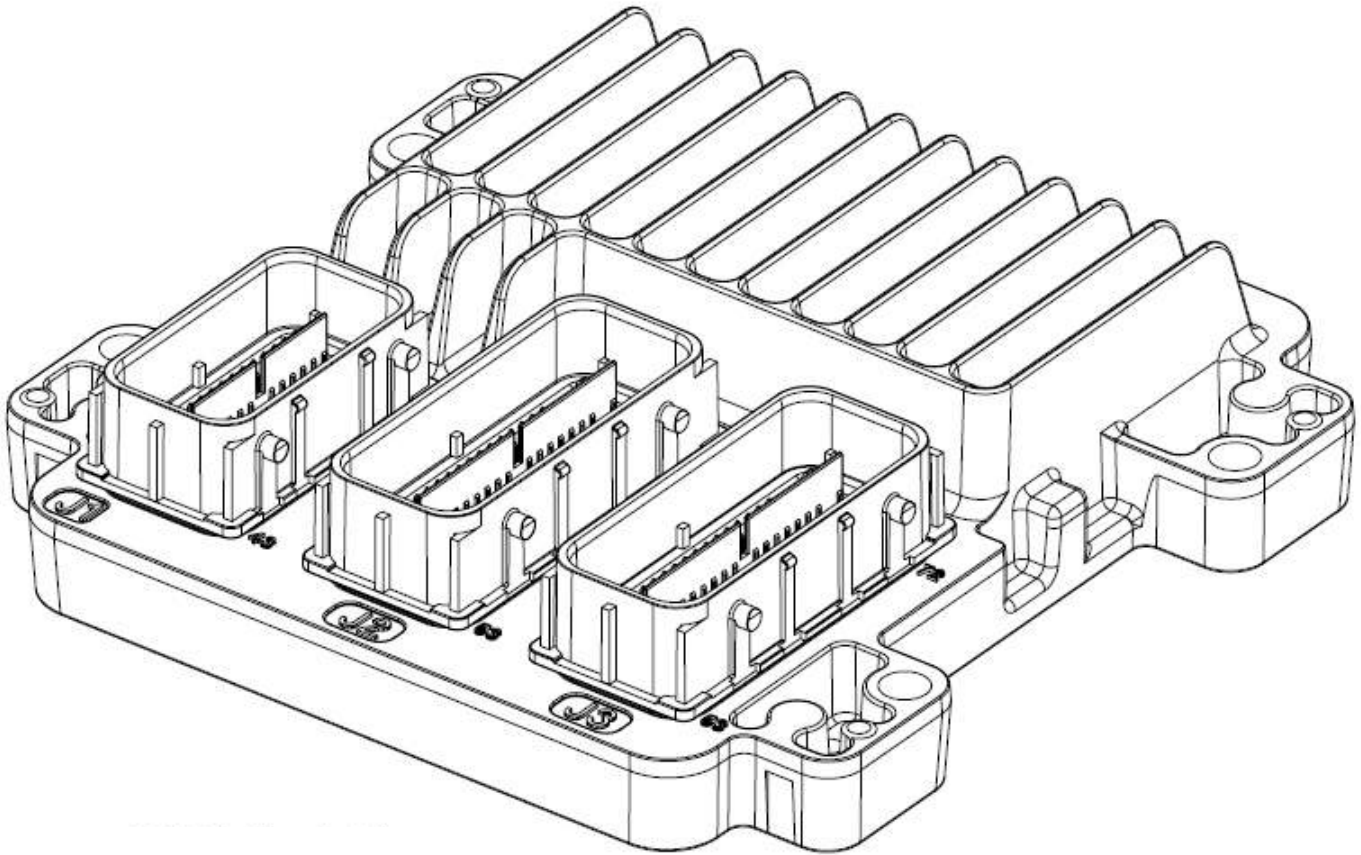
## Diagnostic Aids

- An overheating condition may cause this DTC to set.
- After starting the engine, the ECT should rise steadily, then stabilize near the thermostat opening temperature.
- Use the Temperature vs. Resistance table to test the ECT sensor at various temperature levels to evaluate the possibility of a skewed sensor. A skewed sensor could result in poor driveability concerns. Refer to *Temperature vs Resistance (Page 5-96)*.
- If the condition is suspected of being intermittent, refer to *Testing for Intermittent Conditions and Poor Connections (Page 7-3&7-4)*.

Step	Action	Values	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views or Engine Controls Connector End Views</i>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to Diagnostic System Check
2	Observe the ECT sensor parameter with a scan tool. Is the ECT sensor parameter more than the specified value? (Sensor resistance less than the specified value?) If the indicated temperature is set at a default value, use the sensor resistance value for this step.	150°C (302°F)  47 Ohms	Go to Step 4	Go to Step 3
3	1. Observe the Conditions for Running this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the engine within the Conditions for Running the DTC. Did the DTC fail this ignition?	—	Go to Step 4	Go to Diagnostic Aids
4	1. Disconnect the ECT sensor. 2. Observe the ECT sensor parameter with a scan tool. Is the ECT sensor parameter less than the specified value? (Sensor resistance greater than the specified value?) If the indicated temperature is set at a default value, use the sensor resistance value for this step.	-31°C (-24°F)  57,300 Ohms	Go to Step 6	Go to Step 5
5	Test the signal circuit of the ECT sensor for a short to ground or a short to the ECT low reference circuit. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 10	Go to Step 8
6	Test for an intermittent and for a poor connection at the ECT sensor. Refer to <i>Testing for Intermittent Conditions and Poor Connections and Connector Repairs</i> . Did you find and correct the condition?	—	Go to Step 10	Go to Step 7
7	Replace the ECT sensor. Refer to <i>Engine Coolant Temperature (ECT) Sensor Replacement</i> . Did you complete the replacement?	—	Go to Step 10	—
8	Test for an intermittent and for a poor connection at the ECM. Refer to <i>Testing for Intermittent Conditions and Poor Connections and Connector Repairs</i> . Did you find and complete the replacement?	—	Go to Step 10	Go to Step 9

9	Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?	—	Go to Step 10	—
10	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> <li>4. Operate the engine within the Conditions for Running the DTC.</li> </ol> Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 11
11	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	—	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK

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## Diagnostic Information and Procedures

### SPN 630, FMI 13 Cal Memory Failure

#### Description

This Test allows the ECM to check for a calibration failure by comparing the calibration value to a known value stored in the EEPROM. This test is also used as a security measure to prevent improper use of the calibration or changes to these calibrations that may alter the designed function of MEFI. This diagnostic also addresses whether or not the ECM is programmed.

#### DTC Descriptors

This diagnostic procedure supports the following DTC:

*SPN 630 FMI 13 Cal Memory Failure*

#### Conditions for Running the DTC

- The ignition switch is in the Run or the Crank position.
- The ignition voltage is more than 5 volts.
- SPN 630 FMI 13 runs continuously when the above condition is met.

#### Conditions for Setting the DTC

The ECM detects an internal failure or incomplete programming for more than 14 seconds.

#### Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails.

## Conditions for Clearing the MIL/DTC

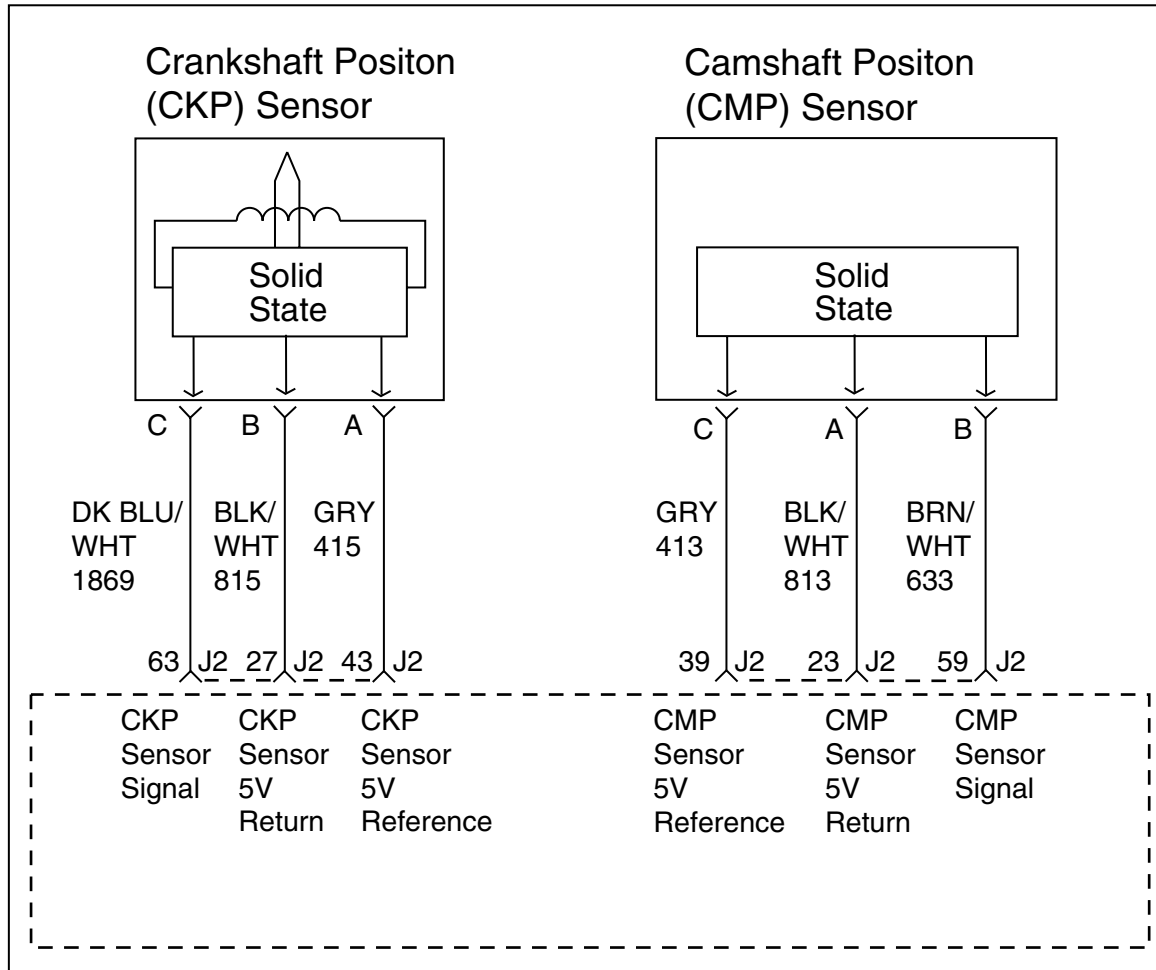
- A current DTC Last Test Failed clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Clear the DTC with a scan tool.

## Test Description

The number below refers to the step number on the diagnostic table.

- This step check indicates the ECM needs to be programmed or replaced.

Step	Action	Yes	No
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	Go to Step 2	Go to <i>Diagnostic System Check</i>
2	Is SPN 630 FMI 13 set?	Go to Step 3	Go to Step 5
3	Program the engine control module (ECM). Refer to <i>Service Programming System (SPS)</i> . Does SPN 630 reset?	Go to Step 4	Go to Step 7
4	1. Ensure that all tool connections are secure. 2. Ensure that the programming equipment is operating correctly. 3. Ensure that the correct software/calibration package is used. 4. Attempt to program the ECM. Refer to <i>Service Programming System (SPS)</i> . Does SPN 630 reset?	Go to Step 5	Go to Step 7
5	Test all voltage and ground inputs to the ECM for an open circuit or high resistance. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	Go to Step 7	Go to Step 6
6	Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?	Go to Step 7	—
7	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. Did the DTC fail this ignition?	Go to Step 2	Go to Step 8
8	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK



## Diagnostic Information and Procedures

### SPN 636, FMI 2 Crank Signal Fault

#### Circuit Description

The crankshaft position (CKP) sensor works in conjunction with the 4X reluctor trigger wheel on the crankshaft. Each tooth on the reluctor wheel is equally spaced at 4 tooth spacing, for the reference sync pulse. The engine control module (ECM) provides a 5-volt reference to the sensor, as well as a low reference, and a signal circuit. As the crankshaft rotates, the reluctor trigger wheel interrupts a magnetic field produced by a magnet internal to the sensor. The CKP sensor internal circuitry detects this interruption of the magnetic field, and produces an ON/OFF DC voltage of varying frequency. The frequency of the CKP sensor output signal is dependent upon crankshaft speed. The ECM uses each CKP output signal to determine crankshaft speed, identify crankshaft position, and to detect engine misfire. If the ECM detects that there is no output signal from the CKP sensor, then SPN 636, FMI 2 will set.

#### DTC Descriptor

This diagnostic procedure supports the following DTC:

SPN 636, FMI 2 Crank Signal Fault (Crankshaft Position (CKP) Sensor Circuit Signal Fault)

#### Conditions for Running the DTC

- The engine is cranking or running.
- SPN 636 FMI 2 runs continuously when the above condition is met.

#### Conditions for Setting the DTC

The ECM detects that there is no signal from the CKP sensor for 3 seconds.

## Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails.

## Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after consecutive ignition cycle that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 20 to 50 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic. Each warm-up cycle must last a minimum of 10 seconds.
- Clear the MIL and the DTC with a scan tool.

## Diagnostic Aids

SPN 636, FMI 2 will set with the ignition switch in the Start position, if the starter motor is inoperative, or the starter motor control circuit is inoperative.

## Test Description

The numbers below refer to the step numbers on the diagnostic table.

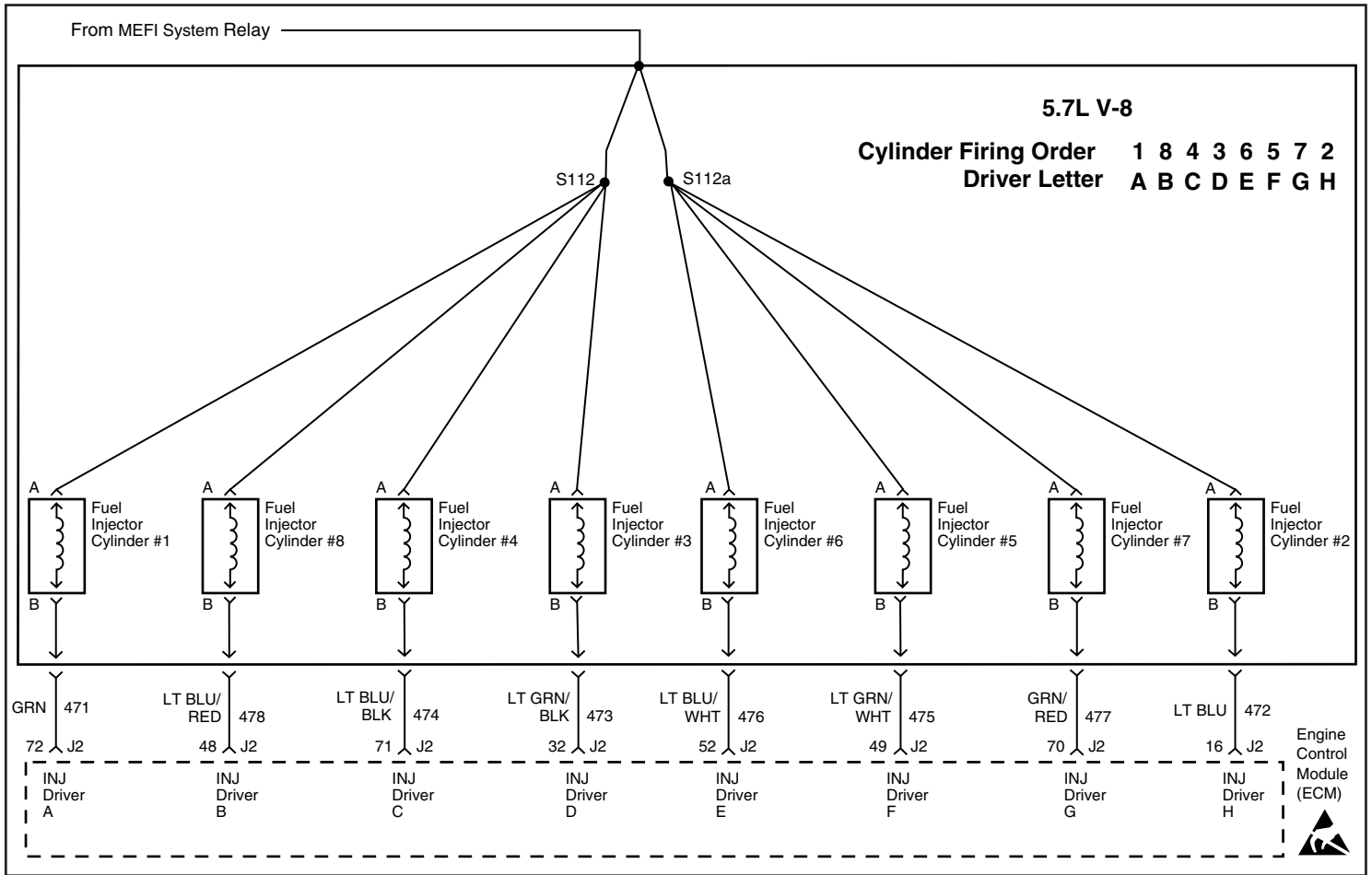
- This step determines if the fault is present.
- This step simulates a CKP sensor signal to the ECM. If the ECM receives the signal, the fuel pump will operate for about 3 seconds.

Step	Action	Values	Yes	No
<b>Schematic Reference: Engine Controls Schematics</b> <b>Connector End View Reference: Engine Control Module (ECM) Connector End Views or Engine Controls Connector End Views</b>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to Diagnostic System Check
2	Attempt to start the engine. Does the engine start and continue to run?	—	Go to Step 3	Go to Step 4
3	1. Observe Conditions for Running this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the engine within the conditions for Running the DTC. Did the DTC fail this ignition?	—	Go to Step 4	Go to Testing for Intermittent Conditions and Poor Connections
4	1. Disconnect the crankshaft position (CKP) sensor connector. 2. Turn ON the ignition, with the engine OFF. 3. Measure the voltage from the 5-volt reference circuit of the crankshaft position (CKP) sensor to a good ground with a DMM. Refer to <i>Troubleshooting with a Digital Multi-meter</i> Does the voltage measure above the specified value?	4.8 V	Go to Step 5	Go to Step 7
5	Measure the voltage between the 5-volt reference circuit of the CKP sensor and the low reference circuit of the CKP sensor with a DMM. Does the voltage measure above the specified value?	4.8 V	Go to Step 6	Go to Step 8
6	Momentarily connect a test lamp between the CKP sensor signal circuit and the 5-volt reference of the CKP sensor. Does the fuel pump operate when the test lamp is applied to the CKP sensor signal circuit?	—	Go to Step 10	Go to Step 9
7	Test the 5-volt reference circuit for the following conditions: <ul style="list-style-type: none"> <li>• An open</li> <li>• A short to ground</li> <li>• High resistance</li> </ul> Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct condition?	—	Go to Step 16	Go to Step 12

8	<p>Test the low reference circuit for the following conditions:</p> <ul style="list-style-type: none"> <li>• An open</li> <li>• A short to voltage</li> <li>• High resistance</li> </ul> <p>Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i>. Did you find and correct the condition?</p>	—	Go to Step 16	Go to Step 12
9	<p>Test the CKP sensor signal circuit for the following conditions:</p> <ul style="list-style-type: none"> <li>• An open</li> <li>• A short to ground</li> <li>• A short to voltage</li> <li>• High resistance</li> </ul> <p>Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i>. Did you find and correct the condition?</p>	—	Go to Step 16	Go to Step 12
10	<p>1. Remove the CKP sensor. Refer to <i>Crankshaft Position (CKP) Sensor Replacement</i>.</p> <p>2. Visually inspect the CKP sensor for the following conditions:</p> <ul style="list-style-type: none"> <li>• Physical damage</li> <li>• Loose or improper installation</li> <li>• Wiring routed too closely to the secondary ignition components</li> </ul> <p>3. The following conditions may cause this DTC to set:</p> <ul style="list-style-type: none"> <li>• Excessive air gap between the CKP sensor and the reluctor wheel</li> <li>• The CKP sensor coming in contact with the reluctor wheel</li> <li>• Foreign material passing between the CKP sensor and the reluctor wheel</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 16	Go to Step 11
11	<p>Visually inspect the CKP sensor reluctor wheel for the following conditions:</p> <ul style="list-style-type: none"> <li>• Loose or improper installation</li> <li>• Physical damage</li> <li>• Excessive end play or looseness</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 16	Go to Step 14
12	<p>Test for poor connections at the CKP sensor. Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Wiring Repairs</i>. Did you find and correct the condition?</p>	—	Go to Step 16	Go to Step 13
13	<p>Test for poor connections at the engine control module (ECM). Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Wiring Repairs</i>. Did you find and correct the condition?</p>	—	Go to Step 16	Go to Step 15
14	<p>Replace the CKP sensor. Refer to <i>Crankshaft Position (CKP) Sensor Replacement</i>. Did you complete the replacement?</p>	—	Go to Step 16	—
15	<p>Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?</p>	—	Go to Step 16	—
16	<p>1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the engine within the Conditions for Running the DTC. Did the DTC fail this ignition?</p>	—	Go to Step 2	Go to Step 17
17	<p>Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?</p>	—	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK



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## Diagnostic Information and Procedures

### SPN 651-658 Fuel Injector DTCs (See DTC Descriptors below, for individual codes)

#### Circuit Description

The control module enables the appropriate fuel injector on the intake stroke for each cylinder. Ignition voltage is supplied to the fuel injectors. The control module controls each fuel injector by grounding the control circuit via a solid state device called a driver. The control module monitors the status of each driver. If the control module detects an incorrect voltage for the commanded state of the driver, a fuel injector control DTC sets.

#### DTC Descriptors

This diagnostic procedure supports the following DTCs:

- SPN 651 FMI 3 Inj 1 Short High (Injector A Circuit High Voltage)
- SPN 651 FMI 4 Inj 1 Short Low (Injector A Circuit Low Voltage)
- SPN 651 FMI 5 Inj 1 Open (Injector A Circuit Open)
- SPN 652 FMI 3 Inj 2 Short High (Injector B Circuit High Voltage)
- SPN 652 FMI 4 Inj 2 Short Low (Injector B Circuit Low Voltage)
- SPN 652 FMI 5 Inj 2 Open (Injector B Circuit Open)
- SPN 653 FMI 3 Inj 3 Short High (Injector C Circuit High Voltage)
- SPN 653 FMI 4 Inj 3 Short Low (Injector C Circuit Low Voltage)
- SPN 653 FMI 5 Inj 3 Open (Injector C Circuit Open)

- SPN 654 FMI 3 Inj 4 Short High (Injector D Circuit High Voltage)
- SPN 654 FMI 4 Inj 4 Short Low (Injector D Circuit Low Voltage)
- SPN 654 FMI 5 Inj 4 Open (Injector D Circuit Open)
  
- SPN 655 FMI 3 Inj 5 Short High (Injector E Circuit High Voltage)
- SPN 655 FMI 4 Inj 5 Short Low (Injector E Circuit Low Voltage)
- SPN 655 FMI 5 Inj 5 Open (Injector E Circuit Open)
  
- SPN 656 FMI 3 Inj 6 Short High (Injector F Circuit High Voltage)
- SPN 656 FMI 4 Inj 6 Short Low (Injector F Circuit Low Voltage)
- SPN 656 FMI 5 Inj 6 Open (Injector F Circuit Open)
  
- SPN 657 FMI 3 Inj 7 Short High (Injector G Circuit High Voltage)
- SPN 657 FMI 4 Inj 7 Short Low (Injector G Circuit Low Voltage)
- SPN 657 FMI 5 Inj 7 Open (Injector G Circuit Open)
  
- SPN 658 FMI 3 Inj 8 Short High (Injector H Circuit High Voltage)
- SPN 658 FMI 4 Inj 8 Short Low (Injector H Circuit Low Voltage)
- SPN 658 FMI 5 Inj 8 Open (Injector H Circuit Open)

**Note:** Injector circuits are named according to the **firing order sequence**.

In this application, injectors A-B-C-D-E-F-G-H correspond to the firing order of 1-8-4-3-6-5-7-2.

Thus, Injector C supplies fuel to cylinder number 4.

### Conditions for Running the DTC

- The engine is running (for FMI 3 condition)
- The key is on (for FMI 4 and FMI 5 conditions)
- The ignition voltage is between 6–18 volts.

### Conditions for Setting the DTC

- The engine control module (ECM) detects an incorrect voltage on a fuel injector control circuit.

### Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.

### Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) when the diagnostic runs and does not fail. After the diagnostic runs and passes, there may be a timed delay before the malfunction indicator lamp (MIL) turns OFF.
- An active DTC clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive run cycles, if no failures are reported by this or any other emission related diagnostic. Each run cycle must last a minimum of 10 seconds.
- Clear the MIL and the DTC with a scan tool.

### Diagnostic Aids

- Performing the Fuel Injector Coil Test may help to isolate an intermittent condition. Refer to *Fuel Injector Coil Test*.
- For an intermittent condition, refer to *Testing for Intermittent Conditions and Poor Connections*.

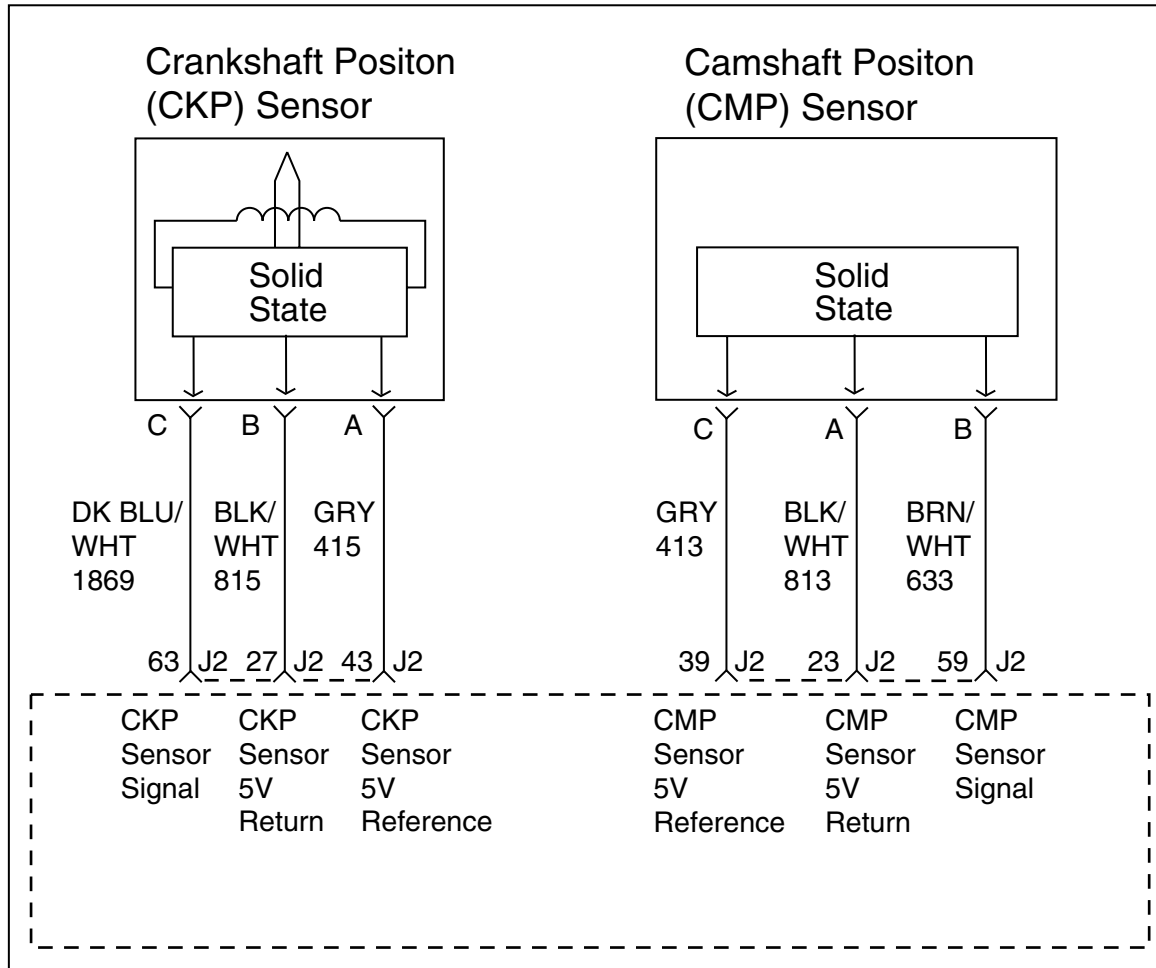
### Test Description

The numbers below refer to the step numbers on the diagnostic table.

4. This step verifies that the ECM is able to control the fuel injector.
5. This step tests if a ground is constantly being applied to the fuel injector.

Step	Action	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views</i> or <i>Engine Controls Connector End Views</i>			
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	Go to Step 2	Go to <i>Diagnostic System Check</i>
2	<ol style="list-style-type: none"> <li>1. Observe and record DTC(s).</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> <li>4. Did the DTC fail this ignition?</li> </ol>	Go to Step 3	Go to <i>Diagnostic Aids</i>
3	<ol style="list-style-type: none"> <li>1. Turn OFF the ignition.</li> <li>2. Disconnect the injector which corresponds to the DTC that has been set.</li> <li>3. Turn ON the ignition, with the engine OFF.</li> <li>4. Probe the ignition voltage circuit of the fuel injector with a test lamp that is connected to a good ground. Does the test lamp illuminate?</li> </ol>	Go to Step 4	Go to Step 10
4	<ol style="list-style-type: none"> <li>1. Connect the J 44603 Fuel Injector Test Lamp between the control circuit of the fuel injector and the ignition voltage circuit of the fuel injector.</li> <li>2. Start the engine. Does the Fuel Injector Test Lamp flash?</li> </ol>	Go to Step 8	Go to Step 5
5	Does the Fuel Injector Test Lamp remain illuminated?	Go to Step 7	Go to Step 6
6	Test the fuel injector control circuit for the following conditions: <ul style="list-style-type: none"> <li>• A short to voltage</li> <li>• An open</li> <li>• High resistance</li> </ul> Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	Go to Step 13	Go to Step 9
7	Test the fuel injector control circuit for a short to ground. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	Go to Step 13	Go to Step 12
8	Test for an intermittent and for a poor connection at the fuel injector. Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Repairing Connector Terminals</i> . Did you find and correct the condition?	Go to Step 13	Go to Step 11
9	Test for an intermittent and for a poor connection at the engine control module (ECM). Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Repairing Connector Terminals</i> . Did you find and correct the condition?	Go to Step 13	Go to Step 12
10	<b>Important:</b> The MEFI System fuse (injector fuse) also supplies voltage to the ignition coil, the ignition control module (ICM), and the ECM. If the fuse is open, inspect all related circuits and components for a short to ground. Refer to <i>Circuit Testing</i> . Test the ignition voltage circuit of the fuel injector for: <ul style="list-style-type: none"> <li>• An open</li> <li>• High resistance</li> <li>• A short to ground</li> </ul> Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	Go to Step 13	—
11	Replace the fuel injector. Refer to <i>Fuel Injector and Fuel Rail Replacement</i> . Did you complete the replacement?	Go to Step 13	—

12	Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?	Go to Step 13	—
13	<ol style="list-style-type: none"><li>1. Clear the DTCs with a scan tool.</li><li>2. Turn OFF the ignition for 30 seconds.</li><li>3. Start the engine.</li><li>4. Did the DTC fail this ignition?</li></ol>	Go to Step 2	Go to Step 14
14	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK



## Diagnostic Information and Procedures

### SPN 723, FMI 2 Cam Signal Fault

#### Circuit Description

The camshaft position (CMP) sensor works in conjunction with the 1X reluctor trigger wheel on the camshaft gear or distributor shaft – hereafter referred to as the camshaft gear. The reluctor trigger wheel on the camshaft gear contains a pattern around the circumference, consisting of 1 wide tooth. The engine control module (ECM) provides a 5-volt reference to the sensor, as well as a low reference and a signal circuit. As the camshaft gear rotates, the reluctor trigger wheel interrupts a magnetic field produced by a magnet internal to the sensor. The CMP sensor internal circuitry detects this interruption of the magnetic field, and produces an ON/OFF DC voltage of varying frequency. The frequency of the CMP sensor output signal is dependent upon camshaft speed. The ECM will recognize wide tooth pattern to identify camshaft position, or which cylinder is in compression and which is in exhaust. If the ECM detects that there is no output signal from the CMP sensor, then SPN 723 FMI 2 will set.

#### DTC Descriptor

This diagnostic procedure supports the following DTC:  
SPN 723 FMI 2 Cam Signal Fault (Camshaft Position (CMP) Sensor Circuit Signal Fault)

#### Conditions for Running the DTC

- The engine is cranking, or the engine is running.
- SPN 723 FMI 2 runs continuously when the above condition is met.

#### Conditions for Setting the DTC

The ECM detects no CMP sensor output for more than 3 seconds.

## Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.

## Conditions for Clearing the MIL/DTC

- The control module turns OFF the MIL after consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC last test failed clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles if no failures are reported by this or any other emission related diagnostic.

## Diagnostic Aids

SPN 723 FMI 2 will set with the ignition switch in the Start position, if the starter motor is inoperative for more than 3 seconds.

## Test Description

The number below refers to the step number on the diagnostic table.

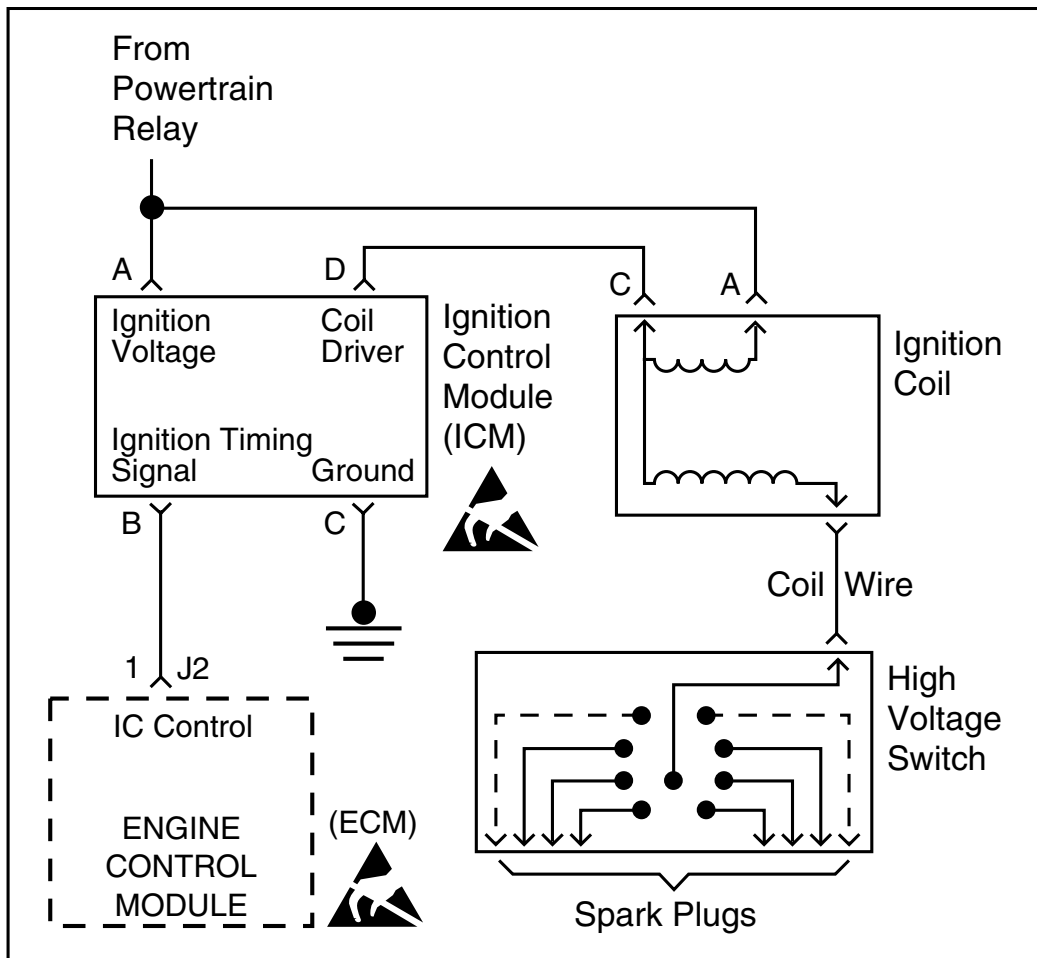
- The test lamp in this step is used to apply a load to the 12-volt reference circuit of the CMP sensor.

Step	Action	Values	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views or Engine Controls Connector End Views</i>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to Diagnostic System Check
2	<ol style="list-style-type: none"> <li>Start and idle the engine.</li> <li>Monitor the camshaft position (CMP) sensor active counter parameter with a scan tool.</li> </ol> Does the CMP sensor active counter number increment?	—	Go to Testing for Intermittent Conditions and Poor Connections	Go to Step 3
3	<ol style="list-style-type: none"> <li>Turn OFF the ignition.</li> <li>Disconnect the CMP sensor electrical connector.</li> <li>Test for shorted terminals and poor connections at the CMP sensor wire harness electrical connector and the mating electrical connector on the CMP sensor. Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Connector Repairs</i>.</li> </ol> Did you find and correct the condition?	—	Go to Step 12	Go to Step 4
4	<ol style="list-style-type: none"> <li>Turn ON the ignition, with the engine OFF.</li> <li>Connect a jumper wire to the 5-volt reference circuit at the CMP sensor wire harness electrical connector.</li> <li>Connect a test lamp between the jumper wire and a good ground.</li> <li>Connect the positive lead of the DMM to the junction of the jumper wire and test lamp.</li> <li>Connect the negative lead of the DMM to a good engine ground.</li> <li>Measure the voltage from the 5-volt reference circuit to a good ground with a DMM. Refer to <i>Circuit Testing</i>.</li> </ol> Is the voltage within the specified range?	4.8–5.2 V	Go to Step 5	Go to Step 6
5	<ol style="list-style-type: none"> <li>Remove the test lamp from the jumper wire.</li> <li>Connect another jumper wire to the signal circuit of the CMP sensor wire harness electrical connector.</li> <li>Turn ON the ignition, with the engine OFF.</li> <li>Monitor the CMP active counter parameter with a scan tool.</li> <li>Momentarily connect the two ends of the jumper wires together several times.</li> </ol> Does the CMP sensor active counter number increment?	—	Go to Step 10	Go to Step 7

6	<p>Test the CMP 5-volt reference circuit between the CMP sensor and the engine control module (ECM) for the following conditions:</p> <ul style="list-style-type: none"> <li>• An open</li> <li>• High resistance</li> <li>• A short to ground</li> </ul> <p>Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i>. Did you find and correct the condition?</p>	—	Go to Step 12	Go to Step 9
7	<p>Test the CMP low reference circuit between the CMP sensor and the ECM for the following conditions:</p> <ul style="list-style-type: none"> <li>• An open</li> <li>• High resistance</li> <li>• A short to ground</li> <li>• A short to voltage</li> </ul> <p>Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i>. Did you find and correct the condition?</p>	—	Go to Step 12	Go to Step 8
8	<p>Test the CMP signal circuit between the CMP sensor and the ECM for the following conditions:</p> <ul style="list-style-type: none"> <li>• An open</li> <li>• High resistance</li> <li>• A short to ground</li> <li>• A short to voltage</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 12	Go to Step 9
9	<p>Test for shorted terminals and poor connections at the ECM wire harness electrical connector. Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Connector Repairs</i>. Did you find and correct the condition?</p>	—	Go to Step 12	Go to Step 11
10	<p>Replace the CMP sensor. Refer to <i>Camshaft Position (CMP) Sensor Replacement</i>. Did you complete the replacement?</p>	—	Go to Step 12	—
11	<p>Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?</p>	—	Go to Step 12	—
12	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> <li>4. Operate the vehicle within the Conditions for Running the DTC.</li> </ol> <p>Did the DTC fail this ignition?</p>	—	Go to Step 2	Go to Step 13
13	<p>Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?</p>	—	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK



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## Diagnostic Information and Procedures

**SPN 65541 FMI 3 EST 1 Short High**

**SPN 65541 FMI 4 EST 1 Short Low**

**SPN 65541 FMI 5 EST 1 Open**

### Circuit Description

The ignition system on this engine uses an ignition coil module to drive the ignition coil. The engine control module (ECM) controls the spark event for each cylinder through an ignition control (IC) circuit. When the ECM commands the IC circuit ON, electrical current will flow through the primary winding of the ignition coil, creating a magnetic field. When a spark event is requested, the ECM will command the IC circuit OFF, interrupting current flow through the primary winding. The magnetic field created by the primary winding will collapse across the secondary coil winding, producing a high voltage across the spark plug electrodes. The ECM uses information from the crankshaft position (CKP) and the camshaft position (CMP) sensor for sequencing and timing of the spark events. The ignition coil module has the following circuits:

- An ignition voltage circuit
- A ground circuit
- An IC circuit
- A low reference circuit

If the ECM detects that the IC circuit has an incorrect voltage level, SPN 65541 will set.

### DTC Descriptors

This diagnostic procedure supports the following DTCs:

- *SPN 65541 FMI 3 EST 1 Short High (Ignition Coil Control Module Circuit Short to Voltage)*
- *SPN 65541 FMI 4 EST 1 Short Low (Ignition Coil Control Module Circuit Short to Ground)*
- *SPN 65541 FMI 5 EST 1 Open (Ignition Coil Control Module Circuit Open Circuit)*

## Conditions for Running the DTC

- The engine is cranking, or the engine is running.
- SPN 65541 runs continuously when the above condition is met.

## Conditions for Setting the DTC

The ECM detects the IC circuit is grounded, open, or shorted to voltage for less than 1 second.

## Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL).

## Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

## Test Description

The numbers below refer to the step numbers on the diagnostic table.

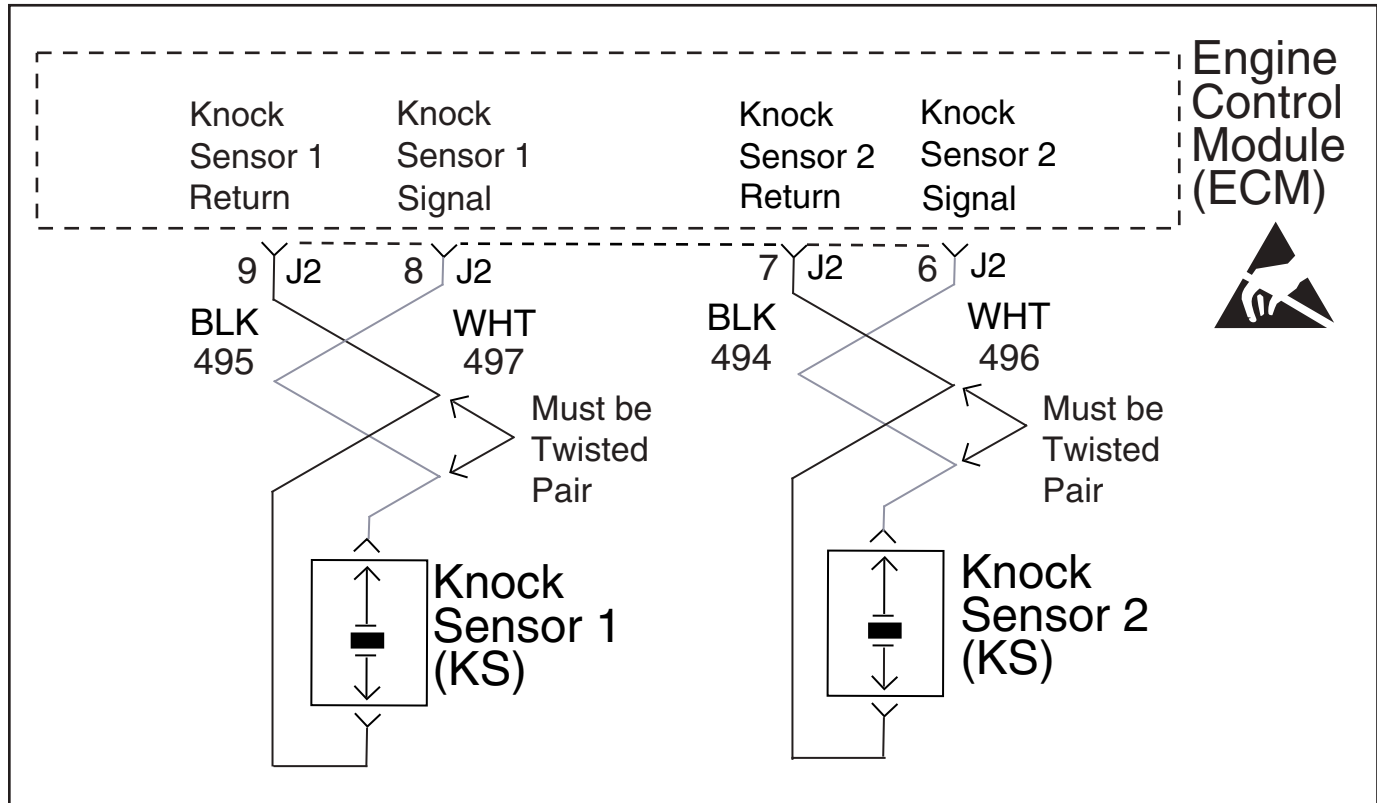
3. This step verifies the integrity of the IC circuit and the ECM output.
4. This step tests for a short to voltage on the IC circuit.

Step	Action	Values	Yes	No
<b>Schematic Reference: <i>Engine Controls Schematics</i></b> <b>Connector End View Reference: <i>Engine Control Module (ECM) Connector End Views or Engine Controls Connector End Views</i></b>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to Diagnostic System Check
2	1. Observe the Conditions for Running this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vessel within the Conditions for Running the DTC. Did the DTC fail this ignition?	—	Go to Step 3	Go to Testing for Intermittent Conditions and Poor Connections
3	1. Turn OFF the engine. 2. Disconnect the ignition control module coil electrical connector. 3. Disconnect the fuel injector electrical connectors. 4. Crank the engine. 5. Measure the frequency at the ignition (IC) circuit with the DMM set to AC Hertz. Is the frequency within the specified range?	3–20 Hz ?	Go to Step 7	Go to Step 4
4	1. Turn ON the ignition, with the engine OFF. 2. Measure the voltage from the IC circuit of the ignition control module to a good ground with a DMM. Is the voltage more than the specified value?	1 V	Go to Step 13	Go to Step 5
5	1. Turn OFF the ignition. 2. Disconnect the engine control module (ECM) connector. 3. Test the IC circuit between the ignition control module connector and the ECM connector for continuity with the DMM. Does the DMM indicate continuity?	—	Go to Step 6	Go to Step 14
6	Test the IC circuit for a short to ground. Refer to <i>Testing for Short to Ground</i> . Did you find and correct the condition?	—	Go to Step 17	Go to Step 10

7	<ol style="list-style-type: none"> <li>1. Turn ON the ignition, with the engine OFF.</li> <li>2. Probe the ignition voltage circuit of the ignition coil control module with a test lamp that is connected to battery ground. Refer to <i>Troubleshooting with a Test Lamp</i>. Does the test lamp illuminate?</li> </ol>	—	Go to Step 8	Go to Step 11
8	<p>Probe the ground circuit of the ignition coil control module with a test lamp connected to battery voltage. Refer to <i>Troubleshooting with a Test Lamp</i>. Does the test lamp illuminate?</p>	—	Go to Step 9	Go to Step 12
9	<p>Test for an intermittent and for a poor connection at the ignition coil control module. Refer to <i>Testing for Intermittent Conditions and Poor Connections and Connector Repairs</i>. Did you find and correct the condition?</p>	—	Go to Step 17	Go to Step 15
10	<p>Test for an intermittent and for a poor connection at the ECM. Refer to <i>Testing for Intermittent Conditions and Poor Connections and Connector Repairs</i>. Did you find and correct the condition?</p>	—	Go to Step 17	Go to Step 16
11	<p>Repair the open or high resistance in the ignition voltage circuit. Refer to <i>Wiring Repairs</i>. Did you complete the repair?</p>	—	Go to Step 17	—
12	<p>Repair the open or high resistance in the ground circuit for the ignition coil control module. Refer to <i>Wiring Repairs</i>. Did you complete the repair?</p>	—	Go to Step 17	—
13	<p>Repair the IC circuit for a short to voltage. Refer to <i>Wiring Repair</i>. Did you complete the repair?</p>	—	Go to Step 17	—
14	<p>Repair the open or high resistance in the IC circuit. Refer to <i>Wiring Repairs</i>. Did you complete the repair?</p>	—	Go to Step 17	—
15	<p>Replace the ignition coil control module. Refer to <i>Ignition Coil Control Module Replacement</i>. Did you complete the replacement?</p>	—	Go to Step 17	—
16	<p>Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?</p>	—	Go to Step 17	—
17	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> <li>4. Operate the vehicle within the Conditions for Running the DTC.</li> </ol> <p>Did the DTC fail this ignition?</p>	—	Go to Step 2	Go to Step 18
18	<p>Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?</p>	—	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK

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## Knock Sensor



## Diagnostic Information and Procedures

**SPN 65551 - FMI 2:** Knock Sensor 1 (KS) Fault

**SPN 65552 - FMI 2:** Knock Sensor 2 (KS) Fault

## DTC Descriptor

**SPN 65551, FMI 2:** Knock Sensor 1 (KS) Fault

**SPN 65552, FMI 2:** Knock Sensor 2 (KS) Fault

## Circuit/System Description

The knock sensor (KS) system enables the engine control module (ECM) to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation. The ECM monitors two separate KS, one on each side of the engine block. Each KS produces an AC voltage that varies, depending on the vibration levels detected during engine operation. The ECM adjusts the spark timing based on the amplitude and frequency of each KS signal. The ECM receives the KS signal through two different signal circuits. Each KS ground is supplied by the ECM through a low reference circuit. The ECM uses the KS signal to calculate the average voltage, then assign a voltage range value. The ECM will then monitor for a normal KS signal within the assigned voltage range.

## Conditions for Running the DTC

- *SPN 65550, 65551, 65552* run continuously when the engine speed is greater than 1,800 RPM, and the manifold absolute pressure (MAP) is greater than 55 kPa.
- *SPN 65551, 65552* run continuously when the ignition is ON or the engine is running.

## Conditions for Setting the DTC

**SPN 65551 and 65552 FMI 2**

- The KS signal circuits are open or shorted together for 5 seconds.
- The KS signal circuits are shorted to voltage or ground.

## Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the DTC at the time the diagnostic fails.

## Conditions for Clearing the DTC

- The control module turns OFF the MIL after consecutive ignition cycles that the diagnostic runs and does not fail.
- A history DTC clears after 25 consecutive warm up cycles if no failures are reported by this diagnostic.
- A current DTC last test failed clears when the diagnostic runs and passes.
- Clear the MIL and the DTC with a scan tool.

## Diagnostic Aids

- Inspect the KS for physical damage.
- Inspect the KS for proper installation. A KS that is loose or over-torque may cause a DTC to set. The KS should be free of thread sealant.
  - The KS mounting surface should be free of burs, casting flash and, foreign material.
  - This test procedure requires that the vehicle battery has passed a load test and is completely charged.
  - When disconnecting electrical connectors or removing fuses and relays from a fuse block, always inspect the component electrical terminals for corrosion, and the mating electrical terminals for tightness.

## Reference Information

### Schematic Reference

*Engine Controls Schematics*

### Connector End View Reference

- *Engine Control Module (ECM) Connector End Views*
- *Engine Controls Connector End Views*

### Electrical Information Reference

- *Testing for Intermittent Conditions and Poor Connections*
- *Circuit Testing*
- *Wiring Repairs*
- *Connector Repairs*
- *Measuring Frequency*

### Scan Tool Reference

- *Scan Tool Data List*
- *Scan Tool Data Definitions*
- *Scan Tool Output Controls*

## Circuit/System Verification

1. Disconnect both KS electrical connectors.
2. Connect one test lead from the DMM to the signal circuit terminal on the KS, and the other test lead from the DMM to the low reference circuit terminal on the KS.
3. Set the DMM to the 400 mV AC hertz scale, and wait for the DMM to stabilize at 0 Hz.

**Important:** DO NOT tap on plastic engine components.

4. Tap on the engine block with a non-metallic object near the KS while observing the Hz signal indicated on the DMM display.
5. The DMM should display a fluctuating frequency while tapping on the engine block.
6. Repeat the above procedure for the KS on the opposite side of the engine block.

If the vehicle passes the Circuit/System Verification test, operate the vehicle within the Conditions for Running the DTC. The other option is to refer to *Testing for Intermittent Conditions and Poor Connections*.

## Circuit/System Testing

### SPN 65551 and 65552 FMI 2

1. Turn OFF the ignition.
2. Disconnect the KS electrical connector.
3. Measure for infinite resistance between the signal circuit terminal at the KS, and to a good engine ground, with a DMM. If continuity is detected on the signal circuit, replace the KS.

5. Measure for infinite resistance between the low reference circuit terminal at the KS and to a good engine ground with a DMM.

If continuity is detected on the low reference circuit, replace the KS.

7. Turn ON the ignition, with the engine OFF.
8. Measure for voltage at the KS signal circuit terminal, on the wire harness electrical connector, for the KS. If the KS signal circuit measures more than 4.2 volts, test for a short to voltage or a faulty ECM.

10. Measure for voltage at the KS low reference circuit terminal, on the wire harness electrical connector, for the KS. If the KS low reference circuit measures more than 4.2 volts, test for a short to voltage, or a faulty ECM.

12. Test the KS signal circuit and the KS low reference circuit for the following conditions:

- An open
- A short to ground
- High resistance—All wire circuit resistance must measure less than 5 ohms.

If the KS and wire circuits test normal, replace the ECM.

## Repair Instructions

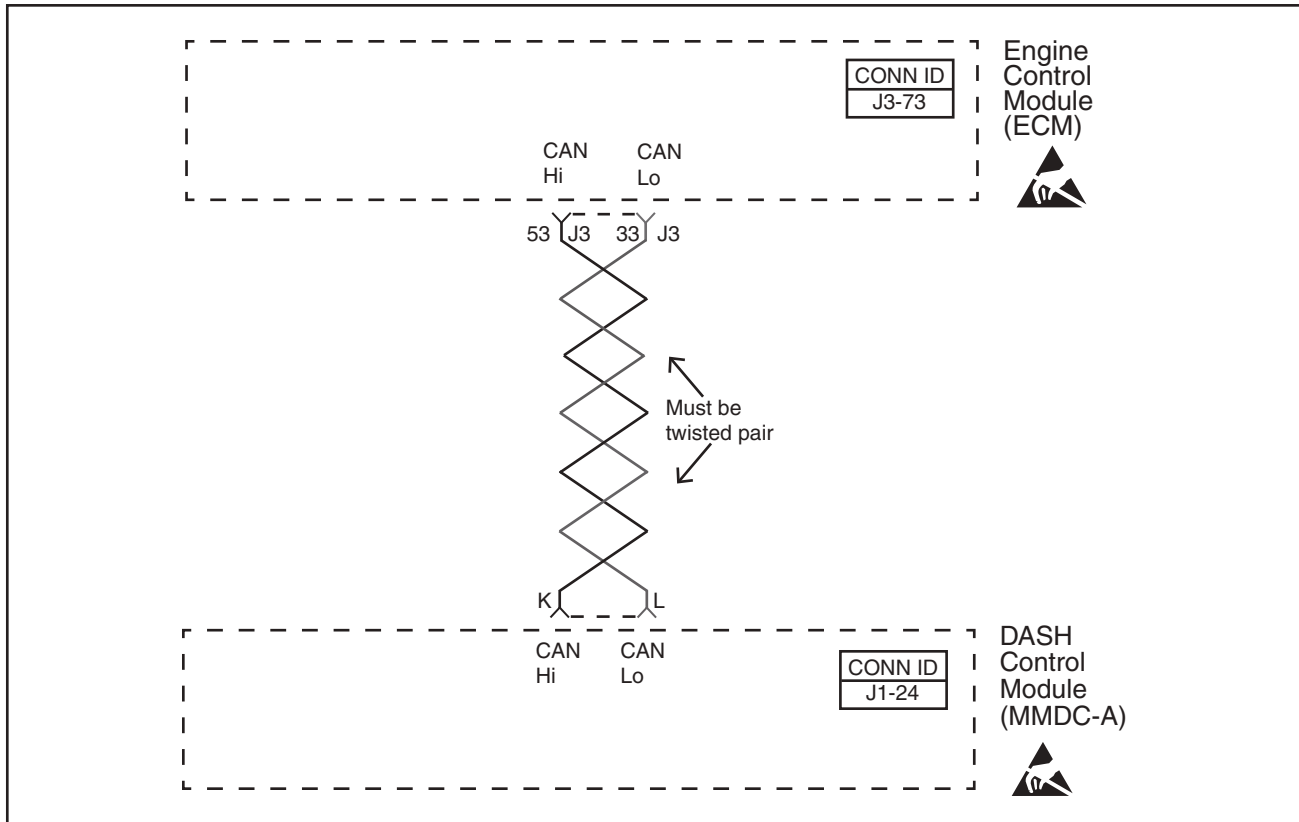
**Important:** Always perform the *Diagnostic Repair Verification* after completing the diagnostic procedure.

- *Knock Sensor (KS) Replacement (Bank 1) Knock Sensor (KS) Replacement (Bank 2)*
- *Control Module References*
- *Symptoms - Engine Mechanical*
- *Symptoms - Engine Controls*



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## Engine Controls Schematics



## Diagnostic Information and Procedures

### SPN 65559, FMI 11 Can Bus Hardware

#### Description

Modules connected to the Can Bus data circuit monitor for Can Communication Protocol (CCP) during normal operation. Operating information and commands are exchanged among the modules. In addition to this, Node Alive messages are transmitted by each module on the CCP data circuit. When the module detects one of the following conditions on the CCP data circuit for approximately 3 seconds, this DTC will set.

- Low voltage on the CCP Data Circuit.
- High voltage on the CCP Data Circuit.

#### DTC Descriptors

This diagnostic procedure supports the following DTC:

*SPN 65559 FMI 11 Can Bus Hardware*

#### Conditions for Running the DTC

- The ignition switch is in the Run or the Crank position.
- The ignition voltage is in the normal operating voltage range.
- SPN 65559 FMI 11 runs continuously when the above condition is met.

#### Conditions for Setting the DTC

- No valid messages are detected on the CCP data circuit
- The voltage level detected on the CCP data circuit is under one of the following conditions:
  - Always high
  - Always low

- The above conditions are met for approximately 3 seconds.

### **Action Taken When the DTC Sets**

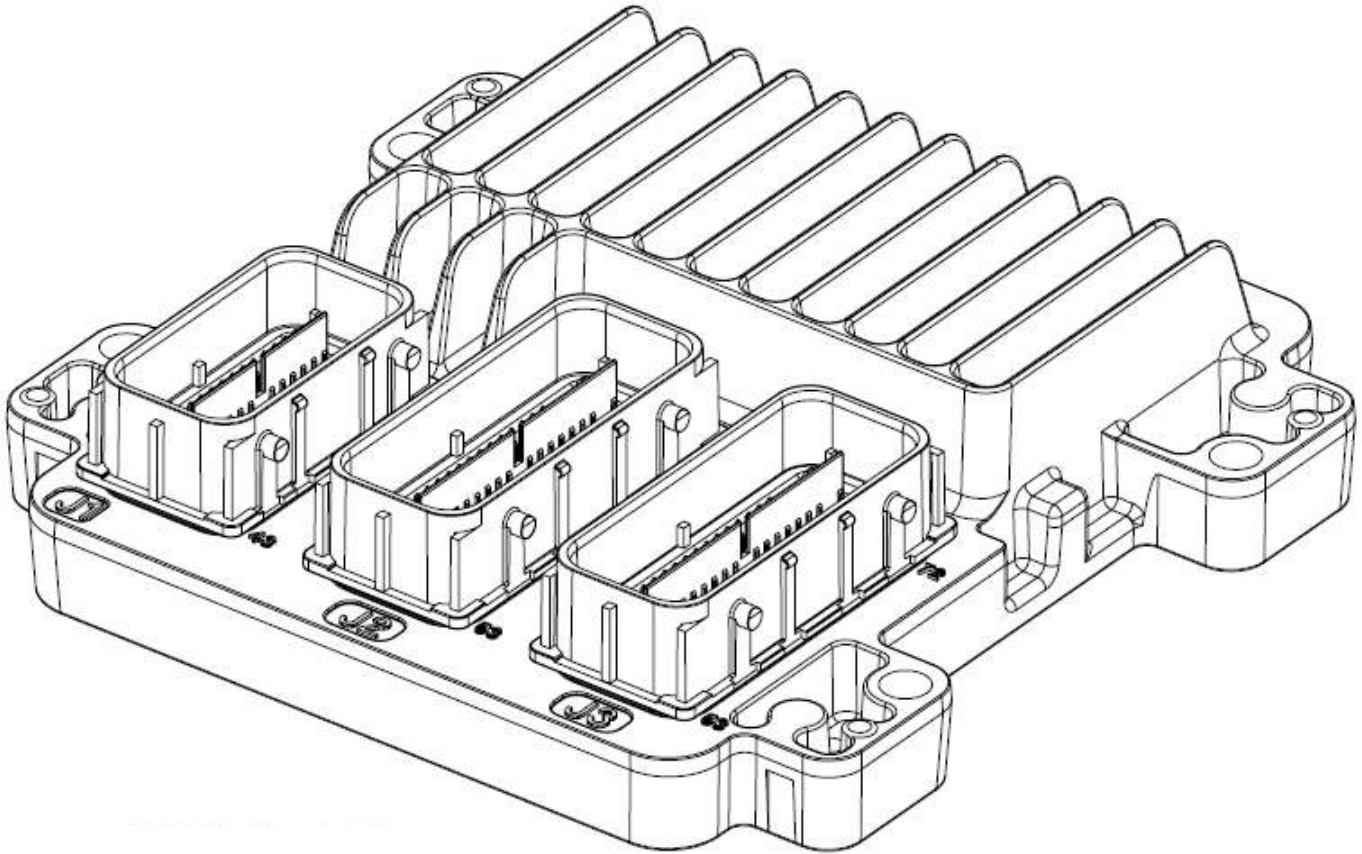
- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails.

### **Conditions for Clearing the MIL/DTC**

- A current DTC Last Test Failed clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Clear the DTC with a scan tool.

### **Diagnostic Aids**

- May have to disconnect external modules (MMDC or Perfect Pass or etc... modules) in order to communicate with the ECM.



## Diagnostic Information and Procedures

### SPN 65580, FMI 12 CPU Failure

#### Description

This diagnostic applies to internal microprocessor integrity conditions within the engine control module (ECM). This diagnostic also addresses whether or not the ECM is not programmed.

#### DTC Descriptors

This diagnostic procedure supports the following DTC:  
*SPN 65580 FMI 12 CPU Failure*

#### Conditions for Running the DTC

- The ignition switch is in the Run or the Crank position.
- The ignition voltage is more than 5 volts.
- SPN 65580 FMI 12 runs continuously when the above condition is met.

#### Conditions for Setting the DTC

The ECM detects an internal failure or incomplete programming for more than 14 seconds.

#### Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails.

## Conditions for Clearing the MIL/DTC

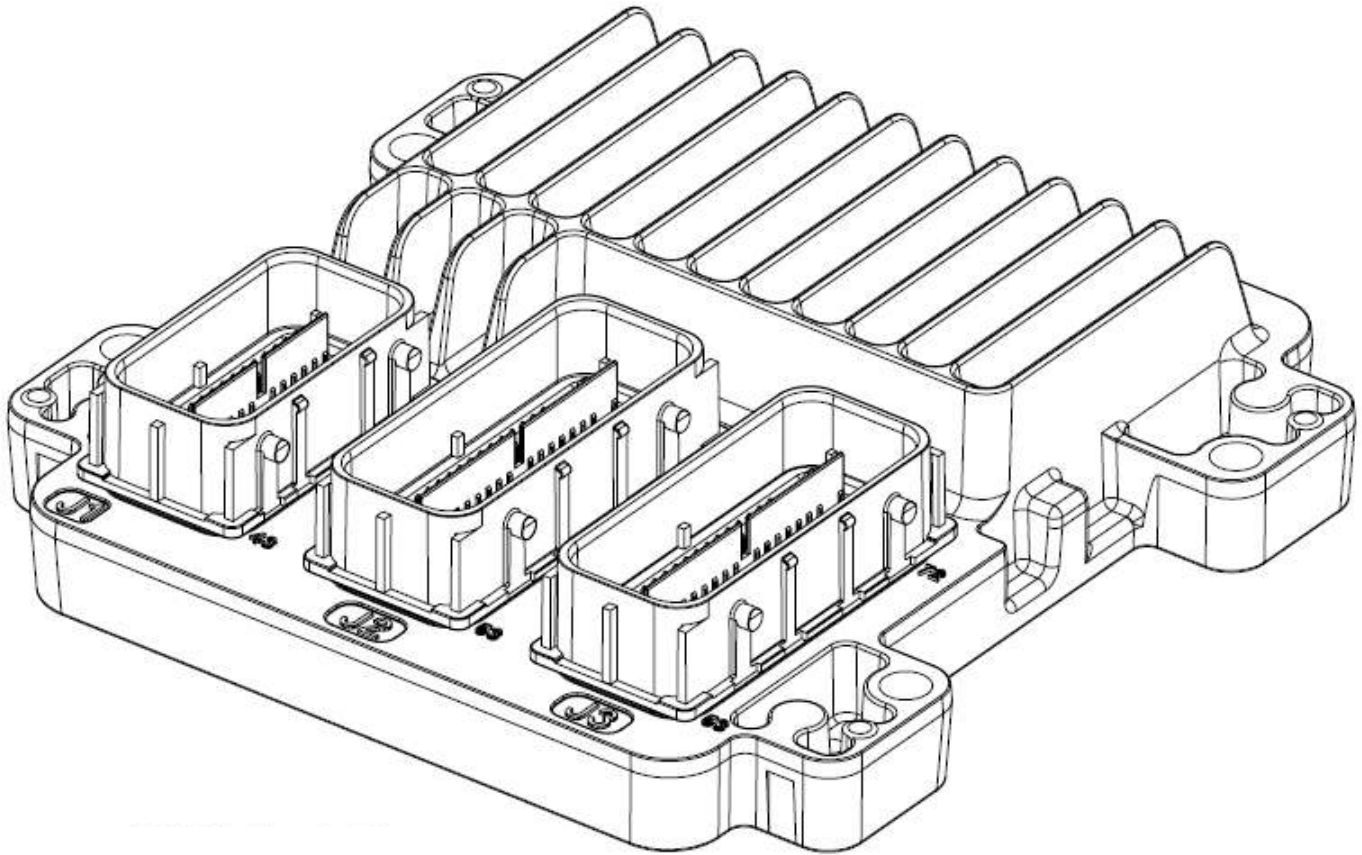
- A current DTC Last Test Failed clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Clear the DTC with a scan tool.

## Test Description

The number below refers to the step number on the diagnostic table.

2. This step check indicates the ECM needs to be programmed or replaced.

Step	Action	Yes	No
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	Go to Step 2	Go to <i>Diagnostic System Check</i>
2	Is SPN 65580 FMI 12 set?	Go to Step 3	Go to Step 5
3	Program the engine control module (ECM). Refer to <i>Service Programming System (SPS)</i> . Does SPN 65580 reset?	Go to Step 4	Go to Step 7
4	1. Ensure that all tool connections are secure. 2. Ensure that the programming equipment is operating correctly. 3. Ensure that the correct software/calibration package is used. 4. Attempt to program the ECM. Refer to <i>Service Programming System (SPS)</i> . Does SPN 65580 reset?	Go to Step 5	Go to Step 7
5	Test all voltage and ground inputs to the ECM for an open circuit or high resistance. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	Go to Step 7	Go to Step 6
6	Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?	Go to Step 7	—
7	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. Did the DTC fail this ignition?	Go to Step 2	Go to Step 8
8	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK



## Diagnostic Information and Procedures

### SPN 65581, FMI 12 MHC Failure

#### Description

This diagnostic applies to internal microprocessor integrity conditions within the engine control module (ECM). Two processors are also used to monitor the TAC system data. The engine control module (ECM) performs an intrusive test in order to monitor these processors. This diagnostic also addresses whether or not the ECM is not programmed.

#### DTC Descriptors

This diagnostic procedure supports the following DTC:

*SPN 65581 FMI 12 MHC Failure*

#### Conditions for Running the DTC

- The ignition switch is in the Run or the Crank position.
- The ignition voltage is more than 5 volts.
- SPN 65581 FMI 12 runs continuously when the above condition is met.

#### Conditions for Setting the DTC

The ECM detects an internal failure or incomplete programming for more than 14 seconds.

#### Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails.

## Conditions for Clearing the MIL/DTC

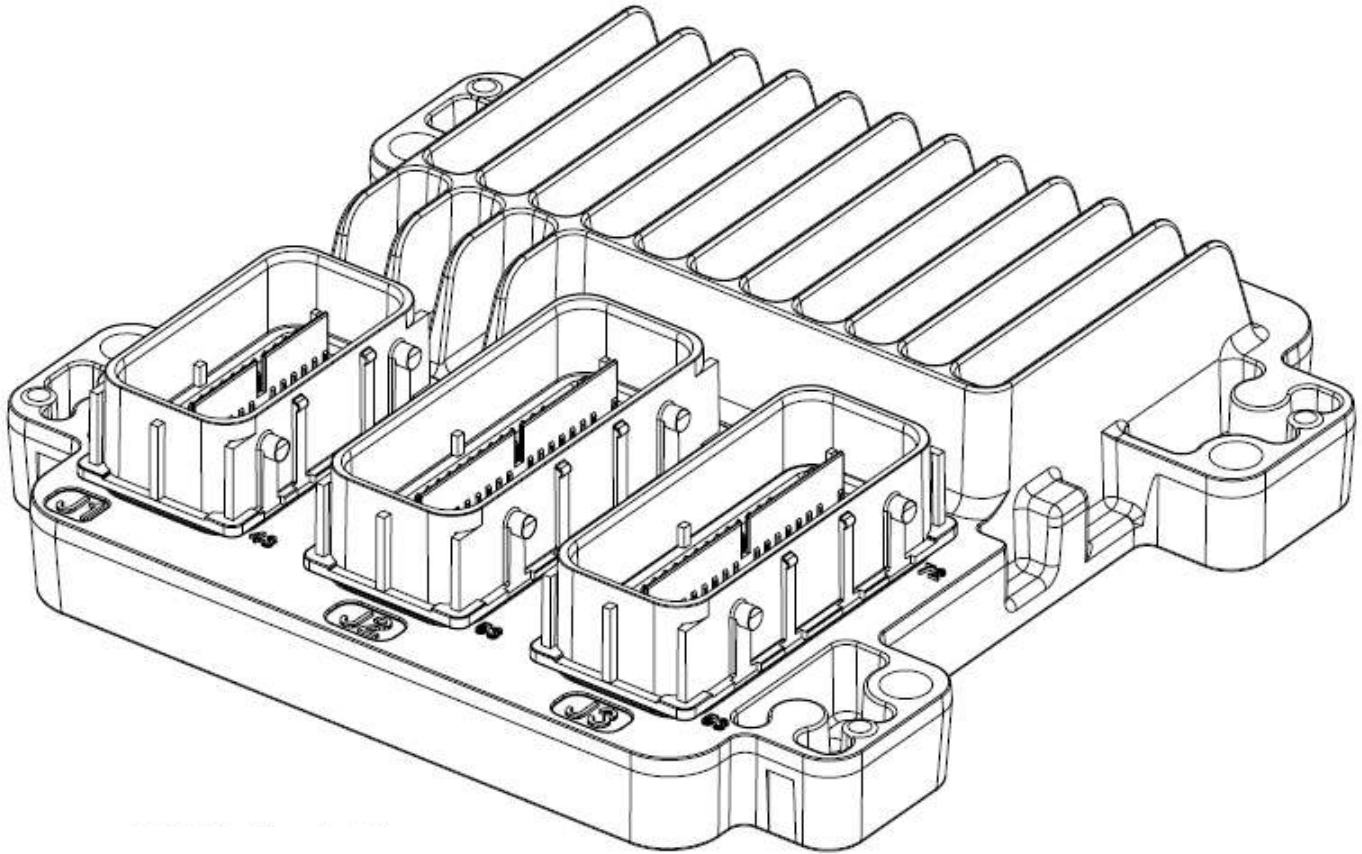
- A current DTC Last Test Failed clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Clear the DTC with a scan tool.

## Test Description

The number below refers to the step number on the diagnostic table.

2. This step check indicates the ECM needs to be programmed or replaced.

Step	Action	Yes	No
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	Go to Step 2	Go to <i>Diagnostic System Check</i>
2	Is SPN 65581 FMI 12 set?	Go to Step 3	Go to Step 5
3	Program the engine control module (ECM). Refer to <i>Service Programming System (SPS)</i> . Does SPN 65581 reset?	Go to Step 4	Go to Step 7
4	1. Ensure that all tool connections are secure. 2. Ensure that the programming equipment is operating correctly. 3. Ensure that the correct software/calibration package is used. 4. Attempt to program the ECM. Refer to <i>Service Programming System (SPS)</i> . Does SPN 65581 reset?	Go to Step 5	Go to Step 7
5	Test all voltage and ground inputs to the ECM for an open circuit or high resistance. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	Go to Step 7	Go to Step 6
6	Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?	Go to Step 7	—
7	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. Did the DTC fail this ignition?	Go to Step 2	Go to Step 8
8	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK



## Diagnostic Information and Procedures

### SPN 65582, FMI 12 NV RAM Failure

#### Description

This diagnostic applies to internal NV RAM integrity conditions within the engine control module (ECM). The NV RAM stores engine hours and DTCs which questions the integrity of this stored data. This diagnostic also addresses whether or not the ECM is programmed.

#### DTC Descriptors

This diagnostic procedure supports the following DTC:

*SPN 65582 FMI 12 NV RAM Failure*

#### Conditions for Running the DTC

- The ignition switch is in the Run or the Crank position.
- The ignition voltage is more than 5 volts.
- SPN 65582 FMI 12 runs continuously when the above condition is met.

#### Conditions for Setting the DTC

The ECM detects an internal failure or incomplete programming for more than 14 seconds.

#### Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails.



## Conditions for Clearing the MIL/DTC

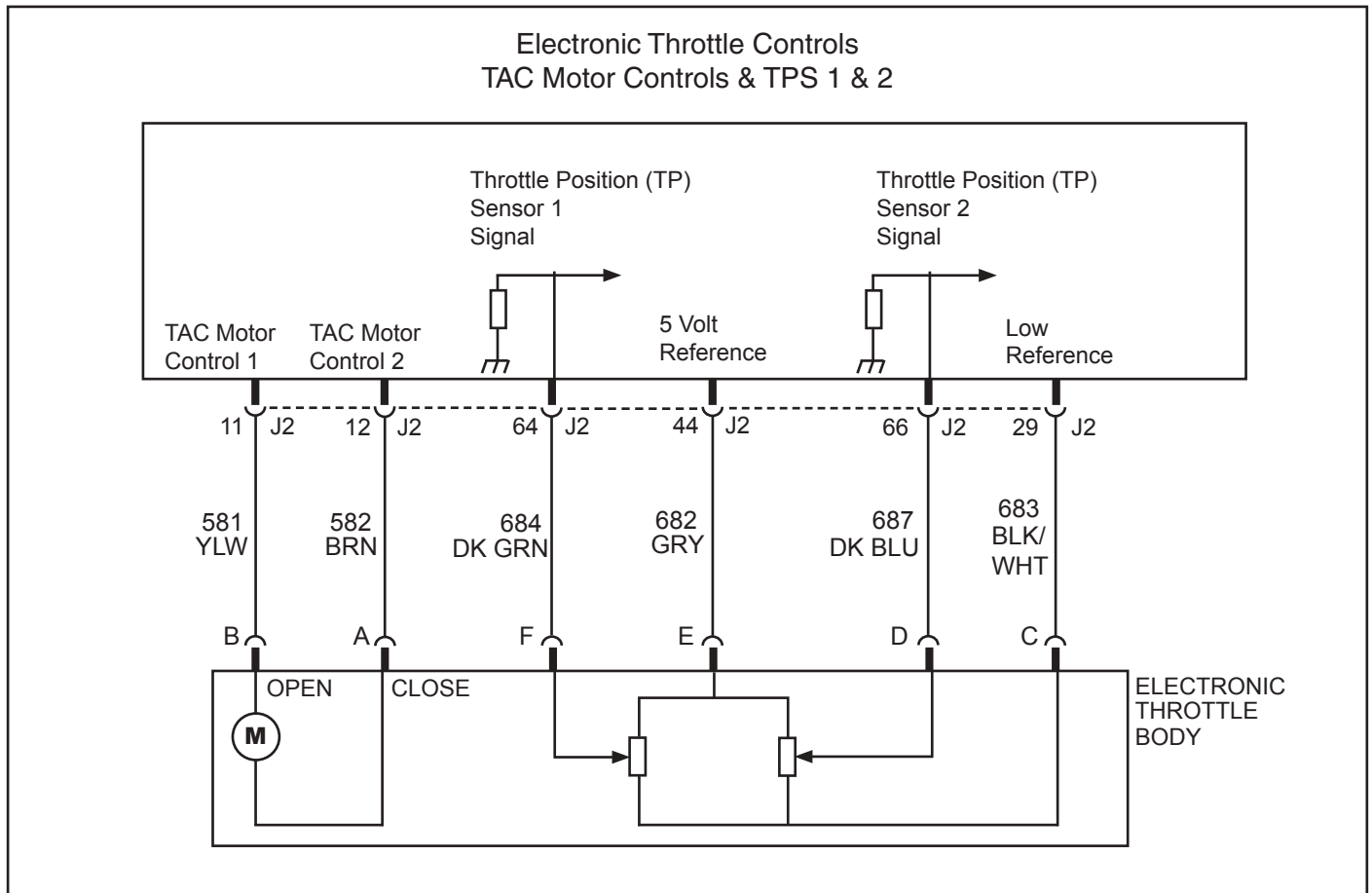
- A current DTC Last Test Failed clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Clear the DTC with a scan tool.

## Test Description

The number below refers to the step number on the diagnostic table.

2. This step check indicates the ECM needs to be programmed or replaced.

Step	Action	Yes	No
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	Go to Step 2	Go to <i>Diagnostic System Check</i>
2	Is SPN 65582 FMI 12 set?	Go to Step 3	Go to Step 5
3	Program the engine control module (ECM). Refer to <i>Service Programming System (SPS)</i> . Does SPN 65582 reset?	Go to Step 4	Go to Step 7
4	1. Ensure that all tool connections are secure. 2. Ensure that the programming equipment is operating correctly. 3. Ensure that the correct software/calibration package is used. 4. Attempt to program the ECM. Refer to <i>Service Programming System (SPS)</i> . Does SPN 65582 reset?	Go to Step 5	Go to Step 7
5	Test all voltage and ground inputs to the ECM for an open circuit or high resistance. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	Go to Step 7	Go to Step 6
6	Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?	Go to Step 7	—
7	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. Did the DTC fail this ignition?	Go to Step 2	Go to Step 8
8	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK



## Diagnostic Information and Procedures

### SPN 65601, FMI 2 ETC TPS 2 Range (Electronic Throttle Control, Throttle Position Sensor 2 Range)

#### Circuit Description

The throttle position (TP) sensors 1 and 2 are located within the throttle body assembly. The ECM supplies the TP sensors with a common 5-volt reference circuit and a common low reference circuit. Each TP sensor has an individual signal circuit, which provides the ECM with a signal voltage that changes in proportion to the throttle plate angle. When the throttle plate is in the closed position, TP sensor 1 signal voltage is near the low reference and TP sensor 2 signal voltage is near the 5-volt reference. As the throttle is opened, TP sensor 1 signal voltage increases and TP sensor 2 signal voltage decreases.

If the ECM detects that TP sensor 2 signal voltage is not within the correct range, SPN 65601, FMI 2 sets.

#### DTC Descriptor

This diagnostic procedure supports the following DTC:

SPN 65601, FMI 2 ETC TPS 2 Range

#### Conditions for Running the DTC

- The ignition is ON, with the engine OFF, or the engine is operating.
- SPN 65601 runs continuously when the above conditions are met.

#### Conditions for Setting the DTC

- The ECM detects that the TP sensor 2 signal voltage is less than 0.3 volt.
- The ECM detects that the TP sensor 2 signal voltage is more than 4.7 volts.

Note: Exact voltages may vary depending on ECM calibration.

## Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM commands the system to operate in the Reduced Engine Power mode.
- The ECM commands the throttle actuator to move the throttle plate to an idle position.
- The throttle actuator does not respond to input from the Throttle-Shift Control (T-SC).
- Under certain conditions the ECM commands the engine OFF.

## Conditions for Clearing the MIL/DTC

- The malfunction indicator lamp (MIL) will remain illuminated through the remainder of the ignition cycle. After turning the key off, the MIL will not illuminate on the next malfunction-free ignition cycle.
- An active DTC clears on the next ignition cycle that the diagnostic runs and passes.
- A history DTC clears after 25 consecutive run cycles, if no failures are reported by this diagnostic. Each run cycle must last a minimum of 10 seconds.
- Clear the history DTC with a scan tool.

## Test Description

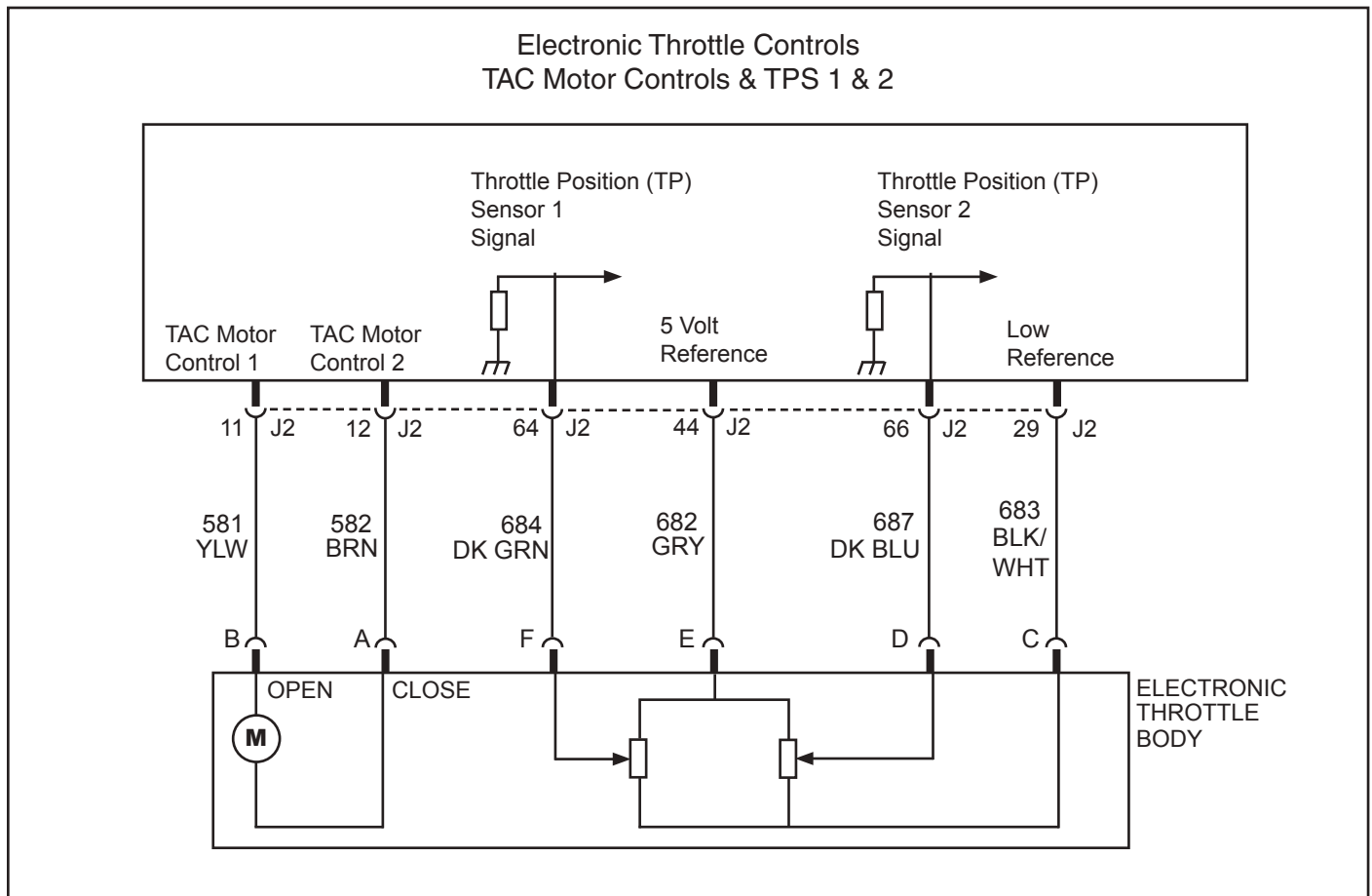
The numbers below refer to the step numbers in the diagnostic table.

**3, 5,& 23.** More than one electronic throttle control (ETC) system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Keep this in mind when reviewing captured DTC info.

Step	Action	Values	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views or Engine Controls Component Views</i>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to <i>Diagnostic System Check</i>
2	1. Turn ON the ignition, with the engine OFF. 2. Observe the throttle position (TP) sensor 2 voltage with a scan tool, while the Throttle-Shift Control (T-SC) is in the locked-neutral (idle) position. Does the scan tool indicate voltage less than the first value or more than the second value?	0.3 V 4.7 V	Go to Step 6	Go to Step 3
3	Is <i>SPN 65610, FMI 2</i> also set?	—	See Diagnostic Aids, Go to <i>Diagnostic Trouble Code (DTC) List</i> Continue to Step 4	Go to Step 4
4	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC. Does <i>SPN 65601, FMI 2</i> set by itself?	—	Go to Step 21	Go to Step 5
5	Are there any other DTCs set?	—	See Diagnostic Aids, Go to <i>Diagnostic Trouble Code (DTC) List</i> Continue to Step 6	Go to <i>Testing for Intermittent Conditions and Poor Connections</i>

6	<ol style="list-style-type: none"> <li>1. Turn OFF the ignition.</li> <li>2. Disconnect the throttle body harness connector.</li> <li>3. Turn ON the ignition, with the engine OFF.</li> <li>4. Observe the TP sensor 2 voltage parameter with a scan tool.</li> </ol> Does the scan tool indicate voltage at the specified value?	0 V	Go to Step 7	Go to Step 12
7	<ol style="list-style-type: none"> <li>1. Connect a fused jumper wire between the TP sensor 5-volt reference circuit and the TP sensor 2 signal circuit at the throttle body harness connector.</li> <li>2. Observe the TP sensor 2 voltage parameter with a scan tool.</li> </ol> Does the scan tool indicate the TP sensor 2 voltage at the specified value?	5 V	Go to Step 8	Go to Step 9
8	Probe the TP sensor low reference circuit with a test lamp connected to B+. Does the test lamp illuminate?	—	Go to Step 18	Go to Step 14
9	Measure the voltage of the TP sensor 2 5-volt reference circuit with a DMM. Does the DMM indicate voltage at the specified value?	5 V	Go to Step 11	Go to Step 10
10	Does the DMM indicate voltage less than the specified value on the TP sensor 2 5-volt reference circuit?	5 V	Go to Step 15	Go to Step 17
11	Test the TP sensor 2 signal circuit for an open or high resistance. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	Go to Step 13
12	Test the TP sensor 2 signal circuit for a short to voltage. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	Go to Step 20
13	Test the TP sensor 2 signal circuit for a short to ground. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	Go to Step 20
14	Test the TP sensor 2 low reference circuit for an open or high resistance. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	Go to Step 20
15	Test the TP sensor 2 5-volt reference circuit for an open or high resistance. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	Go to Step 16
16	Test the TP sensor 2 5-volt reference circuit for a short to ground. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	Go to Step 20
17	Test the TP sensor 2 5-volt reference circuit for a short to voltage. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	—
18	Test for an intermittent and for a poor connection at the throttle body. Refer to <i>Testing for Intermittent Conditions and Poor Connections and Connector Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	Go to Step 19
19	Replace the throttle body assembly. Refer to <i>Throttle Body Assembly Replacement</i> . Did you complete the replacement?	—	Go to Step 22	—
20	Test for an intermittent and for a poor connection at the engine control module (ECM). Refer to <i>Testing for Intermittent Conditions and Poor Connections and Connector Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	Go to Step 21
21	Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?	—	Go to Step 22	—
22	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> <li>4. Operate the vehicle within the Conditions for Running the DTC.</li> </ol> Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 23
23	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

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## Diagnostic Information and Procedures

### SPN 65602, FMI 2 ETC TPS 1 Range (Electronic Throttle Control, Throttle Position Sensor 1 Range)

#### Circuit Description

The throttle position (TP) sensors 1 and 2 are located within the throttle body assembly. The ECM supplies the TP sensors with a common 5-volt reference circuit and a common low reference circuit. Each TP sensor has an individual signal circuit, which provides the ECM with a signal voltage that changes in proportion to the throttle plate angle. When the throttle plate is in the closed position, TP sensor 1 signal voltage is near the low reference and TP sensor 2 signal voltage is near the 5-volt reference. As the throttle is opened, TP sensor 1 signal voltage increases and TP sensor 2 signal voltage decreases.

If the ECM detects that TP sensor 1 signal voltage is not within the correct range, SPN 65602, FMI 2 sets.

#### DTC Descriptor

This diagnostic procedure supports the following DTC:

SPN 65602, FMI 2 ETC TPS 1 Range

#### Conditions for Running the DTC

- The ignition is ON, with the engine OFF, or the engine is operating.
- SPN 65602 runs continuously when the above conditions are met.

#### Conditions for Setting the DTC

- The ECM detects that the TP sensor 1 signal voltage is less than 0.3 volt.
- The ECM detects that the TP sensor 1 signal voltage is more than 4.7 volts.

Note: Exact voltages may vary depending on ECM calibration.

## Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM commands the system to operate in the Reduced Engine Power mode.
- The ECM commands the throttle actuator to move the throttle plate to an idle position.
- The throttle actuator does not respond to input from the Throttle-Shift Control (T-SC).
- Under certain conditions the ECM commands the engine OFF.

## Conditions for Clearing the MIL/DTC

- The malfunction indicator lamp (MIL) will remain illuminated through the remainder of the ignition cycle. After turning the key off, the MIL will not illuminate on the next malfunction-free ignition cycle.
- An active DTC clears on the next ignition cycle that the diagnostic runs and passes.
- A history DTC clears after 25 consecutive run cycles, if no failures are reported by this diagnostic. Each run cycle must last a minimum of 10 seconds.
- Clear the history DTC with a scan tool.

## Diagnostic Aids

The numbers below refer to the step numbers in the diagnostic table.

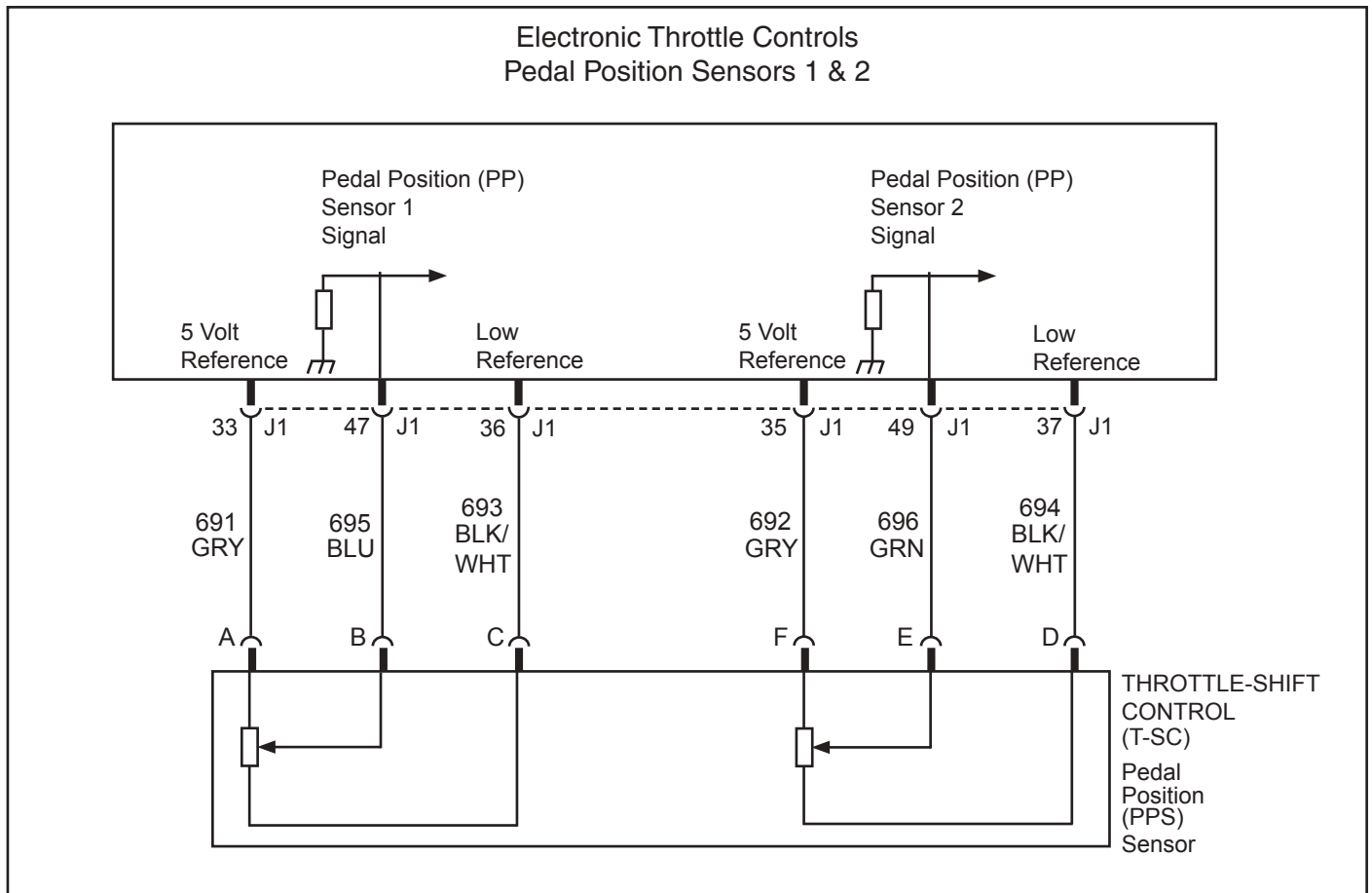
**3, 5, & 23.** More than one electronic throttle control (ETC) system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Keep this in mind when reviewing captured DTC info.

Step	Action	Values	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i>				
<b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views or Engine Controls Component Views</i>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to <i>Diagnostic System Check</i>
2	1. Turn ON the ignition, with the engine OFF. 2. Observe the throttle position (TP) sensor 1 voltage with a scan tool, while the Throttle-Shift Control (T-SC) is in the locked-neutral (idle) position. Does the scan tool indicate voltage less than the first value or more than the second value?	0.3 V 4.7 V	Go to Step 6	Go to Step 3
3	Is <i>SPN 65610, FMI 2</i> also set?	—	See Diagnostic Aids, Go to <i>Diagnostic Trouble Code (DTC) List</i> Continue to Step 4	Go to Step 4
4	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC. Does <i>SPN 65602, FMI 2</i> set by itself?	—	Go to Step 21	Go to Step 5
5	Are there any other DTCs set?	—	See Diagnostic Aids, Go to <i>Diagnostic Trouble Code (DTC) List</i> Continue to Step 6	Go to <i>Testing for Intermittent Conditions and Poor Connections</i>

6	<ol style="list-style-type: none"> <li>1. Turn OFF the ignition.</li> <li>2. Disconnect the throttle body harness connector.</li> <li>3. Turn ON the ignition, with the engine OFF.</li> <li>4. Observe the TP sensor 1 voltage parameter with a scan tool. Does the scan tool indicate voltage at the specified value?</li> </ol>	0 V	Go to Step 7	Go to Step 12
7	<ol style="list-style-type: none"> <li>1. Connect a fused jumper wire between the TP sensor 5-volt reference circuit and the TP sensor 1 signal circuit at the throttle body harness connector.</li> <li>2. Observe the TP sensor 1 voltage parameter with a scan tool. Does the scan tool indicate the TP sensor 1 voltage at the specified value?</li> </ol>	5 V	Go to Step 8	Go to Step 9
8	Probe the TP sensor low reference circuit with a test lamp connected to B+. Does the test lamp illuminate?	—	Go to Step 18	Go to Step 14
9	Measure the voltage of the TP sensor 1 5-volt reference circuit with a DMM. Does the DMM indicate voltage at the specified value?	5 V	Go to Step 11	Go to Step 10
10	Does the DMM indicate voltage less than the specified value on the TP sensor 1 5-volt reference circuit?	5 V	Go to Step 15	Go to Step 17
11	Test the TP sensor 1 signal circuit for an open or high resistance. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	Go to Step 13
12	Test the TP sensor 1 signal circuit for a short to voltage. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	Go to Step 20
13	Test the TP sensor 1 signal circuit for a short to ground. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	Go to Step 20
14	Test the TP sensor 1 low reference circuit for an open or high resistance. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	Go to Step 20
15	Test the TP sensor 1 5-volt reference circuit for an open or high resistance. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	Go to Step 16
16	Test the TP sensor 1 5-volt reference circuit for a short to ground. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	Go to Step 20
17	Test the TP sensor 1 5-volt reference circuit for a short to voltage. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	—
18	Test for an intermittent and for a poor connection at the throttle body. Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Connector Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	Go to Step 19
19	Replace the throttle body assembly. Refer to <i>Throttle Body Assembly Replacement</i> . Did you complete the replacement?	—	Go to Step 22	—
20	Test for an intermittent and for a poor connection at the engine control module (ECM). Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Connector Repairs</i> . Did you find and correct the condition?	—	Go to Step 22	Go to Step 21
21	Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?	—	Go to Step 22	—
22	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> <li>4. Operate the vehicle within the Conditions for Running the DTC. Did the DTC fail this ignition?</li> </ol>	—	Go to Step 2	Go to Step 23
23	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK



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### SPN 65604, FMI 2 ETC PPS 2 Range (Electronic Throttle Control, Pedal Position Sensor 2 Range)

#### Circuit Description

The pedal position (PP) sensors 1 and 2 are located within the throttle-shift control (T-SC) assembly. The engine control module (ECM) supplies each PP sensor with a 5-volt reference circuit and a low reference circuit. Each PP sensor has an individual signal circuit, which provides the ECM with a signal voltage that changes in proportion to the PP sensor (and T-SC lever) position. When the T-SC is in the locked-neutral (idle) position, the PP sensor position is zero percent. As the T-SC lever is moved away from the locked-neutral position, the PP sensor position increases.

At a PP sensor position of zero percent, PP sensor 1 signal voltage is near the low reference, and PP sensor 2 signal voltage is near the 5-volt reference. As the PP sensor position increases, PP sensor 1 signal voltage increases and PP sensor 2 signal voltage decreases.

If the ECM detects that PP sensor 2 signal voltage is not within the correct range, SPN 65604, FMI 2 sets. If the ECM detects that PP sensor 1 signal voltage is not within the correct range, SPN 65605M, FMI 2 sets.

#### DTC Descriptor

This diagnostic procedure supports the following DTC:

SPN 65604, FMI 2 ETC PPS 2 Range

#### Conditions for Running the DTC

- The ignition is ON.
- SPN 65581, SPN 65616 are not set.
- SPN 65604, FMI 2 runs continuously when the above conditions are met.

#### Conditions for Setting the DTC

- The ECM detects that the PP sensor 2 signal voltage is less than 0.2 volt.
- The ECM detects that the PP sensor 2 signal voltage is more than 4.8 volts.

## Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM commands the system to operate in the Reduced Engine Power mode.
- The ECM commands the throttle actuator to move the throttle plate to an idle position.
- The throttle actuator does not respond to input from the Throttle-Shift Control (T-SC).
- Under certain conditions the ECM commands the engine OFF.

## Conditions for Clearing the MIL/DTC

- The malfunction indicator lamp (MIL) will remain illuminated through the remainder of the ignition cycle. After turning the key off, the MIL will not illuminate on the next malfunction-free ignition cycle.
- An active DTC clears on the next ignition cycle that the diagnostic runs and passes.
- A history DTC clears after 25 consecutive run cycles, if no failures are reported by this diagnostic. Each run cycle must last a minimum of 10 seconds.
- Clear the history DTC with a scan tool.

## Diagnostic Aids

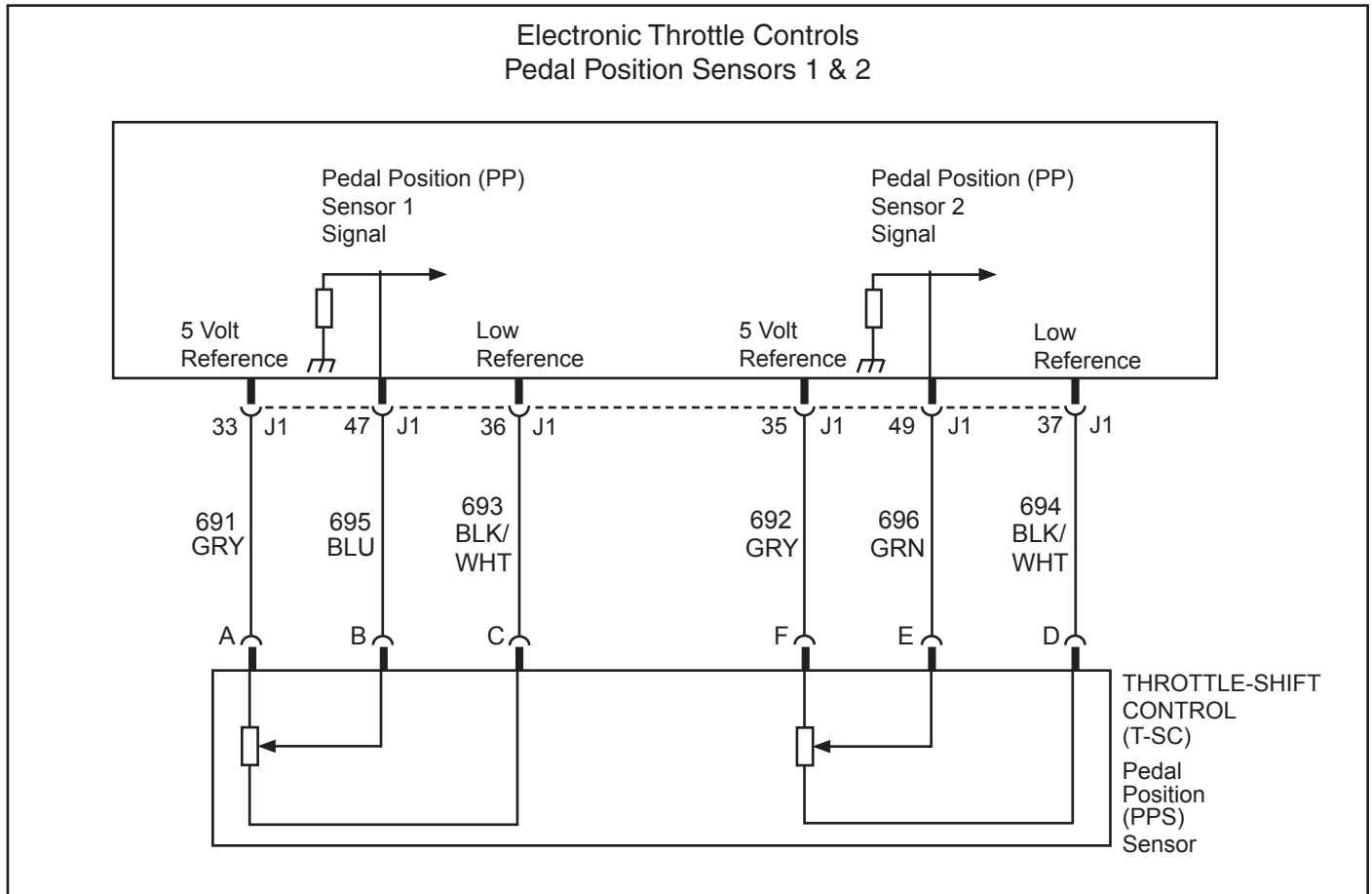
The numbers below refer to the step numbers in the diagnostic table.

**4.& 22.** More than one electronic throttle control (ETC) system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Keep this in mind when reviewing captured DTC info.

Step	Action	Values	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views</i> or <i>Engine Controls Component Views</i>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to <i>Diagnostic System Check</i>
2	1. Turn ON the ignition, with the engine OFF. 2. With a scan tool, observe the pedal position (PP) sensor 2 voltage with the throttle-shift control (T-SC) in neutral position. Does the scan tool indicate voltage less than the first value or greater than the second value?	0.2 V 4.8 V	Go to Step 5	Go to Step 3
3	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the engine within the Conditions for Running the DTC. Is SPN 65604, FMI 2 the only DTC set?	—	Go to Step 20	Go to Step 4
4	Are there any other DTCs set?	—	See Diagnostic Aids, Go to <i>Diagnostic Trouble Code (DTC) List</i> Continue to Step 5	Go to <i>Testing for Intermittent Conditions and Poor Connections</i>
5	1. Turn OFF the ignition. 2. Disconnect the throttle-shift control harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the PP Sensor 2 voltage parameter with a scan tool. Does the scan tool indicate voltage at the specified value?	0 V	Go to Step 6	Go to Step 11

6	<p>1. Connect a fused jumper wire between the PP sensor 2 5-volt reference circuit and the PP sensor 2 signal circuit at the throttle-shift control harness connector.</p> <p>2. Observe the PP sensor 2 voltage parameter with a scan tool. Does the scan tool indicate the PP sensor 2 voltage at the specified value?</p>	5 V	Go to Step 7	Go to Step 8
7	Probe the PP sensor 2 low reference circuit with a test lamp connected to B+. Does the test lamp illuminate?	—	Go to Step 17	Go to Step 13
8	Measure the voltage of the PP sensor 2 5-volt reference circuit with a DMM. Does the DMM indicate voltage at the specified value?	5 V	Go to Step 10	Go to Step 9
9	Does the DMM indicate voltage less than the specified value on the PP sensor 2 5-volt reference circuit?	5 V	Go to Step 14	Go to Step 16
10	Test the PP sensor 2 signal circuit for an open or high resistance. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	Go to Step 12
11	Test the PP sensor 2 signal circuit for a short to voltage. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	Go to Step 19
12	Test the PP sensor 2 signal circuit for a short to ground. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	Go to Step 19
13	Test the PP sensor 2 low reference circuit for an open or high resistance. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	Go to Step 19
14	Test the PP sensor 2 5-volt reference circuit for an open or high resistance. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	Go to Step 15
15	Test the PP sensor 2 5-volt reference circuit for a short to ground. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	Go to Step 19
16	Test the PP sensor 2 5-volt reference circuit for a short to voltage. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	—
17	Inspect for poor connections at the throttle-shift control harness connector. Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Connector Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	Go to Step 18
18	Replace the throttle-shift control (T-SC) assembly. Did you complete the replacement?	—	Go to Step 21	—
19	Inspect for poor connections at the engine control module (ECM) harness connector. Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Connector Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	Go to Step 20
20	Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?	—	Go to Step 21	—
21	<p>1. Clear the DTCs with a scan tool.</p> <p>2. Turn OFF the ignition for 30 seconds.</p> <p>3. Start the engine.</p> <p>4. Operate the engine within the Conditions for Running the DTC. Did the DTC fail this ignition?</p>	—	Go to Step 2	Go to Step 22
22	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	—	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK

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### SPN 65605, FMI 2 ETC PPS 1 Range (Electronic Throttle Control, Pedal Position Sensor 1 Range)

#### Circuit Description

The pedal position (PP) sensors 1 and 2 are located within the throttle-shift control (T-SC) assembly. The engine control module (ECM) supplies each PP sensor with a 5-volt reference circuit and a low reference circuit. Each PP sensor has an individual signal circuit, which provides the ECM with a signal voltage that changes in proportion to the PP sensor (and T-SC lever) position. When the T-SC is in the locked-neutral (idle) position, the PP sensor position is zero percent. As the T-SC lever is moved away from the locked-neutral position, the PP sensor position increases.

At a PP sensor position of zero percent, PP sensor 1 signal voltage is near the low reference, and PP sensor 2 signal voltage is near the 5-volt reference. As the PP sensor position increases, PP sensor 1 signal voltage increases and PP sensor 2 signal voltage decreases.

If the ECM detects that PP sensor 1 signal voltage is not within the correct range, SPN 65605, FMI 2 sets. If the ECM detects that PP sensor 2 signal voltage is not within the correct range, SPN 65604, FMI 2 sets.

#### DTC Descriptor

This diagnostic procedure supports the following DTC:

SPN 65605, FMI 2 ETC PPS 1 Range

#### Conditions for Running the DTC

- The ignition is ON.
- SPN 65581, SPN 65616 are not set.
- SPN 65605, FMI 2 runs continuously when the above conditions are met.

#### Conditions for Setting the DTC

- The ECM detects that the PP sensor 1 signal voltage is less than 0.2 volt.
- The ECM detects that the PP sensor 1 signal voltage is more than 4.8 volts.

## Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM commands the system to operate in the Reduced Engine Power mode.
- The ECM commands the throttle actuator to move the throttle plate to an idle position.
- The throttle actuator does not respond to input from the Throttle-Shift Control (T-SC).
- Under certain conditions the ECM commands the engine OFF.

## Conditions for Clearing the MIL/DTC

- The malfunction indicator lamp (MIL) will remain illuminated through the remainder of the ignition cycle. After turning the key off, the MIL will not illuminate on the next malfunction-free ignition cycle.
- An active DTC clears on the next ignition cycle that the diagnostic runs and passes.
- A history DTC clears after 25 consecutive run cycles, if no failures are reported by this diagnostic. Each run cycle must last a minimum of 10 seconds.
- Clear the history DTC with a scan tool.

## Diagnostic Aids

The numbers below refer to the step numbers in the diagnostic table.

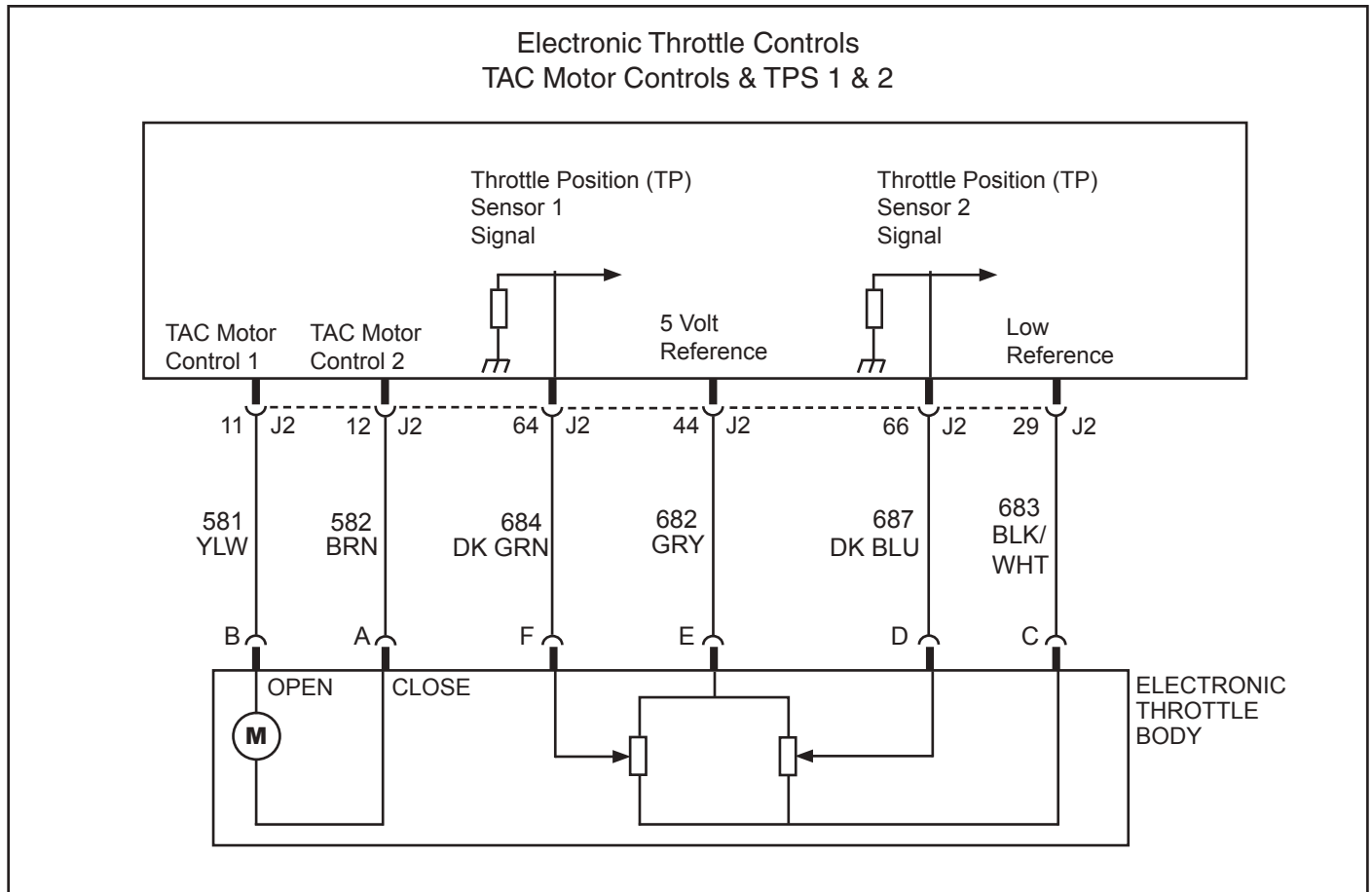
**4.& 22.** More than one electronic throttle control (ETC) system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Keep this in mind when reviewing captured DTC info.

Step	Action	Values	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views</i> or <i>Engine Controls Component Views</i>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to <i>Diagnostic System Check</i>
2	1. Turn ON the ignition, with the engine OFF. 2. With a scan tool, observe the pedal position (PP) sensor 1 voltage with the throttle-shift control (T-SC) in neutral position. Does the scan tool indicate voltage less than the first value or greater than the second value?	0.2 V 4.8 V	Go to Step 5	Go to Step 3
3	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the engine within the Conditions for Running the DTC. Is SPN 65605, FMI 2 the only DTC set?	—	Go to Step 20	Go to Step 4
4	Are there any other DTCs set?	—	See Diagnostic Aids, Go to <i>Diagnostic Trouble Code (DTC) List</i> Continue to Step 5	Go to <i>Testing for Intermittent Conditions and Poor Connections</i>
5	1. Turn OFF the ignition. 2. Disconnect the throttle-shift control harness connector. 3. Turn ON the ignition, with the engine OFF. 4. Observe the PP Sensor 1 voltage parameter with a scan tool. Does the scan tool indicate voltage at the specified value?	0 V	Go to Step 6	Go to Step 11
6	1. Connect a fused jumper wire between the PP sensor 1 5-volt reference circuit and the PP sensor 1 signal circuit at the throttle-shift control harness connector. 2. Observe the PP sensor 1 voltage parameter with a scan tool. Does the scan tool indicate the PP sensor 1 voltage at the specified value?	5 V	Go to Step 7	Go to Step 8

7	Probe the PP sensor 1 low reference circuit with a test lamp connected to B+. Does the test lamp illuminate?	—	Go to Step 17	Go to Step 13
8	Measure the voltage of the PP sensor 1 5-volt reference circuit with a DMM. Does the DMM indicate voltage at the specified value?	5 V	Go to Step 10	Go to Step 9
9	Does the DMM indicate voltage less than the specified value on the PP sensor 1 5-volt reference circuit?	5 V	Go to Step 14	Go to Step 16
10	Test the PP sensor 1 signal circuit for an open or high resistance. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	Go to Step 12
11	Test the PP sensor 1 signal circuit for a short to voltage. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	Go to Step 19
12	Test the PP sensor 1 signal circuit for a short to ground. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	Go to Step 19
13	Test the PP sensor 1 low reference circuit for an open or high resistance. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	Go to Step 19
14	Test the PP sensor 1 5-volt reference circuit for an open or high resistance. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	Go to Step 15
15	Test the PP sensor 1 5-volt reference circuit for a short to ground. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	Go to Step 19
16	Test the PP sensor 1 5-volt reference circuit for a short to voltage. Refer to <i>Circuit Testing and Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	—
17	Inspect for poor connections at the throttle-shift control harness connector. Refer to <i>Testing for Intermittent Conditions and Poor Connections and Connector Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	Go to Step 18
18	Replace the throttle-shift control (T-SC) assembly. Did you complete the replacement?	—	Go to Step 21	—
19	Inspect for poor connections at the engine control module (ECM) harness connector. Refer to <i>Testing for Intermittent Conditions and Poor Connections and Connector Repairs</i> . Did you find and correct the condition?	—	Go to Step 21	Go to Step 20
20	Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?	—	Go to Step 21	—
21	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> <li>4. Operate the engine within the Conditions for Running the DTC.</li> </ol> Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 22
22	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	—	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK



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## Diagnostic Information and Procedures

### SPN 65610, FMI 2 ETC TPS 1-2 CORRELATION (Electronic Throttle Control, Throttle Position Sensor 1-2 Correlation)

#### Circuit Description

The throttle position (TP) sensors 1 and 2 are located within the throttle body assembly. The ECM supplies the TP sensors with a common 5-volt reference circuit and a common low reference circuit. Each TP sensor has an individual signal circuit, which provides the ECM with a signal voltage that changes in proportion to the throttle plate angle. When the throttle plate is in the closed position, TP sensor 1 signal voltage is near the low reference and TP sensor 2 signal voltage is near the 5-volt reference. As the throttle is opened, TP sensor 1 signal voltage increases and TP sensor 2 signal voltage decreases.

If the ECM detects that the TP sensor voltages are not within a predicted value from each other, SPN 65610, FMI 2 sets.

#### DTC Descriptor

This diagnostic procedure supports the following DTC:

SPN 65610, FMI 2 ETC TPS 1-2 Correlation

#### Conditions for Running the DTC

- The ignition is ON, with the engine OFF, or the engine is operating.
- SPN 65610, FMI 2 runs continuously once the above condition is met.

#### Conditions for Setting the DTC

The ECM detects that the difference between TP sensor 1 voltage and TP sensor 2 voltage is more than the predicted value.

## Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM commands the system to operate in the Reduced Engine Power mode.
- The ECM commands the throttle actuator to move the throttle plate to an idle position.
- The throttle actuator does not respond to input from the Throttle-Shift Control (T-SC).
- Under certain conditions the control module commands the engine OFF.

## Conditions for Clearing the MIL/DTC

- The malfunction indicator lamp (MIL) will remain illuminated through the remainder of the ignition cycle. After turning the key off, the MIL will not illuminate on the next malfunction-free ignition cycle.
- An active DTC clears on the next ignition cycle that the diagnostic runs and passes.
- A history DTC clears after 25 consecutive run cycles, if no failures are reported by this diagnostic. Each run cycle must last a minimum of 10 seconds.
- Clear the history DTC with a scan tool.

## Diagnostic Aids

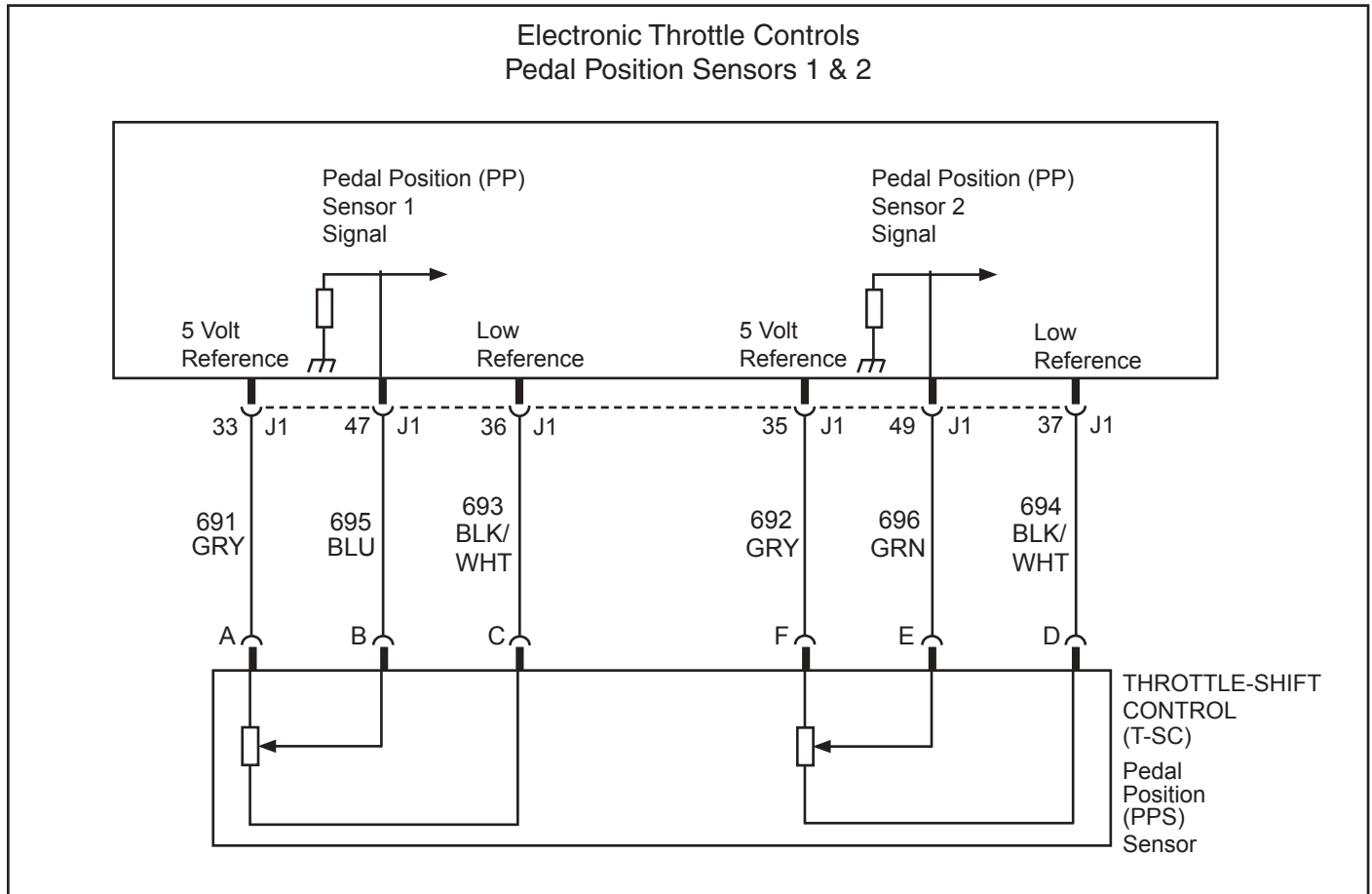
The numbers below refer to the step numbers in the diagnostic table.

**2.& 10.** More than one electronic throttle control (ETC) system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Keep this in mind when reviewing captured DTC info.

Step	Action	Value(s)	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views</i> or <i>Engine Controls Connector End Views</i>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to <i>Diagnostic System Check</i>
2	Observe the DTC information with a scan tool. Is SPN 65601 or 65602 also set?	—	See Diagnostic Aids, Go to <i>Diagnostic Trouble Code (DTC) List</i> Continue to Step 3	Go to Step 3
3	<ol style="list-style-type: none"> <li>1. Turn OFF the ignition.</li> <li>2. Disconnect the throttle position (TP) sensor electrical connector.</li> <li>3. Disconnect the engine control module (ECM). Refer to <i>Engine Control Module (ECM) Replacement</i>.</li> <li>4. Measure the resistance of the following circuits with a DMM for each of the TP sensors: <ul style="list-style-type: none"> <li>• The low reference circuit</li> <li>• The TP sensor signal circuit</li> <li>• The 5-volt reference circuit</li> </ul> </li> </ol> Is the resistance more than the specified value for any circuit?	5 Ω	Go to Step 7	Go to Step 4
4	Test the signal circuit of the TP sensor 1 for a short to the signal circuit of TP sensor 2. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 9	Go to Step 5
5	Test for an intermittent and for a poor connection at the TP sensor. Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Connector Repairs</i> . Did you find and correct the condition?	—	Go to Step 9	Go to Step 6

6	Test for an intermittent and for a poor connection at the ECM. Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Connector Repairs</i> . Did you find and correct the condition?	—	Go to Step 9	Go to Step 8
7	Repair the high resistance in the circuit that measured above the specified value. Refer to <i>Wiring Repairs</i> . Did you complete the repair?	—	Go to Step 9	—
8	Replace the throttle body assembly. Refer to <i>Throttle Body Removal</i> . Did you complete the replacement?	—	Go to Step 9	—
9	<ol style="list-style-type: none"> <li>1. Reconnect the TP sensor and the ECM.</li> <li>2. Clear the DTCs with a scan tool.</li> <li>3. Turn OFF the ignition for 30 seconds.</li> <li>4. Start the engine.</li> <li>5. Operate the engine within the Conditions for Running the DTC.</li> </ol> Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 10
10	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	—	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK

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### SPN 65613, FMI 2 ETC PPS 1-2 Correlation (Electronic Throttle Control, Pedal Position Sensor 1-2 Correlation)

#### Circuit Description

The pedal position (PP) sensors 1 and 2 are located within the throttle-shift control (T-SC) assembly. The engine control module (ECM) supplies each PP sensor with a 5-volt reference circuit and a low reference circuit. Each PP sensor has an individual signal circuit, which provides the ECM with a signal voltage that changes in proportion to the PP sensor (and T-SC lever) position. When the T-SC is in the locked-neutral (idle) position, the PP sensor position is zero percent. As the T-SC lever is moved away from the locked-neutral position, the PP sensor position increases.

At a PP sensor position of zero percent, PP sensor 1 signal voltage is near the low reference, and PP sensor 2 signal voltage is near the 5-volt reference. As the PP sensor position increases, PP sensor 1 signal voltage increases and PP sensor 2 signal voltage decreases.

If the ECM detects that the PP sensor voltages are not within a predicted value from each other, SPN 65613, FMI 2 sets.

#### DTC Descriptor

This diagnostic procedure supports the following DTC:

SPN 65613, FMI 2 ETC PPS 1-2 Correlation

#### Conditions for Running the DTC

- SPN 65581 is not set.
- The ignition is ON.
- SPN 65613, FMI 2 runs continuously once the above conditions are met.

#### Conditions for Setting the DTC

The ECM detects that the PP sensor voltages are not within a predicted value from each other.

## Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM commands the system to operate in the Reduced Engine Power mode.
- The ECM commands the throttle actuator to move the throttle plate to an idle position.
- The throttle actuator does not respond to input from the Throttle-Shift Control (T-SC).
- Under certain conditions the ECM commands the engine OFF.

## Conditions for Clearing the MIL/DTC

- The malfunction indicator lamp (MIL) will remain illuminated through the remainder of the ignition cycle. After turning the key off, the MIL will not illuminate on the next malfunction-free ignition cycle.
- An active DTC clears on the next ignition cycle that the diagnostic runs and passes.
- A history DTC clears after 25 consecutive run cycles, if no failures are reported by this diagnostic. Each run cycle must last a minimum of 10 seconds.
- Clear the history DTC with a scan tool.

## Diagnostic Aids

The numbers below refer to the step numbers in the diagnostic table.

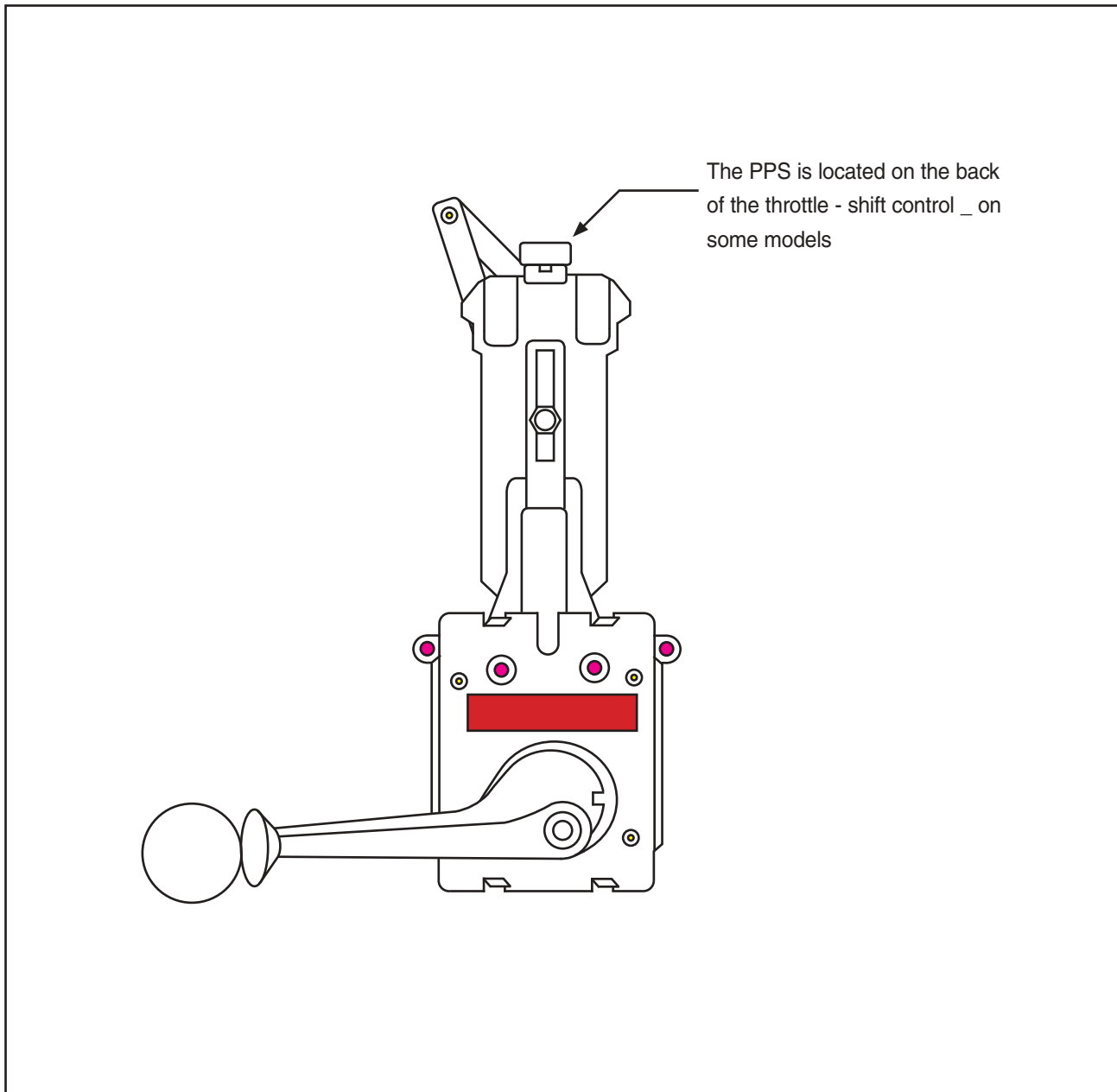
**2.& 10.** More than one electronic throttle control (ETC) system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Keep this in mind when reviewing captured DTC info.

Step	Action	Values	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views or Engine Controls Connector End Views</i>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to Diagnostic System Check
2	Observe the DTC information with a scan tool. Are there any other DTCs set?	—	See Diagnostic Aids, Go to Diagnostic Trouble Code (DTC) List Continue to Step 3	Go to Step 3
3	<ol style="list-style-type: none"> <li>1. Turn OFF the ignition.</li> <li>2. Disconnect the pedal position (PP) sensor electrical connector.</li> <li>3. Disconnect the engine control module (ECM). Refer to <i>Engine Control Module (ECM) Replacement</i>.</li> <li>4. Measure the resistance of the following circuits with a DMM for each of the PP sensors: <ul style="list-style-type: none"> <li>• The low reference circuits</li> <li>• The signal circuits</li> <li>• The 5-volt reference circuits</li> </ul> </li> </ol> Is the resistance more than the specified value for any circuit?	5 Ω	Go to Step 7	Go to Step 4
4	Test the signal circuit of PP sensor 1 for a short to the signal circuit of the PP sensor 2. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	—	Go to Step 9	Go to Step 5
5	Test for an intermittent and for a poor connection at the PP sensor. Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Connector Repairs</i> . Did you find and correct the condition?	—	Go to Step 9	Go to Step 6

6	Test for an intermittent and for a poor connection at the ECM. Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Connector Repairs</i> . Did you find and correct the condition?	—	Go to Step 9	Go to Step 8
7	Repair the high resistance in the circuit that measured above the specified value. Refer to <i>Wiring Repairs</i> . Did you complete the repair?	—	Go to Step 9	—
8	Replace the throttle-shift control (T-SC) assembly. Did you complete the replacement?	—	Go to Step 9	—
9	<ol style="list-style-type: none"> <li>1. Reconnect the PP sensor and the ECM.</li> <li>2. Clear the DTCs with a scan tool.</li> <li>3. Turn OFF the ignition for 30 seconds.</li> <li>4. Start the engine.</li> <li>5. Operate the engine within the Conditions for Running the DTC.</li> </ol> Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 10
10	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	—	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK



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### PPS - Re - Alignment Prodedure

If the PPS becomes mis-aligned the following DTCs will set.

SPN 65604 FMI 2 PPS 2 Out of Range  
 SPN 65605 FMI 2 PPS 1 Out of Range

### Diagnostic Aids

- The Pedal Position Sensor may become out of calibrated position. If this should occur use the following procedure to re-align it.

Over a period of time the throttle-shift control can develop wear and as a result the PPS can become out of alignment.

**Note:**

There are two limits, one is Out of Range High, the other is Out of Range Low.

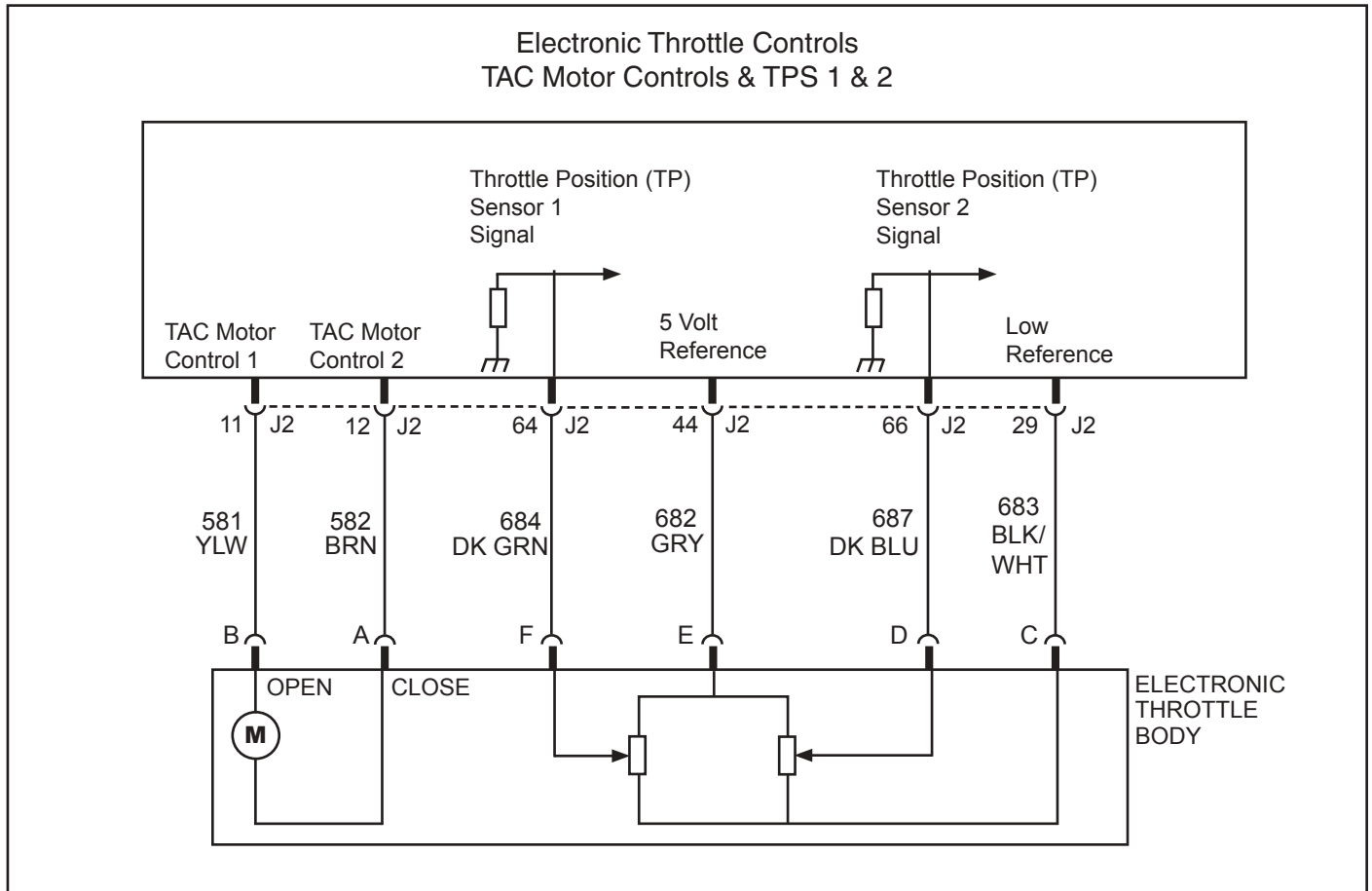
The sensor cannot be calibrated while DTCs are set. Therefore, it will be necessary to start high and work down.

**Tools Required**

- Laptop with diagnostic program.

**PPS - Re - Alignment Procedure**

Step	Action	Value	Yes	No
<b>1</b>	<p>Determine if PPS is mis-aligned high.</p> <ol style="list-style-type: none"> <li>1. Push the throttle-shift control forward slowly until it is close to WOT.</li> <li>2. Then advance it the rest of the way to WOT.</li> </ol> <p>Does the throttle blade move normally until it reaches WOT?</p>		<p>PPS is Out of Range High Go to Step 3</p>	Go to Step 2
<b>2</b>	<p>Determine if PPS is mis-aligned low.</p> <ol style="list-style-type: none"> <li>1. Using the warm up mode, advance the throttle-shift control beyond neutral.</li> <li>2. Turn ignition ON.</li> <li>3. Slowly return the throttle-shift control to neutral.</li> </ol> <p>Does the throttle blade move normally until it reaches neutral?</p>		<p>PPS is Out of Range Low Go to Step 3</p>	
<b>3</b>	<p>Note: Be sure to start high and work low. See Note at top of page for explanation.</p> <ol style="list-style-type: none"> <li>1. Rotate the sensor and cycle the ignition.</li> <li>2. Using the scan tool, check for codes.</li> <li>3. If codes are still active, rotate the sensor a few more degrees and cycle the ignition.</li> </ol> <p>Are the codes still active?</p>		Repeat Step 3	Go to Step 4
<b>4</b>	<p>Calibrate the PPS.</p> <ol style="list-style-type: none"> <li>1. Locate the Pedal Position Sensors 1 &amp; 2 voltage display in the Diacom menu.</li> <li>2. Use Diacom to observe the Pedal Position voltage.</li> <li>3. Rotate the PPS until Diacom reads 0.98–1volts for PPS 1 and 3.95–4.02 volts for PPS 2.</li> <li>4. Re-tighten the fastening screws.</li> </ol> <p>Did you complete the procedure?</p>			Verify Repair



### SPN 65615, FMI 7 ETC Actuation (Electronic Throttle Control Actuation)

#### Circuit Description

The commanded throttle position is compared to the actual throttle position. The commanded throttle position is based on input from the Pedal Position (PP) sensors 1 and 2 in the Throttle-Shift Control (T-SC) housing. Actual throttle position is detected by the Throttle Position (TP) sensors 1 and 2 in the throttle body. The commanded and actual throttle positions should be within a calibrated range of each other. The engine control module (ECM) continuously monitors the commanded and actual throttle positions. This DTC sets if the commanded and actual positions differ by more than the allowable range.

#### DTC Descriptor

This diagnostic procedure supports the following DTC:  
SPN 65615, FMI 7 ETC Actuation

#### Conditions for Running the DTC

- The ignition is ON.
- The engine is running, OR  
the engine is not running, and less than 10 seconds have passed since the key was turned on, OR  
the engine is not running, and the T-SC has been in the locked-neutral (idle) position for less than 10 seconds.
- SPN 65618, FMI 7 ETC Return Fault is not set.

#### Conditions for Setting the DTC

The difference between the commanded and the actual throttle position is more than a calibrated amount.

NOTE: This DTC will not set if all of the following conditions are present: The throttle actuator motor circuit is OPEN, the ignition is on, the throttle plate is in the spring loaded rest position, the Throttle-Shift Control (T-SC) is in the locked-neutral (idle) position, and the engine is not started. The code will set if the engine is then started, or if the T-SC is moved, or if the throttle plate is moved within 10 seconds of turning the ignition on.

### Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM commands the system to operate in the Reduced Engine Power mode.
- The throttle plate is allowed to return to the rest position, as determined by the springs in the throttle body.
- The throttle actuator does not respond to input from the Throttle-Shift Control (T-SC).
- Under certain conditions the control module commands the engine OFF.

### Conditions for Clearing the MIL/DTC

- The malfunction indicator lamp (MIL) will remain illuminated through the remainder of the ignition cycle. After turning the key off, the MIL will not illuminate on the next malfunction-free ignition cycle. See Note above, in Conditions for Setting the DTC.
- An active DTC clears on the next ignition cycle that the diagnostic runs and passes. See Note above, in Conditions for setting the DTC.
- A history DTC clears after 25 consecutive run cycles, if no failures are reported by this diagnostic. Each run cycle must last a minimum of 10 seconds.
- Clear the history DTC with a scan tool.

### Diagnostic Aids

The throttle plate is spring loaded to a slightly open position. The throttle plate should be open approximately 20–25 percent. This is referred to as the rest position. The throttle plate should not be completely closed nor should it be open any more than the specified amount. The throttle plate should move open and to the closed position without binding under the normal spring pressure. The throttle should NOT be free to move open or closed WITHOUT spring pressure. Replace the throttle body if any of these conditions are found.

Inspect for mechanical conditions or binding that may be temperature related. Components may not move freely in extreme heat or cold due to the presence of contaminants or ice formation.

**Important:** Operating the throttle plate with the Throttle Blade Control function of the scan tool may cause additional DTCs to set. Do not attempt to diagnose DTCs set during this function.

The scan tool has the ability to operate the throttle control system using special functions. Actuate the throttle plate using the Throttle Blade Control function of the scan tool. This function will operate the throttle plate through the entire range in order to determine if the throttle body and system operate correctly.

Check for the following conditions:

- Use the *J 35616* Connector Test Adapter Kit for any test that requires probing the engine control module (ECM) harness connector or a component harness connector.
- Poor connections at the ECM or at the component—Inspect the harness connectors for a poor terminal to wire connection. Refer to *Testing for Intermittent Conditions and Poor Connections* for the proper procedure.
- For intermittent, refer to *Testing for Intermittent Conditions and Poor Connections*.

The numbers below refer to the step numbers in the diagnostic table.

**2.& 20.** More than one electronic throttle control (ETC) system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Keep this in mind when reviewing captured DTC info.

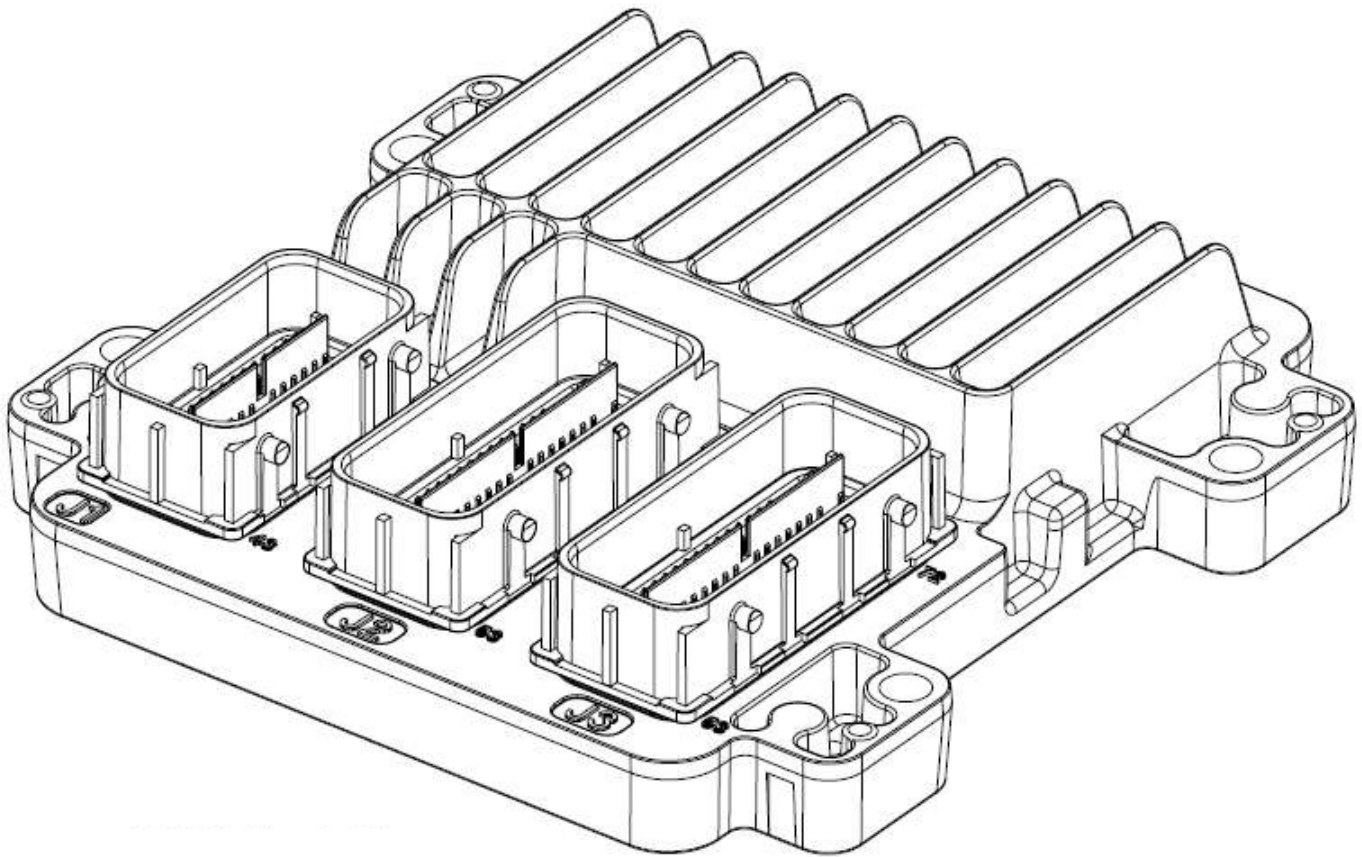
### Test Description

The numbers below refer to the step numbers in the diagnostic table.

**8.& 9.** When the ignition is turned ON, the ECM operates the Throttle Actuator Control (TAC) motor to verify the integrity of the system prior to start-up. This can be seen by the momentary flash of the test lamp as the ignition is turned ON.

Step	Action	Values	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Controls Connector End Views</i> or <i>Engine Control Module (ECM) Connector End Views</i>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to <i>Diagnostic System Check</i>
2	Is SPN 65601, 65602, 65604, 65605, 65610, or 65613 also set?	—	See Diagnostic Aids, Go to <i>Diagnostic Trouble Code (DTC) List</i>	Go to Step 3
3	<ol style="list-style-type: none"> <li>Turn ON the ignition, with the engine OFF.</li> <li>Observe the throttle position (TP) angle parameter (visually or using a scan tool).</li> <li>Move the throttle-shift control (T-SC) away from neutral (idle), and back to neutral (idle) several times.</li> </ol> Does the TP angle parameter increase as the throttle-shift control (T-SC) is moved away from neutral (idle) and decrease as the T-SC is returned to neutral (idle)?	—	Go to Step 4	Go to Step 5
4	<ol style="list-style-type: none"> <li>Observe the Conditions for Running this DTC.</li> <li>Start the engine.</li> <li>Operate the engine within the Conditions for Running the DTC.</li> </ol> Did the DTC fail this ignition?	—	Go to Step 5	Go to Diagnostic Aids
5	<ol style="list-style-type: none"> <li>Turn OFF the ignition.</li> <li>Refer to Diagnostic Aids, and inspect the throttle body for the following conditions:               <ul style="list-style-type: none"> <li>A throttle plate that is NOT in the rest position</li> <li>A throttle plate that is binding open or closed</li> <li>A throttle plate that is free to move open or closed WITHOUT spring pressure</li> </ul> </li> </ol> Did you find any of these conditions with the throttle body?	—	Go to Step 17	Go to Step 6
6	<b>Important:</b> The test lamp may momentarily flash when testing these circuits. This is considered normal. <ol style="list-style-type: none"> <li>Disconnect the throttle body harness connector.</li> <li>Turn ON the ignition, with the engine OFF.</li> <li>Probe the throttle actuator control (TAC) motor circuits (1 and 2) of the throttle body harness connector with a test lamp that is connected to ground.</li> </ol> Did the test lamp illuminate and remain illuminated on either circuit?	—	Go to Step 10	Go to Step 7
7	<b>Important:</b> The test lamp may momentarily flash when testing these circuits. This is considered normal.           Probe the TAC motor circuits 1 and 2 of the throttle body harness connector with the test lamp connected to battery positive.           Did the test lamp illuminate and remain illuminated on either circuit?	—	Go to Step 11	Go to Step 8
8	<ol style="list-style-type: none"> <li>Turn OFF the ignition.</li> <li>Connect the test lamp between the TAC motor circuit 1 of the throttle body harness connector and battery ground.</li> </ol> <b>Important:</b> Ensure that the ECM completely powers down. This can be verified by loss of communication with the scan tool. <ol style="list-style-type: none"> <li>Observe the test lamp as you turn ON the ignition.</li> </ol> Does the test lamp flash ON and then turn OFF?	—	Go to Step 9	Go to Step 12
9	<ol style="list-style-type: none"> <li>Turn OFF the ignition.</li> <li>Connect a test lamp between the TAC motor circuit 2 of the throttle body harness connector and battery ground.</li> </ol> <b>Important:</b> Ensure that the ECM completely powers down. This can be verified by loss of communication with the scan tool. <ol style="list-style-type: none"> <li>Observe the test lamp as you turn ON the ignition.</li> </ol> Does the test lamp flash ON and then OFF?	—	Go to Step 13	Go to Step 12

10	<ol style="list-style-type: none"> <li>1. Turn OFF the ignition.</li> <li>2. Disconnect the ECM connector (J2) that contains the TAC motor circuits.</li> <li>3. Turn ON the ignition, with the engine OFF.</li> <li>4. Probe the TAC motor circuits 1 and 2 with the test lamp connected to ground.</li> </ol> Does the test lamp illuminate?	—	Go to Step 15	Go to Step 18
11	<ol style="list-style-type: none"> <li>1. Turn OFF the ignition.</li> <li>2. Disconnect the ECM connector (J2) that contains the TAC motor circuits.</li> <li>3. Probe the TAC motor circuits 1 and 2 with the test lamp connected to battery positive.</li> </ol> Does the test lamp illuminate?	—	Go to Step 16	Go to Step 18
12	<ol style="list-style-type: none"> <li>1. Turn OFF the ignition.</li> <li>2. Disconnect the ECM connector (J2) that contains the TAC motor circuits.</li> <li>3. Test the TAC motor circuits 1 and 2 for an open or high resistance.</li> <li>4. Repair the circuit as necessary. Refer to <i>Wiring Repairs</i>.</li> </ol> Did you find and correct the condition?	—	Go to Step 19	Go to Step 14
13	Test for a poor connection or terminal tension at the throttle body connector. Refer to <i>Testing for Intermittent Conditions and Poor Connections and Connector Repairs</i> . Did you find and correct the condition?	—	Go to Step 19	Go to Step 17
14	Test for a poor connection or terminal tension at the ECM. Refer to <i>Testing for Intermittent Conditions and Poor Connections and Connector Repairs</i> . Did you find and correct the condition?	—	Go to Step 19	Go to Step 18
15	Repair the short to voltage on the circuit where the test lamp remained illuminated. Refer to <i>Wiring Repairs</i> . Did you complete the repair?	—	Go to Step 19	—
16	Repair the short to ground on the circuit where the test lamp remained illuminated. Refer to <i>Wiring Repairs</i> . Did you complete the repair?	—	Go to Step 19	—
17	Replace the throttle body assembly. Refer to <i>Throttle Body Assembly Replacement</i> . Did you complete the replacement?	—	Go to Step 19	—
18	Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?	—	Go to Step 19	—
19	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> <li>4. Operate the engine within the Conditions for Running the DTC.</li> </ol> Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 20
20	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	—	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK



## Diagnostic Information and Procedures

### SPN 65616, FMI 12 ETC Process (Electronic Throttle Control Process)

#### Circuit Description

The throttle actuator control (TAC) system uses two pedal position (PP) sensors to monitor the pedal position. Two processors are also used to monitor the TAC system data. The engine control module (ECM) performs an intrusive test in order to detect that the PP signals are not shorted together. The ECM accomplishes this by pulling the PP sensor 2 low momentarily and looking for sensor 1 to also be low. The TAC system also performs this test on the throttle position (TP) sensors. This diagnostic monitors the transistor used to pull one pedal and one throttle sensor to ground simultaneously. Additionally, both processors monitor each other's data to verify that the indicated PP calculation is correct. If the transistor does not toggle within a calibrated period, or the indicated PP calculation is incorrect, SPN 65616, FMI 12 sets.

#### DTC Descriptor

This diagnostic procedure supports the following DTC:

*SPN 65616, FMI 12 ETC Process (Control Module Pedal Position (PP) System Performance)*

#### Conditions for Running the DTC

- The system voltage is more than 5.23 volts.
- The ignition switch is in the Run or the Crank position.
- SPN 65580, 65581 are not set.
- SPN 65616 runs continuously when the above conditions are met.



## Conditions for Setting the DTC

- The PP sensor 2 voltage is more than 2.05 volts for more than 0.3 second during the intrusive test.
- OR
- The PP sensor calculations in the main processor differ from the motor control processor by more than 5 percent.

## Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails.
- The control module commands the TAC system to operate in the Reduced Engine Power mode.
- Under certain conditions the control module commands the engine OFF.

## Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

## Test Description

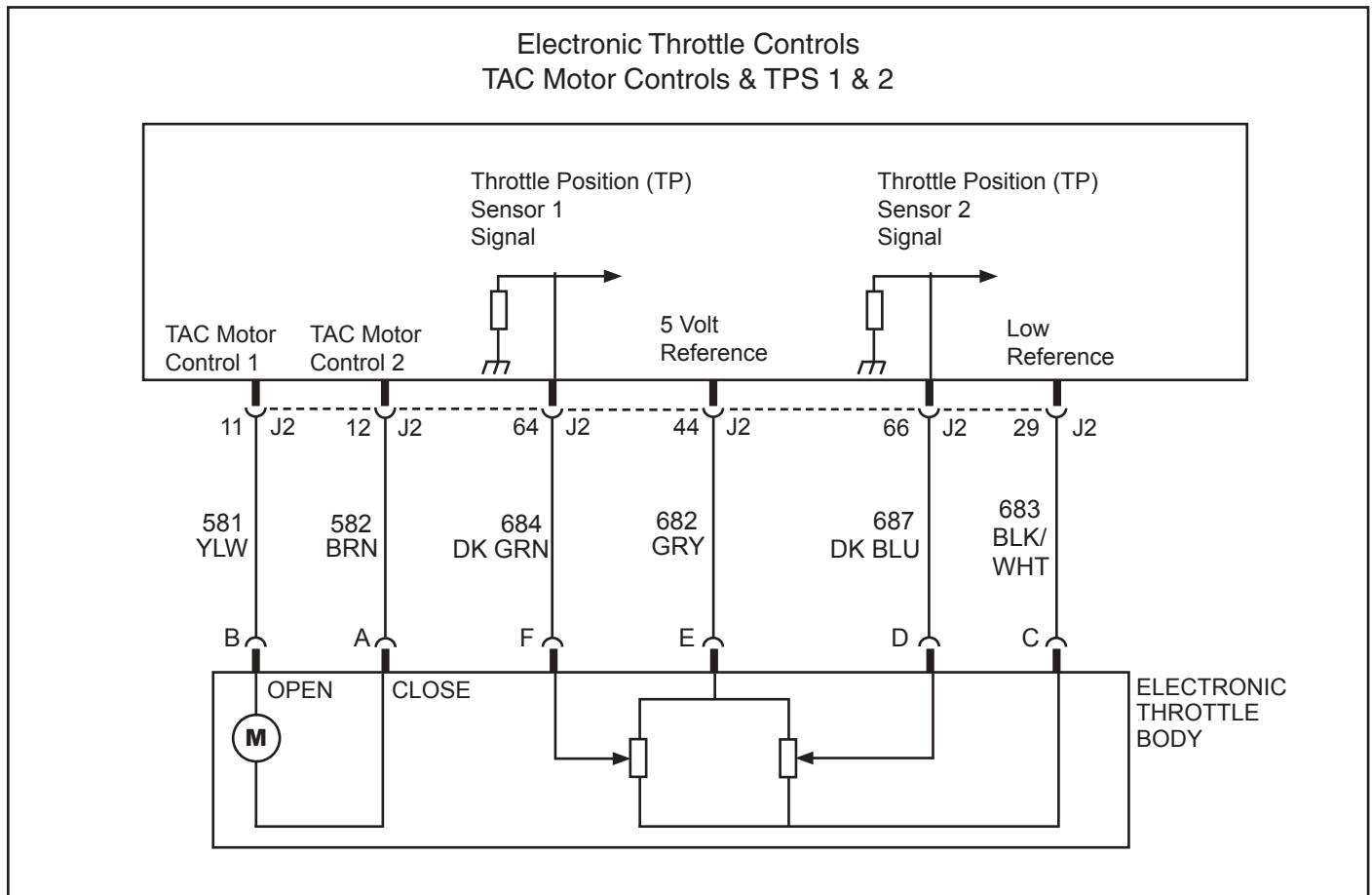
The numbers below refer to the step numbers on the diagnostic table.

2. A SPN 65616, FMI 12 indicates that the ECM is not programmed.
5. Resistance is measured at the pedal assembly because a pedal resistance that is lower than the specified value will set this DTC.

Step	Action	Values	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i>				
<b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views or Engine Controls Connector End Views</i>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to Diagnostic System Check
2	Is SPN 65616 set?	—	Go to Step 3	Go to Step 5
3	Program the engine control module (ECM). Refer to <i>Service Programming System (SPS)</i> . Does SPN 65616 reset?	—	Go to Step 4	Go to Step 8
4	1. Ensure that all tool connections are secure. 2. Ensure that the programming equipment is operating correctly. 3. Ensure that the correct software/calibration package is used. 4. Attempt to program the ECM. Refer to <i>Service Programming System (SPS)</i> . Does DTC P0602 reset?	—	Go to Step 7	Go to Step 8
5	1. Turn OFF the ignition. 2. Disconnect the throttle-shift control connector. 3. Ensure that the throttle-shift control is at the neutral position. 4. Measure the resistance from the 5-volt reference of the pedal position to the pedal position (PP) sensor 2 signal of the throttle-shift control assembly with a DMM. Refer to <i>Circuit Testing</i> . Is the resistance less than the specified value?	300 Ω	Go to Step 6	Go to Step 7
6	Replace the throttle-shift control (T-SC) assembly. Did you complete the replacement?	—	Go to Step 8	—

7	Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?	—	Go to Step 8	—
8	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> </ol> Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 9
9	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	—	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK

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## Diagnostic Information and Procedures

### SPN 65618, FMI 7 ETC Return Fault (Electronic Throttle Control Return Fault)

#### Circuit Description

When the key is turned on, prior to starting the engine, the engine control module (ECM) determines if the throttle plate has returned to the correct spring-loaded rest position. The throttle position (TP) sensors provide this information to the ECM. If the ECM detects that the throttle plate is not at the correct position, this DTC is set.

#### DTC Descriptor

This diagnostic procedure supports the following DTC:  
SPN 65618, FMI 7 ETC Return Fault

#### Conditions for Running the DTC

- The ignition is ON, and the engine is OFF.
- The ignition voltage is more than 10 volts.
- SPN 65618 runs once when the above conditions are met.

#### Conditions for Setting the DTC

- The ECM detects that the throttle plate is not in the rest position.

#### Action Taken When the DTC Sets

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The ECM commands the system to operate in the Reduced Engine Power mode.
- When the engine is started, the ECM commands the throttle actuator to move the throttle plate to an idle position. (Note that this may not occur if there is an obstruction.)
- The throttle actuator does not respond to input from the Throttle-Shift Control (T-SC).

## Conditions for Clearing the MIL/DTC

- The malfunction indicator lamp (MIL) will remain illuminated through the remainder of the ignition cycle. After turning the key off, the MIL will not illuminate on the next malfunction-free ignition cycle.
- An active DTC clears on the next ignition cycle that the diagnostic runs and passes.
- A history DTC clears after 25 consecutive run cycles, if no failures are reported by this diagnostic. Each run cycle must last for a minimum of 10 seconds.
- Clear the history DTC with a scan tool.

## Diagnostic Aids

The throttle plate is spring loaded to a slightly open position. The throttle plate should be open approximately 20–25 percent. This is referred to as the rest position. The throttle plate should not be completely closed nor should it be open any more than the specified amount. The throttle plate should move open and to the closed position without binding under the normal spring pressure. The throttle should NOT be free to move open or closed WITHOUT spring pressure. Replace the throttle body if any of these conditions are found.

**Important:** Operating the throttle plate with the Throttle Blade Control function of the scan tool may cause additional DTCs to set. Do not attempt to diagnose DTCs set during this function.

Inspect for mechanical conditions or binding that may be temperature related. Components may not move freely in extreme heat or cold due to the presence of contaminants or ice formation.

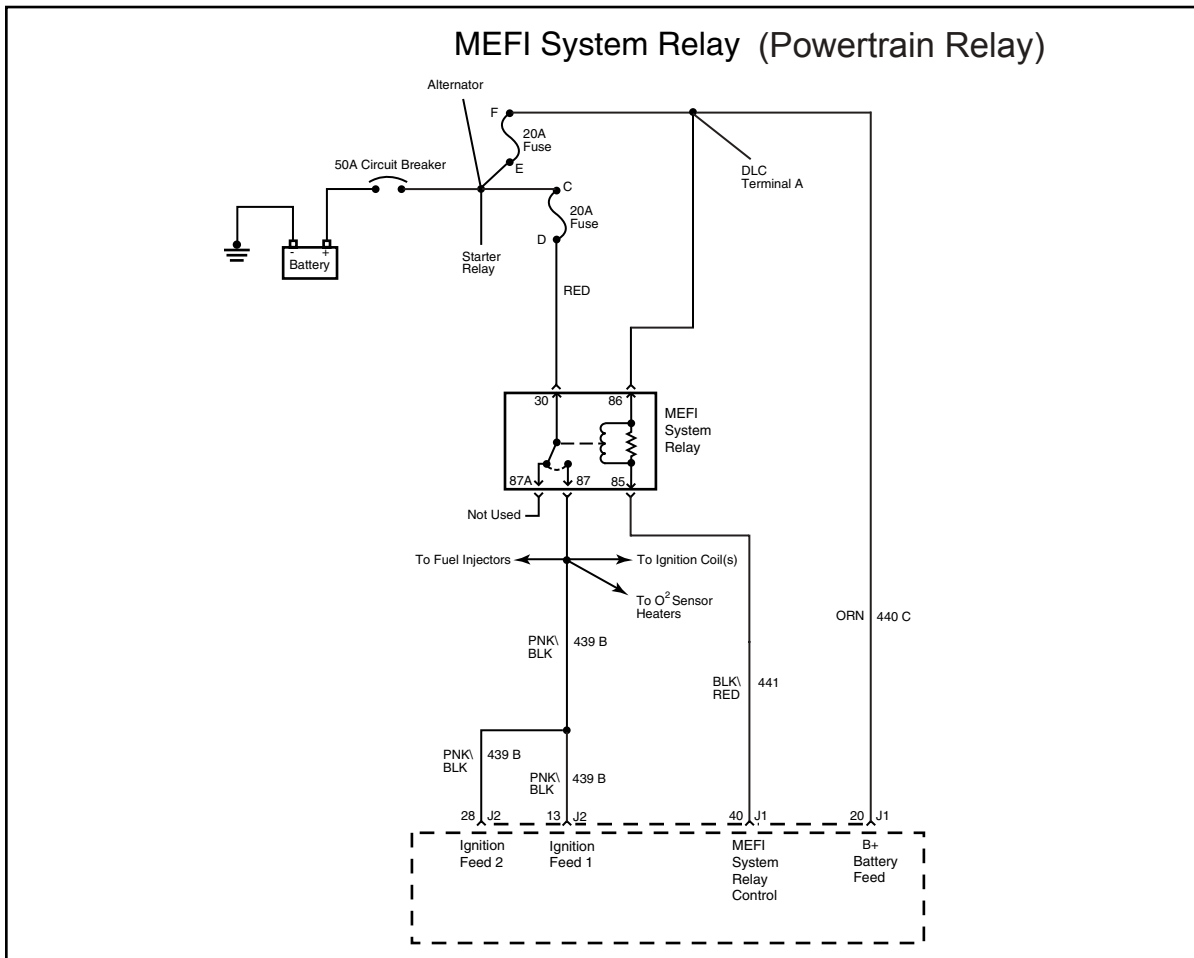
The numbers below refer to the step numbers in the diagnostic table.

**2.& 8.** More than one electronic throttle control (ETC) system related DTC may set. This is due to the many redundant tests run continuously on this system. Locating and repairing one individual condition may correct more than one DTC. Keep this in mind when reviewing captured DTC info.

Step	Action	Values	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views or Engine Controls Connector End Views</i>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to <i>Diagnostic System Check</i>
2	Are any other DTCs set?	—	See Diagnostic Aids, Refer to <i>Diagnostic Trouble Code (DTC) List</i> Continue to Step 3	Go to Step 3
3	<ol style="list-style-type: none"> <li>1. Turn OFF the ignition for 30 seconds.</li> <li>2. Turn ON the ignition, with the engine OFF.</li> <li>3. Allow the Throttle-Shift Control (T-SC) to remain in the locked-neutral (idle) position for 20 seconds.</li> <li>4. Observe the indicated throttle position parameter with a scan tool.</li> </ol> Does the scan tool indicate throttle position within the specified values?	15–25%	Go to Step 6	Go to Step 4
4	Check for obstructions preventing the throttle plate from returning to the rest position. If necessary, remove the throttle body assembly for a thorough examination. Refer to <i>Throttle Body Assembly Replacement</i> . Did you find an obstruction?	—	Go to Step 5	Go to Step 6
5	Remove the obstruction and reinstall the throttle body. Did you complete the action?	—	Go to Step 7	—

6	Replace the throttle body assembly. Refer to <i>Throttle Body Assembly Replacement</i> . Did you complete the replacement?	—	Go to Step 7	—
7	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Place the Throttle-Shift Control (T-SC) in the locked-neutral (idle) position.</li> <li>4. Turn ON the ignition, with the engine OFF.</li> </ol> Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 8
8	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	—	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK

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## Diagnostic Information and Procedures

- SPN 66013, FMI 5 Powertrain Relay Short Low**
- SPN 66013, FMI 6 Powertrain Relay Short High**
- SPN 66013, FMI 7 Powertrain Relay Open**
- SPN 66014, FMI 4 Powertrain Relay Contact Low**

**(Note: The MEFI System Relay is referred to as a “Powertrain Relay” by the SAE J1939 standard.)**

### Circuit Description

The MEFI system relay is a normally open relay. The relay armature is held in the open position by spring tension. Battery positive voltage is supplied directly to the relay coil and the armature contact at all times. The engine control module (ECM) supplies the ground path to the relay coil control circuit via an internal integrated circuit called an output driver module (ODM). The ODM output control is configured to operate as a low side driver for the main relay. The ODM for the main relay also incorporates a fault detection circuit, which is continuously monitored by the ECM. When the ECM commands the main relay ON, ignition voltage is supplied to the following circuits

- ECM Pin J2-13 & J2-28
- Injectors
- Coil & Ignition Module

The ignition voltage that is supplied to the ECM through the Powertrain (MEFI System) fuse, provides power to the internal ECM circuits associated with the throttle actuator control (TAC) operation. The ECM also monitors the voltage level on the ignition voltage circuit to confirm that the main relay contacts have closed.



## DTC Descriptor

This diagnostic procedure supports the following DTCs:

*SPN 66013, FMI 5 Powertrain (MEFI System) Relay Short Low*  
*SPN 66013, FMI 6 Powertrain (MEFI System) Relay Short High*  
*SPN 66013, FMI 7 Powertrain (MEFI System) Relay Open*  
*SPN 66014, FMI 4 Powertrain (MEFI System) Relay Contact Low*

## Conditions for Setting the DTC

### SPN 66013

- The commanded state of the ODM and the actual state of the control circuit do not match.
- The condition is present for more than 5 seconds.

Note: This code deals with pin 85 (Supplied ground to activate - ECM ODM) and pin 86 (B+) of the relay coil circuit.

### SPN 66014

• The ECM detects less than 10 volts on the ignition voltage circuit from the Powertrain (MEFI System) fuse to the ECM.

Note: This code deals with pin 30 (B+) and pin 87 (Output Voltage – Ignition 1) of the relay contact circuit.

## Action Taken When the DTC Sets

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The malfunction indicator lamp (MIL) will illuminate.
- The driver information center, if equipped, may display a message.

## Conditions for Clearing the DTC

- A current DTC clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive run cycles, if this or any other related diagnostic reports no other failures.
- Clear the DTC with a scan tool.

## Diagnostic Aids

- This test procedure requires that the vehicle battery has passed a load test and is completely charged. Refer to *Battery Inspection/Test*.
- When disconnecting electrical connectors or removing fuses and relays, always inspect the component electrical terminals for corrosion and the mating electrical terminals for tightness.

## Reference Information

### Schematic Reference

*Engine Controls Schematics*

### Connector End View Reference

- *Engine Controls Connector End Views*
- *Electrical Center Identification Views*
- *Engine Control Module (ECM) Connector End Views*

### Electrical Information Reference

- *Circuit Testing*
- *Connector Repairs*
- *Testing for Intermittent Conditions and Poor Connections*
- *Wiring Repairs*

### Scan Tool Reference

- *Scan Tool Data List*
- *Scan Tool Data Definitions*
- *Scan Tool Output Controls*

### Circuit/System Verification

1. With the ignition ON, engine OFF, command the MEFI System relay ON and OFF several times using the scan tool output control function. If this function is not available on the scan tool, turn the key ON and OFF. You should either hear or feel the relay click with each command.

2. With the ignition OFF, connect one lead of a test lamp to ground, and probe both sides of each of the following fuses:

- Powertrain (MEFI System) Relay Fuse (Connected to MEFI System Relay Pin 30)
- ECM Battery Fuse (Connected to MEFI System Relay Pin 86)

The lamp should illuminate on at least one side of each fuse, at all times. If not, check the main circuit breaker, and continue with Circuit/System Testing.

3. With the ignition ON, engine OFF, ignition voltage should be present on the MEFI System Relay Pin 87, enabling the following circuits:

- ECM Pin J2-13 & J2-28
- Injectors
- Coil & Ignition Module

The test lamp should illuminate on at least one test point of each circuit. If the test lamp does not illuminate continue with Circuit/System Testing.

If the boat passes the Circuit/System Verification test, operate the boat within the Conditions for Running the DTC. The other option is to refer to *Testing for Intermittent Conditions and Poor Connections*.

### Circuit/System Testing

1. With the ignition OFF, remove the Powertrain (MEFI System) relay.

2. With the ignition ON, measure for battery positive voltage (B+) between the relay coil voltage supply circuit (pin 86) and ground.

If the voltage measures less than B+, repair the open or high resistance in the circuit to the relay coil. All wire circuit resistance should measure less than 2 ohms.

3. Measure for voltage between the relay coil control circuit (pin 85) and ground.

If voltage is measured on the control circuit of the relay, test for a short to voltage or a faulty ECM.

4. Connect a test lamp between the battery positive voltage supply circuit (pin 86) of the relay coil and the relay coil control circuit (pin 85). Use a scan tool to command the main relay ON and OFF. The test lamp should turn ON and OFF when toggling between the commanded states.

If the test lamp stays ON all the time, test for a short to ground on the relay coil control circuit or a faulty ECM.

If the test lamp stays OFF all the time, test for an open or high resistance on the relay coil control circuit or a faulty ECM. All wire circuit resistance should measure less than 2 ohms.

5. Measure for B+ between the relay armature supply circuit (pin 30), and ground.

If the voltage measures less than B+, repair the open or high resistance in the circuit to the relay armature. All wire circuit resistance should measure less than 2 ohms.

6. Connect a 20-amp fused jumper wire between the B+ termination (Pin 30) and the ignition voltage terminal (Pin 87) of the main relay. With a test lamp, test for voltage on both test points of the following circuits:

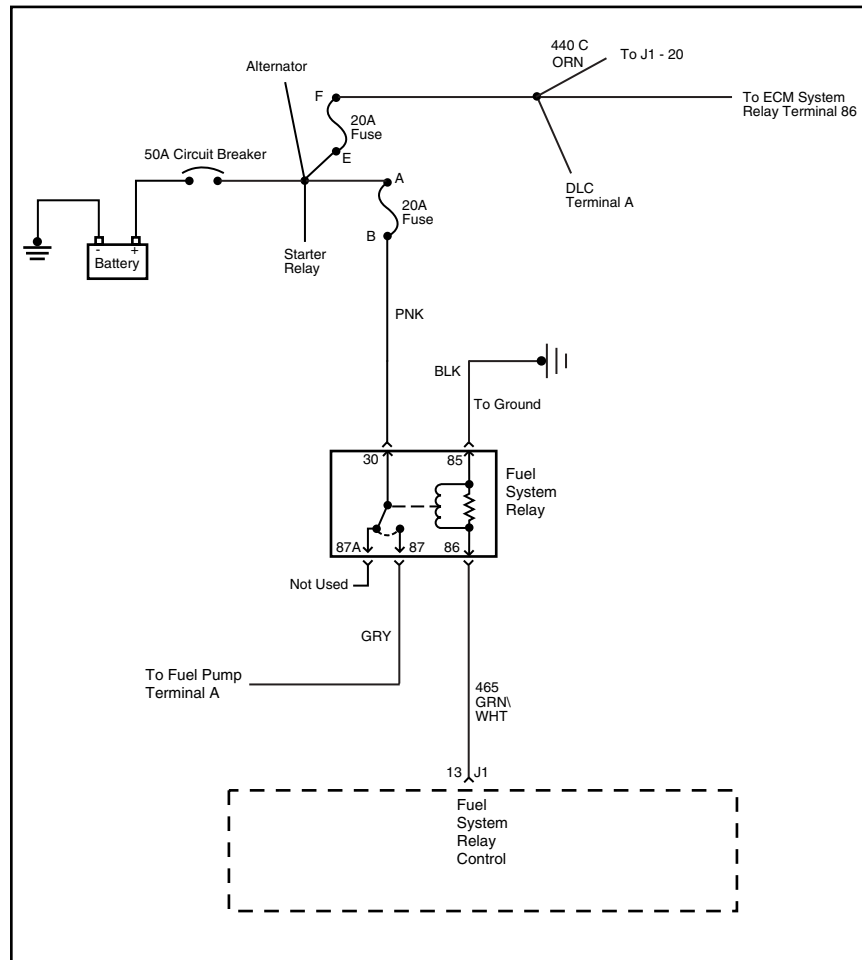
- ECM Pin J2-13 & J2-28
- Injectors
- Coil & Ignition Module

If the test lamp fails to illuminate on one test point of each circuits, repair the open or high resistance between the termination and the main relay. All wire circuit resistance should measure 2 ohms or less.

## Component Testing

- Measure for 70–110 ohms between terminals 85 and 86 of the relay.  
If the resistance is not within the specified range, replace the relay.
- Measure for infinite resistance between terminals 30 and 86 of the relay.  
If continuity is detected, replace the relay.
- Measure for infinite resistance between terminals 30 and 87 of the relay.  
If continuity is detected, replace the relay.
- Measure for infinite resistance between terminals 30 and 85 of the relay.  
If continuity is detected, replace the relay.
- Measure for infinite resistance between terminals 85 and 87 of the relay.  
If continuity is detected, replace the relay.
- Connect a 20-amp fused jumper wire from the battery positive cable at the battery, to relay terminal 85. Connect a jumper wire from the negative battery cable at the battery, to relay terminal 86. Measure for less than 2 ohms between terminals 30 and 87 of the relay, with a DMM.  
If the resistance measures more than 2 ohms, replace the relay.

## Fuel System Relay



### Diagnostic Information and Procedures

**SPN 66017 FMI 5 Fuel Pump Short Low**  
**SPN 66017 FMI 6 Fuel Pump Short High**  
**SPN 66017 FMI 7 Fuel Pump Open**

#### Circuit Description

When the ignition switch is turned ON, the control module enables the fuel pump relay, which supplies current to the fuel pump. The fuel pump remains enabled as long as the engine is cranking or running and the control module receives ignition reference pulses. If there are no ignition reference pulses, the control module shuts the fuel pump OFF approximately 3 seconds after the ignition was switched to the ON position or if the engine stops. The control module monitors the voltage on the fuel pump relay control circuit. If the control module detects an incorrect voltage on the fuel pump relay control circuit, a fuel pump relay control DTC sets.

#### DTC Descriptor

This diagnostic procedure supports the following DTC:  
 SPN 66017, FMI 5 Fuel Pump Short Low  
 SPN 66017, FMI 6 Fuel Pump Short High  
 SPN 66017, FMI 7 Fuel Pump Open

#### Conditions for Running the DTC

- The ignition voltage is supplied to the ECM.
- The ignition voltage is between 6–18 volts.

## Conditions for Setting the DTC

- The engine control module (ECM) detects that the commanded state of the driver and the actual state of the control circuit do not match.

## Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the ignition cycle that the diagnostic runs and fails.

## Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

## Diagnostic Aids

### Test Description

The numbers below refer to the step numbers on the diagnostic table.

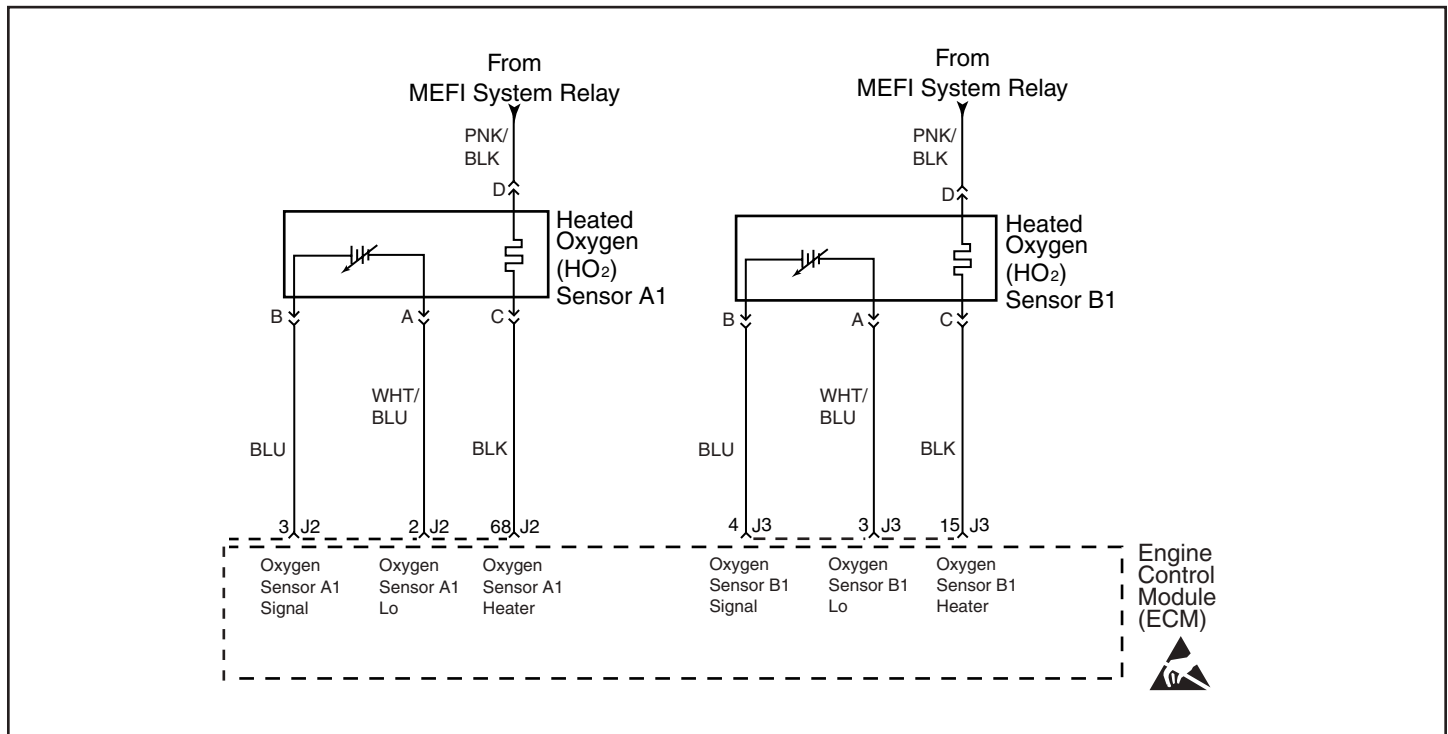
- This step verifies that the ECM is providing voltage to the fuel pump relay. (FMI 5)
- This step tests for an open in the ground circuit to the fuel pump relay. (FMI 7)
- This step tests if the voltage is constantly being applied to the control circuit of the fuel pump relay. (FMI 6)

Step	Action	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views</i> or <i>Engine Controls Connector End Views</i>			
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	Go to Step 2	Go to <i>Diagnostic System Check</i>
2	1. Turn ON the ignition, with the engine OFF. 2. Command the fuel pump relay ON and OFF with a scan tool. Does the fuel pump relay turn ON and OFF when commanded with a scan tool?	Go to <i>Testing for Intermittent Conditions and Poor Connections</i>	Go to Step 3
3	1. Turn OFF the ignition. 2. Remove the fuel pump relay. 3. Turn ON the ignition, with the engine OFF. 4. Probe the control circuit of the fuel pump relay with a test lamp that is connected to a good ground. Refer to <i>Probing Electrical Connectors</i> . 5. Command the fuel pump relay ON and OFF with a scan tool. Does the test lamp turn ON and OFF when commanded with a scan tool?	Go to Step 4	Go to Step 5
4	1. Connect a test lamp between the control circuit of the fuel pump relay and the ground circuit of the fuel pump relay. 2. Command the fuel pump relay ON and OFF with a scan tool. Does the test lamp turn ON and OFF when commanded with a scan tool?	Go to Step 8	Go to Step 10
5	Does the test lamp remain illuminated?	Go to Step 7	Go to Step 6
6	Test the control circuit of the fuel pump relay for a short to ground or an open. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	Go to Step 13	Go to Step 9
7	Test the control circuit of the fuel pump relay for a short to voltage. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	Go to Step 13	Go to Step 9
8	Test for an intermittent and for a poor connection at the fuel pump relay. Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Connector Repairs</i> . Did you find and correct the condition?	Go to Step 13	Go to Step 11

9	Test for an intermittent and for a poor connection at the engine control module (ECM). Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Connector Repairs</i> . Did you find and correct the condition?	Go to Step 13	Go to Step 12
10	Test the ground circuit of the fuel pump relay for an open. Refer to <i>Circuit Testing</i> and <i>Wiring Repairs</i> . Did you find and correct the condition?	Go to Step 14	—
11	Replace the fuel pump relay. Did you complete the replacement?	Go to Step 13	—
12	Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?	Go to Step 13	—
13	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> <li>4. Operate the boat within the Conditions for Running the DTC.</li> </ol> Did the DTC fail this ignition?	Go to Step 2	Go to Step 14
14	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK

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## Oxygen Sensors A &amp; B

**SPN 65561 FMI 0 - Oxygen Sensor A1 Rich****SPN 65563 FMI 0 - Oxygen Sensor B1 Rich****Circuit Description**

Heated oxygen sensors (HO<sub>2</sub>S) are used for fuel control. Each HO<sub>2</sub>S compares the oxygen content of the surrounding air with the oxygen content in the exhaust stream. The HO<sub>2</sub>S must reach operating temperature to provide an accurate voltage signal. Heating elements inside the HO<sub>2</sub>S minimize the time required for the sensors to reach operating temperature. The engine control module (ECM) supplies the HO<sub>2</sub>S with a reference, or bias, voltage of about 450 mV. When the engine is first started the ECM operates in Open Loop, ignoring the HO<sub>2</sub>S voltage signal. Once the HO<sub>2</sub>S reaches operating temperature and Closed Loop is achieved, the HO<sub>2</sub>S generates a voltage within a range of 0–1,000 mV that fluctuates above and below bias voltage. High HO<sub>2</sub>S voltage indicates a rich exhaust stream. low HO<sub>2</sub>S voltage indicates a lean exhaust stream. If the ECM detects an HO<sub>2</sub>S voltage that stays above a specified value, SPN 65561 FMI 0 sets for HO<sub>2</sub>S A1, or SPN 65563 FMI 0 sets for HO<sub>2</sub>S B1.

**DTC Descriptors**

This diagnostic procedure supports the following DTCs:

- SPN 65561 FMI 0 HO<sub>2</sub>S - Oxygen Sensor A1 Rich
- SPN 65563 FMI 0 HO<sub>2</sub>S - Oxygen Sensor B1 Rich

**Conditions for Running the DTC**

- The Loop Status parameter is closed.
- The above conditions are met for 2 seconds.
- This diagnostic runs continuously when the above conditions are met.

**Conditions for Setting the DTC**

The ECM detects that the affected HO<sub>2</sub>S voltage parameter is more than 1,050 mV for approximately 48 seconds.



**Action Taken When the DTC Sets**

- The control module illuminates the malfunction indicator lamp (MIL).
- The control module commands the Loop Status open.

**Conditions for Clearing the MIL/DTC**

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

**Test Description**

The number below refers to the step number on the diagnostic table.

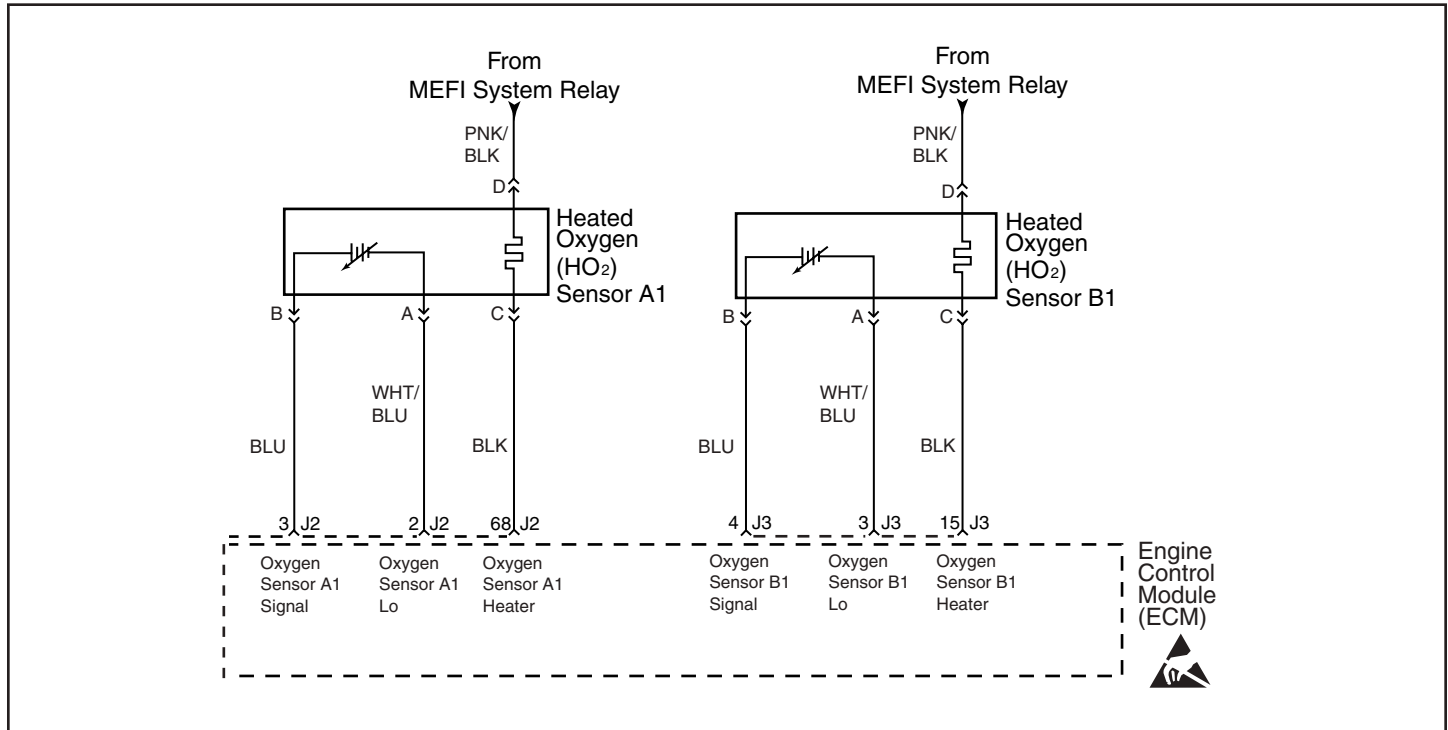
2. If the voltage is varying above and below the specified range, the condition is not present.

Step	Action	Value(s)	Yes	No
Schematic Reference: Engine Controls Schematics Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views				
1	Did you perform the Diagnostic System Check - Vehicle?	—	Go to Step 2	Go to Diagnostic System Check - Vehicle
2	1. Start the engine. 2. Allow the engine to reach operating temperature. Refer to Scan Tool Data List . 3. Observe the affected HO2S voltage parameter with a scan tool. Is the HO2S voltage parameter varying above and below the specified range?	300–600 mV	Go to Step 3	Go to Step 4
3	1. Turn OFF the ignition for 30 seconds. 2. Start the engine. 3. Operate the vehicle within the Conditions for Running the DTC. Did the DTC fail this ignition?	—	Go to Step 4	Go to Testing for Intermittent Conditions and Poor Connections
4	1. Turn OFF the ignition. 2. Disconnect the affected heated oxygen sensor (HO2S). 3. Turn ON the ignition, with the engine OFF. 4. Observe the HO2S voltage parameter with a scan tool. Is the HO2S voltage parameter within the specified range?	400–500 mV	Go to Step 5	Go to Step 6
5	1. Connect a 3-amp fused jumper wire between the high signal circuit of the HO2S harness connector on the engine harness side and a good ground. 2. Observe the HO2S voltage parameter with a scan tool. Is the HO2S voltage parameter less than the specified value?	100 mV	Go to Step 7	Go to Step 8

6	<p>Test the HO2S high signal circuit for a short to the HO2S heater low control circuit. Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Circuit Testing</li> <li>• Wiring Repairs</li> <li>• Heated Oxygen Sensor (HO2S) Wiring Repairs</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 17	Go to Step 10
7	<ol style="list-style-type: none"> <li>1. Remove the jumper wire from the previous step.</li> <li>2. Connect a 3-amp fused jumper wire between the high signal circuit of the HO2S harness connector on the engine harness side and the low signal circuit of the HO2S harness connector on the engine harness side.</li> <li>3. Observe the HO2S voltage parameter with a scan tool.</li> </ol> <p>Is the HO2S voltage parameter less than the specified value?</p>	100 mV	Go to Step 9	Go to Step 11
8	<p>Test the HO2S high signal circuit for an open or high resistance. Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Circuit Testing</li> <li>• Wiring Repairs</li> <li>• Heated Oxygen Sensor (HO2S) Wiring Repairs</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 17	Go to Step 14
9	<p>Test the HO2S low signal circuit for a short to the HO2S heater low control circuit. Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Circuit Testing</li> <li>• Wiring Repairs</li> <li>• Heated Oxygen Sensor (HO2S) Wiring Repairs</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 17	Go to Step 12
10	<p>Important: The sensor may be damaged if the circuit is shorted to a voltage source.</p> <p>Test the HO2S high signal circuit for a short to voltage. Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Circuit Testing</li> <li>• Wiring Repairs</li> <li>• Heated Oxygen Sensor (HO2S) Wiring Repairs</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 17	Go to Step 14
11	<p>Test the HO2S low signal circuit for an open or high resistance. Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Circuit Testing</li> <li>• Wiring Repairs</li> <li>• Heated Oxygen Sensor (HO2S) Wiring Repairs</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 17	Go to Step 14

12	<p>1. The HO2S may be detecting a rich exhaust condition or may be contaminated. Inspect for the following conditions:</p> <p>Notice: Refer to Silicon Contamination of Heated Oxygen Sensors Notice .</p> <ul style="list-style-type: none"> <li>. A silicon contaminated HO2S</li> <li>. Any water intrusion into the HO2S connector</li> <li>. Engine oil contaminated with fuel</li> <li>. An incorrect fuel pressure—Refer to Fuel System Diagnosis .</li> <li>. Any rich fuel injectors—Refer to Fuel Injector Balance Test with Tech 2 .</li> <li>. An air intake restriction</li> </ul> <p>2. Repair any of the above or similar engine conditions as necessary. Did you find and correct the condition?</p>	—	Go to Step 17	Go to Step 13
13	<p>Test for shorted terminals and for poor connections at the HO2S. Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Testing for Intermittent Conditions and Poor Connections</li> <li>• Connector Repairs</li> <li>• Heated Oxygen Sensor (HO2S) Wiring Repairs</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 17	Go to Step 15
14	<p>Test for shorted terminals and for poor connections at the engine control module (ECM). Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Testing for Intermittent Conditions and Poor Connections</li> <li>• Connector Repairs</li> <li>• Heated Oxygen Sensor (HO2S) Wiring Repairs</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 17	Go to Step 16
15	<p>Replace the affected HO2S. Refer to Heated Oxygen Sensor (HO2S) Replacement Bank 1 Sensor 1 or Heated Oxygen Sensor (HO2S) Replacement Bank 2 Sensor 1 . Did you complete the replacement?</p>	—	Go to Step 17	—
16	<p>Replace the ECM. Refer to Control Module References for replacement, setup, and programming. Did you complete the replacement?</p>	—	Go to Step 17	—
17	<p>1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC. Did the DTC fail this ignition?</p>	—	Go to Step 2	Go to Step 18
18	<p>Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?</p>	—	Go to Diagnostic Trouble Code (DTC) List - Vehicle	System OK

## Oxygen Sensors A &amp; B



**SPN 65561 FMI 1 - Oxygen Sensor A1 Lean**  
**SPN 65563 FMI 1 - Oxygen Sensor B1 Lean**

### Circuit Description

Heated oxygen sensors (HO<sub>2</sub>S) are used for fuel control. Each HO<sub>2</sub>S compares the oxygen content of the surrounding air with the oxygen content in the exhaust stream. The HO<sub>2</sub>S must reach operating temperature to provide an accurate voltage signal. Heating elements inside the HO<sub>2</sub>S minimize the time required for the sensors to reach operating temperature. The engine control module (ECM) supplies the HO<sub>2</sub>S with a reference, or bias, voltage of about 450 mV. When the engine is first started the ECM operates in Open Loop, ignoring the HO<sub>2</sub>S voltage signal. Once the HO<sub>2</sub>S reaches operating temperature and Closed Loop is achieved, the HO<sub>2</sub>S generates a voltage within a range of 0–1,000 mV that fluctuates above and below bias voltage. High HO<sub>2</sub>S voltage indicates a rich exhaust stream. Low HO<sub>2</sub>S voltage indicates a lean exhaust stream. If the ECM detects an HO<sub>2</sub>S voltage that stays below a specified value, SPN 65561 FMI 1 sets for HO<sub>2</sub>S A1, or SPN 65563 FMI 1 sets for HO<sub>2</sub>S B1.

### DTC Descriptors

This diagnostic procedure supports the following DTCs:

- SPN 65561 FMI 1 HO<sub>2</sub>S - Oxygen Sensor A1 Lean
- SPN 65563 FMI 1 HO<sub>2</sub>S - Oxygen Sensor B1 Lean

### Conditions for Running the DTC

- The Loop Status parameter is closed.
- The above conditions are met for 2 seconds.
- This diagnostic runs continuously when the above conditions are met.

### Conditions for Setting the DTC

The ECM detects that the affected HO<sub>2</sub>S voltage parameter is less than 200 mV for approximately 165 seconds.

### Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL).
- The control module commands the Loop Status open.

### Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- Clear the MIL and the DTC with a scan tool.

### Test Description

The number below refers to the step number on the diagnostic table.

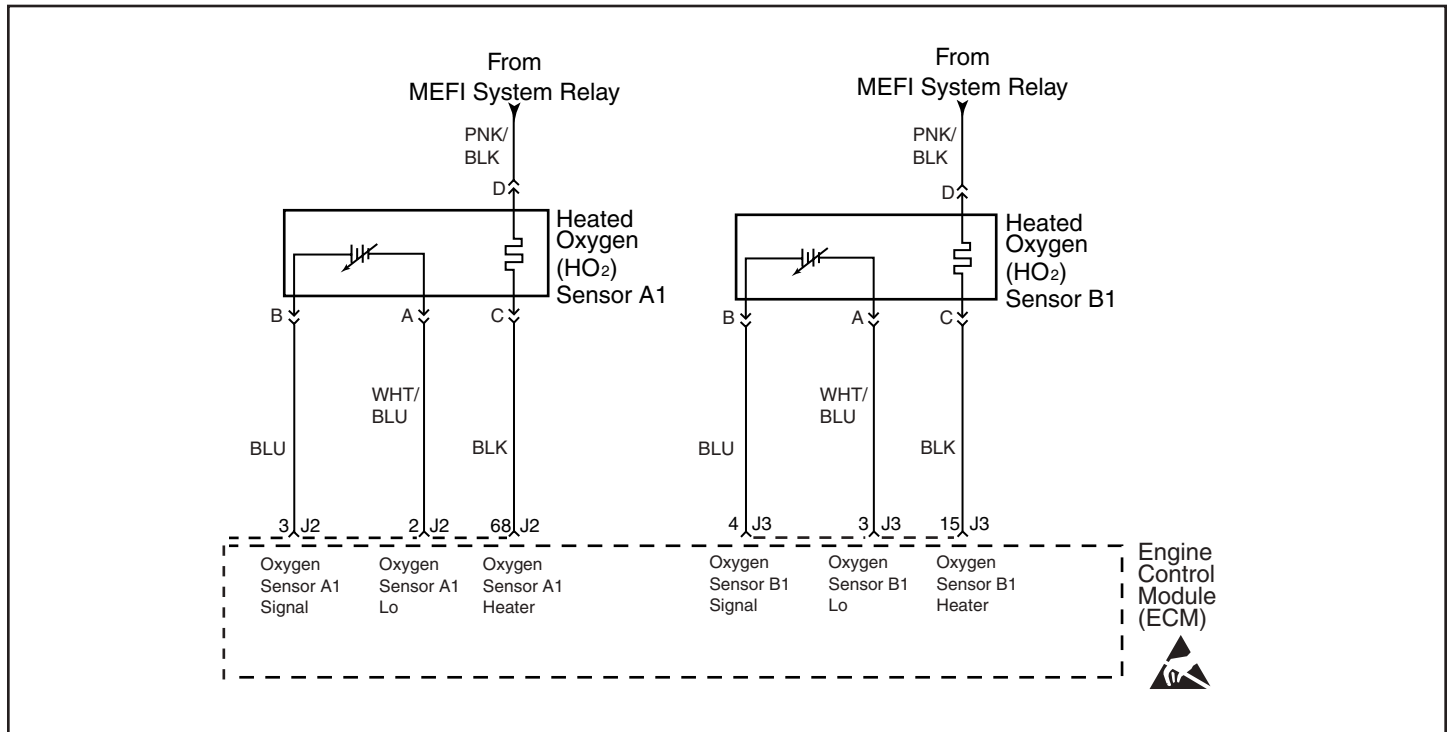
2. If the voltage is varying above and below the specified range, the condition is not present.

Step	Action	Value(s)	Yes	No
Schematic Reference: Engine Controls Schematics Connector End View Reference: Engine Controls Connector End Views or Engine Control Module (ECM) Connector End Views				
1	Did you perform the Diagnostic System Check - Vehicle?	—	Go to Step 2	Go to Diagnostic System Check - Vehicle
2	1. Start the engine. 2. Allow the engine to reach operating temperature. Refer to Scan Tool Data List . 3. Observe the affected HO2S voltage parameter with a scan tool. Is the HO2S voltage parameter varying above and below the specified range?	300–600 mV	Go to Step 3	Go to Step 4
3	1. Turn OFF the ignition for 30 seconds. 2. Start the engine. 3. Operate the vehicle within the Conditions for Running the DTC. Did the DTC fail this ignition?	—	Go to Step 4	Go to Testing for Intermittent Conditions and Poor Connections
4	1. Turn OFF the ignition. 2. Disconnect the affected heated oxygen sensor (HO2S). 3. Turn ON the ignition, with the engine OFF. 4. Observe the HO2S voltage parameter with a scan tool. Is the HO2S voltage parameter less than the specified value?	100 mV	Go to Step 6	Go to Step 5
5	1. Connect a 3-amp fused jumper wire between the high signal circuit of the HO2S harness connector on the engine harness side and a good ground. 2. Observe the HO2S voltage parameter with a scan tool. Is the HO2S voltage parameter less than the specified value?	100 mV	Go to Step 7	Go to Step 8
6	Test the HO2S high signal circuit for a short to ground. Refer to the following procedures: <ul style="list-style-type: none"> <li>• Circuit Testing</li> <li>• Wiring Repairs</li> <li>• Heated Oxygen Sensor (HO2S) Wiring Repairs</li> </ul> Did you find and correct the condition?	—	Go to Step 15	Go to Step 9

7	<p>Test the HO2S low signal circuit for a short to the HO2S heater low control circuit. Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Circuit Testing</li> <li>• Wiring Repairs</li> <li>• Heated Oxygen Sensor (HO2S) Wiring Repairs</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 15	Go to Step 10
8	<p>Test the HO2S high signal circuit for an open or high resistance. Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Circuit Testing</li> <li>• Wiring Repairs</li> <li>• Heated Oxygen Sensor (HO2S) Wiring Repairs</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 15	Go to Step 12
9	<p>Test the HO2S high signal circuit for a short to the following circuits:</p> <ul style="list-style-type: none"> <li>• HO2S low signal circuit</li> <li>• HO2S heater low control circuit</li> </ul> <p>Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Circuit Testing</li> <li>• Wiring Repairs</li> <li>• Heated Oxygen Sensor (HO2S) Wiring Repairs</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 15	Go to Step 12
10	<p>1. The HO2S may be detecting a lean exhaust condition or may be contaminated. Inspect for the following conditions:</p> <p>Notice: Refer to Silicon Contamination of Heated Oxygen Sensors Notice .</p> <ul style="list-style-type: none"> <li>• A silicon contaminated HO2S</li> <li>• Any water intrusion into the HO2S connector</li> <li>• An exhaust leak between the HO2S and the engine</li> <li>• Any vacuum leaks</li> <li>• An incorrect fuel pressure—Refer to Fuel System Diagnosis .</li> <li>• Any lean fuel injectors—Refer to Fuel Injector Balance Test with Tech 2 .</li> </ul> <p>2. Repair any of the above or similar engine conditions as necessary.</p> <p>Did you find and correct the condition?</p>	—	Go to Step 15	Go to Step 11
11	<p>Test for shorted terminals and for poor connections at the HO2S. Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Testing for Intermittent Conditions and Poor Connections</li> <li>• Connector Repairs</li> <li>• Heated Oxygen Sensor (HO2S) Wiring Repairs</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 15	Go to Step 13

12	<p>Test for shorted terminals and for poor connections at the engine control module (ECM). Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Testing for Intermittent Conditions and Poor Connections</li> <li>• Connector Repairs</li> <li>• Heated Oxygen Sensor (HO2S) Wiring Repairs</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 15	Go to Step 14
13	<p>Replace the affected HO2S. Refer to Heated Oxygen Sensor (HO2S) Replacement Bank 1 Sensor 1 or Heated Oxygen Sensor (HO2S) Replacement Bank 2 Sensor 1 .</p> <p>Did you complete the replacement?</p>	—	Go to Step 15	—
14	<p>Replace the ECM. Refer to Control Module References for replacement, setup, and programming.</p> <p>Did you complete the replacement?</p>	—	Go to Step 15	—
15	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> <li>4. Operate the vehicle within the Conditions for Running the DTC.</li> </ol> <p>Did the DTC fail this ignition?</p>	—	Go to Step 2	Go to Step 16
16	<p>Observe the Capture Info with a scan tool.</p> <p>Are there any DTCs that have not been diagnosed?</p>	—	Go to Diagnostic Trouble Code (DTC) List - Vehicle	System OK

## Oxygen Sensors A &amp; B



**SPN 66019 FMI 5 Oxygen Sensor A1 Heater Short Low**

**SPN 66020 FMI 5 Oxygen Sensor B1 Heater Short Low**

**SPN 66019 FMI 6 Oxygen Sensor A1 Heater Short High**

**SPN 66020 FMI 6 Oxygen Sensor B1 Heater Short High**

**SPN 66019 FMI 7 Oxygen Sensor A1 Heater Open**

**SPN 66020 FMI 7 Oxygen Sensor B1 Heater Open**

### Circuit Description

Heated oxygen sensors (HO<sub>2</sub>S) are used for fuel control. Each HO<sub>2</sub>S compares the oxygen content of the surrounding air with the oxygen content in the exhaust stream. The HO<sub>2</sub>S must reach operating temperature to provide an accurate voltage signal. A heating element inside the HO<sub>2</sub>S minimizes the time required for the sensor to reach operating temperature. Voltage is provided to the heater by the ignition 1 voltage circuit through a fuse. With the engine running, ground is provided to the heater by the HO<sub>2</sub>S heater low control circuit, through a low side driver within the engine control module (ECM).

The ECM commands the heater ON or OFF to maintain a specific HO<sub>2</sub>S operating temperature range. The ECM monitors the voltage on the HO<sub>2</sub>S heater low control circuit for heater fault diagnosis. If the ECM detects that the HO<sub>2</sub>S heater low control circuit voltage is not within a specified range, SPN 66019 FMI 7 sets for HO<sub>2</sub>S A1, or SPN 66020 FMI 7 sets for HO<sub>2</sub>S B1.

### DTC Descriptors

This diagnostic procedure supports the following DTCs:

- SPN 66019 FMI 7 Oxygen Sensor A1 Heater Open
- SPN 66020 FMI 7 Oxygen Sensor B1 Heater Open

### Conditions for Running the DTC

- The engine speed is more than 425 RPM.
- This diagnostic runs continuously once the above conditions are met.

### Conditions for Setting the DTC

The ECM detects that the affected HO<sub>2</sub>S heater low control circuit is not within a specified range for 0.25 seconds.



**Action Taken When the DTC Sets**

- The control module illuminates the malfunction indicator lamp (MIL).

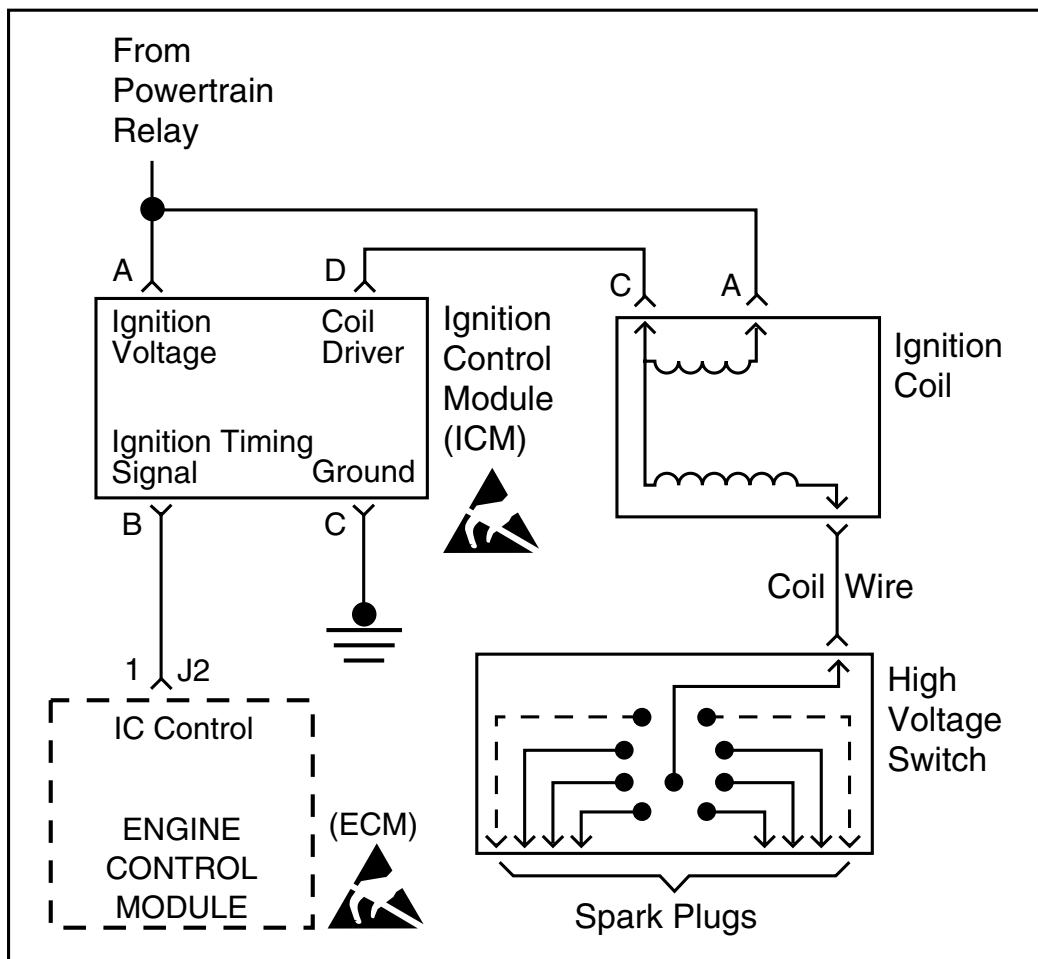
**Conditions for Clearing the MIL/DTC**

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
  - A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
  - A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

Step	Action	Values	Yes	No
Schematic Reference: Engine Controls Schematics Connector End View Reference: Engine Control Module (ECM) Connector End Views or Engine Controls Connector End Views				
1	Did you perform the Diagnostic System Check – Vehicle?	—	Go to Step 2	Go to Diagnostic System Check - Vehicle
2	Is SPN 66019 FMI 5,6,7 or SPN 66020 FMI 5,6,7 set?	—	Go to Step 4	Go to Step 3
3	1. Start the engine. 2. Wait 1 minute to allow the heated oxygen sensor (HO2S) heater current to stabilize. 3. Observe the affected HO2S heater current parameter with a scan tool. Is the HO2S heater current parameter within the specified range?	0.25–1.375 A	Go to Step 5	Go to Step 6
4	1. Start the engine. 2. Wait 1 minute to allow the HO2S heater current to stabilize. 3. Observe the affected HO2S heater current parameter with a scan tool. Is the HO2S heater current parameter within the specified range?	0.25–3.125 A	Go to Step 5	Go to Step 6
5	1. Turn OFF the ignition for 30 seconds. 2. Start the engine. 3. Operate the vehicle within the Conditions for Running the DTC. Did the DTC fail this ignition?	—	Go to Step 6	Go to Testing for Intermittent Conditions and Poor Connections
6	1. Turn OFF the ignition. 2. Inspect the fuse that supplies the applicable HO2S heater. Is the fuse open?	—	Go to Step 7	Go to Step 8
7	Test the ignition 1 voltage circuit for a short to ground. Refer to the following procedures: <ul style="list-style-type: none"> <li>Circuit Testing</li> <li>Wiring Repairs</li> <li>Heated Oxygen Sensor (HO2S)</li> </ul> Wiring Repairs Did you find and correct the condition?	—	Go to Step 21	Go to Step 10

8	<p>1. Disconnect the affected HO2S.</p> <p>2. Turn ON the ignition, with the engine OFF.</p> <p>3. Probe the ignition 1 voltage circuit of the HO2S harness connector on the engine harness side with a test lamp that is connected to a good ground. Refer to Probing Electrical Connectors . Does the test lamp illuminate?</p>	—	Go to Step 9	Go to Step 18
9	<p>1. Turn OFF the ignition.</p> <p>2. Probe the HO2S heater low control circuit of the HO2S harness connector on the engine harness side with a test lamp connected to battery voltage.</p> <p>3. With the ignition still OFF, observe the test lamp. Does the test lamp illuminate?</p>	—	Go to Step 12	Go to Step 11
10	<p>Test the ignition 1 voltage circuit on the sensor side of the HO2S 1 connector for a short to ground. Refer to Circuit Testing . Is the sensor shorted to ground?</p>	—	Go to Step 19	Go to Testing for Intermittent Conditions and Poor Connections
11	<p>Start the engine with the test lamp still connected from the previous step. Is the test lamp ON steady or blinking?</p>	—	Go to Step 15	Go to Step 13
12	<p>Test the HO2S heater low control circuit for a short to ground. Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Circuit Testing</li> <li>• Wiring Repairs</li> <li>• Heated Oxygen Sensor (HO2S)</li> </ul> <p>Wiring Repairs Did you find and correct the condition?</p>	—	Go to Step 21	Go to Step 17
13	<p>Test the HO2S heater low control circuit for a short to voltage. Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Circuit Testing</li> <li>• Wiring Repairs</li> <li>• Heated Oxygen Sensor (HO2S)</li> </ul> <p>Wiring Repairs Did you find and correct the condition?</p>	—	Go to Step 21	Go to Step 14
14	<p>Test the HO2S heater low control circuit for an open or for high resistance. Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Circuit Testing</li> <li>• Wiring Repairs</li> <li>• Heated Oxygen Sensor (HO2S)</li> </ul> <p>Wiring Repairs Did you find and correct the condition?</p>	—	Go to Step 21	Go to Step 17
15	<p>Measure the resistance of the following circuits with a DMM:</p> <ul style="list-style-type: none"> <li>• The HO2S heater low control circuit</li> <li>• The ignition 1 voltage circuit</li> </ul> <p>Refer to Circuit Testing . Is the resistance of either circuit more than the specified value?</p>	3 ohms	Go to Step 18	Go to Step 16

16	<p>Test for shorted terminals and for poor connections at the HO2S. Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Testing for Intermittent Conditions and Poor Connections</li> <li>• Connector Repairs</li> <li>• Heated Oxygen Sensor (HO2S)</li> </ul> <p>Wiring Repairs Did you find and correct the condition?</p>	—	Go to Step 21	Go to Step 19
17	<p>Test for shorted terminals and for poor connections at the engine control module (ECM). Refer to the following procedures:</p> <ul style="list-style-type: none"> <li>• Testing for Intermittent Conditions and Poor Connections</li> <li>• Connector Repairs</li> <li>• Heated Oxygen Sensor (HO2S)</li> </ul> <p>Wiring Repairs Did you find and correct the condition?</p>	—	Go to Step 21	Go to Step 20
18	<p>Repair the open or high resistance in the circuit. Refer to Wiring Repairs and Heated Oxygen Sensor (HO2S) Wiring Repairs in Wiring Systems. Did you complete the repair?</p>	—	Go to Step 21	—
19	<p>Replace the affected HO2S. Did you complete the replacement?</p>	—	Go to Step 21	—
20	<p>Replace the ECM. Refer to Control Module References for replacement, setup, and programming. Did you complete the replacement?</p>	—	Go to Step 21	—
21	<ol style="list-style-type: none"> <li>1. Replace the fuse, if necessary.</li> <li>2. Clear the DTCs with a scan tool.</li> <li>3. Turn OFF the ignition for 30 seconds.</li> <li>4. Start the engine.</li> <li>5. Operate the vehicle within the Conditions for Running the DTC.</li> </ol> <p>Did the DTC fail this ignition?</p>	—	Go to Step 2	Go to Step 22
22	<p>Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?</p>	—	Go to Diagnostic Trouble Code (DTC) List - Vehicle	System OK



## Diagnostic Information and Procedures

### SPN 65590 Misfire

#### System Description

The engine control module (ECM) uses information from the crankshaft position (CKP) sensor and the camshaft position (CMP) sensor to determine when an engine misfire is occurring. By monitoring variations in the crankshaft rotation speed for each cylinder, the ECM is able to detect individual misfire events. A misfire rate that is high enough can cause the catalytic converters (if equipped) to overheat under certain operating conditions. If the ECM detects a misfire rate sufficient to cause emission levels to exceed mandated standards, SPN 65590 FMI 7 will set. In some applications, the ECM is able to determine that a specific cylinder is misfiring, and will set a corresponding SPN 65591 - 65598 for that cylinder.

#### DTC Descriptors

SPN 65590 FMI 7: Misfire

#### Conditions for Running the DTC

- The engine speed is between 600–6,000 RPM.
- The ignition voltage is between 9–18 volts.
- The throttle angle is steady or does not vary by more than approximately 5 percent.
- The ECM is not in fuel shut-off or decel fuel cut-off mode.
- SPN 65590 run continuously when the above conditions are met.

#### Conditions for Setting the DTC

The ECM is detecting a crankshaft rotation speed variation indicating a misfire sufficient to cause emission levels to exceed mandated standards, or misfiring enough to cause damage to the catalytic converter (if equipped).

## Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) after the diagnostic runs and fails.
- The diagnostic may fail for approximately 30 seconds prior to illuminating the MIL.

## Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

## Diagnostic Aids

- Excessive vibration from sources other than the engine could cause SPN 65590 to set. The following are possible sources of vibration:
  - Excessive driveline vibration
  - Worn or damaged accessory drive belt
- There may be more or less cylinders actually misfiring than indicated by the scan tool.
- Spray water on the secondary ignition components using a spray bottle. Look and listen for arcing or misfiring.
- If there are multiple misfires on only one bank, inspect the fuel injector and ignition coil, power and ground circuits for that bank. Refer to *Engine Controls Schematics* .

## Test Description

The number below refers to the step number on the diagnostic table.

2. If the actual CKP variation values are not within the learned values, the misfire counters may increment.

Step	Action	Values	Yes	No
1	Did you perform the Diagnostic System Check – Vehicle?	—	Go to Step 2	Go to Diagnostic System Check
2	1. Start the engine. 2. Allow the engine to idle or operate within the conditions for running the DTC. 3. Monitor all of the Misfire counters with the scan tool. Are any of the Misfire current counters incrementing?	—	Go to Step 3	Go to Diagnostic Aids
3	Are any DTCs other than SPN 65590 set?	—	Go to Diagnostic Trouble Code (DTC) List - Vehicle	Go to Step 4
4	Can any abnormal engine noise be heard?	—	Go to Symptoms - Engine Mechanical	Go to Step 5
5	Does the scan tool indicate that the heated oxygen sensor (HO2S) A1 or HO2S B1 voltage parameters are below the specified value?	200 mV	Go to SPN 65561 FMI 1 SPN 65563 FMI 1	Go to Step 6
6	Does the scan tool indicate that the HO2S A1 or HO2S B1 voltage parameters are fixed above the specified value?	900 mV	Go to SPN 65561 FMI 0 SPN 65563 FMI 0	Go to Step 7

7	<p>Inspect the following components:</p> <ul style="list-style-type: none"> <li>• The vacuum hoses and seals for splits, restrictions, and improper connections.</li> <li>• The throttle body and intake manifold for vacuum leaks</li> <li>• The crankcase ventilation system for vacuum leaks.</li> <li>• The engine control module (ECM) grounds for corrosion and loose connections.</li> <li>• The exhaust system for restrictions.</li> <li>• The fuel for contamination.</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 19	Go to Step 8
8	<p>Important: An erratic or inconsistent spark is considered a no spark.</p> <ol style="list-style-type: none"> <li>1. Turn OFF the ignition.</li> <li>2. Disconnect the spark plug wire from the spark plug that corresponds to the affected cylinder.</li> <li>3. Install the J 26792 Spark Tester.</li> <li>4. Start the engine.</li> </ol> <p>Does the spark jump the tester gap?</p>	—	Go to Step 10	Go to Step 9
9	<ol style="list-style-type: none"> <li>1. Remove the spark plug wire for the affected cylinders.</li> <li>2. Inspect the spark plug wire.</li> <li>3. Measure the resistance of the spark plug wire with a DMM.</li> </ol> <p>Is the resistance within the specified value?</p>	188–312	Go to Electronic Ignition (EI) System Diagnosis	Go to Step 18
10	<ol style="list-style-type: none"> <li>1. Remove the spark plug from the cylinder that indicated a misfire.</li> <li>2. Inspect the spark plug.</li> </ol> <p>Does the spark plug appear to be OK?</p>	—	Go to Step 11	Go to Step 12
11	<ol style="list-style-type: none"> <li>1. Exchange the suspected spark plug with another cylinder that is operating properly.</li> <li>2. Operate the vehicle under the same conditions that the misfire occurred.</li> </ol> <p>Did the misfire move with the spark plug?</p>	—	Go to Step 17	Go to Step 15
12	Is the spark plug oil or coolant fouled?	—	Go to Symptoms - Engine Mechanical	Go to Step 13
13	Is the spark plug gas fouled?	—	Go to Step 16	Go to Step 14
14	Did the spark plug show any signs of being cracked, worn, or improperly gapped?	—	Go to Step 17	Go to Step 15
15	<p>Perform the fuel injector coil test.</p> <p>Did you find and correct the condition?</p>	—	Go to Step 19	Go to Symptoms - Engine Mechanical
16	<p>Perform the fuel system diagnosis.</p> <p>Did you find and correct the condition?</p>	—	Go to Step 19	Go to Symptoms - Engine Mechanical
17	<p>Replace the faulty spark plug.</p> <p>Did you complete the replacement?</p>	—	Go to Step 19	—
18	<p>Replace the faulty spark plug wires.</p> <p>Did you complete the replacement?</p>	—	Go to Step 19	—

19	1. Clear the DTCs with a scan tool. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that were observed when the DTC was set. Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 22
20	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List - Vehicle	System OK

## Complete Fault Code List

SPN	FMI	Enumeration Name
100	3	DTC_Oil Pressure Voltage High
100	4	DTC_Oil Pressure Voltage Low
106	3	DTC_Map Sensor High
106	4	DTC_Map Sensor Low
110	3	DTC_Coolant Sensor High
110	4	DTC_Coolant Sensor Low
630	13	DTC_Cal Memory Failure
636	2	DTC_Crank Signal Fault
651	3	DTC_Injector A Short High
651	4	DTC_Injector A Short Low
651	5	DTC_Injector A Open
652	3	DTC_Injector B Short High
652	4	DTC_Injector B Short Low
652	5	DTC_Injector B Open
653	3	DTC_Injector C Short High
653	4	DTC_Injector C Short Low
653	5	DTC_Injector C Open
654	3	DTC_Injector D Short High
654	4	DTC_Injector D Short Low
654	5	DTC_Injector D Open
655	3	DTC_Injector E Short High
655	4	DTC_Injector E Short Low
655	5	DTC_Injector E Open
656	3	DTC_Injector F Short High
656	4	DTC_Injector F Short Low
656	5	DTC_Injector F Open
657	3	DTC_Injector G Short High
657	4	DTC_Injector G Short Low
657	5	DTC_Injector G Open
658	3	DTC_Injector H Short High
658	4	DTC_Injector H Short Low
658	5	DTC_Injector H Open
723	2	DTC_Cam Signal Fault
65541	3	DTC_Est 1 Short High
65541	4	DTC_Est 1 Short Low
65541	5	DTC_Est 1 Open
65551	2	DTC_Knock Sensor 1 Fault
65552	2	DTC_Knock Sensor 2 Fault
65559	11	DTC_Can Bus Hardware
65561	0	DTC_Oxygen Sensor A Rich
65561	1	DTC_Oxygen Sensor A Lean
65563	0	DTC_Oxygen Sensor B Rich



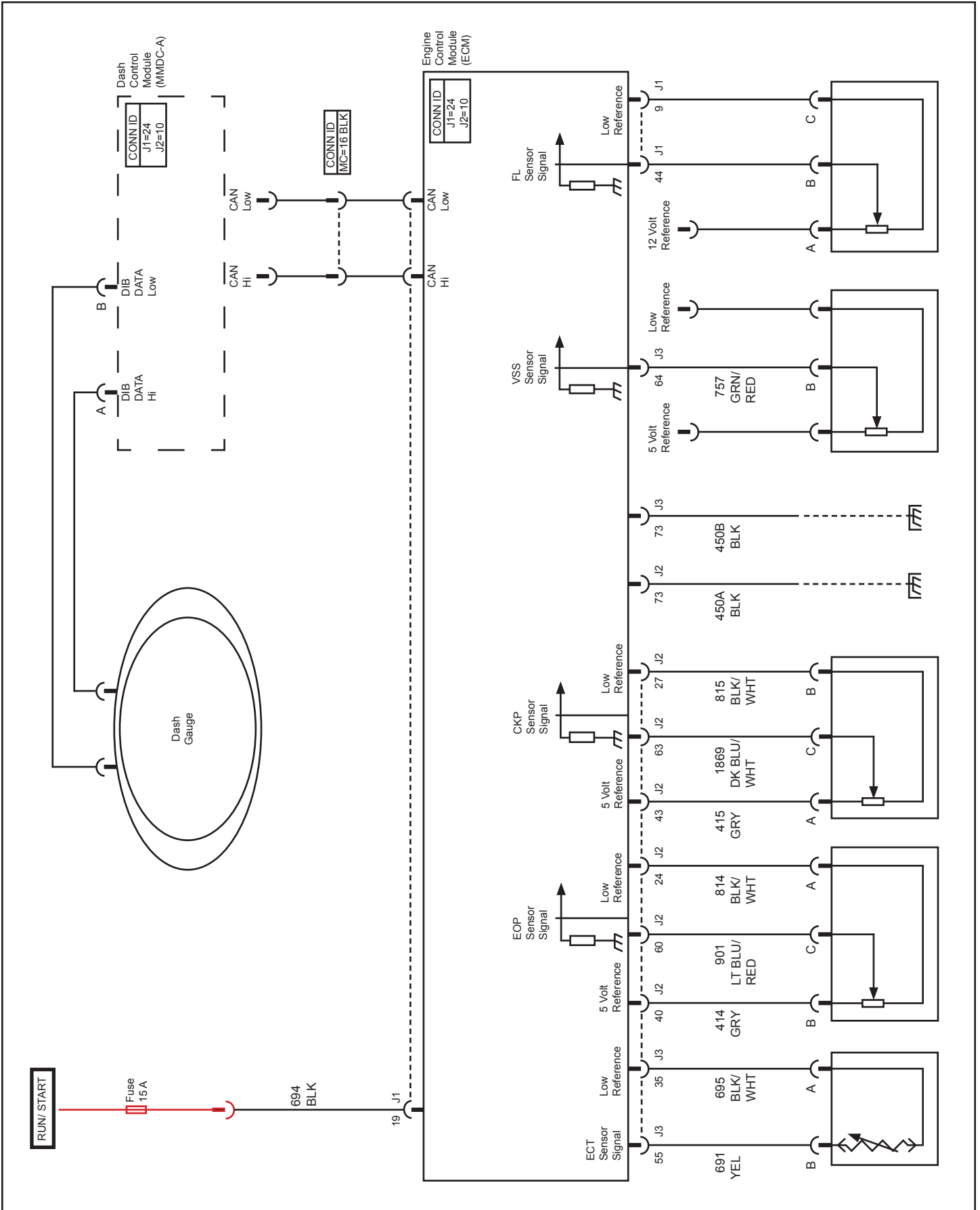
65563	1	DTC_Oxygen Sensor B Lean
65580	12	DTC_Cpu Failure
65581	12	DTC_Mhc Failure
65582	2	DTC_Nv Ram Failure
65590	7	DTC_Misfire
65601	2	DTC_Etc Tps 2 Range
65602	2	DTC_Etc Tps 1 Range
65604	2	DTC_Etc Pps 2 Range
65605	2	DTC_Etc Pps 1 Range
65610	2	DTC_Etc Tps 1-2 Correlation
65613	2	DTC_Etc Pps 1-2 Correlation
65615	7	DTC_Etc Actuation
65616	12	DTC_Etc Process
65618	7	DTC_Etc Return Fault
66013	5	DTC_Powertrain Relay Short Low
66013	6	DTC_Powertrain Relay Short High
66013	7	DTC_Powertrain Relay Open
66014	4	DTC_Powertrain Relay Contact Low
66017	5	DTC_Fuel Pump Short Low
66017	6	DTC_Fuel Pump Short High
66017	7	DTC_Fuel Pump Open
66019	5	DTC_Oxygen Sensor A Heater Short Low
66019	6	DTC_Oxygen Sensor A Heater Short High
66019	7	DTC_Oxygen Sensor A Heater Open
66020	5	DTC_Oxygen Sensor B Heater Short Low
66020	6	DTC_Oxygen Sensor B Heater Short High
66020	7	DTC_Oxygen Sensor B Heater Open
		NOTE -- MEFI-5 Does Not Support Occurrence Count
		FAILURE MODE INDICATOR (FMI)
		0 = Data valid but above normal
		1 = Data valid but below normal
		2 = Data erratic, intermittent or incorrect
		3 = Voltage above normal or shorted high
		4 = Voltage below normal or shorted low
		5 = Current below normal or open circuit
		6 = Current above normal or grounded circuit
		7 = Mechanical system not responding or out of adjustment
		8 = Abnormal frequency or pulse width
		9 = Abnormal update rate
		10 = Abnormal rate of change
		11 = Root cause unknown

		12 = Bad intelligent device or component
		13 = Out of calibration
		14 = Special instructions
		15 = Data valid but above normal range - Least Severe Level
		16 = Data valid but above normal range - Moderate Severe Level
		17 = Data valid but below normal range - Least Severe Level
		18 = Data valid but below normal range - Moderate Severe Level
		19 = Received network data error

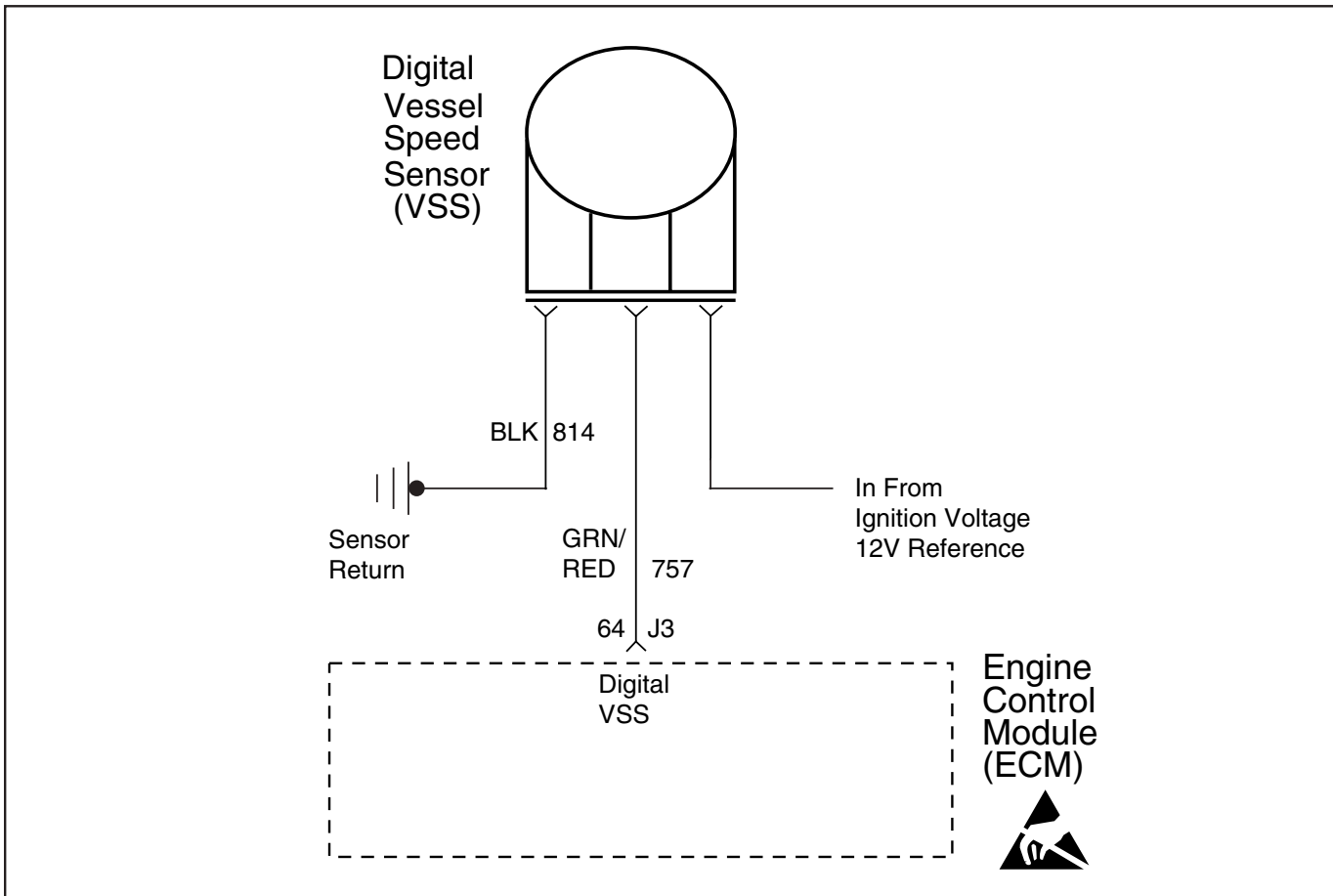
## Section 6 - Dash Instrumentation

Dash Wiring Schematics ..... Pages 2  
VSS Circuit Fault  
    SPN 84 FMI 2.....Pages 4 - 5  
Fuel Level Sensor Circuit Check.....Pages 6 - 8  
MMDC Pin Out ..... Pages 10 - 11

Dash Wiring Schematics (ECT, EOP, CKP, VSS, & FL)



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### SPN 84, FMI 2 - Vessel Speed Sensor (VSS) Circuit

#### Circuit Description

The vessel speed is provided to the ECM by means of the Vessel Speed Sensor (VSS). The sensor is a “paddle wheel” type and is usually located through hull or attached to the transom. The thru-hull transducer produces a 12 volt digital signal whenever the vessel is moving. The number of pulses increases with vessel speed. The ECM converts this signal into MPH, which can be monitored with a scan tool. This information may be used by the ECM for several reasons such as governing the vessel speed to a maximum speed.

The sensor is a three-wire sensor. Terminal “C” of the sensor is provided a ground on CKT 814 through the ECM. Terminal “A” of the sensor is provided ignition voltage. Terminal “B” of the sensor is the signal to the ECM through CKT 757.

#### Diagnostic Aids

Check for the following conditions:

- Poor connection in harness. Inspect harness connectors for backed out terminals, improper mating, broken locks, improperly formed or damaged terminals and poor terminal to wire connection.

Check VSS circuits for proper connections and the harness is routed properly.

After repairs, clear DTC's following “Clear DTC's Procedure.” Failure to do so may result in DTC's not properly being cleared.

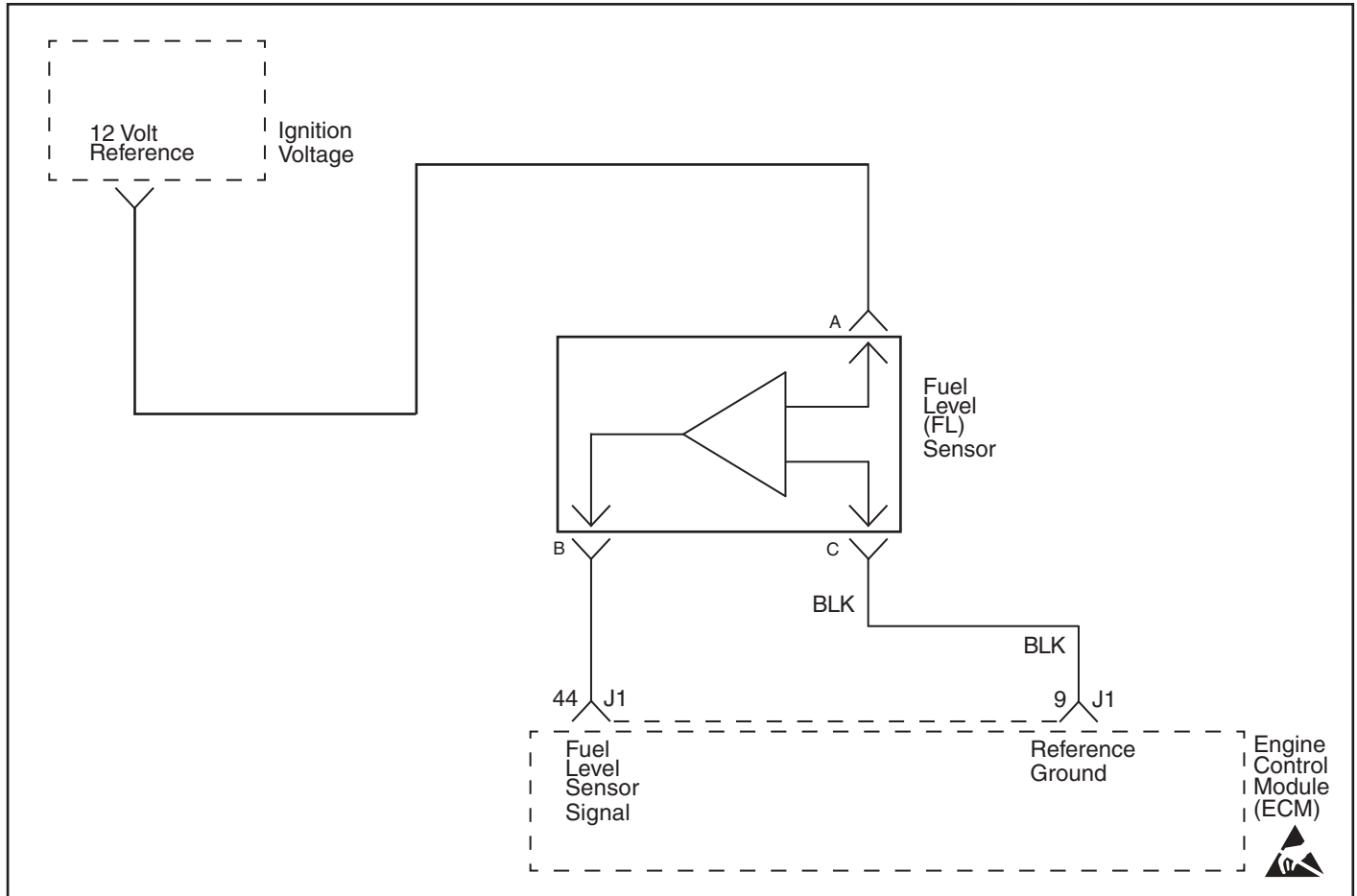
#### Test Description

2. This step determines if the VSS is receiving ignition voltage.
3. This step checks for a good ground circuit.

## SPN 84, FMI 2 - Vessel Speed Sensor (VSS) Circuit

Step	Action	Value	Yes	No
1	Was the "On-Board Diagnostic" (OBD) system check performed?	—	Go to Step 2	Go to OBD System Check on Page 2-12
2	1. Disconnect the vessel speed sensor electrical connector. 2. Turn ignition ON. 3. Using a test light connected to a known good ground, probe ECM harness terminal "C". Does the test light illuminate brightly?	—	Go to Step 3	Go to Step 7
3	1. Turn ignition ON. 2. Using a test light connected to B+, probe ECM harness terminal "A". Does the test light illuminate brightly?	—	Go to Step 4	Go to Step 8
4	1. Ignition OFF. 2. Reconnect VSS electrical connector. 3. Turn ignition ON. 4. Be sure the vessel is secured on the trailer per manufacturer's recommendations. 5. Using J39978, Fluke 78 or Fluke 87 connected to a known good ground, back probe ECM harness connector terminal "J3-64". 6. While observing the DVOM, slowly rotate the paddle wheel. Does the DVOM indicate a voltage changing as the wheel is rotated?	—	Go to Step 9	Go to Step 5
5	Locate and repair open or short to ground on CKT 757. If a problem is found, repair as necessary. Was a problem found?	—	Verify repair	Go to Step 6
6	Replace faulty VSS. Is action complete?	—	Verify repair	—
7	Locate and repair open or short to ground in the ignition circuit to the VSS. Is action complete?	—	Verify Repair	—
8	Locate and repair open in the ground circuit to the VSS. Is action complete?	—	Verify Repair	—
9	SPN 84 FMI 2 may be intermittent. Clear DTC and drive the vessel. If SPN 84 FMI 2 returns, repair faulty ECM connections or replace faulty ECM. Is action complete?	—	Verify Repair	—

## Fuel Level Sensor



## Fuel Level Sensor Circuit

**Circuit Description**

The fuel level sensor changes resistance based on the weight of the fuel in the fuel tank. The ECM monitors the signal circuit of the fuel level sensor.

When the fuel weight is high, the sensor resistance is high, and the ECM senses a high signal voltage. When the fuel weight is low, the sensor resistance is low, and the ECM senses a low signal voltage.

The ECM sends the fuel level information to the IPC (dash) via the CAN BUS J1939 data circuit.

**Diagnostic Aids**

Check for the following conditions:

- Poor connection at ECM. Inspect harness connectors for backed out terminals, improper mating, broken locks, improperly formed or damaged terminals and poor terminal to wire connection.
- Damaged harness. Inspect the wiring harness for damage. If the harness appears to be OK, observe the fuel level sensor display on the scan tool while moving connectors and wiring harnesses related to the fuel level sensor. A change in the fuel level sensor display will indicate the location of the fault.
- The instrument panel cluster (IPC) displays the fuel level reading.

After repairs, clear DTC's following "Clear DTC's Procedure" in the *General Information* section. Failure to do so may result in DTC's not properly being cleared.



## Fuel Level Sensor Circuit

Step	Action	Value	Yes	No
1	Was the "On-Board Diagnostic" (OBD) system check performed?	—	Go to Step 2	Go to OBD System Check Page 2-12
2	Check for 12 volts. 1. Unplug the sensor. 2. Back probe Pin A & Pin C. 3. Attach the voltmeter leads. 4. Turn the ignition ON, with the engine OFF. Does the voltmeter indicate voltage greater than the specified value?	11.6 V	Go to Step 6	Go to Step 3
3	Inspect the circuit breaker or remove the fuse and inspect its condition. Did you find and correct the condition?		Verify Repair	Go to Step 4
4	Test the ignition wire for an open or for high resistance. Did you find and correct the condition?		Verify Repair	Go to Step 5
5	Test the ground wire for an open, for a short to ground, or for high resistance. Did you find and correct the condition?		Verify Repair	Go to Step 6
6	Measure the signal wire voltage. 1. Back Pin B. 2. Attach the positive voltmeter lead to B. 3. Attach the negative voltmeter lead to the negative battery lead. Normal range is: ~0.5 volts for low fuel and ~4.5 for a full tank. Does the voltmeter indicate voltage other than the specified value?		Verify Repair	Go to Step 7
7	Test the signal wire for continuity. Did you find and correct the condition?		Verify Repair	Go to Step 8
8	Inspect for poor connections at the harness connector of the fuel level sensor. Did you find and correct the condition?		Verify Repair	Go to Step 9

### Fuel Level Sensor Circuit

Step	Action	Value	Yes	No
9	Inspect for poor connections at the harness connector of the ECM. Did you find and correct the condition?		Verify Repair	Go to Step 10
10	Replace the fuel level sensor. Did you find and correct the condition?		Verify Repair	Go to Step 11
11	<b>Important:</b> Program the replacement ECM. Replace the ECM. Did you complete the replacement?		Verify Repair	

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## MMDC - CAN BUS Dash Pin Outs

## 1.1 MMDC-A Connector J1 (24 Pin)

Pin	MMDC-A	Signal Description	Specification
1	Analog Input	Primary Speed Cal	12v/open/ground
2	Analog Input	Secondary Speed Cal	12v/open/ground
3	Analog Input	Tach LCD Control Switch	12v/open/ground
4	Analog Input	Cruise ON/OFF Switch	12v/open/ground
5	Analog Input	Not Used	
6	Analog Input	Not Used	
7	Analog Input	Lake Temperature Sender	10K Thermistor (77 F = 10k ohms)
8	Program Input	Not Used	
9	Program Input	Not Used	
10	Program Input	Not Used	
11	Ignition - 2	Not Used	
12	Output - 2	Unused Output	
13	Analog Input	Air Temperature Sender	10K Thermistor (77 F = 10k ohms)
14	Analog Input	Cruise +/- Switch	12v/open/ground
15	Analog Input	Cruise RPM/SPD Switch	12v/open/ground
16	Analog Input	Not Used	
17	Analog Input	Not Used	
18	Analog Input	Ballast 1 Level Sender	Capacitive Sender
19	Analog Input	Not Used	
20	Analog Input	Not Used	
21	Analog Input	Not Used	
22	ECU1 + CAN +		
23	ECU1 - CAN -		

**MMDC - CAN BUS Dash Pin Outs**

## 1.2 MMDC Connector J2 (10 Pin)

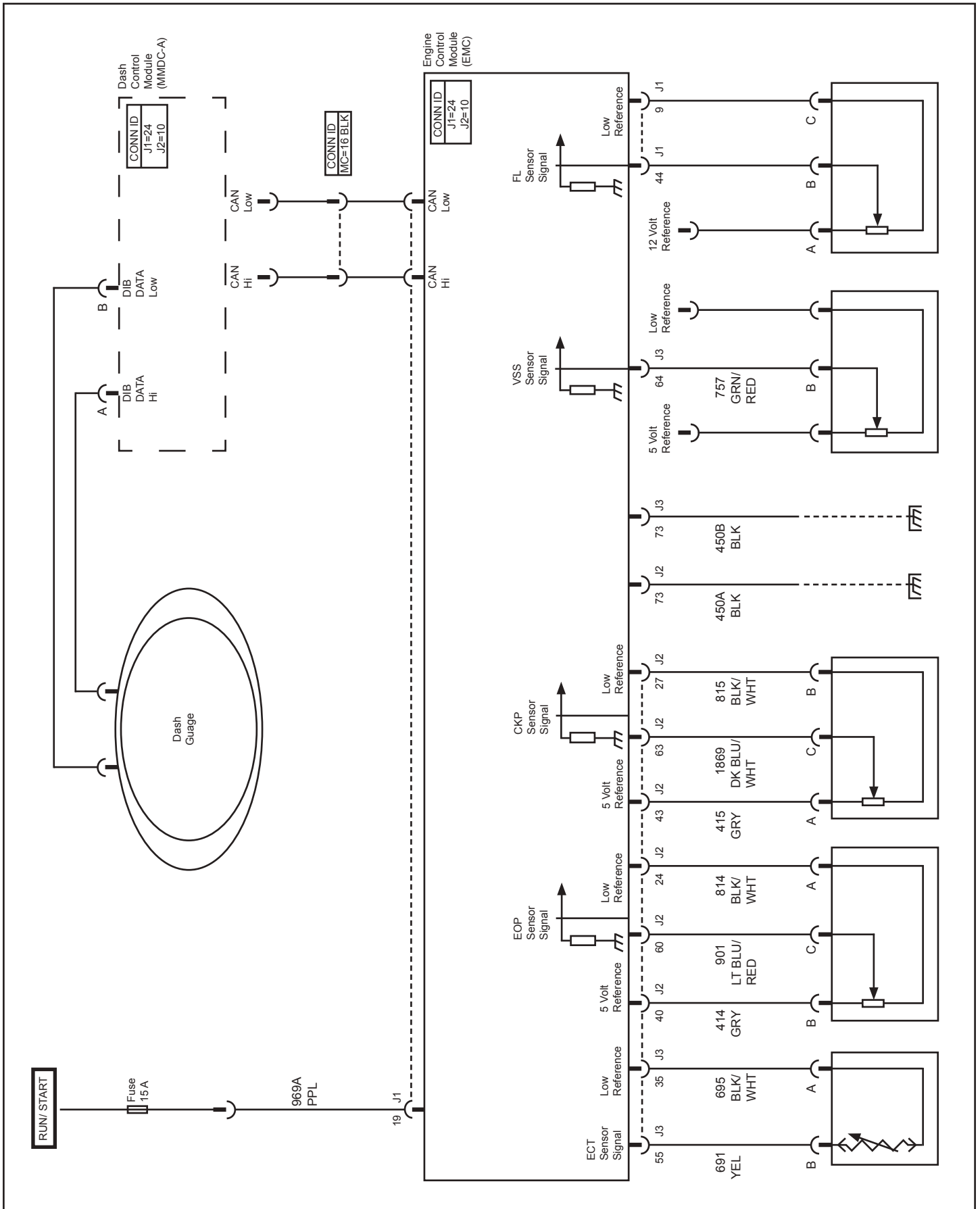
<b>Pin</b>	<b>MMDC-A</b>	<b>Signal Description</b>	<b>Specification</b>
A	AIB	Digital Data To Gauges	
B	Gauge Power	Dedicated Gauge 7 VDC	
C	Gauge Ground	Dedicated Gauge GND	
D	Battery Ground	Dedicated Battery Ground	
E	Battery Dedicated	Battery Power	
F	Ignition	Ignition Input	
G	Output 1	Alarm Control Output (2 Amps Max.)	Active Low
H	DIB Shield	DIB Data Link Shield	
J	DIB -	DIB Data Link	
K	DIB +	DIB Data Link	

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## Section 7 - Symptoms

Dash Wiring Schmatic.....	Page 2
<b>Symptoms</b> .....	Page 3
Important Preliminary Checks .....	Page 3
Before Starting .....	Page 3
Visual / Physical Check.....	Page 3
Intermittents .....	Pages 3-4
Hard Start Symptoms.....	Pages 6
Surges and/or Chuggles Symptom .....	Page 10
Lack of Power, Sluggish or	
Spongy Symptom.....	Pages 12
Detonation / Spark Knock Symptom .....	Page 14
Hesitation, Sag, Stumble Symptom .....	Page 16
Cuts Out, Misses Symptom.....	Page 18
Rough, Unstable or Incorrect Idle,	
Stalling Symptom.....	Page 20
Poor Fuel Economy Symptom .....	Page 24
Dieseling, Run-On Symptom.....	Page 26
Backfire Symptom .....	Page 28
ECM Connector "J1" Symptom Table.....	Page 30
ECM Connector "J2" Symptom Table.....	Page 34
ECM Connector "J3" Symptom Table.....	Page 38

Dash Wiring Schematics (ECT, EOP, CKP, VSS, & FL)





## Symptoms

### Important Preliminary Checks

#### Before Starting

Before using this section you should have performed the "On-Board Diagnostic (OBD) System Check" and determined that:

- The ECM and MIL (Malfunction Indicator Lamp) are operating correctly.
- There are no DTC(s) stored.

Verify the customer complaint and locate the correct symptom in the table of contents. Check the items indicated under that symptom.

#### Visual / Physical Check

Several of the symptom procedures call for a careful Visual / Physical Check. The importance of this step cannot be stressed too strongly - it can lead to correcting a problem without further checks and can save valuable time. This check should include:

- ECM grounds and sensor connections for being clean, tight and in their proper location.
- Vacuum hoses for splits, kinks and proper connections. Check thoroughly for any type of leak or restriction.
- Air leaks at throttle body mounting area and intake manifold sealing surfaces.
- Ignition wires for cracking, hardness, proper routing and carbon tracking.
- Wiring for proper connections, pinches and cuts. If wiring harness or connector repair is necessary, refer to *General Information* section for correct procedure.
- Moisture in primary or secondary ignition circuit connections.
- Salt corrosion on electrical connections and exposed throttle body linkages.

#### Intermittents

**Important:** Problem may or may not turn "ON" the Malfunction Indicator Lamp (MIL) or store a DTC. DO NOT use the Diagnostic Trouble Code (DTC) tables for intermittent problems. The fault must be present to locate the problem.

Most intermittent problems are caused by faulty electrical connections or wiring. Perform careful visual / physical check.

Check for the following conditions:

- Poor mating of the connector halves, or a terminal not fully seated in the connector body (backed out or loose).
- Improperly formed or damaged terminals and / or connectors.
- All connector terminals in the problem circuit should be carefully checked for proper contact tension.
- Poor terminal to wire connection (crimping). This requires removing the terminal from the connector body to check. Refer to "Wiring Harness Service" in the *General Information* section.

The vessel may be driven with a **J 39200** Digital Multimeter connected to a suspected circuit. An abnormal voltage when malfunction occurs is a good indication that there is a fault in the circuit being monitored.

A scan tool may also be used to help detect intermittent conditions. The **Snapshot** feature can be triggered to capture and store engine parameters within the scan tool when the malfunction occurs. This stored information then can be reviewed by the service technician to see what caused the malfunction.

To check loss of DTC memory, disconnect ECT sensor and idle engine until the MIL comes "ON." DTC SPN 110 should be stored and kept in memory when ignition is turned "OFF." If not the ECM is faulty. When this test is completed, make sure that you clear the DTC SPN 110 from memory using "Clearing DTC Procedure" found in *General Information* section.

An intermittent MIL with no stored DTC may be caused by the following:

- Ignition coil shorted to ground and arcing at ignition wires or plugs.
- MIL wire to ECM shorted to ground.
- Poor ECM grounds.
- Check for an electrical system interference caused by a sharp electrical surge. Normally, the problem will occur when the faulty component is operated.
- Check for improper installation of electrical options such as lights, ship to shore radios, sonar, etc.
- Check that knock sensor wires are routed away from spark plug wires, ignition system components and charging system components.
- Check for secondary ignition components shorted to ground, or an open ignition coil ground (coil mounting brackets).
- Check for components internally shorted to ground such as starters, alternators or relays.

All Ignition Control (IC) module wiring should be kept away from the alternator. Check all wires from the ECM to the ignition control module for poor connections.

If problem has not been found go to "ECM Connector Symptom Tables" at the end of *Symptoms* section.

**Temperature vs Resistance**

C	F	OHMS
Temperature vs Resistance Values (Approximate)		
150	302	47
140	284	60
130	266	77
120	248	100
110	230	132
100	212	177
90	194	241
80	176	332
70	158	467
60	140	667
50	122	973
45	113	1188
40	104	1459
35	95	1802
30	86	2238
25	77	2796
20	68	3520
15	59	4450
10	50	5670
5	41	7280
0	32	9420
-5	23	12300
-10	14	16180
-15	5	21450
-20	-4	28680
-30	-22	52700
-40	-40	100700

**Testing for Intermittent Wiring Conditions**

Perform the following procedures while wiggling the harness from side to side. Continue this at convenient points (about 6 inches apart) while watching the test equipment.

- Test for Short to Ground
- Test for Continuity
- Test for a Short to Voltage

If the fault is not identified, perform a data log or snapshot to capture data, which may show the source of the fault.

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### Hard Start Symptom

Step	Action	Value	Yes	No
<b>Definition:</b> Engine cranks OK, but does not start for a long time. Does eventually run, or may start but immediately dies.				
1	Was the "On-Board Diagnostic" (OBD) system check performed?	—	Go to Step 2	Go to OBD System Check Page 2-12
2	Check to see if the operator is using the correct starting procedure as described in the owners manual. Educate the operator if they do not know. Does the operator know the correct starting procedure?	—	Go to Step 3	System normal
3	Was visual/physical check performed?	—	Go to Step 4	Go to Visual/Physical Check
4	1. Check for correct base ignition timing. • Refer to "Ignition Timing Set Procedure" in the <i>Distributor Ignition</i> Section. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 5
5	1. Check for proper operation of fuel pump relay circuit. • Refer to Fuel System Electrical Test Section 6. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 6
6	1. Check for contaminated fuel. 2. Check fuel filters and water separator. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 7
7	1. Check for proper fuel pressure. • Refer to Fuel System Diagnosis Section 6. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 8
8	1. Check for proper ignition voltage output. • Refer to Distributor Ignition System Check in Section . 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 9
9	Is a scan tool being used?	—	Go to Step 11	Go to Step 10
10	1. Check for a ECT sensor shifted in value. 2. With engine completely cool, measure the resistance of the ECT sensor. 3. Refer to the Engine Coolant Temperature Sensor Temperature vs. Resistance value table on page 7-3, Symptoms. Compare the approximate temperature of the ECT sensor to an accurate reading of ambient air temperature. Are the readings within the specified value?	-12° C (10° F)	Go to Step 15	Go to Step 14

## Hard Start Symptom (Cont.)

Step	Action	Value	Yes	No
11	1. Check ECT sensor for being shifted in value. 2. With the engine completely cool, compare the ECT sensor temperature with an accurate reading of ambient air temperature. Are the temperatures within the specified value of each other?	-12° C (10° F)	Go to Step 12	Go to Step 14
12	1. Using a scan tool, display ECT sensor temperature and note value. 2. Check resistance of ECT sensor. 3. Go to Engine Coolant Temperature Sensor Temperature vs. Resistance value table on page 7-4. Is resistance value of ECT sensor near the resistance of the value noted?	—	Go to Step 15	Go to Step 13
13	Locate and repair high resistance or poor connection in the ECT signal circuit or the ECT sensor ground. Is action complete?	—	Go to OBD System Check	—
14	Replace the ECT sensor. Is action complete?	—	Go to OBD System Check	—
15	1. Check for intermittent opens or shorts to ground in the MAP sensor circuits. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 16
16	1. Check for proper operation of the TP sensor. 2. Check for throttle linkage sticking, binding or worn causing TP sensor voltage to be higher than normal. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 17
17	1. Check for proper operation of the throttle body blade. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 18
18	1. Check for the following engine mechanical problems: <ul style="list-style-type: none"> <li>• Low compression.</li> <li>• Leaking cylinder head gaskets.</li> <li>• Worn or incorrect camshaft.</li> <li>• Proper valve timing / valve train problem.</li> <li>• Restricted exhaust system.</li> </ul> 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 19

## Hard Start Symptom (Cont.)

19	<ol style="list-style-type: none"> <li>1. Review all diagnostic procedures within this table.</li> <li>2. If all procedures have been completed and no malfunctions have been found, review/inspect the following: <ul style="list-style-type: none"> <li>• Visual/physical inspection.</li> <li>• Scan tool data.</li> <li>• All electrical connections within a suspected circuit and/or system.</li> </ul> </li> <li>3. If a problem is found, repair as necessary.</li> </ol> <p>Was a problem found?</p>	—	Go to OBD System Check	Contact OEM
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## Surges and / or Chuggles Symptom

Step	Action	Value	Yes	No
<b>1</b>	Was the "On-Board Diagnostic" (OBD) system check performed?	—	Go to Step 2	Go to OBD System Check Page 2-12
<b>2</b>	Was the visual/physical check performed?	—	Go to Step 3	Go to Visual/Physical Check
<b>3</b>	1. Check for correct base ignition timing. • Refer to "Ignition Timing Set Procedure" in the <i>Distributor Ignition</i> section. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check Page 2-12	Go to Step 4
<b>4</b>	1. Check for engine going into RPM reduction mode. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 5
<b>5</b>	1. Check for contaminated fuel. 2. Check fuel filters and water separator. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 6
<b>6</b>	1. Check for proper fuel pressure while the condition exists. • Refer to Fuel System Diagnosis Section 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 7
<b>7</b>	1. Check for intermittent opens or short to grounds in the ECT sensor, MAP sensor and TP sensor circuits. Also check for throttle linkage sticking, binding or worn. 2. An intermittent failure may not store a DTC. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 8
<b>8</b>	1. Check for proper ignition voltage output. • Refer to High Voltage Switch (replaces distributor) System Check. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 9
<b>9</b>	1. Check ignition coil for cracks or carbon tracking. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 10
<b>10</b>	1. Check integrity of the primary and secondary wiring. 2. Check routing of the wiring. 3. Check condition of IC module, pick-up coil, distributor cap, rotor and spark plug wires. 4. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 11



## Surges and/or Chuggles Symptom

Step	Action	Value	Yes	No
11	<ol style="list-style-type: none"> <li>Remove spark plugs and check for wet plugs, cracks, wear, improper gap, burned electrodes or heavy deposits. <ul style="list-style-type: none"> <li>Refer to Distributor Ignition System.</li> </ul> </li> </ol> <p><b>Notice:</b> If spark plugs are gas or oil fouled, the cause of the fouling must be determined before replacing the spark plugs.</p> <ol style="list-style-type: none"> <li>If a problem is found, repair as necessary.</li> </ol> <p>Was a problem found?</p>	—	Go to OBD System Check	Go to Step 12
12	<ol style="list-style-type: none"> <li>Check items that can cause the engine to run rich.</li> <li>If a problem is found, repair as necessary.</li> </ol> <p>Was a problem found?</p>	—	Go to OBD System Check	Go to Step 13
13	<ol style="list-style-type: none"> <li>Check items that can cause the engine to run lean.</li> <li>If a problem is found, repair as necessary.</li> </ol> <p>Was a problem found?</p>	—	Go to OBD System Check	Go to Step 14
14	<ol style="list-style-type: none"> <li>Check the injector connections for proper mating.</li> <li>If any of the injectors connectors are connected to an incorrect cylinder, correct as necessary.</li> </ol> <p>Was a problem found?</p>	—	Go to OBD System Check	Go to Step 15
15	<ol style="list-style-type: none"> <li>Check ECM grounds for being clean, tight and in the proper locations.</li> <li>If a problem is found, repair as necessary.</li> </ol> <p>Was a problem found?</p>	—	Go to OBD System Check	Go to Step 16
16	<ol style="list-style-type: none"> <li>Visually/physically check vacuum hoses for splits, kinks and proper connections and routing.</li> <li>If a problem is found, repair as necessary.</li> </ol> <p>Was a problem found?</p>	—	Go to OBD System Check	Go to Step 17
17	<ol style="list-style-type: none"> <li>Check for proper alternator voltage output.</li> <li>The voltage should be between specified values.</li> <li>If a problem is found, repair as necessary.</li> </ol> <p>Was a problem found?</p>	11-16V	Go to OBD System Check	Go to Step 18
18	<ol style="list-style-type: none"> <li>Review all diagnostic procedures within this table.</li> <li>If all procedures have been completed and no malfunctions have been found, review/inspect the following: <ul style="list-style-type: none"> <li>Visual/physical inspection.</li> <li>Scan tool data.</li> <li>All electrical connections within a suspected circuit and/or system.</li> </ul> </li> <li>If a problem is found, repair as necessary.</li> </ol> <p>Was a problem found?</p>	—	Go to OBD System Check	Contact OEM

## Lack of Power, Sluggish or Spongy Symptom

Step	Action	Value	Yes	No
<b>Definition:</b> Engine delivers less than expected power. Little or no increase in speed when the throttle control is moved part way.				
1	Was the "On-Board Diagnostic" (OBD) system check performed?	—	Go to Step 2	Go to OBD System Check Page 2-12
2	Compare vessel performance with a similar vessel. Both Vehicle's performance should be close. Is vehicle performance close to similar vehicle.	—	No Problem found	Go to Step 3
3	Was visual/physical check performed?	—	Go to Step 4	Go to Visual/ Physical check
4	1. Check for correct base ignition timing. • Refer to "Ignition Timing Set Procedure" in the <i>Distributor Ignition</i> section. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 5
5	1. Remove and check flame arrestor for dirt, or for being restricted. 2. Replace flame arrestor if necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 6
6	1. Check for contaminated fuel. 2. Check fuel filters and water separator. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 7
7	1. Check for proper fuel pressure while the condition exists. • Refer to Fuel System Diagnosis. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 8
8	1. Check for injector driver CKT's for an open. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 9
9	1. Check for proper operation of Ignition Control (IC) circuit and the Knock Sensor (KS) circuit(s). 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 10
10	1. Check for proper ignition voltage output. • Refer to High Voltage Switch (replaces distributor) System Check. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 11
11	1. Remove spark plugs, check for wet plugs, cracks, wear, improper gap, burned electrodes or heavy deposits. <b>Notice:</b> If spark plugs are gas or oil fouled, the cause of the fouling must be determined before replacing the spark plugs. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 12

## Lack of Power, Sluggish or Spongy Symptom (Cont.)

Step	Action	Value	Yes	No
12	1. Check ignition coil for cracks or carbon tracking. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 13
13	1. Check for intermittent opens or short to grounds in the ECT sensor, MAP sensor and TP sensor circuits. Also check for throttle linkage sticking, binding or worn. 2. An intermittent failure may not store a DTC. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 14
14	1. Check ECM grounds for being clean, tight and in their proper locations. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 15
15	1. Check for engine going into RPM reduction mode. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 16
16	1. Check for proper alternator voltage output. 2. The voltage should be between specified values. 3. If a problem is found, repair as necessary. Was a problem found?	11-16V	Go to OBD System Check	Go to Step 17
17	1. Check for the following engine mechanical problems: <ul style="list-style-type: none"> <li>• Low compression.</li> <li>• Leaking cylinder head gaskets.</li> <li>• Worn or incorrect camshaft.</li> <li>• Proper valve timing / valve train problem.</li> <li>• Restricted exhaust system.</li> </ul> 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 18
18	1. Check for excessive resistance on the bottom of the boat such as dirt, barnacles, etc. 2. Check for proper propeller size and pitch for that application. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 19
19	1. Review all diagnostic procedures within this table. 2. When all procedures have been completed and no malfunctions are found, review / inspect the following: <ul style="list-style-type: none"> <li>• Visual / physical inspection.</li> <li>• Scan tool data.</li> <li>• All connections within a suspected circuit and / or system.</li> </ul> 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Contact OEM

## Detonation / Spark Knock Symptom

Step	Action	Value	Yes	No
<b>1</b>	Was the "On-Board Diagnostic" (OBD) system check performed?	—	Go to Step 2	Go to OBD System Check Page 2-12
<b>2</b>	Was visual/physical check performed?	—	Go to Step 3	Go to Visual/Physical check
<b>3</b>	1. Check for correct base ignition timing. <ul style="list-style-type: none"> <li>Refer to "Ignition Timing Set Procedure" in the <i>Distributor Ignition</i> section.</li> </ul> 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 4
<b>4</b>	1. Check for proper operation of Ignition Control (IC) circuit and the Knock Sensor (KS) circuit(s). 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 5
<b>5</b>	1. Check for good ignition system ground. 2. Check spark plugs for proper gap and heat range. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 6
<b>6</b>	1. Check for contaminated fuel. 2. Check for poor fuel quality and proper octane rating. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 7
<b>7</b>	1. Check for proper fuel pressure. <ul style="list-style-type: none"> <li>Refer to Fuel System Diagnosis.</li> </ul> 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 8
<b>8</b>	Is a scan tool being used?	—	Go to Step 9	Go to Step 10
<b>9</b>	If scan tool readings are normal ( <i>Refer to "Typical Scan Values"</i> ) and there are no engine mechanical faults, fill fuel tank with a known quality gasoline that has a minimum octane reading of 92 and re-evaluate vehicle performance. Is detonation present?	—	Go to Step 10	Go to OBD System Check
<b>10</b>	1. Check for obvious overheating problems: <ul style="list-style-type: none"> <li>Loose water pump belt.</li> <li>Faulty or incorrect water pump.</li> <li>Restriction in cooling system.</li> <li>Faulty or incorrect thermostat.</li> </ul> 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 11

## Detonation/Spark Knock Symptom

Step	Action	Value	Yes	No
11	1. Check items that can cause an engine to run lean. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 12
12	1. Check for ECT sensor being shifted in value. 2. Check for proper output voltage of the TP sensor at closed throttle and wide open throttle. Also check throttle linkage for sticking, binding or worn. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 13
13	1. Check for the following engine mechanical problems: <ul style="list-style-type: none"> <li>• Low compression.</li> <li>• Low oil level.</li> <li>• Excessive oil in the combustion chambers due to valve seals leaking.</li> <li>• Worn or incorrect camshaft.</li> <li>• Proper valve timing/valve train problem.</li> <li>• Combustion chambers for excessive carbon build up.</li> </ul> 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 14
14	1. Remove excessive carbon buildup with a top engine cleaner. <ul style="list-style-type: none"> <li>• Refer to instructions on top engine cleaner can.</li> </ul> 2. Re-evaluate vehicle performance. Is detonation still present?	—	Go to Step 15	Go to OBD System Check
15	1. Review all diagnostic procedures within this table. 2. If all procedures have been completed and no malfunctions have been found, review/inspect the following: <ul style="list-style-type: none"> <li>• Visual/physical inspection.</li> <li>• Scan tool data.</li> <li>• All electrical connections within a suspected circuit and/or system.</li> </ul> 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Contact OEM

## Hesitation, Sag, Stumble Symptom

Step	Action	Value	Yes	No
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**Definition:** Momentary lack of response as the accelerator is pushed down. Can occur at all vessel speeds. Usually most severe when first trying to make the vehicle move, as from a stop. May cause engine to stall if severe enough.

1	Was the "On-Board Diagnostic" (OBD) System Check performed?	—	Go to Step 2	Go to OBD System Check Page 2-12
2	Was visual/physical check performed?	—	Go to Step 3	Go to Visual/Physical check
3	1. Check for correct base ignition timing. • Refer to "Ignition Timing Set Procedure" in the <i>Distributor Ignition</i> section. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 4
4	1. Check for contaminated fuel. 2. Check fuel filters and water separator. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 5
5	1. Check for proper fuel pressure while the condition exists. • Refer to Table Fuel System Diagnosis section 6. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 6
6	1. Check fuel injectors. • Refer to Injector Coil Test and Injector Balance Test at the end of this section. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 7
7	1. Check for proper operation of Ignition Control (IC) circuit and the Knock Sensor (KS) circuit(s). 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 8
8	1. Check integrity of the primary and secondary wiring. 2. Check routing of the wiring. 3. Check condition of IC module, pick-up coil, distributor cap, rotor and spark plug wires. 4. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 9
9	1. Remove spark plugs and check for wet plugs, cracks, wear, improper gap, burned electrodes or heavy deposits. <b>Notice:</b> If spark plugs are gas or oil fouled, the cause of the fouling must be determined before replacing the spark plugs. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 10

## Hesitation, Sag, Stumble Symptom

Step	Action	Value	Yes	No
10	<ol style="list-style-type: none"> <li>Check for obvious overheating problems. <ul style="list-style-type: none"> <li>Loose water pump belt.</li> <li>Faulty or incorrect water pump.</li> <li>Restriction in cooling system.</li> <li>Faulty or incorrect thermostat.</li> </ul> </li> <li>If a problem is found, repair as necessary.</li> </ol> <p>Was a problem found?</p>	—	Go to OBD System Check	Go to Step 11
11	<ol style="list-style-type: none"> <li>Check for the ECT sensor shifted in value.</li> <li>Check for intermittent opens or short to grounds in the ECT sensor, MAP sensor and TP sensor circuits. Also check for throttle linkage sticking, binding or worn.</li> <li>An intermittent failure may not store a DTC.</li> <li>If a problem is found, repair as necessary.</li> </ol> <p>Was a problem found?</p>	—	Go to OBD System Check	Go to Step 12
12	<ol style="list-style-type: none"> <li>Check for engine going into RPM reduction mode.</li> <li>If a problem is found, repair as necessary.</li> </ol> <p>Was a problem found?</p>	—	Go to OBD System Check	Go to Step 13
13	<ol style="list-style-type: none"> <li>Check for proper alternator voltage output.</li> <li>The voltage should be between specified values.</li> <li>If a problem is found, repair as necessary.</li> </ol> <p>Was a problem found?</p>	11-16V	Go to OBD System Check	Go to Step 14
14	<ol style="list-style-type: none"> <li>Check for faulty or incorrect thermostat.</li> <li>If a problem is found, repair as necessary.</li> </ol> <p>Was a problem found?</p>	—	Go to OBD System Check	Go to Step 15
15	<ol style="list-style-type: none"> <li>Check intake valves for valve deposits.</li> <li>If deposits are found, remove as necessary.</li> </ol> <p>Were deposits found on the intake valves?</p>	—	Go to OBD System Check	Go to Step 16
16	<ol style="list-style-type: none"> <li>Review all diagnostic procedures within this table.</li> <li>If all procedures have been completed and no malfunctions have been found, review/inspect the following: <ul style="list-style-type: none"> <li>Visual/physical inspection.</li> <li>Scan tool data.</li> <li>All electrical connections within a suspected circuit and/or system.</li> </ul> </li> <li>If a problem is found, repair as necessary.</li> </ol> <p>Was a problem found?</p>	—	Go to OBD System Check	Contact OEM

## Cuts Out, Misses Symptom

Step	Action	Value	Yes	No
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**Definition:** Steady pulsation or jerking that follows engine speed, usually more pronounced as engine load increases.

The exhaust has a steady spitting sound at idle, low speed or on hard acceleration for fuel starvation that can cause engine to cut out.

1	Was the "On-Board Diagnostic" (OBD) System Check performed?	—	Go to Step 2	Go to OBD System Check Page 2-12
2	Was visual/physical check performed?	—	Go to Step 3	Go to Visual/Physical check
3	1. Check for contaminated fuel. 2. Check fuel filters and water separator. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 4
4	1. Check for proper fuel pressure while the condition exists. • Refer to Fuel System Diagnosis. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 5
5	1. Disconnect all injector harness connectors and install an injector test light J 34730-2 between the harness terminal connector of each injector. 2. Crank engine and note light on each connector. If test light fails to blink at any one of the connectors, it is a faulty injector drive circuit, harness, connector or terminal. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 6
6	1. Check fuel injectors. • Refer to Injector Coil Test and Injector Balance Test at the end of this section. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 7
7	1. Check for proper spark at each cylinder per manufactures recommendation. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 8
8	1. Remove spark plugs and check for wet plugs, cracks, wear, improper gap, burned electrodes or heavy deposits. <b>Notice:</b> If spark plugs are gas or oil fouled, the cause of the fouling must be determined before replacing the spark plugs. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 9



## Cuts Out, Misses Symptom

Step	Action	Value	Yes	No
9	<p>1. Remove spark plugs and check for wet plugs, cracks, wear, improper gap, burned electrodes or heavy deposits.</p> <p><b>Notice:</b> If spark plugs are gas or oil fouled, the cause of the fouling must be determined before replacing the spark plugs.</p> <p>2. If a problem is found, repair as necessary. Was a problem found?</p>	—	Go to OBD System Check	Go to Step 10
10	<p>1. Check for obvious overheating problems.</p> <ul style="list-style-type: none"> <li>• Loose water pump belt.</li> <li>• Faulty or incorrect water pump.</li> <li>• Restriction in cooling system.</li> <li>• Faulty or incorrect thermostat.</li> </ul> <p>2. If a problem is found, repair as necessary. Was a problem found?</p>	—	Go to OBD System Check	Go to Step 11
11	<p>1. Check engine mechanical for the following conditions.</p> <ul style="list-style-type: none"> <li>• Low compression.</li> <li>• Sticking or leaking valves.</li> <li>• Bent push rods.</li> <li>• Worn rocker arms.</li> <li>• Broken valve springs.</li> <li>• Worn camshaft lobe(s).</li> <li>• Incorrect valve timing.</li> </ul> <p>2. If a problem is found, repair as necessary. Was a problem found?</p>	—	Go to OBD System Check	Go to Step 12
12	<p>1. Check Intake and exhaust manifold(s) for casting flash.</p> <p>2. If a problem is found, repair as necessary. Was a problem found?</p>	—	Go to OBD System Check	Go to Step 13
13	<p>1. Check for Electromagnetic Interference (EMI). A missing condition can be caused by EMI on the reference circuit. EMI can usually be detected by monitoring engine RPM with a scan tool or tachometer. A sudden increase in RPM with little change in actual engine RPM change, may indicate EMI is present.</p> <p>2. If EMI is present, locate and repair the source. Was a problem found?</p>	—	Go to OBD System Check	Go to Step 14
14	<p>1. Review all diagnostic procedures within this table.</p> <p>2. If all procedures have been completed and no malfunctions have been found, review/inspect the following:</p> <ul style="list-style-type: none"> <li>• Visual/physical inspection.</li> <li>• Scan tool data.</li> <li>• All electrical connections within a suspected circuit and/or system.</li> </ul> <p>3. If a problem is found, repair as necessary. Was a problem found?</p>	—	Go to OBD System Check	Contact OEM

### Rough, Unstable or Incorrect Idle, Stalling Symptom

Step	Action	Value	Yes	No
<b>1</b>	Was the "On-Board Diagnostic" (OBD) System Check performed?	—	<i>Go to Step 2</i>	<i>Go to OBD System Check Page 2-12</i>
<b>2</b>	Was visual/physical check performed?	—	<i>Go to Step 3</i>	<i>Go to Visual/Physical check</i>
<b>3</b>	1. Check for correct base ignition timing. <ul style="list-style-type: none"> <li>• Refer to "Ignition Timing Set Procedure" in the <i>Distributor Ignition</i> section.</li> </ul> 2. If a problem is found, repair as necessary. Was a problem found?	—	<i>Go to OBD System Check</i>	<i>Go to Step 4</i>
<b>4</b>	1. Check for proper operation of the throttle body blade. 2. If a problem is found, repair as necessary. Was a problem found?	—	<i>Go to OBD System Check</i>	<i>Go to Step 5</i>
<b>5</b>	1. Check for proper operation of Ignition Control (IC) circuit and the Knock Sensor (KS) circuit(s). 2. If a problem is found, repair as necessary. Was a problem found?	—	<i>Go to OBD System Check</i>	<i>Go to Step 6</i>
<b>6</b>	1. Check integrity of the primary and secondary wiring. 2. Check routing of the wiring. 3. Check condition of IC module, pick-up coil, distributor cap, rotor and spark plug wires. 4. If a problem is found, repair as necessary. Was a problem found?	—	<i>Go to OBD System Check</i>	<i>Go to Step 7</i>
<b>7</b>	1. Check ignition coil for cracks or carbon tracking. 2. If a problem is found, repair as necessary. Was a problem found?	—	<i>Go to OBD System Check</i>	<i>Go to Step 8</i>
<b>8</b>	1. Remove spark plugs and check for wet plugs, cracks, wear, improper gap, burned electrodes or heavy deposits. <b>Notice:</b> If spark plugs are gas or oil fouled, the cause of the fouling must be determined before replacing the spark plugs. 2. If a problem is found, repair as necessary. Was a problem found?	—	<i>Go to OBD System Check</i>	<i>Go to Step 9</i>
<b>9</b>	Check the injector connections. If any of the injectors are connected to an incorrect cylinder, correct as necessary. Was a problem found?	—	<i>Go to OBD System Check</i>	<i>Go to Step 10</i>

## Rough, Unstable or Incorrect Idle, Stalling Symptom

Step	Action	Value	Yes	No
10	1. Check for obvious overheating problems: <ul style="list-style-type: none"> <li>• Loose water pump belt.</li> <li>• Faulty or incorrect water pump.</li> <li>• Restriction in cooling system.</li> <li>• Faulty or incorrect thermostat.</li> </ul> 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 11
11	1. Disconnect all injector harness connectors and install an injector test light J 34730-2 between the harness terminal connector of each injector. 2. Crank engine and note light on each connector. If test light fails to blink at any one of the connectors, it is a faulty injector drive circuit, harness, connector or terminal. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 12
12	1. Check fuel injectors. <ul style="list-style-type: none"> <li>• Refer to Injector Coil Test and Injector Balance Test at the end of this section.</li> </ul> 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 13
13	1. Check for fuel in pressure regulator vacuum hose. 2. If fuel is present, replace the fuel pressure regulator assembly. <ul style="list-style-type: none"> <li>• Refer to Fuel Metering System.</li> </ul> 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 14
14	1. Check for intermittent opens or short to grounds in the ECT sensor, MAP sensor and TP sensor circuits. Also check for throttle linkage sticking, binding or worn. 2. An intermittent failure may not store a DTC. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 15
15	1. Check ECM grounds for being clean, tight and in their proper locations. 2. Also check that battery cables and ground straps are clean and secure. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 16

### Rough, Unstable, or Incorrect Idle, Stalling Symptom

Step	Action	Value	Yes	No
<b>16</b>	1. Check items that can cause the engine to run rich. 2. If a problem is found, repair as necessary. Was a problem found?	—	<i>Go to OBD System Check</i>	<i>Go to Step 17</i>
<b>17</b>	1. Check items that can cause the engine to run lean. 2. If a problem is found, repair as necessary. Was a problem found?	—	<i>Go to OBD System Check</i>	<i>Go to Step 18</i>
<b>18</b>	1. Check for proper alternator voltage output. 2. The voltage should be between specified values. 3. If a problem is found, repair as necessary. Was a problem found?	11-16V	<i>Go to OBD System Check</i>	<i>Go to Step 19</i>
<b>19</b>	1. Check the following engine mechanical items: <ul style="list-style-type: none"> <li>• Check compression.</li> <li>• Sticking or leaking valves.</li> <li>• Worn camshaft lobe(s).</li> <li>• Valve timing.</li> <li>• Broken valve springs.</li> </ul> 2. If a problem is found, repair as necessary. Was a problem found?	—	<i>Go to OBD System Check</i>	<i>Go to Step 20</i>
<b>20</b>	1. Check intake valves for valve deposits. 2. If deposits are found, remove as necessary. Were deposits found on the intake valves?	—	<i>Go to OBD System Check</i>	<i>Go to Step 21</i>
<b>21</b>	1. Check for faulty motor mounts. 2. If a problem is found, repair as necessary. Was a problem found?	—	<i>Go to OBD System Check</i>	<i>Go to Step 22</i>
<b>22</b>	1. Review all diagnostic procedures within this table. 2. If all procedures have been completed and no malfunctions have been found, review/inspect the following: <ul style="list-style-type: none"> <li>• Visual/physical inspection.</li> <li>• Scan tool data.</li> <li>• All electrical connections within a suspected circuit and/or system.</li> </ul> 3. If a problem is found, repair as necessary. Was a problem found?	—	<i>Go to OBD System Check</i>	Contact OEM

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### Poor Fuel Economy Symptom

Step	Action	Value	Yes	No
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**Definition:** Fuel economy, as measured at selected intervals, is noticeably lower than expected. Also, economy is noticeably lower than it was on this vessel at one time, as previously shown by documentation.

1	Was the "On-Board Diagnostic" (OBD) System Check performed?	—	Go to Step 2	Go to OBD System Check Page 2-12
2	Was visual/physical check performed?	—	Go to Step 3	Go to Visual/Physical check
3	1. Check owner's driving habits. Are excessively heavy loads being carried? Is accelerating too much, too often? 2. If a problem is found, repair as necessary. Was a problem found?	—	System Normal	Go to Step 4
4	1. Check for correct base ignition timing. • Refer to "Ignition Timing Set Procedure" in the <i>Distributor Ignition</i> section. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 5
5	1. Check flame arrestor for dirt or being plugged. 2. Check for fuel leaks. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 6
6	1. Check for proper fuel pressure. • Refer to Fuel System Diagnosis. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 7
7	1. Check for proper operation of Ignition Control (IC) circuit and the Knock Sensor (KS) circuit(s). 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 8
8	1. Remove spark plugs and check for wet plugs, cracks, wear, improper gap, burned electrodes or heavy deposits. <b>Notice:</b> If spark plugs are gas or oil fouled, the cause of the fouling must be determined before replacing the spark plugs. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 9
9	1. Visually (physically) check vacuum hoses for splits, kinks and improper connections and routing. 2. If a problem is found, repair as necessary. Was a repair required?	—	Go to OBD System Check	Go to Step 10
10	1. Check engine compression for being low. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 11

### Poor Fuel Economy Symptom

Step	Action	Value	Yes	No
<b>11</b>	1. Check exhaust system for possible restriction. 2. Inspect exhaust system for damaged or collapsed pipes. 3. If a problem is found, repair as necessary. Was a problem found?	—	<i>Go to OBD System Check</i>	<i>Go to Step 12</i>
<b>12</b>	1. Check for excessive resistance on the bottom of the boat such as dirt, barnacles, etc. 2. Check for proper propeller size and pitch for that application. 3. If a problem is found, repair as necessary. Was a problem found?	—	<i>Go to OBD System Check</i>	<i>Go to Step 13</i>
<b>13</b>	1. Review all diagnostic procedures within this table. 2. When all procedures have been completed and no malfunctions are found, review/inspect the following: <ul style="list-style-type: none"> <li>• Visual/physical inspection.</li> <li>• Scan tool data.</li> <li>• All connections within a suspected circuit and/or system.</li> </ul> 3. If a problem is found, repair as necessary. Was a problem found?	—	<i>Go to OBD System Check</i>	Contact OEM

## Dieseling, Run-On Symptom

Step	Action	Value	Yes	No
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**Definition:** Engine continues to run after key is turned "OFF," but runs very rough. If engine runs smooth, check ignition switch and adjustment.

1	Was the "On-Board Diagnostic" (OBD) System Check performed?	—	Go to Step 2	Go to OBD System Check Page 2-12
2	Was visual/physical check performed?	—	Go to Step 3	Go to Visual/Physical check
3	1. Check for leaking fuel injectors. • Refer to Fuel System Diagnosis. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 4
4	1. Check for proper operation of Ignition Control (IC) circuit and the Knock Sensor (KS) circuit(s). 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 5
5	1. Check for obvious overheating problems: • Loose water pump belt. • Faulty or incorrect water pump. • Restriction in cooling system. • Faulty or incorrect thermostat. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 6
6	1. Check for proper operation of the MEFI relay. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 7
7	1. Review all diagnostic procedures within this table. 2. If all procedures have been completed and no malfunctions have been found, review/inspect the following: • Visual/physical inspection. • Scan tool data. • All electrical connections within a suspected circuit and/or system. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Contact OEM



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## Backfire Symptom

Step	Action	Value	Yes	No
<b>Definition:</b> Fuel ignites in the intake manifold, or in the exhaust system, making loud popping noise.				
1	Was the "On-Board Diagnostic (OBD) System Check" performed?	—	Go to Step 2	Go to OBD System Check
2	Was visual/physical check performed?	—	Go to Step 3	Go to Visual/Physical check
3	1. Check flame arrestor for proper installation per manufactures recommendation. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 4
4	1. Check for proper fuel pressure. • Refer to Fuel System Diagnosis Section 5. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 5
5	1. Check for correct base ignition timing. • Refer to "Ignition Timing Set Procedure" in the Distributor Ignition section. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 6
6	1. Check to see if engine is going into RPM reduction. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 7
7	Check the injector connections. If any of the injectors are connected to an incorrect cylinder, correct as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 8
8	1. Check fuel injectors. • Refer to Injector Coil Test and Injector Balance Test at the end of this section. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 9
9	1. Check for proper operation of Ignition Control (IC) circuit and the Knock Sensor (KS) circuit(s). 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 10
10	1. Check integrity of the primary and secondary wiring. 2. Check routing of the wiring. 3. Check condition of IC module, pick-up coil, distributor cap, rotor and spark plug wires. 4. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 11
11	1. Check ignition coil for cracks or carbon tracking. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 12

## Backfire Symptom

Step	Action	Value	Yes	No
12	Check for intermittent open or short to ground in the ignition circuit to the system relay. Was a problem found?	—	Go to OBD System Check	Go to Step 13
13	1. Remove spark plugs, check for wet plugs, cracks, wear, improper gap, burned electrodes or heavy deposits. <b>Notice:</b> If spark plugs are gas or oil fouled, the cause of the fouling must be determined before replacing the spark plugs. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 14
14	1. Check for intermittent opens or short to grounds in the MAP sensor and TP sensor circuits. Also check for throttle linkage sticking, binding or worn. 2. An intermittent failure may not store a DTC. 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 15
15	1. Check engine mechanical for the following conditions: <ul style="list-style-type: none"> <li>• Low compression.</li> <li>• Sticking or leaking valves.</li> <li>• Worn camshaft lobe(s).</li> <li>• Incorrect valve timing.</li> </ul> 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 16
16	1. Check Intake and exhaust manifold(s) for casting flash. 2. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Go to Step 17
17	1. Review all diagnostic procedures within this table. 2. If all procedures have been completed and no malfunctions have been found, review/inspect the following: <ul style="list-style-type: none"> <li>• Visual/physical inspection.</li> <li>• Scan tool data.</li> <li>• All electrical connections within a suspected circuit and/or system.</li> </ul> 3. If a problem is found, repair as necessary. Was a problem found?	—	Go to OBD System Check	Contact OEM

## ECM Connector "J1"

Pin Function		CKT No.	Wire Color	Component Connector	DTC(s) Affected	Possible Symptoms From Faulty Circuit
J1-01	Crank Request					No Start
J1-02	Not Used					
J1-03	Perfect Pass Enable	759	TAN/WHT			
J1-04	Slave Engine Select	941	YEL			
J1-05	Not Used					
J1-06	Not Used					
J1-07	Emergency Stop					
J1-08	Not Used					
J1-09	Low Reference - Fuel Level Sensor					
J1-10	Not Used					
J1-11	Troll Mode					
J1-12	Malfunction Indicator Lamp					
J1-13	Fuel Pump Enable	465	GRN/WHT		SPN 66017, FMI 5,6,7	
J1-14	Not Used					
J1-15	Not Used					
J1-16	Not Used					
J1-17	Governor Mode					
J1-18	Boot Mode					
J1-19	Ignition Feed	969A	PPL		SPN 65541, FMI 3,4,5	
J1-20	Battery Feed	440C	ORN		SPN 66013, FMI 5,6,7	
J1-21	Cruise Increment Up/ Accelerate	751	PNK/BLU			
J1-22	Cruise Set	752	PNK/WHT			
J1-23	Not Used					
J1-24	Pullup For Tach	921B	GRY			
J1-25	Tachometer	921A	GRY			
J1-26	Starter Control HS		TAN			
J1-27	Not Used					
J1-28	Not Used					
J1-29	Not Used					
J1-30	Cruise/Sync ON/OFF	753A	LT GRN			

## ECM Connector "J1"

Pin Function		CKT No.	Wire Color	Component Connector	DTC(s) Affected	Possible Symptoms From Faulty Circuit
J1-31	Sensor Return - VSS Analog					
J1-32	5 V Reference - VSS Analog					
J1-33	5 V Reference - Pedal Position #1	691	GRY		SPN 65605 FMI 2 SPN 65613 FMI 2	
J1-34	5 V Reference - Fuel Pressure Sensor					
J1-35	5 V Reference - Pedal Position #2	692	GRY		SPN 65604 FMI 2 SPN 65613 FMI 2	
J1-36	Low Reference - Pedal Position #1	693	BLK/WHT		SPN 65605 FMI 2 SPN 65613 FMI 2	
J1-37	Low Reference - Pedal Position #2	694	BLK/WHT		SPN 65604 FMI 2 SPN 65613 FMI 2	
J1-38	Load Anticipate 1 (In Gear)	906A	YLW/BLK			
J1-39	Not Used					
J1-40	MEFI System Relay Enable	441	BLK/RED		SPN 66013, FMI 5,6,7 SPN 66014, FMI 4	
J1-41	Check Gauge Lamp					
J1-42	Not Used					
J1-43	Not Used					
J1-44	Fuel Level Sensor					
J1-45	Fuel Level Sensor #2	753B				
J1-46	VSS Analog					
J1-47	Pedal Position Sensor 1	695	BLU		SPN 65605 FMI 2 SPN 65613 FMI 2	
J1-48	Fuel Pressure Sensor					
J1-49	Pedal Position Sensor 2	696	GRN		SPN 65604 FMI 2 SPN 65613 FMI 2	
J1-50	Fuel Temperature Sensor					

## ECM Connector "J1"

Pin Function		CKT No.	Wire Color	Component Connector	DTC(s) Affected	Possible Symptoms From Faulty Circuit
J1-51	General Warning Lamp 1					
J1-52	General Warning Lamp 2					
J1-53	Speed Based Output					
J1-54	Buzzer					
J1-55	Cruise Status Lamp	754	LT GRN/ BLK			
J1-56	Starter Control LS					
(1) Open Circuit (2) Grounded Circuit (3) Open/Grounded Circuit						

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## ECM Connector "J2"

Pin Function		CKT No.	Wire Color	Component Connector	DTC(s) Affected	Possible Symptoms From Faulty Circuit
J2-01	EST A	423	WHT	Ignition Control Module	SPN 65541 FMI 3,4,5	rough unstable idle, hard or no start
J2-02	Oxygen Sensor A1 Lo		WHT/BLU	Oxygen Sensor		
J2-03	Oxygen Sensor A1 Hi		DK BLU	Oxygen Sensor		
J2-04	Oxygen Sensor A2 Hi					
J2-05	Oxygen Sensor A2 Lo					
J2-06	Knock Sensor Flat Response #2	496	WHT		SPN 65552 FMI 2	
J2-07	Knock Sensor Return #2	494	BLK		SPN 65552 FMI 2	
J2-08	Knock Sensor Flat Response	497	WHT		SPN 65551 FMI 2	
J2-09	Knock Sensor Return	495	BLK		SPN 65551 FMI 2	
J2-10	Knock Sensor Shield					
J2-11	ETC Motor Open: IAC 1 PWM	581	YLW		SPN 65615 FMI 7	Reduced Engine Power mode, no throttle response
J2-12	ETC Motor Close: IAC 2 PWM	582	BRN		SPN 65615 FMI 7	Reduced Engine Power mode, no throttle response
J2-13	Ignition 1 Voltage	439B	PNK/BLK		SPN 65541 FMI 3,4,5	rough unstable idle, hard or no start
J2-14	CAM Phase Control W					
J2-15	CAM Phase Control Y					
J2-16	Fuel Injector H (Cylinder 2)	472	LT BLU		SPN 658 FMI 3,4,5	rough unstable idle, surges and or chuggles,
J2-17	EST B					
J2-18	EST G					
J2-19	EST Return #2					
J2-20	Sensor Return-CAM X					
J2-21	Sensor Return-CAM Y					
J2-22	Sensor Return-CAM Z					
J2-23	Low Reference-CAM Sensor (Distributor)	813	BLK/WHT		SPN 723 FMI 2	
J2-24	Low Reference-Engine Oil Pressure	814	BLK/WHT		SPN 100 FMI 3,4	
J2-25	Low Reference-LEGR Sensor					



## ECM Connector "J2"

Pin Function		CKT No.	Wire Color	Component Connector	DTC(s) Affected	Possible Symptoms From Faulty Circuit
J2-26	Knock Sensor Shield #2					
J2-27	Low Reference - Crank Sensor	815	BLK/WHT		SPN 636, FMI 2	
J2-28	Ignition 1 Voltage	439C	PNK/BLK		SPN 65541, FMI 3,4,5	
J2-29	Low Reference - Throttle Position Sensor	683	BLK/WHT		SPN 65601, 65602, SPN 65610, FMI 2	
J2-30	CAM Phase Return X					
J2-31	LEGR/ CAM Phase Return Z					
J2-32	Fuel Injector D (Cylinder 3)	473	LT GRN/ BLK		SPN 654, FMI 3,4,5	
J2-33	EST C					
J2-34	EST F					
J2-35	EST Return					
J2-36	5V Reference - CAMX (CAMB, CAM 4X)					
J2-37	5V Reference - CAMY (CAMC, CAM 4X2)					
J2-38	5V Reference - CAMZ (CAMD, CAM 4X3)					
J2-39	5V Reference - CAM Sensor (Distributor)	413	GRY		SPN 723, FMI 2	
J2-40	5V Reference - Engine Oil Pressure	414	GRY		SPN 100, FMI 3,4	
J2-41	5V Reference - Linear EGR Position					
J2-42	Sensor Return - Induction Air					
J2-43	5V Reference - Crank Sensor	415	GRY		SPN 636, FMI 2	
J2-44	5V Reference - Throttle Position Sensor	682	GRY		SPN 65601, 65602, SPN 65610, FMI 2	
J2-45	Sensor Return - Engine Oil Temp					
J2-46	CAM Phase Return W					

## ECM Connector "J2"

Pin Function		CKT No.	Wire Color	Component Connector	DTC(s) Affected	Possible Symptoms From Faulty Circuit
J2-47	CAM Phase Return Y					
J2-48	Fuel Injector B (Cylinder 8)	478	LT BLU/ RED		SPN 652, FMI 3,4,5	
J2-49	Fuel Injector F (Cylinder 5)	475	LT GRN/ WHT		SPN 656, FMI 3,4,5	
J2-50	CAM Phase Control X					
J2-51	LEGR: CAM Phase Control Z					
J2-52	Fuel Injector E (Cylinder 6)	476	LT BLU/ WHT		SPN 655, FMI 3,4,5	
J2-53	EST D					
J2-54	EST E					
J2-55	EST H					
J2-56	CAMX Sensor (CAMB, CAM 4X)					
J2-57	CAMY Sensor (CAMC, CAM 4X2)					
J2-58	CAMZ Sensor (CAMD, CAM 4X3)					
J2-59	CAM Sensor Signal (Distributor) (CAMA, CAM 8XPWP)	633	BRN/WHT		SPN 723, FMI 2	
J2-60	Engine Oil Pressure Sensor Signal	901	LT BLU/ RED		SPN 100, FMI 3,4	
J2-61	Dash	756	PNK			
J2-62	Induction Air Temp (or MAT) Sensor					
J2-63	Crank Sensor	1869	DK BLU/ WHT		SPN 636, FMI 2	
J2-64	Throttle Position Sensor #1	684	DK GRN		SPN 65602, FMI 2 SPN 65610, FMI 2	
J2-65	Engine Oil Temperature Sensor					
J2-66	Throttle Position Sensor #2	687	DK BLU		SPN 65601, FMI 2 SPN 65610, FMI 2	

## ECM Connector "J2"

Pin Function		CKT No.	Wire Color	Component Connector	DTC(s) Affected	Possible Symptoms From Faulty Circuit
J2-67	High Speed Mass Air Flow					
J2-68	Oxygen Sensor A1 Heater					
J2-69	Oxygen Sensor A2 Heater					
J2-70	Fuel Injector G	477	GRN/RED		SPN 657, FMI 3,4,5	
J2-71	Fuel Injector C	474	LT BLU/ BRN		SPN 653, FMI 3,4,5	
J2-72	Fuel Injector A	471	GRN		SPN 651, FMI 3,4,5	
J2-73	Power Ground	450A	BLK			
(1) Open Circuit (2) Grounded Circuit (3) Open/Grounded Circuit						

## ECM Connector "J3"

Pin Function		CKT No.	Wire Color	Component Connector	DTC(s) Affected	Possible Symptoms From Faulty Circuit
J3-01	CAT Temperature Sensor A					
J3-02	CAT Temperature Sensor B					
J3-03	Oxygen Sensor B1 Lo					
J3-04	Oxygen Sensor B1 Hi					
J3-05	Oxygen Sensor B2 Hi					
J3-06	Oxygen Sensor B2 Lo					
J3-07	Not Used					
J3-08	Low Oil Level Lamp					
J3-09	Not Used					
J3-10	Cylinder Deactivate C					
J3-11	Cylinder Deactivate A					
J3-12	Governor PWM Output (Non-ETC Governor)					
J3-13	Transmission Up-Shift					
J3-14	Not Used					
J3-15	Oxygen Sensor B1 Heater					
J3-16	Troll Mode Lamp					
J3-17	Not Used					
J3-18	Engine Oil Level Low Sensor					
J3-19	Sensor Return - CAT Temp Sensor A					
J3-20	Sensor Return - CAT Temp Sensor B					
J3-21	Sensor Return - Variable Governor					
J3-22	Not Used					
J3-23	Low Reference - MAP	816	BLK/WHT		SPN 106, FMI 3,4	
J3-24	AUX Analog Return					
J3-25	Sensor Return - General Warning 2					
J3-26	Sensor Return - General Warning 1					

## ECM Connector "J3"

Pin Function		CKT No.	Wire Color	Component Connector	DTC(s) Affected	Possible Symptoms From Faulty Circuit
J3-27	Not Used					
J3-28	Sensor Return - Digital VSS					
J3-29	Not Used					
J3-30	Not Used					
J3-31	Not Used					
J3-32	Not Used					
J3-33	CAN BUS Lo Terminated (To Dash & DLC)	804A	WHT/BLK		SPN 65559, FMI 11	
J3-34	Not Used					
J3-35	Low Reference - ECT Sensor	817	BLK/WHT		SPN 110, FMI 3,4	
J3-36	Not Used					
J3-37	5V Reference - Variable Governor					
J3-38	Not Used					
J3-39	5V Reference - MAP	416	GRY		SPN 106, FMI 3,4	
J3-40	5V Reference - AUX Analog					
J3-41	5V Reference - General Warning 2					
J3-42	5V Reference - General Warning 1 (Trans Over Temp Sensor)	417	GRY			
J3-43	Not Used					
J3-44	5V Reference - Digital VSS					
J3-45	Load Anticipate					
J3-46	Shift Interrupt/ Transmission Lock Low					
J3-47	Not Used					
J3-48	Control Canister Purge					
J3-49	Not Used					

## ECM Connector "J3"

Pin Function		CKT No.	Wire Color	Component Connector	DTC(s) Affected	Possible Symptoms From Faulty Circuit
J3-50	Oxygen Sensor B2 Heater					
J3-51	Not Used					
J3-52	Not Used					
J3-53	CAN BUS Hi Terminated (Goes to DLC-C & Dash K)	803A	WHT/RED		SPN 65559, FMI 11	
J3-54	Not Used					
J3-55	ECT Sensor Signal	410	YLW		SPN 110, FMI 3,4	
J3-56	Not Used					
J3-57	Variable Governor (to Dash-E)	755	LT GRN/ WHT			
J3-58	Not Used					
J3-59	MAP Sensor Signal	432	LT GRN		SPN 106, FMI 3,4	
J3-60	AUX Analog Input					
J3-61	General Warning 1 (To Trans Temp Sensor Signal)	933	TAN/BLK			
J3-62	General Warning 2					
J3-63	Not Used					
J3-64	Digital VSS (TO Dash-N)	757	GRN/RED			
J3-65	Engine Oil Pressure Switch					
J3-66	VR VSS Freq Hi					
J3-67	VR VSS Freq Lo					
J3-68	Cylinder Deactivate B					
J3-69	Cylinder Deactivate D					
J3-70	Not Used					
J3-71	Not Used					
J3-72	Not Used					
J3-73	Power Ground #2	450B	BLK			

- (1) Open Circuit  
(2) Grounded Circuit  
(3) Open/Grounded Circuit

## Section 8

## Marine Catalytic Converter

**Contents**

<b>Catalytic Converter Fundamentals</b> .....	Page 2
Reduction Catalyst .....	Page 2
Oxidation Catalyst .....	Page 2
Optimal Operating Conditions .....	Page 2
Marine Exhaust Manifold –	
Catalytic Converter Equipped .....	Page 3
Marine Catalytic Converter Assembly .....	Page 4
Need for Fuel Control .....	Page 5
Engine Mixture Measurement .....	Page 5
Oxygen Sensor Method of Operation .....	Page 5
Fuel Management & Operation Modes .....	Page 7
Oxygen Sensor Connector Pin Outs .....	Page 8
Closed Loop Operation .....	Page 9
Open Loop Operation .....	Page 9
Power Enrichment Operation.....	Page 9

### Catalytic Converter Fundamentals

A catalytic converter in simple terms is a device that increases the rate of a chemical reaction while not undergoing any permanent change itself. For our use, the catalytic converter continues the combustion process to further alter the chemical composition of exhaust gases.

The two types of catalytic converters typically used in current applications are those made of a ceramic substrate and those made of a metallic substrate. Both types have varied advantages for particular applications. The majority of catalytic converters are currently monolithic or honeycomb material. This allows for a large surface area on which to impregnate the chemical material used as the catalyzing agent. The honeycomb substrate is usually found in the form of a carrier called a puck or a brick. The brick is coated or "washed" with a metal or metal oxide formula that contains various chemical combinations that react with the exhaust gasses to cause them to become chemically altered. This chemical alteration changes much of the gas structure of the exhaust and renders many of the noxious gasses less harmful to the environment.

### The Reduction Catalyst

The reduction catalyst is the first stage of the catalytic converter. It uses platinum and rhodium to help reduce the NO<sub>x</sub> emissions. When an NO or NO<sub>2</sub> molecule contacts the catalyst, the catalyst rips the nitrogen atom out of the molecule and holds on to it, freeing the oxygen in the form of O<sub>2</sub>. The nitrogen atoms bond with other nitrogen atoms that are also stuck to the catalyst, forming N<sub>2</sub>. For example:



### The Oxidation Catalyst

The oxidation catalyst is the second stage of the catalytic converter. It reduces the unburned hydrocarbons and carbon monoxide by burning (oxidizing) them over a platinum and palladium catalyst. This catalyst aids the reaction of the CO and hydrocarbons with the remaining oxygen in the exhaust gas. For example:



### Optimal Operating Conditions

In order for the catalyst to operate at peak efficiency, there are several conditions that need to be considered.

1. The exhaust mixture will be catalyzed most effectively if the air/fuel ratio (AFR) is near 14.7:1; an ideal air/fuel ratio we call stoichiometric.
2. The exhaust mixture is catalyzed most effectively if the catalyst brick is hot; preferably a temperature in excess of 200°C. For high conversion rates and extended service, temperatures of 400°C to 800°C are optimal.
3. The catalyst needs to be mounted in some sort of a canister that isolates it from excessive vibration and excessive thermal shock.
4. There should be an absence of lead (tetraethyllead) or lead substitutes or other chemicals that would adversely effect the catalyzation reaction.



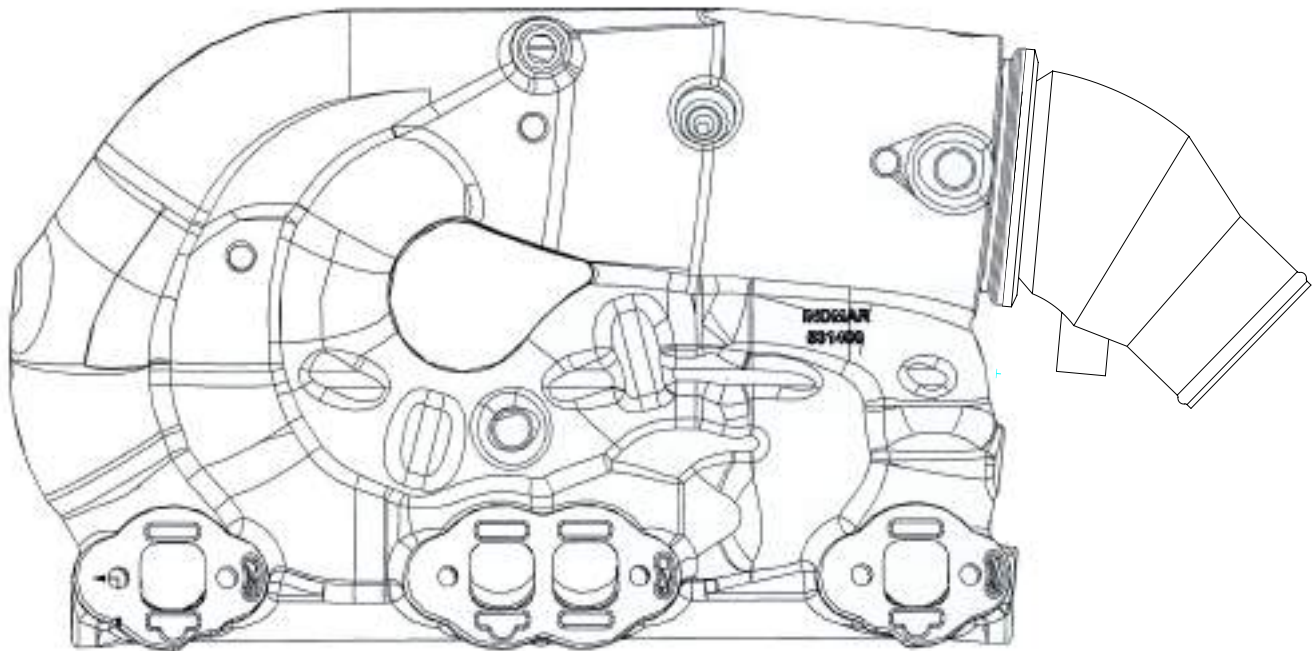


Figure 1 – Marine Exhaust Manifold – Catalytic Converter Equipped

Figure 1, illustrates a good functional design for a marine exhaust system equipped with catalyts. Indmar engineers have formulated this design with a significant level of testing.

This manifold features the following design elements:

1. Large exhaust runners intricately designed to maintain a small manifold footprint
2. Water jacketing to keep the “under-motor-box” temperatures manageable
3. The location of a jacketed catalyst brick close to the individual runner outlet. This insures a high level of exhaust heat to insure optimal functionality of the catalyst.
4. The incorporation of a metal mesh buffer gasket. The mesh design allows for expansion of the catalyst can as well as isolation from thermal and vibratory shock
5. A removable down-swept exit cap to allow easy serviceability of the catalyst.

### Catalytic Converter Assembly

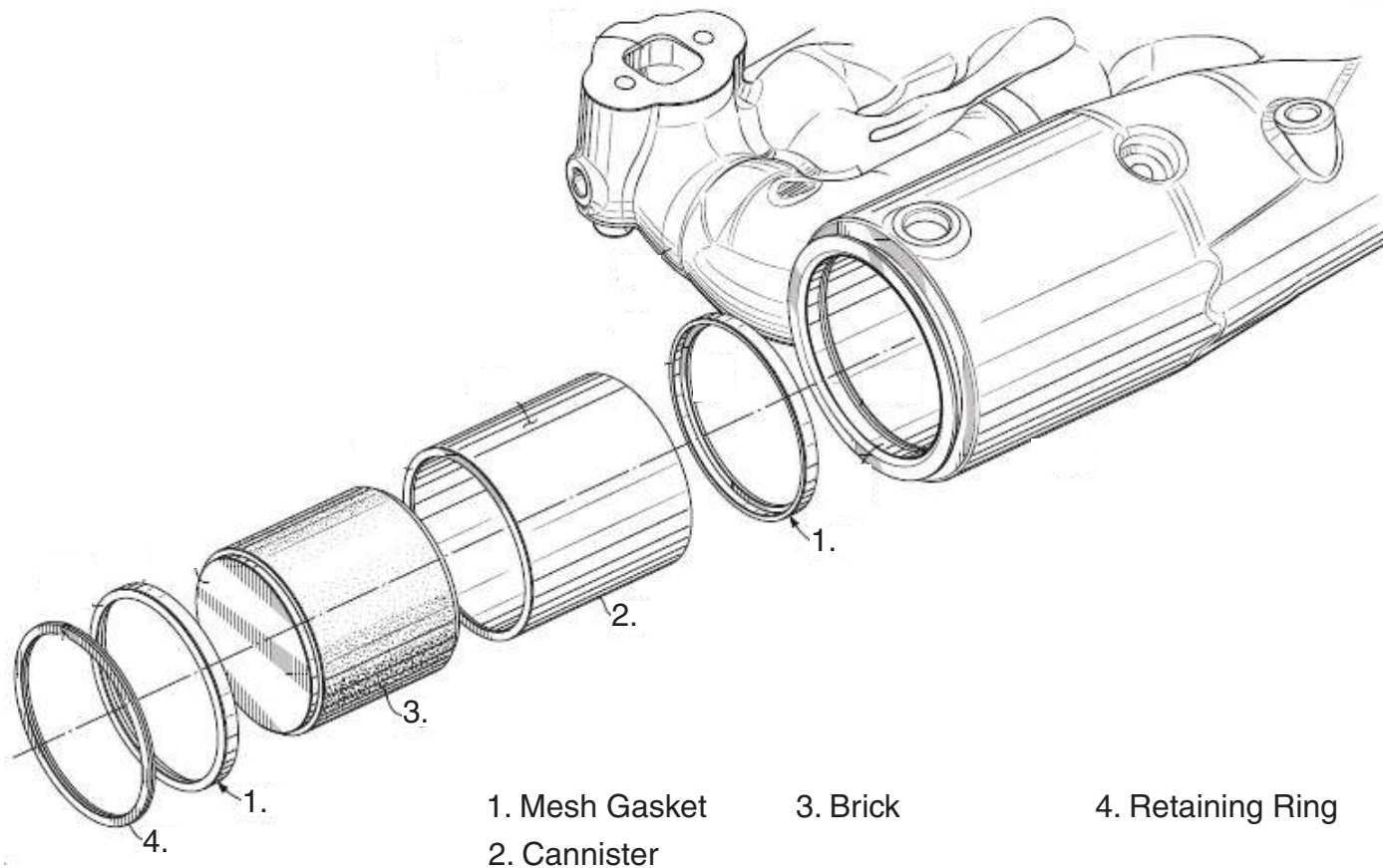


Figure 2 – Marine Catalytic Converter Assembly



Figure 3 – Marine Catalytic Converter Components

### The Need for Fuel Control

As previously mentioned, In order to reduce emissions, modern engines carefully control the amount of fuel they burn. They try to keep the air-to-fuel ratio very close to the stoichiometric point, which is the calculated ideal ratio of air to fuel. Theoretically, at this ratio, all of the fuel will be burned using all of the oxygen in the air. For gasoline, the stoichiometric ratio is about 14.7:1, meaning that for each pound of gasoline, 14.7 pounds of air will be burned. The fuel mixture actually varies from the ideal ratio quite a bit during normal engine operation. Sometimes the mixture can be **lean** (an air-to-fuel ratio higher than 14.7), and other times the mixture can be **rich** (an air-to-fuel ratio lower than 14.7).

The by-products of combustion are typically known to be carbon dioxide (CO<sub>2</sub>) and Water (H<sub>2</sub>O) Maintaining the air fuel ratio near the 14.7:1 ratio enhances the catalytic converter's capability to optimally convert the exhaust gasses to the cleanest possible state.

### Engine Mixture Measurement

The electronic engine management system is responsible for orchestrating the mixture control in the combustion chamber to the stoichiometric (14.7:1) ratio.

One of the ways the engine monitors the air/fuel ratio is through the oxygen sensor or lambda sensor. This sensor is mounted in the exhaust system at a location that allows for even measurement of the exhaust sample from all of the cylinders. On a V style engine there are often two sensors, one for each bank.

### Oxygen Sensor- Method of Operation

The oxygen sensor is constructed with a zirconia sensing element. A porous platinum electrode material covers the inner and outer surfaces of the zirconia solid-state electrolyte.

The inner surface of the sensing element is exposed to an outside air reference, while the gasses in the exhaust stream surround the sensor's outer portion. The oxygen content of outside air is approximately 21% while exhaust gasses have an oxygen content of about 1 to 3%. Measured differences in the two oxygen levels as well as the electrolytic properties existing between the two platinum electrodes, allow an ion transfer to take place and generate a small electrical charge. Oxygen ions are electrically charged particles that flow through the zirconia sensing element when there is a differentiation in oxygen levels. The greater the ion flow, the greater the voltage produced. Once an operating temperature of the sensing components reaches a temperature of about 350°C, the signal voltage can range from approximately 0 to 1 volt depending on the oxygen content of the exhaust gas.

This serves as a measurement of the difference in oxygen concentration on the two sides of the sensors. The oxygen concentration remaining in the exhaust of the engine depends greatly on the air/fuel ratio supplied to the engine. Even with an excess fuel mixture there is still some oxygen in the exhaust.

## OXYGEN SENSOR – PARTIAL DETAIL

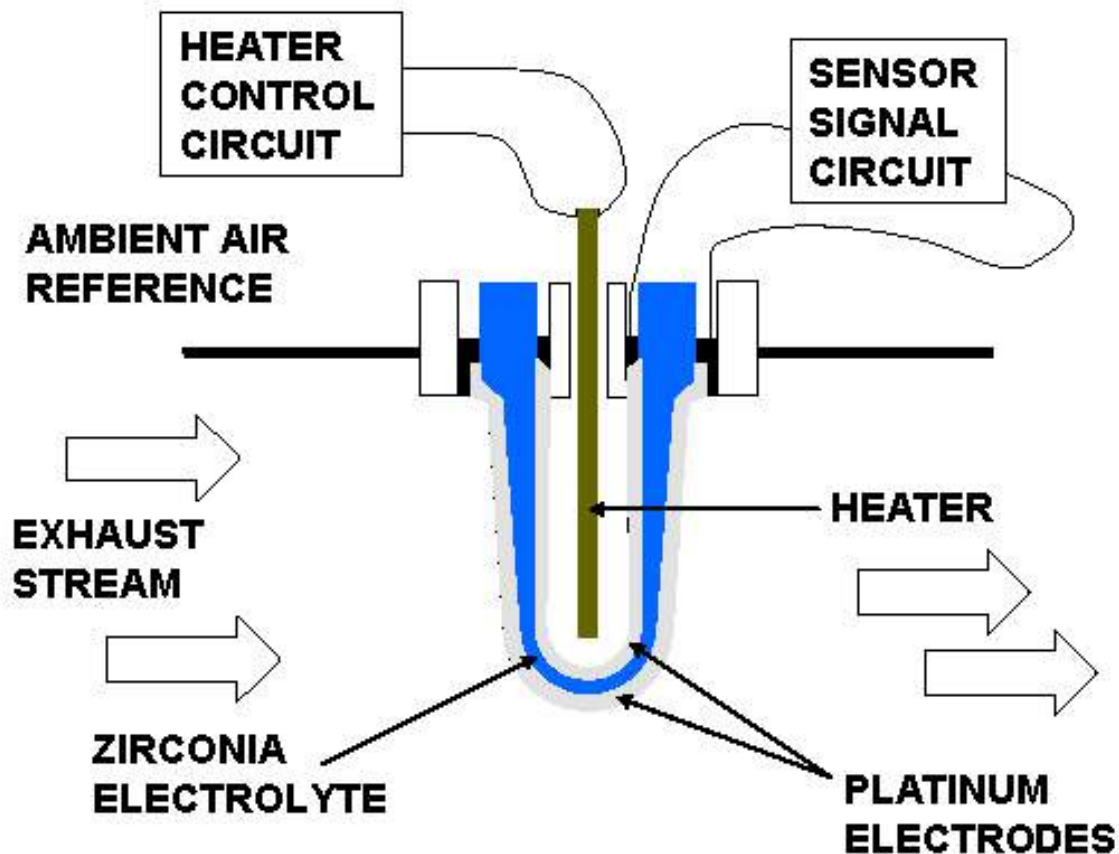


Figure 4 – Oxygen Sensor

As mentioned, traditionally the oxygen sensor operates in a 0 to 1 volt range. A stoichiometric ratio of 14.7:1 is usually indicated as the mid-point of the sensor range and usually falls somewhere in the 450 to 500 mV (milli-volt) range. Mixtures yielding a voltage of say 500 to 1000 mV are thought to be rich and those yielding a voltage in the 400 to 100 mV range are thought to be lean.

The ECM will set an O<sub>2</sub> sensor diagnostic code if the sensor does not produce a voltage signal, stays rich too long, stays lean too long, or does not switch fast enough.

In addition to the oxygen concentration in the exhaust, the temperature of the ceramic body is thought to play a decisive role- since it influences the conductivity for oxygen ions. Thus

the curve of the voltage supplied as a function of the excess-air factor ( $\lambda$ ) is strongly influenced by the temperature. Hence, the figure generally thought to be an acceptable working temperature is  $\sim 600^{\circ}\text{C}$ . For the reason of slow response and compromised accuracy, we usually do not activate control until the oxygen sensor reaches a minimum threshold temperature of  $350^{\circ}\text{C}$ . Until this point is reached, the engine is operated in an open-loop condition. In order to be able to use the oxygen sensor sooner during the warm-up cycle, sensors in our system employ an electrical heating element to decrease the time needed for good response from the oxygen sensor.

### HEATED OXYGEN SENSOR (LAMBDA SENSOR)

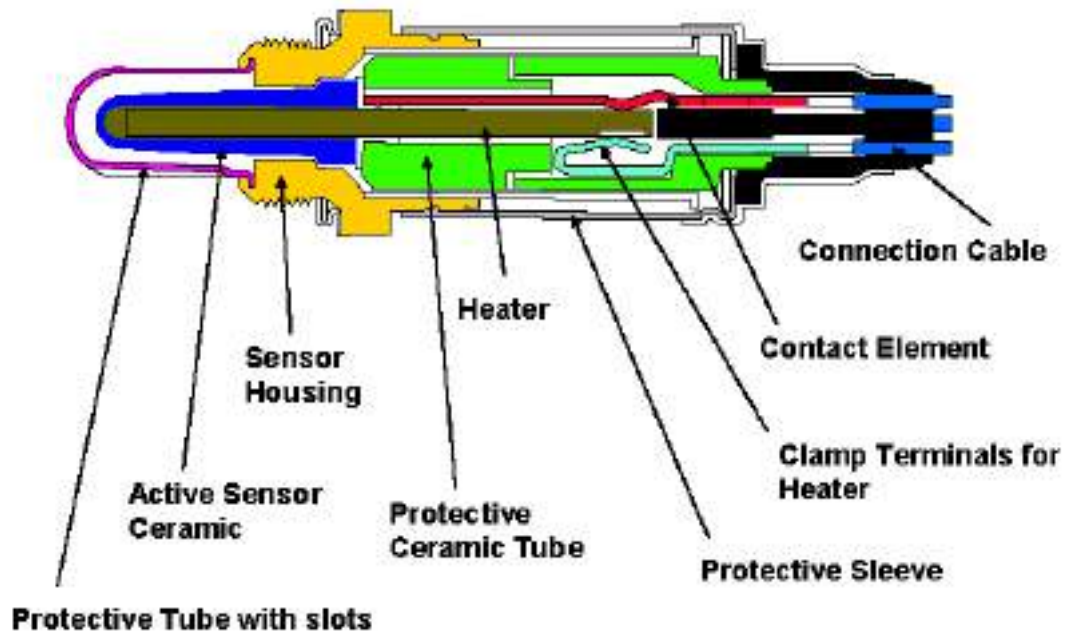


Figure 5 – Heated Lambda Sensor

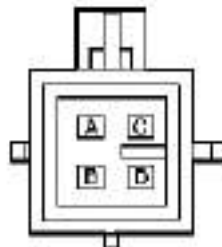
#### Fuel Management and Operating Modes

Fuel injection control systems have different operating modes depending on the power requirements of the engine. The modes are typically known as open loop, closed loop, power enrichment.

Engine systems built before the implementation of catalytic converters ran for the most part in open loop. During this operation regimen, the engine control module (ECM) accumulated

data from sensors as to engine temperature, engine load, and throttle opening required by the operator. From this data, the ECM process control from a set of look-up tables. These tables had values defined by the engine calibration engineer that were designed to run the engine in the most optimal conditions possible.

## Heated Oxygen Sensor (HO2S) Bank 1 Sensor 1

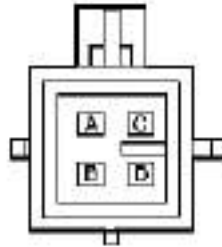


## Connector Part Information

- 12160825
- 4-Way F Metri-Pack 150 Series Sealed (BK)

Pin	Wire Color	Circuit No.	Function
A	WHT/BLU	1664	HO2S Heater Low Control – Bank 1 Sensor 1
B	BLU	1665	HO2S High Signal □ Bank 1 Sensor 1
C	BLK	3113	HO2S Heater Low Control □ Bank 1 Sensor 1
D	PNK/BLK	5293	Ignition - 1 Voltage

## Heated Oxygen Sensor (HO2S) Bank 2 Sensor 1



## Connector Part Information

- 12160825
- 4-Way F Metri-Pack 150 Series Sealed (BK)

Pin	Wire Color	Circuit No.	Function
A	WHT/BLU	1667	HO2S Low Signal – Bank 2 Sensor 1
B	BLU	1666	HO2S High Signal □ Bank 1 Sensor 1
C	BLK	3212	HO2S Heater Low Control □ Bank 2 Sensor 1
D	PNK/BLK	5293	Ignition - 1 Voltage

However, as the engine began to wear and subtle changes in the engine operating environment began to erode, the ability to control for these changes was limited as best. There became a need for a system that could monitor engine function and offer a feed-back to the ECM so that it could further control engine fueling.

**Closed loop** means that the ECM is taking an air/fuel measurement through the oxygen sensor. From this measurement the ECM is attempting to control the air/fuel ratio to the stoichiometric value or 14.7:1 AFR during normal run conditions (Engine fully warmed, etc.) . Transient maneuvers such as acceleration and deceleration will affect the air fuel ratio and it will vary to some extent; however, the ECM will try to effect control of the run fuel system as close to 14.7:1 as possible. The 14.7:1 ratio allows the catalytic converter to operate at its highest level of efficiency.

**Open loop** means that the ECM is controlling the fuel mixture from a set of known values that have been entered into the ECM control tables. It is not trying to run a perfect 14.7:1 and it is not acting on information received from the oxygen

sensor. Without feed-back the loop is open hence the term "open loop." Open loop is commonly experienced when the engine is cold (during cold start and warm-up) and during periods of very high loads and wide-open throttle conditions) A good example of open loop is when the engine is first started on a cold day. It required a rich mixture to start and to stay running. Levels of fuel vaporization are low. Additionally, as mentioned earlier, the oxygen sensor is still too cold to offer good data as it relates to oxygen content of the exhaust stream.

**Power enrichment** only occurs during wide open throttle (WOT) or at times when the engine is heavily loaded. In this mode, the oxygen sensor ignores the signal from the oxygen sensor and runs the mixture very rich in order to protect the engine from excessively high combustion temperatures. Additionally, the engine is capable of developing higher levels of power at somewhat richer mixtures.

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## Section 9

### CAM Phase Solenoid Control System LY 6 Engine - 6.0L Engine

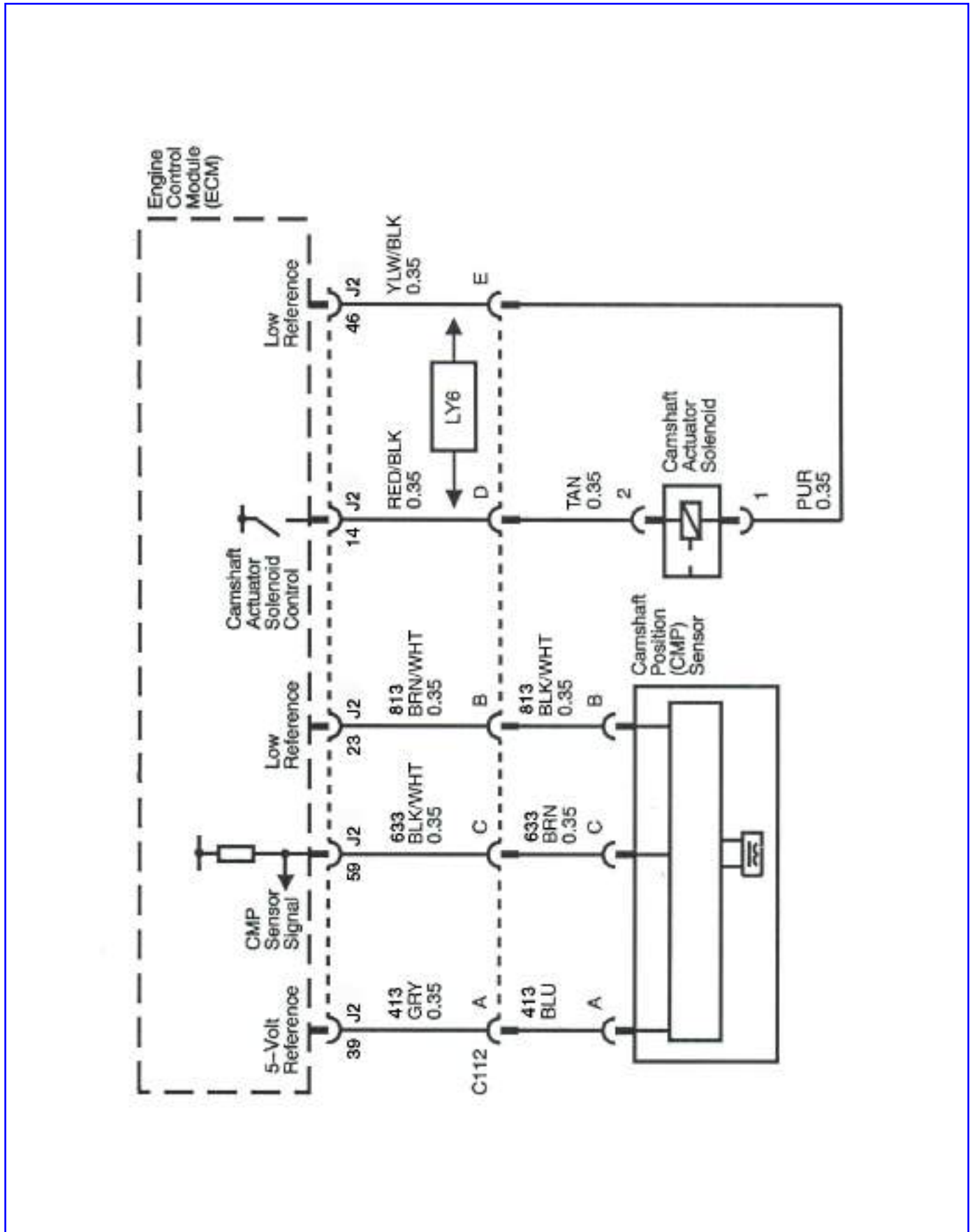
This section will be used to perform diagnostic procedures on the LY6 CAM Phaser equipped engines. The section describes system circuits and diagnostic tables used to diagnose the circuits. It will be used to correct Diagnostic Trouble Codes (DTCs) by following tables for scan tool use. This section contains the On-Board Diagnostic (OBD) System Check that is the first step to perform before any further diagnostics or repairs are made to this system. The assumption is made that on all diagnostic tables, the engine is equipped with a System 5 ECM, wiring harness, fuel components and GM sensors and ignition components. The wiring schematics and circuit identifications are for the System 5 originally equipped wiring harness.

The diagnostic tables and voltages shown are prepared with the requirement that the system functioned correctly at the time of assembly and that there are no multiple failures.

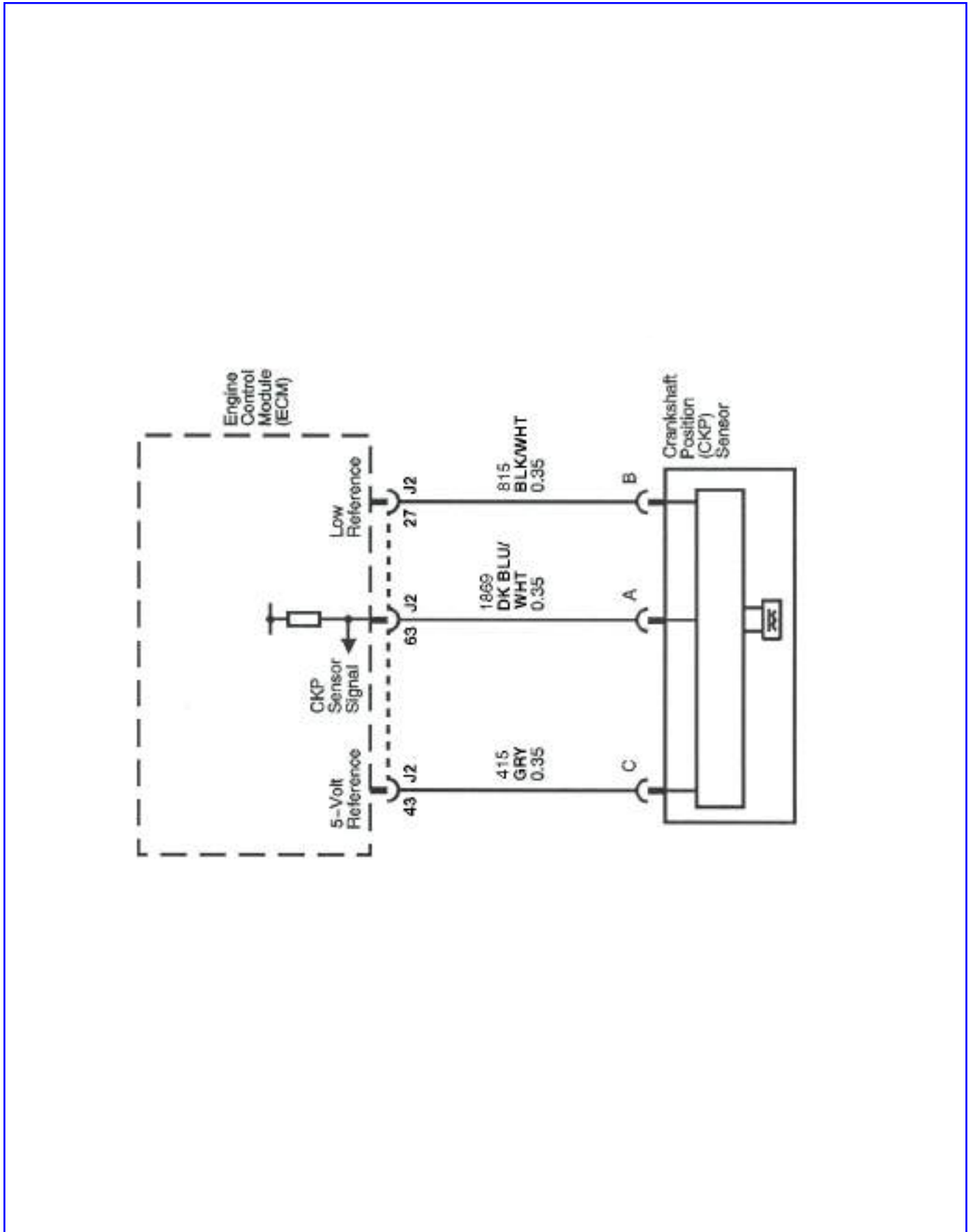
### Contents

CAM Phase Solenoid Wiring.....	Page 2	EST - Ignition Coil DTCs	
CAM Sensor Wiring.....	Page 2	EST 1 SPN 65541 FMI 3 Short High	
CNK Sensor Wiring.....	Page 3	SPN 65541 FMI 4 Short Low	
Even Bank Ignition Coils Wiring.....	Page 4	SPN 65541 FMI 5 Open	
Odd Bank Ignition Coils Wiring.....	Page 5	EST 2 SPN 65542 FMI 3 Short High	
ECM Connector Identification.....	6-15	SPN 65542 FMI 4 Short Low	
Harness Connector Identification.....	16-21	SPN 65542 FMI 5 Open	
<b>Description and Operation.....</b>	<b>22-28</b>	EST 3 SPN 65543 FMI 3 Short High	
Camshaft Actuator System Description.....	22-23	SPN 65543 FMI 4 Short Low	
Electronic Ignition (EI) System Description....	23-25	SPN 65543 FMI 5 Open	
Camshaft & Drive System Description.....	26-28	EST 4 SPN 65544 FMI 3 Short High	
<b>Diagnostic Trouble Codes</b>		SPN 65544 FMI 4 Short Low	
<b>Repair Procedures.....</b>	<b>29-67</b>	SPN 65544 FMI 5 Open	
<b>Camshaft Position Actuator:</b>		EST 5 SPN 65545 FMI 3 Short High	
Magnet Replacement.....	29	SPN 65545 FMI 4 Short Low	
Cleaning and Inspection.....	30-32	SPN 65545 FMI 5 Open	
Magnet Cleaning and Inspection.....	32-33	EST 6 SPN 65546 FMI 3 Short High	
Solenoid Valve Inspection		SPN 65546 FMI 4 Short Low	
(On-Vehicle).....	33-34	SPN 65546 FMI 5 Open	
Solenoid Valve Inspection		EST 7 SPN 65547 FMI 3 Short High	
(Off-Vehicle).....	34-35	SPN 65547 FMI 4 Short Low	
Camshaft Position Sensor		SPN 65547 FMI 5 Open	
SPN 723 FMI 2.....	36-39	EST 8 SPN 65548 FMI 3 Short High	
Camshaft Phaser Solenoid		SPN 65548 FMI 4 Short Low	
SPN 65570 FMI 3 - W Short High		SPN 65548 FMI 5 Open.....	48-53
SPN 65570 FMI 4 - W Short Low		Misfire DTCs	
SPN 65570 FMI 5 - W Open		SPN 65590-65598 FMI 7.....	54-57
SPN 65570 FMI 7 - W Accuracy.....	40-43	<b>Removal &amp; Replacement Instructions.....</b>	<b>58-67</b>
Crankshaft Position Sensor		Ignition Coil.....	58-61
SPN 636 FMI 2.....	44-47	Crankshaft Position Sensor.....	62-63
		Camshaft Position Sensor.....	64-67

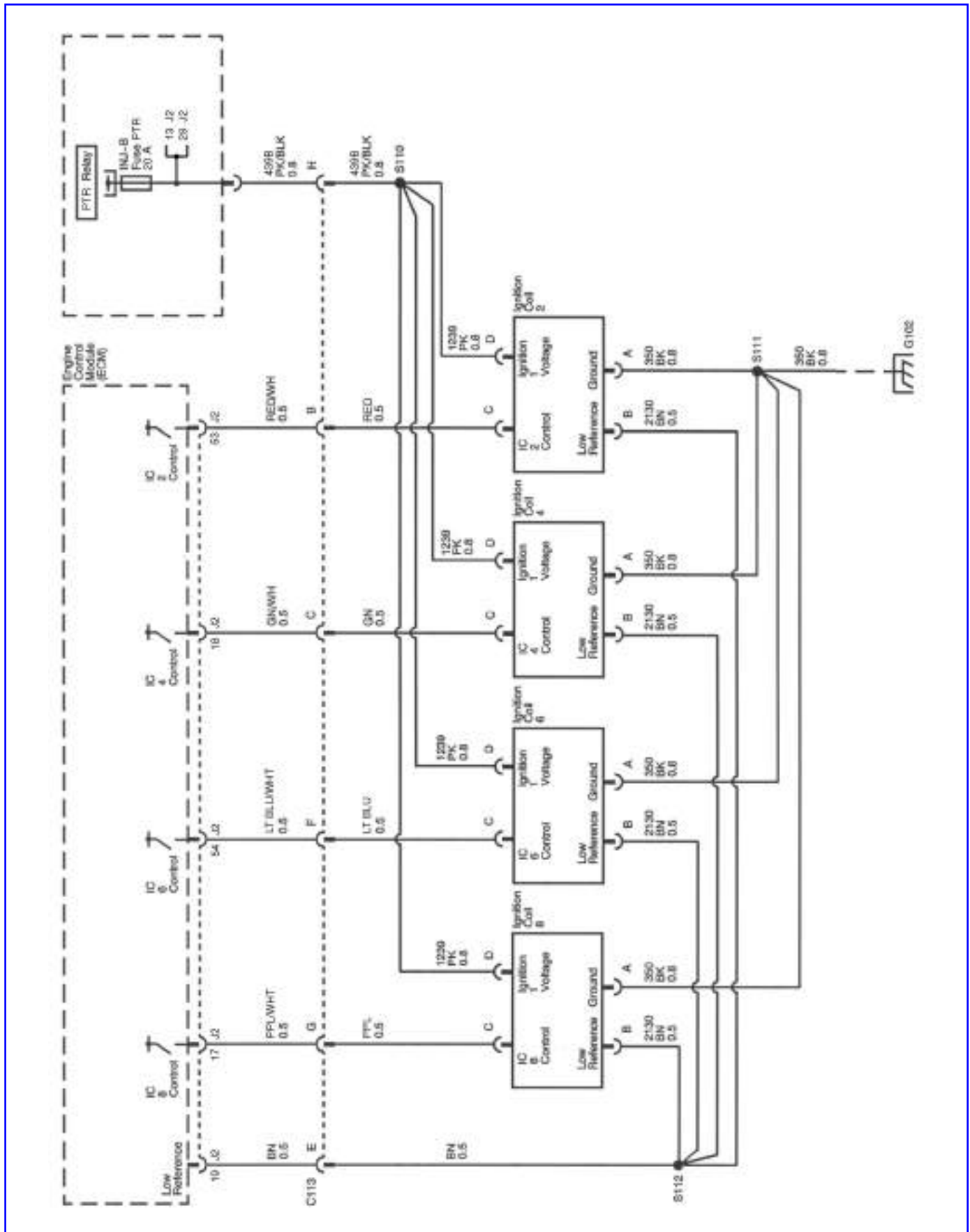
CAM Sensor and CAM Phase Solenoid Wiring - LY6



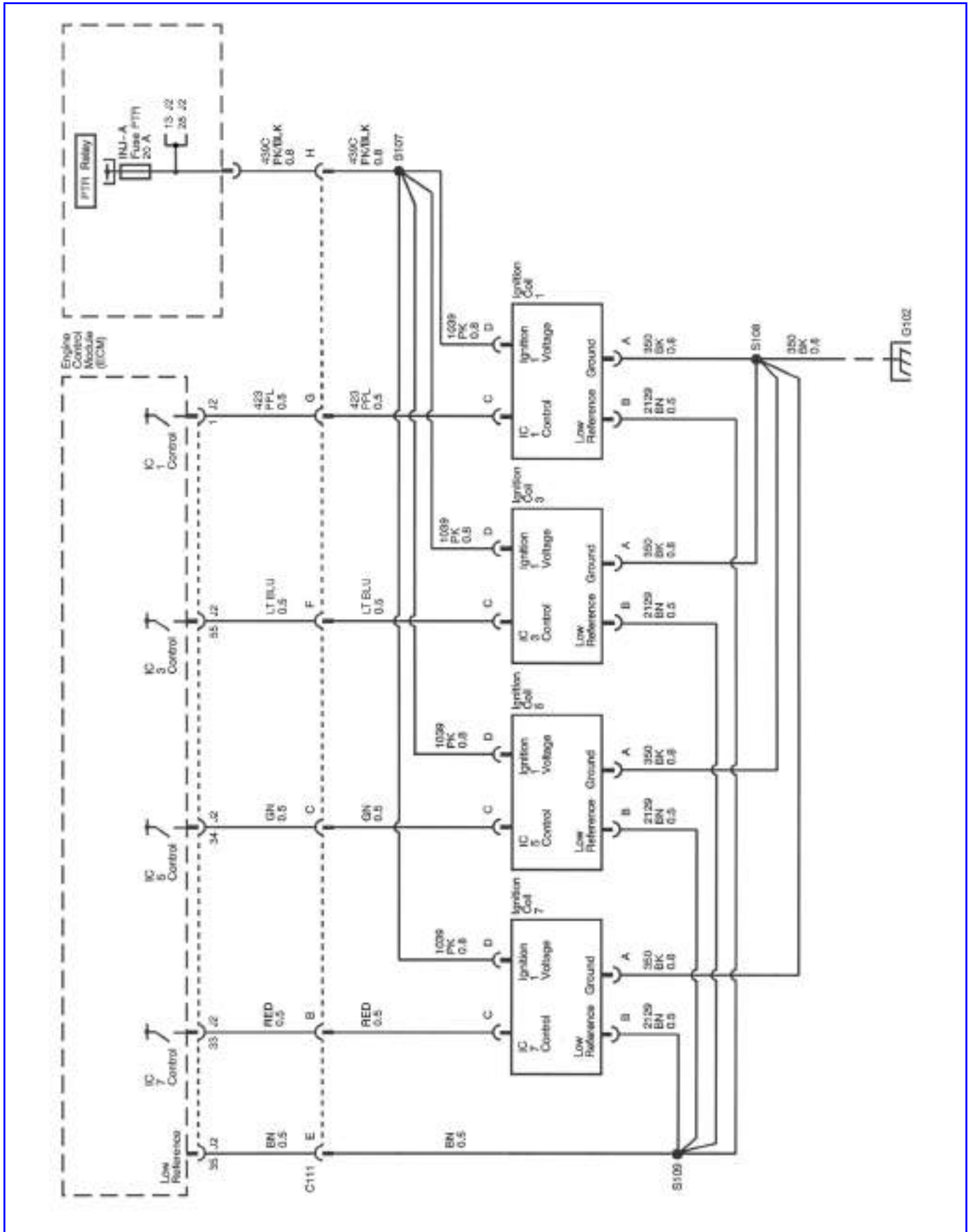
CNK Sensor Wiring - LY6



Even Bank Ignition Coils Wiring - LY6

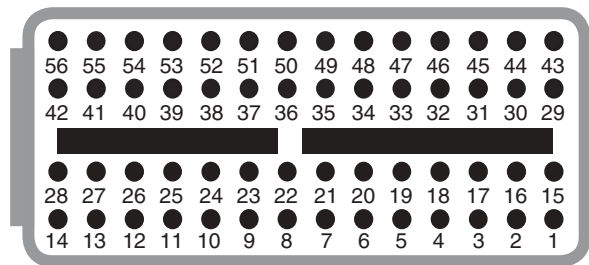


Odd Bank Ignition Coils Wiring - LY6



## J-1 ECM Connector Identification (1 of 2 J-1)

## LY6 - CAM PHASE ENGINE

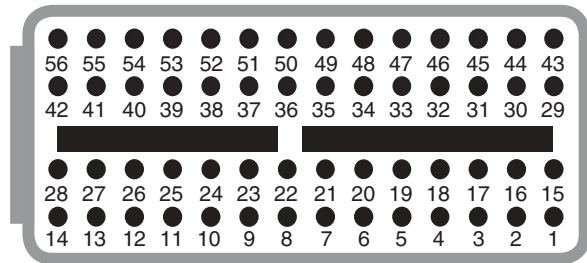


## ECM 56 WAY OUTPUT CONNECTOR

ECM PIN NUMBER	CKT(WIRE) NUMBER	CKT (WIRE) COLOR	CIRCUIT DESCRIPTION
J1-1			CRANK REQUEST
J1-2			N/A
J1-3	759	TAN/WHT	PERFECT PASS ENABLE
J1-4	941	YEL	SLAVE ENGINE SELECT
J1-5			N/A
J1-6			N/A
J1-7			EMERGENCY STOP
J1-8			N/A
J1-9			LOW REFERENCE - FUEL LEVEL SENSOR
J1-10			N/A
J1-11			TROLL MODE
J1-12			MALFUNCTION INDICATOR LAMP
J1-13	465	GRN/WHT	FUEL PUMP ENABLE
J1-14			N/A
J1-15			N/A
J1-16			N/A
J1-17			GOVERNOR MODE
J1-18			BOOT MODE
J1-19	969A	PURPLE	IGNITION FEED
J1-20	440C	ORN	BATTERY FEED
J1-21	751	PNK/BLU	CRUISE INCREMENT UP / ACCELERATE
J1-22	752	PNK/WHT	CRUISE SET
J1-23			N/A
J1-24	921B	GRY	PULLUP FOR TACH
J1-25	921A	GRY	TACHOMETER
J1-26		TAN	STARTER CONTROL HS
J1-27			N/A
J1-28			N/A
J1-29			N/A
J1-30	753A	LT GRN	CRUISE/SYNC ON/OFF
J1-31			SENSOR RETURN - VSS ANALOG
J1-32			5V REFERENCE - VSS ANALOG

## J-1 ECM Connector Identification (2 of 2 J-1)

## LY6 - CAM PHASE ENGINE

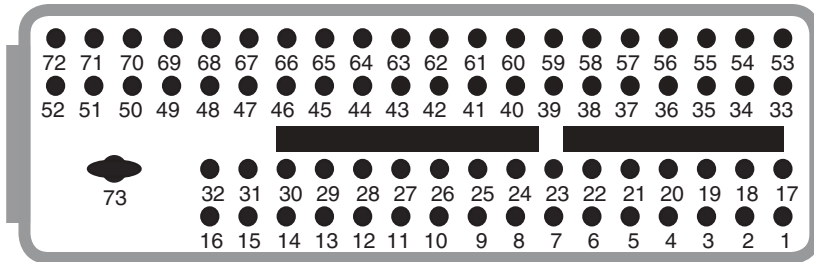


## ECM 56 WAY OUTPUT CONNECTOR

ECM PIN NUMBER	CKT(WIRE) NUMBER	CKT (WIRE) COLOR	CIRCUIT DESCRIPTION
J1-33	691	GRY	5V REFERENCE - PEDAL POSITION #1
J1-34			5V REFERENCE - FUEL PRESSURE SENSOR
J1-35	692	GRY	5V REFERENCE - PEDAL POSITION #2
J1-36	693	BLK/WHT	LOW REFERENCE - PEDAL POSITION #1
J1-37	694	BLK/WHT	LOW REFERENCE - PEDAL POSITION #2
J1-38	906A	YLW/BLK	LOAD ANTICIPATE 1 (IN GEAR)
J1-39			N/A
J1-40	441	BLK/RED	MEFI SYSTEM RELAY ENABLE
J1-41			CHECK GAUGE LAMP
J1-42			N/A
J1-43			N/A
J1-44			FUEL LEVEL SENSOR
J1-45	753B		FUEL LEVEL SENSOR #2
J1-46			VSS ANALOG
J1-47	695	BLU	PEDAL POSITION SENSOR 1
J1-48			FUEL PRESSURE SENSOR
J1-49	696	GRN	PEDAL POSITION SENSOR 2
J1-50			FUEL TEMPERATURE SENSOR
J1-51			GENERAL WARNING 1 LAMP
J1-52			GENERAL WARNING 2 LAMP
J1-53			SPEED BASED OUTPUT
J1-54			BUZZER
J1-55	754	LT GRN/BLK	CRUISE STATUS LAMP
J1-56			STARTER CONTROL LS

J-2 ECM Connector Identification (1 of 3 J-2)

LY6 - CAM PHASE ENGINE



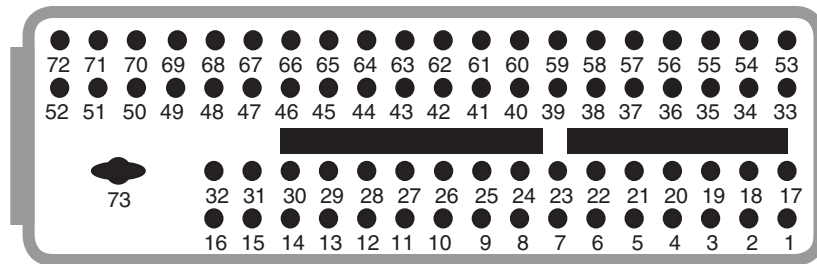
ECM 73 WAY OUTPUT CONNECTOR

ECM PIN NUMBER	CKT(WIRE) NUMBER	CKT (WIRE) COLOR	CIRCUIT DESCRIPTION
J2-1	423	PPL	EST 1 - IGNITION COIL PIN G - CYLINDER 1
J2-2		WHT/BLU	OXYGEN SENSOR A1 LO
J2-3		BLU	OXYGEN SENSOR A1 HI
J2-4			OXYGEN SENSOR A2 HI
J2-5			OXYGEN SENSOR A2 LO
J2-6	496	WHT	KNOCK SENSOR FLAT RESPONSE#2
J2-7	494	BLK	KNOCK SENSOR RETURN #2
J2-8	497	WHT	KNOCK SENSOR-FLAT RESPONSE
J2-9	495	BLK	KNOCK SENSOR RETURN
J2-10			KNOCK SENSOR SHIELD
J2-11	581	YLW	ETC MOTOR OPEN: IAC1 PWM
J2-12	582	BRN	ETC MOTOR CLOSE: IAC2 PWM
J2-13	439B	PNK/BLK	IGNITION 1 VOLTAGE - PINS H IGNITION COILS EVEN & ODD BANKS
J2-14		RED/BLK	CAM PHASE CONTROL W PIN D
J2-15			CAM PHASE CONTROL Y
J2-16	472	LT BLU	FUEL INJECTOR H (CYLINDER 2)
J2-17		PPL/WHT	EST 8 - IGNITION COIL G - CYLINDER 8
J2-18		GRN/WHT	EST 4 - IGNITION COIL C - CYLINDER 4
J2-19		BRN	EST RETURN #2 - IGNITION COIL EVEN BANK
J2-20			SENSOR RETURN - CAMX
J2-21			SENSOR RETURN - CAMY
J2-22			SENSOR RETURN - CAMZ
J2-23	813	BLK/WHT	LOW REFERENCE - CAM SENSOR - PIN B
J2-24	814	BLK/WHT	LOW REFERENCE - ENGINE OIL PRESSURE
J2-25			LOW REFERENCE - LEGR SENSOR
J2-26			KNOCK SENSOR SHIELD #2
J2-27	815	BLK/WHT	LOW REFERENCE - CRANK SENSOR - PIN B
J2-28	439C	PNK/BLK	IGNITION 1 VOLTAGE - PIN H - IGNITION COIL EVEN & ODD BANKS
J2-29	683	BLK/WHT	LOW REFERENCE - THROTTLE POSITION SENSOR
J2-30			CAM PHASE RETURN X
J2-31			LEGR / CAM PHASE RETURN Z
J2-32	473	LT GRN/BLK	FUEL INJECTOR D (CYLINDER 3)



## J-2 ECM Connector Identification (2 of 3 J-2)

## LY6 - CAM PHASE ENGINE

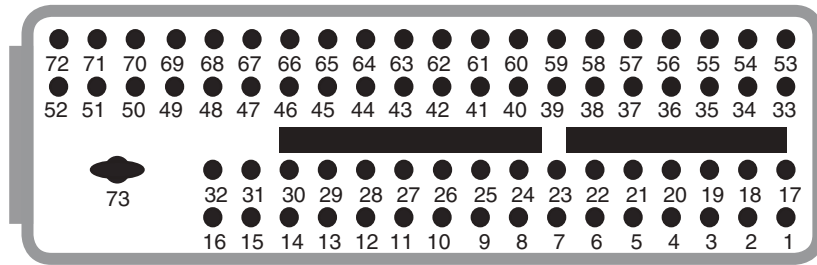


## ECM 73 WAY OUTPUT CONNECTOR

ECM PIN NUMBER	CKT(WIRE) NUMBER	CKT (WIRE) COLOR	CIRCUIT DESCRIPTION
J2-33		RED	EST 7 - IGNITION COIL B - CYLINDER 7
J2-34		GRN	EST 5 - IGNITION COIL C - CYLINDER 5
J2-35		BRN	EST RETURN - IGNITION COIL E - ODD BANK
J2-36			5V REFERENCE - CAMX (CAMB, CAM 4X)
J2-37			5V REFERENCE - CAMY (CAMC, CAM 4X2)
J2-38			5V REFERENCE - CAMZ (CAMD, CAM 4X3)
J2-39	413	GRY	5V REFERENCE - CAM SENSOR - PIN A
J2-40	414	GRY	5V REFERENCE - ENGINE OIL PRESSURE
J2-41			5V REFERENCE - LINEAR EGR POSITION
J2-42			SENSOR RETURN - INDUCTION AIR
J2-43	415	GRY	5V REFERENCE - CRANK SENSOR - PIN C
J2-44	682	GRY	5V REFERENCE - THROTTLE POSITION SENSOR
J2-45			SENSOR RETURN - ENGINE OIL TEMP
J2-46		YLW/BLK	CAM PHASE RETURN W - PIN E
J2-47			CAM PHASE RETURN Y
J2-48	478	LT BLU/RED	FUEL INJECTOR B (CYLINDER 8)
J2-49	475	LT GRN/WHT	FUEL INJECTOR F (CYLINDER 5)
J2-50			CAM PHASE CONTROL X
J2-51			LEGR: CAM PHASE CONTROL Z
J2-52	476	LT BLU/WHT	FUEL INJECTOR E (CYLINDER 6)
J2-53			EST 2 - IGNITION COIL D - CYLINDER 2
J2-54			EST 6 - IGNITION COIL E - CYLINDER 6
J2-55			EST 3 - IGNITION COIL H - CYLINDER 3
J2-56			CAMX SENSOR (CAMB, CAM 4X)
J2-57			CAMY SENSOR (CAMC, CAM 4X2)
J2-58			CAMZ SENSOR (CAMD, CAM 4X3)
J2-59	633	BRN/WHT	CAM SENSOR SIGNAL - PIN C (CAMA, CAM 8XPWP)
J2-60	901	LT BLU/RED	ENGINE OIL PRESSURE SENSOR SIGNAL
J2-61	756	PNK	DASH
J2-62			INDUCTION AIR TEMPERATURE (OR MAT) SENSOR
J2-63	1869	BLU/WHT	CRANK SENSOR - PIN A
J2-64	684	DK GRN	THROTTLE POSITION SENSOR #1

## J-2 ECM Connector Identification (3 of 3 J-2)

## LY6 - CAM PHASE ENGINE



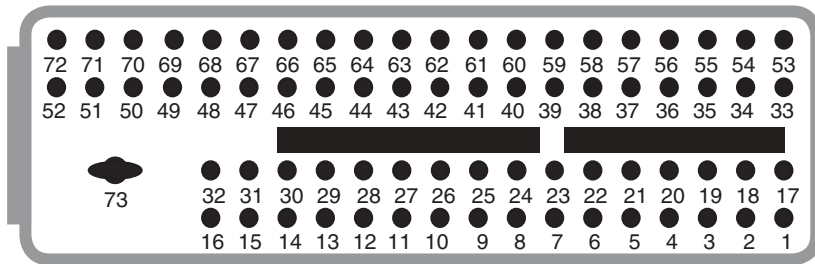
**J-2 (Continued)**  
**ECM 73 WAY OUTPUT CONNECTOR**

ECM PIN NUMBER	CKT(WIRE) NUMBER	CKT (WIRE) COLOR	CIRCUIT DESCRIPTION
J2-65			ENGINE OIL TEMPERATURE SENSOR
J2-66	687	DK BLU	THROTTLE POSITION SENSOR #2
J2-67			HIGH SPEED MASS AIR FLOW
J2-68		BLK	OXYGEN SENSOR A1 HEATER
J2-69			OXYGEN SENSOR A2 HEATER
J2-70	477	GRN/RED	FUEL INJECTOR G
J2-71	474	LT BLU/BRN	FUEL INJECTOR C
J2-72	471	GRN	FUEL INJECTOR A
J2-73	450A	BLK	POWER GROUND

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## J-3 ECM Connector Identification (1 of 3 J-3)

## LY6 - CAM PHASE ENGINE

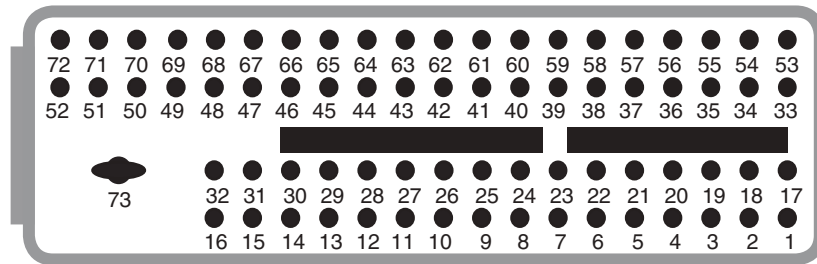


## ECM 73 WAY OUTPUT CONNECTOR

ECM PIN NUMBER	CKT(WIRE) NUMBER	CKT (WIRE) COLOR	CIRCUIT DESCRIPTION
J3-1			CAT TEMPERATURE SENSOR A
J3-2			CAT TEMPERATURE SENSOR B
J3-3		WHT/BLU	OXYGEN SENSOR B1 LO
J3-4		BLU	OXYGEN SENSOR B1 HI
J3-5			OXYGEN SENSOR B2 HI
J3-6			OXYGEN SENSOR B2 LO
J3-7			N/A
J3-8			LOW OIL LEVEL LAMP
J3-9			N/A
J3-10			CYLINDER DEACTIVATE C
J3-11			CYLINDER DEACTIVATE A
J3-12			GOVENOR PWM OUTPUT (NON-ETC GOVENOR)
J3-13			TRANSMISSION UP-SHIFT
J3-14			N/A
J3-15		BLK	OXYGEN SENSOR B1 HEATER
J3-16			TROLL MODE LAMP
J3-17			N/A
J3-18			ENGINE OIL LEVEL LOW SENSOR
J3-19			SENSOR RETURN - CAT TEMP SENSOR A
J3-20			SENSOR RETURN - CAT TEMP SENSOR B
J3-21			SENSOR RETURN - VARIABLE GOVERNOR
J3-22			N/A
J3-23	816	BLK/WHT	LOW REFERENCE - MANIFOLD ABSOLUTE PRESSURE
J3-24			AUX ANALOG RETURN
J3-25			SENSOR RETURN - GENERAL WARNING 2
J3-26			SENSOR RETURN - GENERAL WARNING 1
J3-27			N/A
J3-28			SENSOR RETURN - DIGITAL VSS
J3-29			N/A
J3-30			N/A
J3-31			N/A
J3-32			N/A

## J-3 ECM Connector Identification (2 of 3 J-3)

## LY6 - CAM PHASE ENGINE

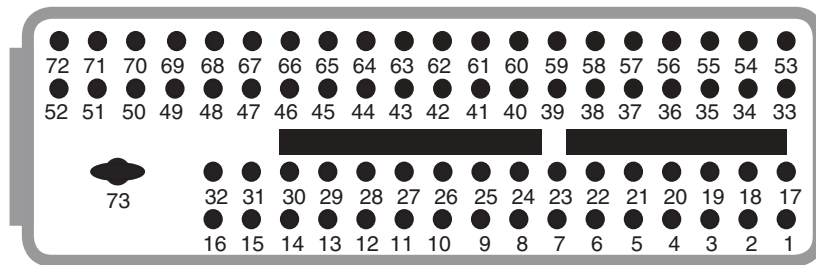


## ECM 73 WAY OUTPUT CONNECTOR

ECM PIN NUMBER	CKT(WIRE) NUMBER	CKT (WIRE) COLOR	CIRCUIT DESCRIPTION
J3-33	804A	WHT/BLK	CAN BUS LO TERMINATED (TO DASH & DLC)
J3-34			N/A
J3-35	817	BLK/WHT	LOW REFERENCE - ENGINE COOLANT TEMP SENSOR
J3-36			N/A
J3-37			5V REFERENCE - VARIABLE GOVERNOR
J3-38			N/A
J3-39	416	GRY	5V REFERENCE - MANIFOLD ABSOLUTE PRESSURE
J3-40			5V REFERENCE - AUX ANALOG
J3-41			5V REFERENCE - GENERAL WARNING 2
J3-42	417	GRY	5V REFERENCE - GENERAL WARNING 1 (TRANSMISSION OVER TEMP SENSOR)
J3-43			N/A
J3-44			5V REFERENCE - DIGITAL VSS
J3-45			LOAD ANTICIPATE 2
J3-46			SHIFT INTERRUPT / TRANSMISSION LOCK LOW
J3-47			N/A
J3-48			CONTROL CANISTER PURGE
J3-49			N/A
J3-50			OXYGEN SENSOR B2 HEATER
J3-51			N/A
J3-52			N/A
J3-53	803A	WHT/RED	CAN BUS HI TERMINATED (GOES TO DLC-C & DASH K)
J3-54			N/A
J3-55	410	YLW	ENGINE COOLANT TEMPERATURE SENSOR SIGNAL
J3-56			N/A
J3-57	755	LT GRN/WHT	VARIABLE GOVERNOR (TO DASH-E)
J3-58			N/A
J3-59	432	LT GRN	MANIFOLD ABSOLUTE PRESSURE SENSOR SIGNAL
J3-60			AUX ANALOG INPUT
J3-61	933	TAN/BLK	GENERAL WARNING 1 (TO TRANS TEMP SENSOR SIGNAL)
J3-62			GENERAL WARNING 2
J3-63			N/A
J3-64	757	GRN/RED	DIGITAL VSS (TO DASH-N)

J-3 ECM Connector Identification (3 of 3 J-3)

LY6 - CAM PHASE ENGINE

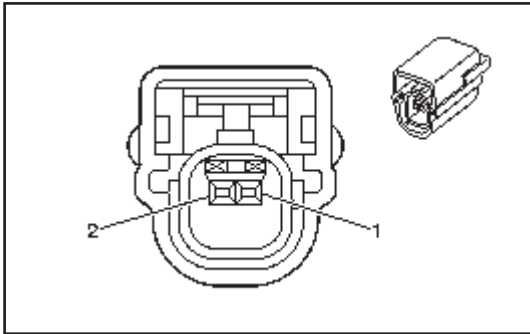


ECM 73 WAY OUTPUT CONNECTOR

ECM PIN NUMBER	CKT(WIRE) NUMBER	CKT (WIRE) COLOR	CIRCUIT DESCRIPTION
J3-65			ENGINE OIL PRESSURE SWITCH
J3-66			VR VSS FREQ HI
J3-67			VR VSS FREQ LO
J3-68			CYLINDER DEACTIVATE B
J3-69			CYLINDER DEACTIVATE D
J3-70			N/A
J3-71			N/A
J3-72			N/A
J3-73	450B	BLK	POWER GROUND #2

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**Camshaft Actuator Solenoid**



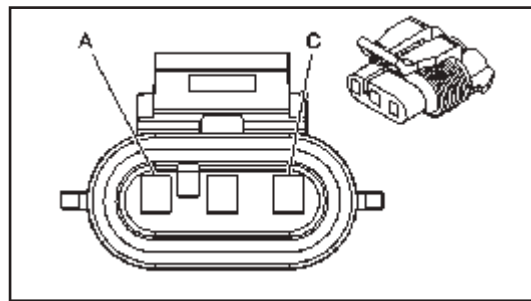
**Connector Part Information**  
 OEM: 15472554  
 Service: 88988610  
 Description: 2-Way F 0.64 Series Sealed (BK)

**Terminal Part Information**  
 Terminal/Tray: 1393364-2/7  
 Core/Insulation Crimp: K/K  
 Release Tool/Test Probe: 15315247/J-35616-64B (L-BU)

**Camshaft Actuator Solenoid**

Pin	Wire Color	Circuit No.	Function
1	PUR		Low Reference
2	TAN		Camshaft Actuator Solenoid Control

**Camshaft Position (CMP) Sensor**



**Connector Part Information**  
 OEM: 12059595  
 Service: 88986451  
 Description: 3-Way F Metri-Pack 150 Series, Sealed (BK)

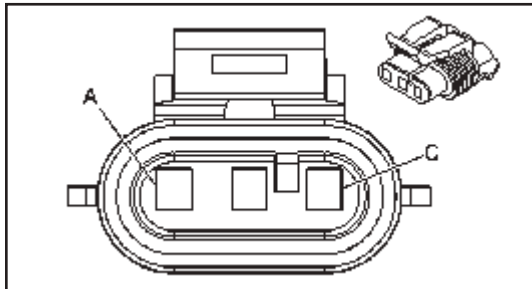
**Terminal Part Information**  
 Terminal/Tray: 12048074/2  
 Core/Insulation Crimp: E/1  
 Release Tool/Test Probe: 12094429/J-35616-2A (GY)

**Camshaft Position (CMP) Sensor**

Pin	Wire Color	Circuit No.	Function
A	BLU	413	5-Volt Reference
B	BLK/ WHT	813	Low Reference
C	BRN	633	CMP Sensor Signal



**Crankshaft Position (CKP) Sensor**



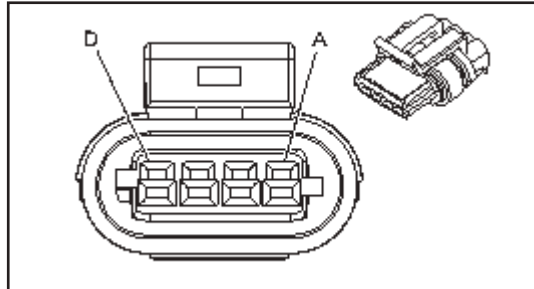
**Connector Part Information**  
 OEM: 12129946  
 Service: 88987997  
 Description: 3-Way F Metri-Pack 150 Series, Sealed (M-GY)

**Terminal Part Information**  
 Terminal/Tray: 12048074/2  
 Core/Insulation Crimp: E/1  
 Release Tool/Test Probe: 12094429/J-35616-2A (GY)

**Crankshaft Position (CKP) Sensor**

Pin	Wire Color	Circuit No.	Function
A	DK BLU/ WHT	1869	CKP Sensor Signal
B	BLK/ WHT	815	Low Reference
C	GRY	415	5-Volt Reference

**Ignition Coil 1**



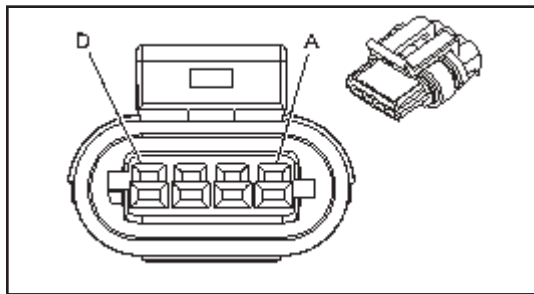
**Connector Part Information**  
 OEM: 15439568  
 Service: 88987184  
 Description: 4-Way F GT 150 Series, Sealed (BK)

**Terminal Part Information**  
 Terminal/Tray: 15326267/19  
 Core/Insulation Crimp: Pins A, D: E/1  
 Core/Insulation Crimp: Pins B, C: E/4  
 Release Tool/Test Probe: 15315247/J-35616-2A (GY)

**Ignition Coil 1**

Pin	Wire Color	Circuit No.	Function
A	BK	151	Ground
B	BN	2129	Low Reference
C	PU	2121	IC 1 Control
D	PK	39	Ignition 1 Voltage

**Ignition Coil 2**



**Connector Part Information**

OEM: 15439568  
 Service: 88987184  
 Description: 4-Way F GT 150 Series, Sealed (BK)

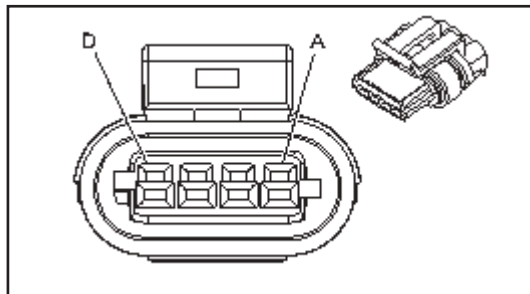
**Terminal Part Information**

Terminal/Tray: 15326267/19  
 Core/Insulation Crimp: Pins A, D: E/1  
 Core/Insulation Crimp: Pins B, C: E/4  
 Release Tool/Test Probe: 15315247/J-35616-2A (GY)

**Ignition Coil 2**

Pin	Wire Color	Circuit No.	Function
A	BK	151	Ground
B	BN	2129	Low Reference
C	RD	2127	IC 7 Control
D	PK	39	Ignition 1 Voltage

**Ignition Coil 3**



**Connector Part Information**

OEM: 15439568  
 Service: 88987184  
 Description: 4-Way F GT 150 Series, Sealed (BK)

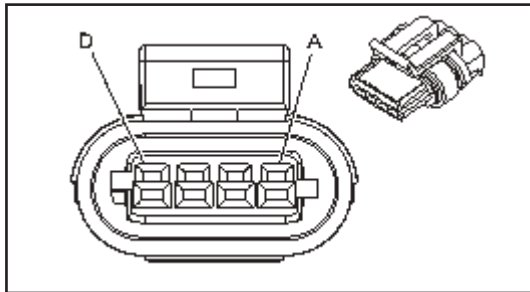
**Terminal Part Information**

Terminal/Tray: 15326267/19  
 Core/Insulation Crimp: Pins A, D: E/1  
 Core/Insulation Crimp: Pins B, C: E/4  
 Release Tool/Test Probe: 15315247/J-35616-2A (GY)

**Ignition Coil 3**

Pin	Wire Color	Circuit No.	Function
A	BK	151	Ground
B	BN	2129	Low Reference
C	L-BU	2123	IC 3 Control
D	PK	39	Ignition 1 Voltage

**Ignition Coil 4**



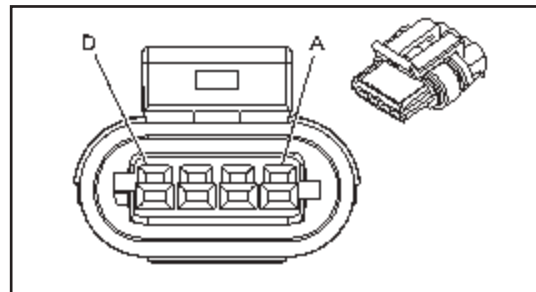
**Connector Part Information**  
 OEM: 15439568  
 Service: 88987184  
 Description: 4-Way F GT 150 Series, Sealed (BK)

**Terminal Part Information**  
 Terminal/Tray: 15326267/19  
 Core/Insulation Crimp: Pins A, D: E/1  
 Core/Insulation Crimp: Pins B, C: E/4  
 Release Tool/Test Probe: 15315247/J-35616-2A (GY)

**Ignition Coil 4**

Pin	Wire Color	Circuit No.	Function
A	BK	151	Ground
B	BN	2129	Low Reference
C	D-GN	2125	IC 5 Control
D	PK	39	Ignition 1 Voltage

**Ignition Coil 5**

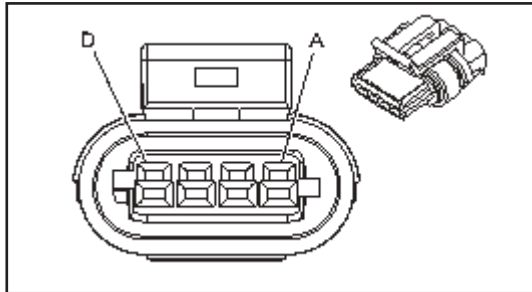


**Connector Part Information**  
 OEM: 15439568  
 Service: 88987184  
 Description: 4-Way F GT 150 Series, Sealed (BK)

**Terminal Part Information**  
 Terminal/Tray: 15326267/19  
 Core/Insulation Crimp: Pins A, D: E/1  
 Core/Insulation Crimp: Pins B, C: E/4  
 Release Tool/Test Probe: 15315247/J-35616-2A (GY)

**Ignition Coil 5**

Pin	Wire Color	Circuit No.	Function
A	BK	151	Ground
B	BN	2129	Low Reference
C	D-GN	2125	IC 5 Control
D	PK	39	Ignition 1 Voltage

**Ignition Coil 6****Connector Part Information**

OEM: 15439568

Service: 88987184

Description: 4-Way F GT 150 Series, Sealed (BK)

**Terminal Part Information**

Terminal/Tray: 15326267/19

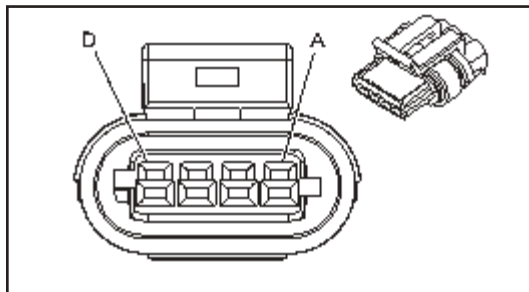
Core/Insulation Crimp: Pins A, D: E/1

Core/Insulation Crimp: Pins B, C: E/4

Release Tool/Test Probe: 15315247/J-35616-2A (GY)

**Ignition Coil 6**

Pin	Wire Color	Circuit No.	Function
A	BK	151	Ground
B	BN	2129	Low Reference
C	L-BU	2123	IC 3 Control
D	PK	39	Ignition 1 Voltage

**Ignition Coil 7****Connector Part Information**

OEM: 15439568

Service: 88987184

Description: 4-Way F GT 150 Series, Sealed (BK)

**Terminal Part Information**

Terminal/Tray: 15326267/19

Core/Insulation Crimp: Pins A, D: E/1

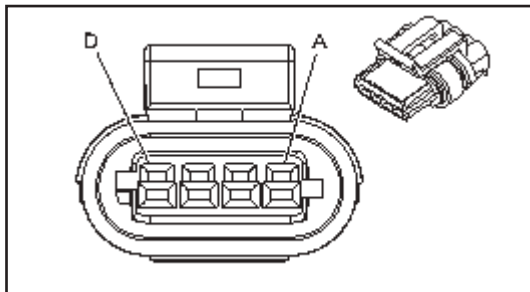
Core/Insulation Crimp: Pins B, C: E/4

Release Tool/Test Probe: 15315247/J-35616-2A (GY)

**Ignition Coil 7**

Pin	Wire Color	Circuit No.	Function
A	BK	151	Ground
B	BN	2129	Low Reference
C	RD	2127	IC 7 Control
D	PK	39	Ignition 1 Voltage

## Ignition Coil 8



### Connector Part Information

OEM: 15439568

Service: 88987184

Description: 4-Way F GT 150 Series, Sealed (BK)

### Terminal Part Information

Terminal/Tray: 15326267/19

Core/Insulation Crimp: Pins A, D: E/1

Core/Insulation Crimp: Pins B, C: E/4

Release Tool/Test Probe: 15315247/J-35616-2A (GY)

## Ignition Coil 8

Pin	Wire Color	Circuit No.	Function
A	BK	151	Ground
B	BN	2129	Low Reference
C	PU	2121	IC 1 Control
D	PK	39	Ignition 1 Voltage

## Description and Operation

### Camshaft Actuator System Description

#### Camshaft Position (CMP) Actuator System

The camshaft (CMP) actuator system is an electro-hydraulic operated device used for a variety of engine performance and operational enhancements. These enhancements include lower emission output through exhaust gas dilution of the intake charge in the combustion chamber, a broader engine torque range, and improved fuel economy. The CMP actuator system accomplishes this by, changing the angle or timing of the camshaft, relative to the crankshaft position. The CMP actuator simply allows earlier or later intake and exhaust valve opening, during the four stroke engine cycle. The CMP actuator cannot vary the duration of valve opening, or the valve lift.

During engine OFF, engine idling conditions, and engine shutdown, the camshaft actuator is held in the park position. Internal to the CMP actuator assembly is a return spring and a locking pin. During non-phasing modes of the camshaft, the return spring rotates the camshaft back to the park position, and the locking pin retains the CMP actuator sprocket to the camshaft. For the Gen IV small block engines, the park position for the CMP actuator and camshaft is, 8.5 degrees before top dead center (BTDC), which is equal to 17 crankshaft degrees BTDC, to the next cylinder in firing order. The engine control module (ECM) can only command the CMP actuator to retard the valve timing from the park position, or advance the valve timing back to the park position. The total range of valve timing authority is 31 degrees of camshaft rotation, which is equal to 62 degrees of crankshaft rotation. The control range is from the park position of 8.5 degrees camshaft, or 17 degrees of crankshaft BTDC, to 22.5 degrees camshaft, or 45 degrees crankshaft, after top dead center (ATDC).

#### CMP Actuator System Operation

The camshaft position (CMP) actuator system is controlled by the engine control module (ECM). The ECM sends a pulse width modulated, 12-volt signal to the CMP actuator solenoid to control the amount of pressurized engine oil, into the CMP actuator. A low reference circuit, or ground wire between the CMP actuator solenoid and the ECM completes the electrical circuit. The frequency of the pulse width modulated signal is fixed at 150Hz. To regulate the pressurized engine oil into the CMP actuator, the solenoid uses electromagnetic force on the solenoid pintle to pulse the oil control spool valve. The pressurized engine oil is sent to unseat the locking pin, and to the vane and rotor assembly of the CMP actuator, to either retard or advance the valve timing. The ECM will control the amount of ON time applied to the solenoid, through the 12-volt signal from the ECM.

The ECM uses the following inputs before assuming control of the CMP actuator, and to calculate the optimum valve timing.

- Engine speed
- Manifold absolute pressure (MAP)
- Throttle position angle
- Camshaft position sensor (CMP)
- Crankshaft position sensor (CKP)
- Crankshaft/camshaft correlation
- Engine coolant temperature (ECT)

- Closed loop fuel control
- Engine oil pressure (EOP)
- Engine oil level
- CMP actuator solenoid circuit state

### **CMP Actuator Solenoid Circuit Diagnostics**

The engine control module (ECM) monitors the control circuit of the camshaft position (CMP) actuator solenoid for electrical faults. The control module has the ability to determine if a control circuit is open, shorted high, or shorted low. If the control module detects a fault with the CMP actuator solenoid control circuit, SPN 65570, FMI 3, 4, 5, or 7 will set.

### **CMP Actuator System Performance Diagnostic**

The engine control module (ECM) monitors the performance of the camshaft position (CMP) actuator system by monitoring the calibrated desired position, and the actual position of the camshaft, through the 4X signal of the CMP sensor. If the difference between the actual and desired position is greater than a calibrated angle, for more than a calibrated amount of time, SPN 65570, FMI 7 will set.

For the system descriptions covering the hydraulic/mechanical part of the CMP actuator refer to Camshaft Position (CMP) Actuator and Solenoid Valve Description .

## **Description and Operation**

### **Electronic Ignition (EI) System Description**

The electronic ignition (EI) system is responsible for producing and controlling a high energy secondary spark. This spark is used to ignite the compressed air/fuel mixture at precisely the correct time. This provides optimal performance, fuel economy, and control of exhaust emissions. This ignition system consists of a separate ignition coil connected to each spark plug by a short secondary wire. The driver modules within each coil assembly are commanded ON/OFF by the engine control module (ECM). The ECM primarily uses engine speed and position information from the crankshaft and camshaft position (CMP) sensors to control the sequence, dwell, and timing of the spark event. The EI system consists of the following components:

### **Crankshaft Reluctor Wheel**

The crankshaft reluctor wheel is part of the crankshaft. The reluctor wheel consists of 58 teeth and a reference gap. Each tooth on the reluctor wheel is spaced at 6 degrees apart from each other,

for a total of 60-tooth spacing around the circumference of the wheel. The crankshaft reluctor wheel is missing 2 of the 60 teeth. The 2 missing teeth are used to create 12 degrees of spacing, which is used for the reference or sync pulse. The sync pulse is used by the engine control module (ECM) to synchronize the coil firing with the crankshaft position, while the other teeth provide cylinder location during each crankshaft revolution.

### **Crankshaft Position (CKP) Sensor**

The crankshaft position (CKP) sensor is a 3-wire sensor that provides a digital output signal. The wire circuits consist of an engine control module (ECM) supplied 5-volt reference circuit, a low reference circuit between the CKP sensor and the ECM, and an output signal circuit from the CKP sensor to the ECM. The CKP sensor detects magnetic flux changes of the teeth and slots of the 58-tooth reluctor on the crankshaft. The CKP sensor provides an ON/OFF DC voltage of varying frequency, with 58 output pulses per each crankshaft revolution. The frequency of the CKP sensor output signal depends on the speed of the crankshaft. The CKP sensor sends a digital square wave signal, which represents an image of the teeth on the reluctor wheel, to the ECM. The 12 degree reference gap on the reluctor wheel is used to identify crankshaft position. The CKP information, along with the camshaft position (CMP) sensor information is used to determine the correct time and sequence for fuel injection, ignition spark events, detect cylinder misfire, and the camshaft to crankshaft relative position.

### **Camshaft Reluctor Wheel**

The camshaft reluctor wheel is part of the camshaft gear. The reluctor wheel contains a pattern of 2 narrow teeth, and 2 wide teeth around the circumference of the wheel. The falling or trailing edges of the 4 teeth are evenly spaced at 90 degrees apart. The engine control module (ECM) recognizes the narrow and wide tooth patterns to identify camshaft position, or which cylinder is in compression, and which is in exhaust. The ECM also uses the reluctor wheel information to determine the camshaft relative position to the crankshaft position.

### **Camshaft Position (CMP) Sensor**

The camshaft position (CMP) sensor is a 3-wire sensor that provides a digital output signal. The wire circuits consist of an engine control module (ECM) supplied 5-volt reference circuit, a low reference circuit between the CMP sensor and the ECM, and an output signal circuit from the CMP sensor to the ECM. The CMP sensor detects magnetic flux changes between the teeth and slots on the 4-tooth reluctor wheel. The CMP sensor provides a digital ON/OFF DC voltage of varying frequency, with 4 varying width output pulses, per each camshaft revolution. The frequency of the CMP sensor output signal depends on the speed of the camshaft. The ECM will recognize the narrow and wide tooth patterns to identify camshaft position, or which cylinder is in compression and which is in exhaust. The information is then used to determine the correct time and sequence for fuel injection and ignition spark events. The ECM also uses the CMP sensor output signal to determine the camshaft relative position to the crankshaft position.

### **Ignition Coils**

Each ignition coil has an ignition 1 voltage feed and a ground circuit. The engine control module (ECM) supplies a low reference and an ignition control (IC) circuit. Each ignition coil contains a solid state driver module. The ECM will command the IC circuit ON, which allows the current



to flow through the primary coil windings for the appropriate time or dwell. When the ECM commands the IC circuit OFF, this will interrupt current flow through the primary coil windings. The magnetic field created by the primary coil windings will collapse across the secondary coil windings, which induces a high voltage across the spark plug electrodes. The primary coils are current limited to prevent overloading if the IC circuit is held ON for an extended time. The spark plugs are connected to their respective coils by a short secondary wire. The spark plugs are tipped with iridium for long life and efficiency.

### Circuit/System Description

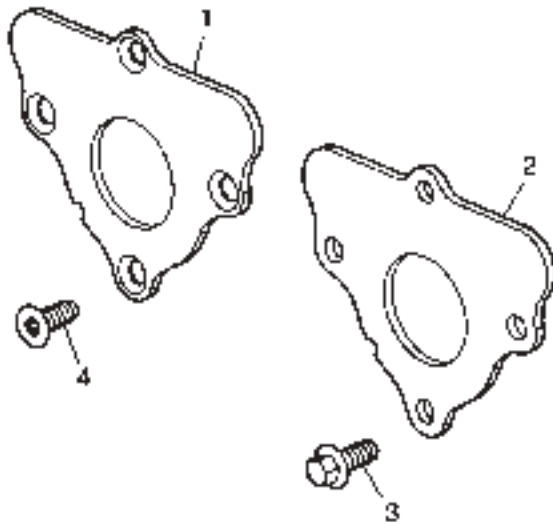
The camshaft position (CMP) actuator solenoid is controlled by the engine control module (ECM). The ECM sends a 12 volt, pulse width modulated (PWM) signal to the CMP actuator solenoid. The CMP actuator solenoid positions the CMP actuator spool valve to control the amount of pressurized engine oil, which enters into the CMP actuator assembly. A low reference wire circuit between the CMP actuator solenoid and the ECM completes the electrical circuit. The frequency of the pulse width modulated signal is fixed at 150Hz. The ECM can only command the CMP actuator to retard the valve timing from the camshaft park position, or advance the valve timing back to the park position. The total range of valve timing command is 31 degrees as measured at the camshaft, or 62 degrees as measured at the crankshaft.

### Camshaft and Drive System LY6

A billet steel 1 piece camshaft is supported by 5 bearings pressed into the engine block. The camshaft position (CMP) actuator is mounted to the front of the camshaft and retained by the CMP solenoid valve. The CMP actuator is driven by the crankshaft sprocket through the camshaft timing chain. The CMP sensor wheel is incorporated into the front face of the CMP actuator with the CMP sensor and CMP actuator magnet mounted in the engine front cover. A timing chain tensioner is mounted to the front of the engine block above the crankshaft sprocket. The externally splined crankshaft sprocket is positioned to the crankshaft by a key and keyway. The crankshaft sprocket external splines drive the oil pump drive gear. A retaining plate mounted to the front of the engine block maintains camshaft location. Refer to Camshaft Position Actuator and Solenoid Valve Description.

### Crankshaft

A crankshaft position (CKP) reluctor ring is press fit mounted at the rear of the crankshaft. The reluctor ring is not serviceable separately.



**Notice: Refer to Fastener Notice.**

#### 6. Tighten the camshaft retainer bolts.

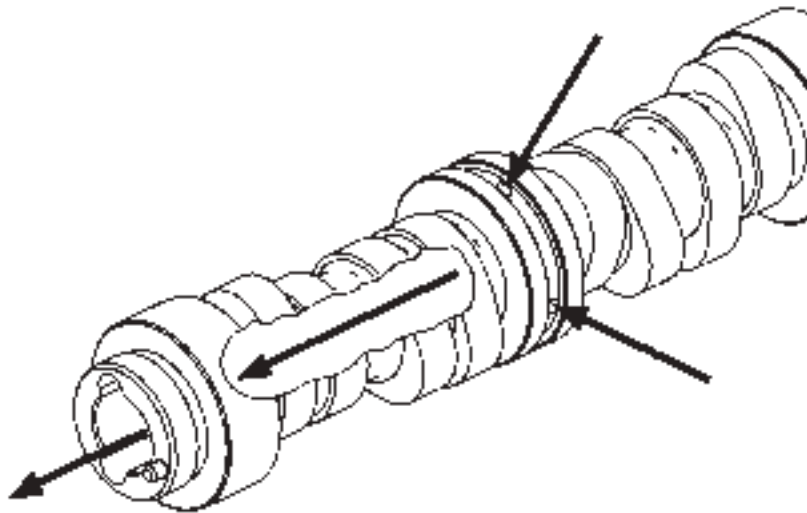
Tighten:

- Tighten the first design hex head bolts (3) to 25N•m (18 lb ft).
- Tighten the second design TORX® head bolts (4) to 15N•m (11 lb ft).

## Description and Operation

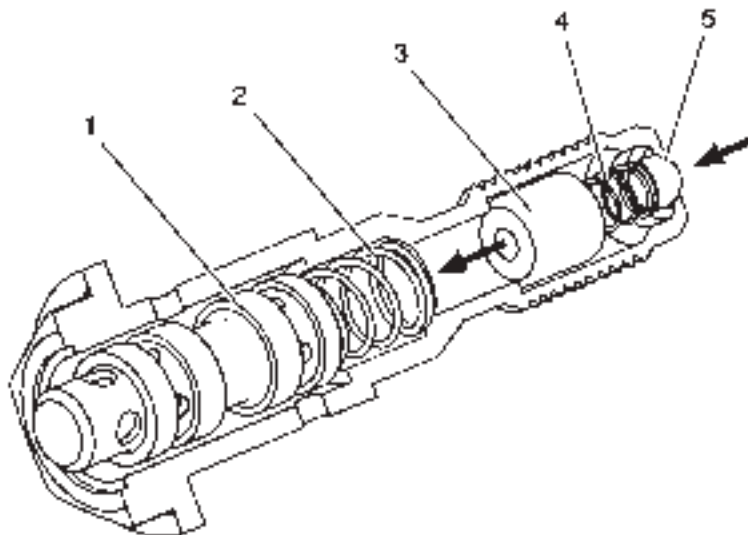
### Camshaft Position Actuator and Solenoid Valve Description

#### Camshaft

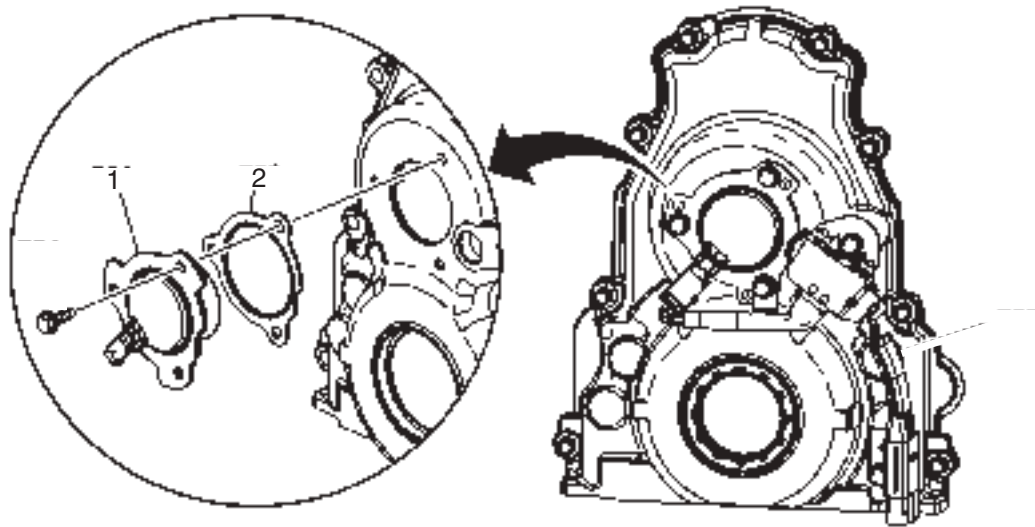


The camshaft is designed to provide a lubrication path for pressurized engine oil to flow to the camshaft position (CMP) actuator. Pressurized engine oil enters the camshaft at bearing journal location number 2. Oil travels through the camshaft, out the front, and into the CMP actuator solenoid valve.

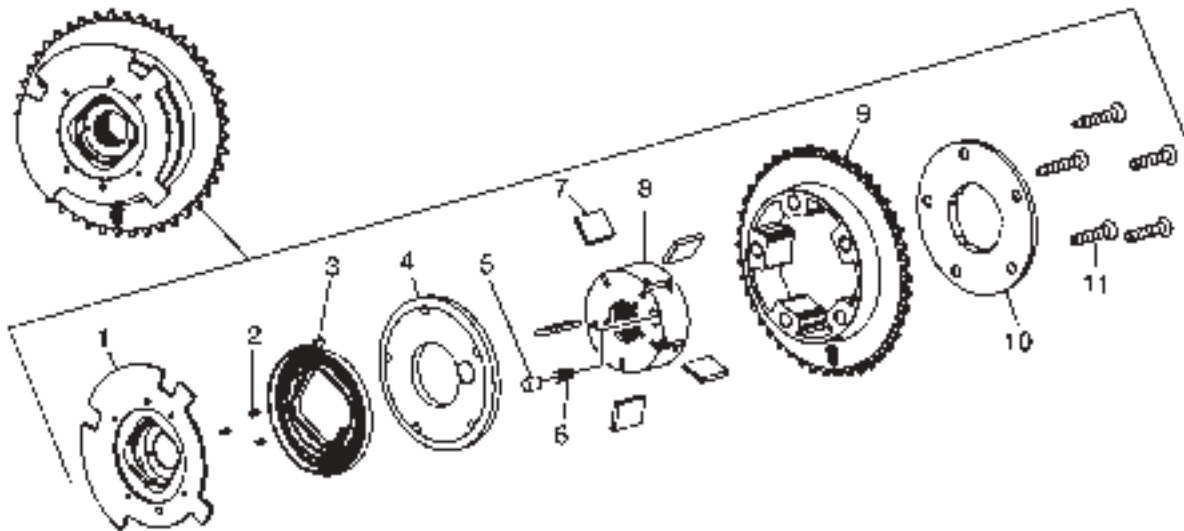
#### Camshaft Position (CMP) Actuator Solenoid Valve



The CMP actuator solenoid valve consists of a housing, spool valve (1), spool return spring (2), oil filter (3), inlet check ball return spring (4), and inlet check ball (5). Pressurized engine oil enters the valve and travels through the filter to the spool. Spool position is controlled by the CMP magnet and engine control module (ECM). When the spool is moved to the proper position, oil flow is directed through the valve and into the CMP actuator assembly. The CMP solenoid valve is a torque-to-yield design and should be replaced each time it is removed.

**CMP Actuator Magnet**

The CMP actuator magnet (1) is located in the engine front cover and is sealed by a gasket (2). The CMP actuator magnet is controlled by a 12-volt pulse width modulated signal from the ECM. When energized, the solenoid uses electromagnetic force on the magnet pintle to position the spool valve of the CMP solenoid valve.

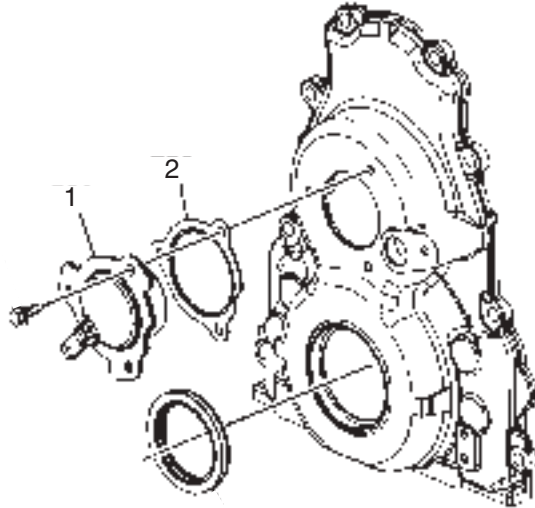
**CMP Actuator**

The CMP actuator is a vane type design that hydraulically changes angle or timing of the camshaft relative to crankshaft position. The CMP actuator allows earlier or later intake and exhaust valve opening during the 4-stroke engine cycle. The CMP actuator cannot vary the duration of valve opening or valve lift. The CMP actuator is to be serviced as an assembly. For system operation, refer to Camshaft Actuator System Description .

The CMP actuator consists of the CMP reluctor wheel (1), pins (2), return spring (3), front cover (4), locking pin (5), locking pin spring (6), vanes and vane springs (7), rotor (8), stator (9), sealing cover/thrust plate (10), and bolts (11).

## Repair Instructions

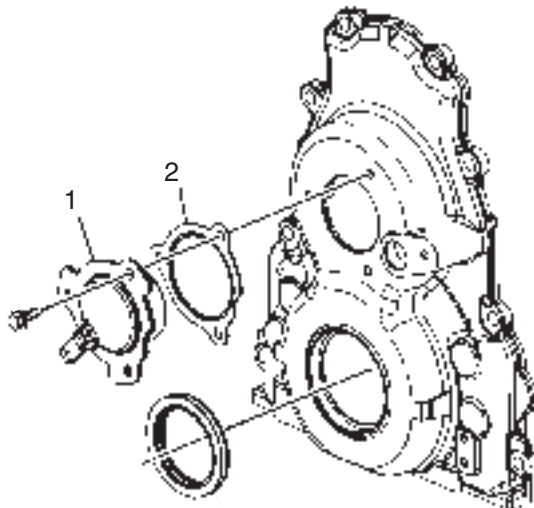
### Camshaft Position Actuator Magnet Replacement Removal Procedure



1. Remove the water pump. Refer to Water Pump Replacement.
2. Disconnect the engine harness electrical connector from the camshaft position (CMP) actuator magnet.
3. Remove the CMP actuator magnet bolts and magnet (1).
4. Remove and discard the CMP actuator magnet gasket (2).

### Installation Procedure

**Important:** The gasket surface should be free of oil or other foreign material during assembly.



1. Install a NEW CMP actuator magnet gasket (2) onto the CMP actuator magnet.
2. Install the CMP actuator magnet (1) to the front cover.

**Notice:** Refer to Fastener Notice.

3. Install the CMP actuator magnet bolts.

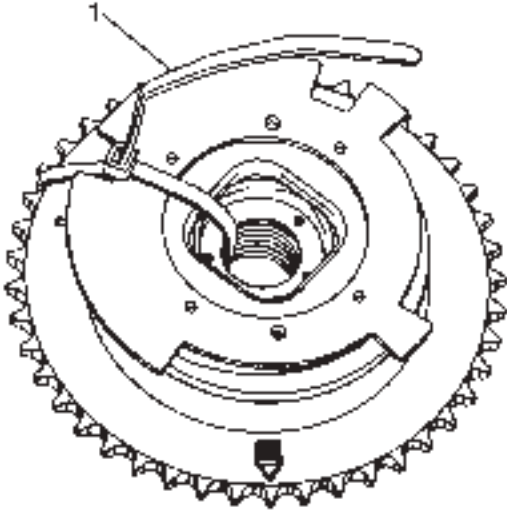
**Tighten:** Tighten the bolts to 12 N•m (106 lbin).

4. Connect the engine harness electrical connector to the CMP actuator magnet.
5. Install the water pump. Refer to Water Pump Replacement Water Pump Replacement.

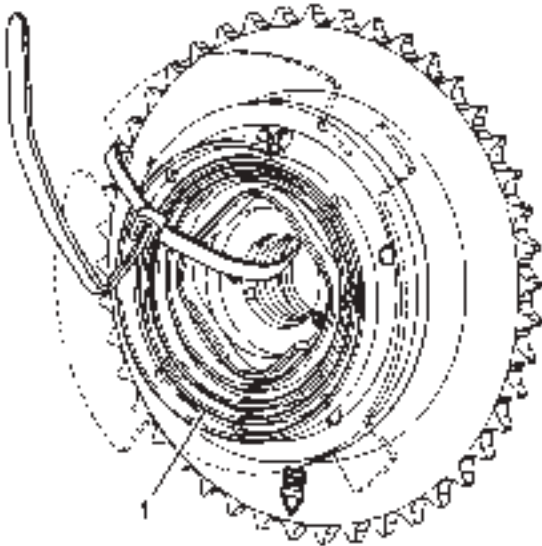
## Repair Instructions

### Camshaft Position Actuator Cleaning and Inspection

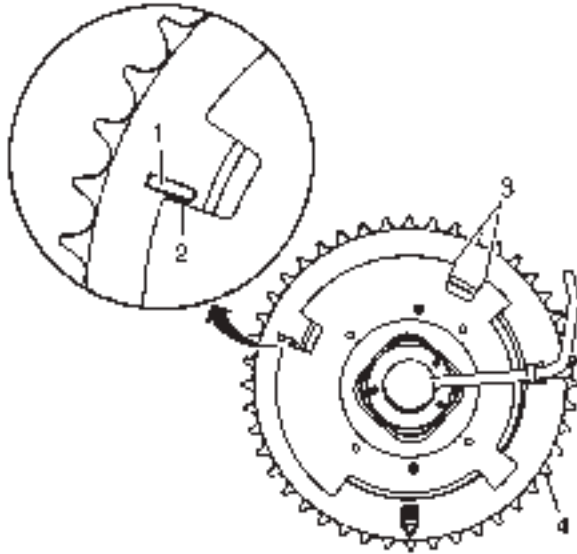
Caution: Refer to *Camshaft Position Actuator Removal and Installation Caution* .



1. Insert a tie strap (1) through the center of the camshaft position (CMP) actuator and over the reluctor wheel.

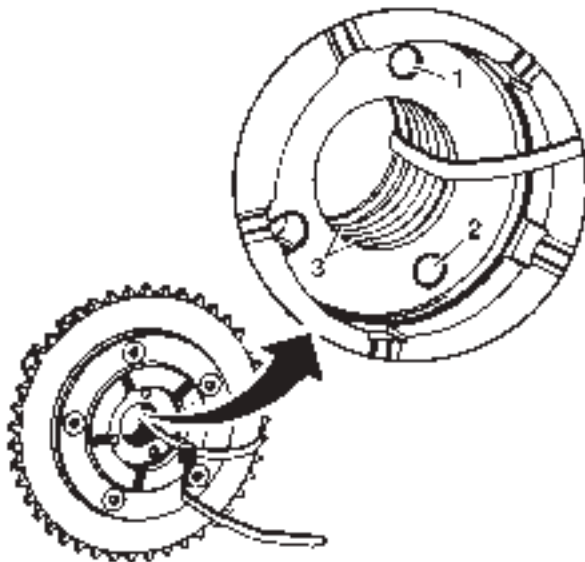


2. Clean the CMP actuator with cleaning solvent.  
Caution: Refer to *Safety Glasses and Compressed Air Caution* .
3. Dry the components with compressed air.
4. Inspect the CMP actuator for a broken spring (1).

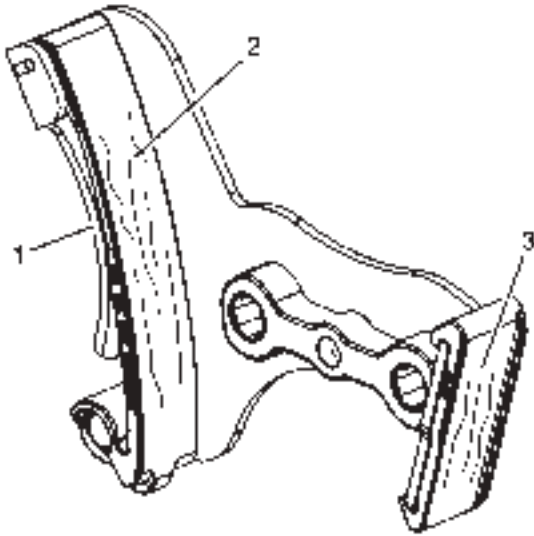


5. Inspect the CMP actuator for the following conditions:

- Improper positioning of the CMP reluctor wheel. The actuator return spring should reposition the reluctor wheel to the PARK position. Inspect for proper alignment of the mark on the face of the sprocket (1) with the flat edge of the reluctor wheel (2). If the reluctor wheel is not properly positioned, the internal components of the actuator are sticking or the return spring is broken and the actuator should be replaced as an assembly.
- Nicked or damaged edges (3) on the CMP reluctor wheel
- Damaged timing chain teeth (4)



6. Inspect the CMP actuator for dirt, debris, or restrictions within the oil passages (1, 2, 3).

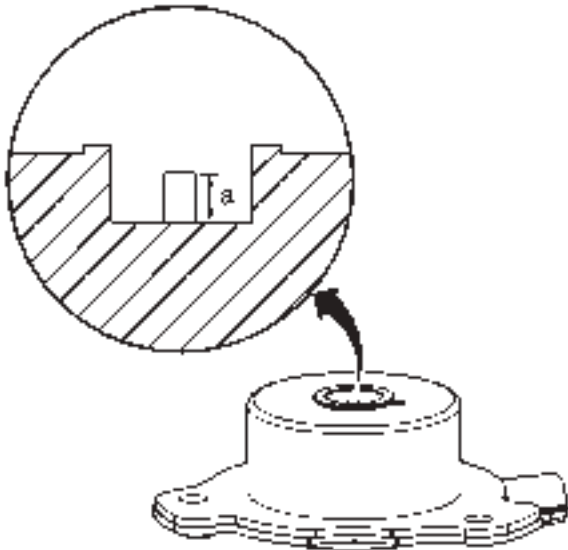


7. Inspect the timing chain tensioner for the following conditions:

- Damaged or broken tension spring (1)
- Excessive wear or scoring on the chain guide surfaces (2, 3)

## Repair Instructions

### Camshaft Position Actuator Magnet Cleaning and Inspection



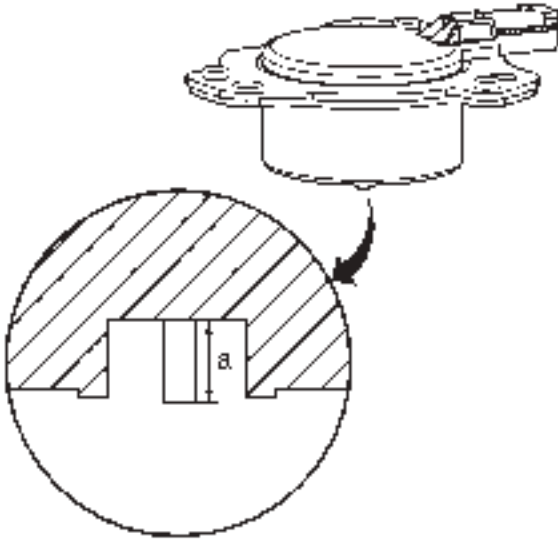
**Important:** Do not energize the camshaft position (CMP) magnet using a 12-volt power supply.

1. Inspect the CMP magnet for the following conditions:

- A damaged electrical connector
- An accumulation of dirt or debris in the recessed area around the pintle
- A build-up of burnt engine oil on the shaft of the pintle which may cause the pintle to stick and not move freely within the proper range of travel



2. Holding the CMP magnet with the pintle facing upward, measure the pintle retracted position (a). Record the dimension.



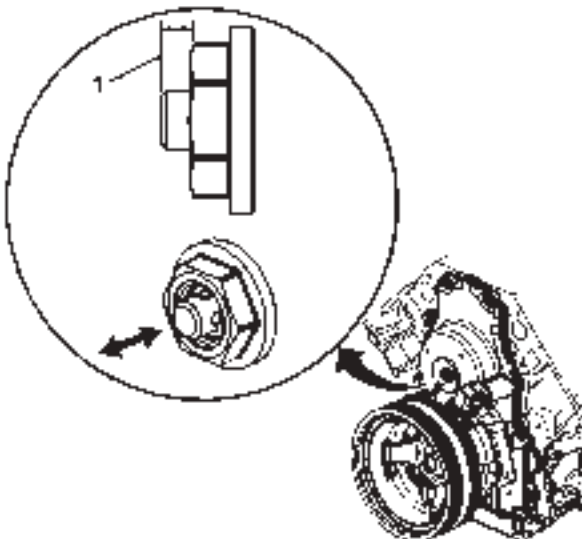
3. Holding the CMP magnet with the pintle facing downward, measure the pintle extended position (a). Record the dimension.

4. Subtract the retracted dimension from the extended dimension to determine pintle travel. A properly moving pintle will travel 3.0–5.5 mm (0.12–0.22 in).

5. If the pintle of the CMP magnet is binding or does not move within the proper range of travel, replace the CMP magnet as an assembly.

## Repair Instructions

### Camshaft Position Actuator Solenoid Valve Inspection (On-Vehicle)

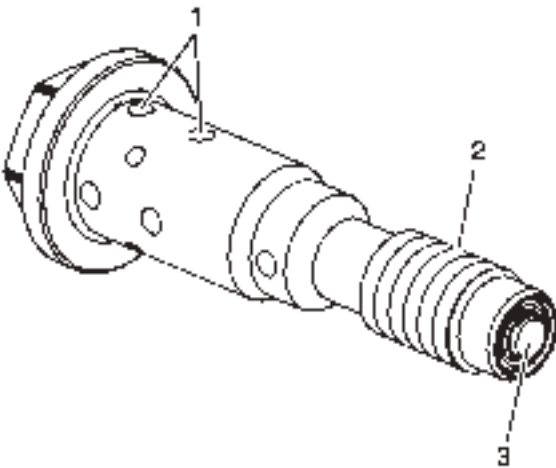


**Important:** Do not use the camshaft position (CMP) actuator solenoid valve again. Install a NEW valve during assembly. The inspection procedure below is provided for on-vehicle diagnostic purposes only.

1. With the CMP magnet removed, inspect for a sticking valve spool or broken valve spool spring.
2. Depress the valve spool into the housing. The valve should move freely with no binding or sticking and minimal resistance inward. When released, the valve spring should return the spool to the proper extended position (1) of 6.08–6.12 mm (0.239–0.241 in).

## Repair Instructions

### Camshaft Position Actuator Solenoid Valve Inspection (Off-Vehicle)



**Important:** Do not use the camshaft position (CMP) actuator solenoid valve again. Install a NEW valve during assembly. The inspection procedure below is provided for off-vehicle diagnostic purposes only.

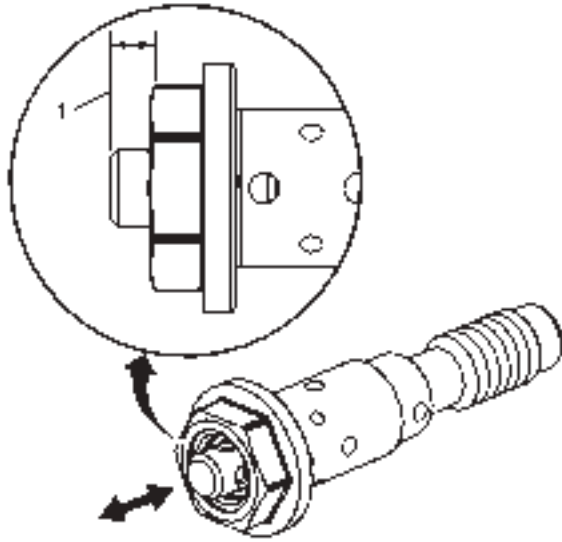
1. Inspect the CMP valve for the following conditions:

- Dirt, debris, or restrictions within the oil passages (1)
- Damaged threads (2)

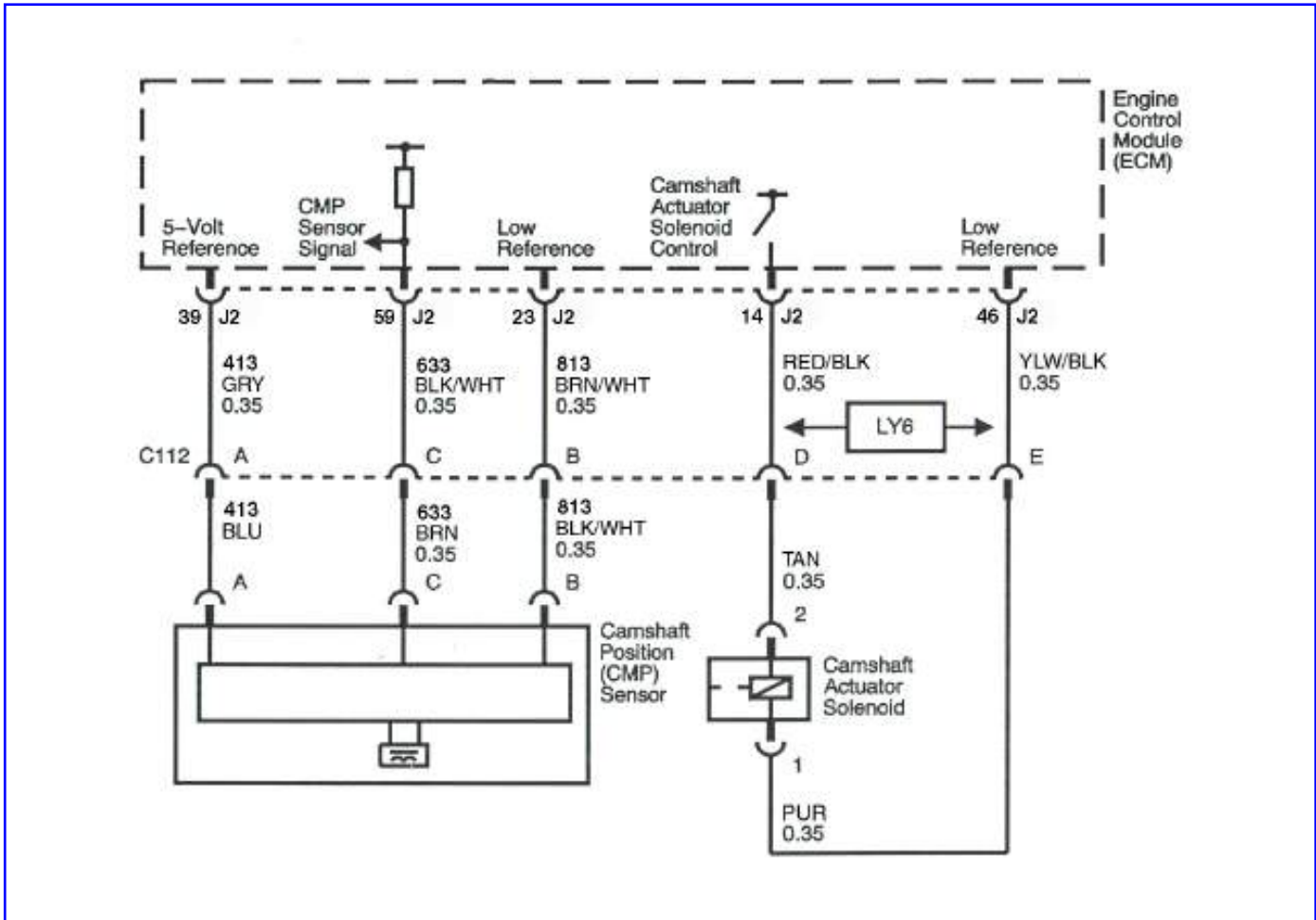
If the threads of the valve are damaged, also inspect the threads in the front of the camshaft for damage.

- Dirt, debris, or restrictions within the oil inlet check valve (3)

If debris is detected, the engine assembly should be inspected to determine the source of contamination.



2. Inspect for a sticking valve spool or broken valve spool spring.
3. Depress the valve spool into the housing. The valve should move freely with no binding or sticking and minimal resistance inward. When released, the valve spring should return the spool to the proper extended position (1) of 6.08–6.12 mm (0.239–0.241 in).



## Diagnostic Information and Procedures

### SPN 723, FMI 2 Cam Signal Fault

#### Circuit Description

The camshaft position (CMP) sensor works in conjunction with the 4X reluctor trigger wheel on the camshaft gear. The reluctor trigger wheel on the camshaft gear contains a pattern around the circumference, consisting of 2 narrow teeth and 2 wide teeth. The engine control module (ECM) provides a 5-volt reference to the sensor, as well as a low reference and a signal circuit. As the camshaft gear rotates, the reluctor trigger wheel interrupts a magnetic field produced by a magnet internal to the sensor. The CMP sensor internal circuitry detects this interruption of the magnetic field, and produces an ON/OFF DC voltage of varying frequency. The frequency of the CMP sensor output signal is dependent upon camshaft speed. The ECM will recognize the narrow and wide tooth patterns to identify camshaft position, or which cylinder is in compression and which is in exhaust. If the ECM detects that there is no output signal from the CMP sensor, then SPN 723 FMI 2 will set.

#### DTC Descriptor

This diagnostic procedure supports the following DTC:

SPN 723 FMI 2 Cam Signal Fault (Camshaft Position (CMP) Sensor Circuit Signal Fault)

#### Conditions for Running the DTC

- The engine is cranking, or the engine is running.
- SPN 723 FMI 2 runs continuously when the above condition is met.

#### Conditions for Setting the DTC

The ECM detects no CMP sensor output for more than 3 seconds.

## Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.

## Conditions for Clearing the MIL/DTC

- The control module turns OFF the MIL after consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC last test failed clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles if no failures are reported by this or any other emission related diagnostic.

## Diagnostic Aids

SPN 723 FMI 2 will set with the ignition switch in the Start position, if the starter motor is inoperative for more than 3 seconds.

## Test Description

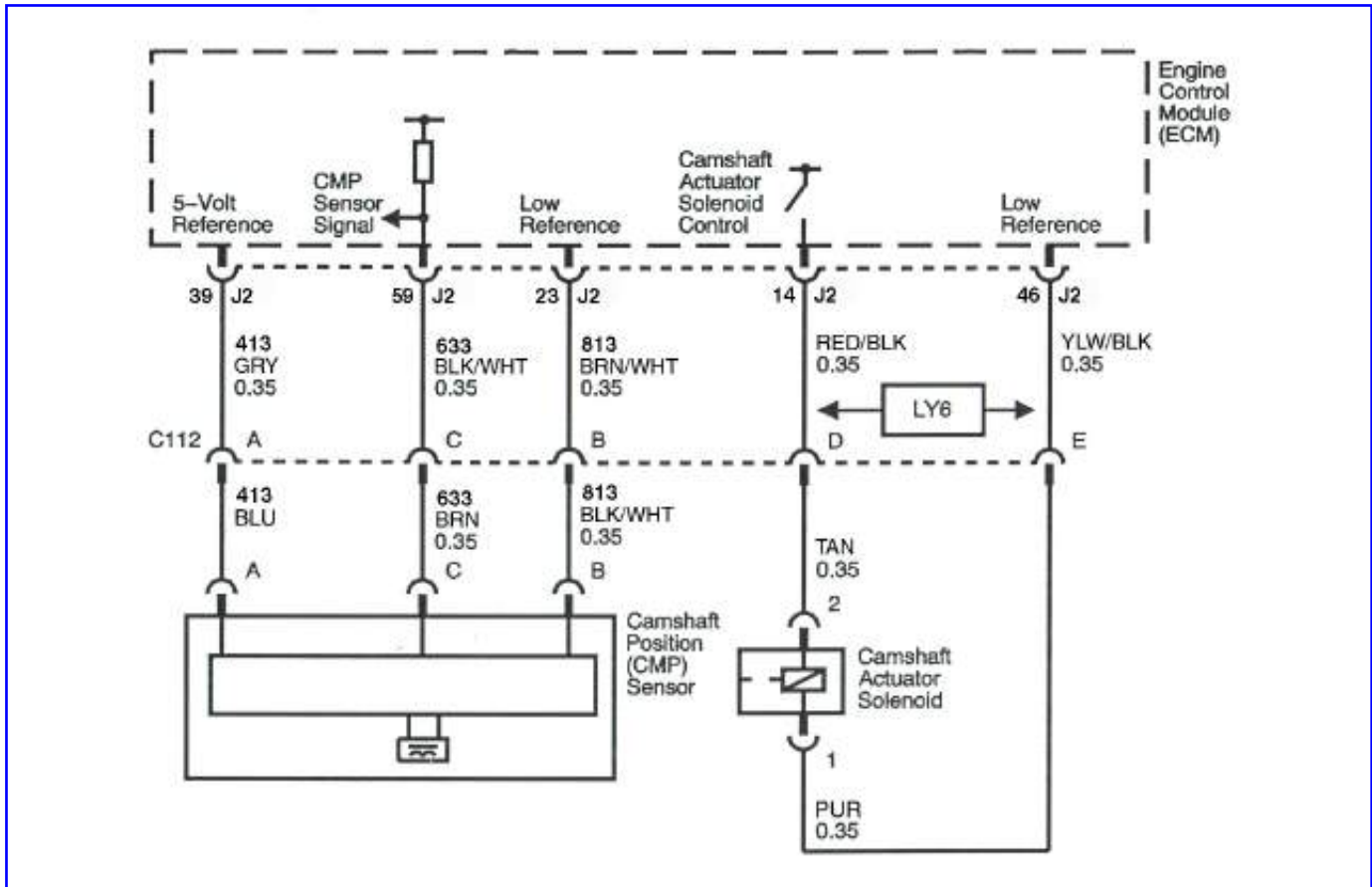
The number below refers to the step number on the diagnostic table.

- The test lamp in this step is used to apply a load to the 12-volt reference circuit of the CMP sensor.

Step	Action	Values	Yes	No
<b>Schematic Reference:</b> <i>Engine Controls Schematics</i> <b>Connector End View Reference:</b> <i>Engine Control Module (ECM) Connector End Views</i> or <i>Engine Controls Connector End Views</i>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to Diagnostic System Check
2	<ol style="list-style-type: none"> <li>Start and idle the engine.</li> <li>Monitor the camshaft position (CMP) sensor active counter parameter with a scan tool.</li> </ol> Does the CMP sensor active counter number increment?	—	Go to Testing for Intermittent Conditions and Poor Connections	Go to Step 3
3	<ol style="list-style-type: none"> <li>Turn OFF the ignition.</li> <li>Disconnect the CMP sensor electrical connector.</li> <li>Test for shorted terminals and poor connections at the CMP sensor wire harness electrical connector and the mating electrical connector on the CMP sensor. Refer to <i>Testing for Intermittent Conditions and Poor Connections</i> and <i>Connector Repairs</i>.</li> </ol> Did you find and correct the condition?	—	Go to Step 12	Go to Step 4
4	<ol style="list-style-type: none"> <li>Turn ON the ignition, with the engine OFF.</li> <li>Connect a jumper wire to the 5-volt reference circuit at the CMP sensor wire harness electrical connector.</li> <li>Connect a test lamp between the jumper wire and a good ground.</li> <li>Connect the positive lead of the DMM to the junction of the jumper wire and test lamp.</li> <li>Connect the negative lead of the DMM to a good engine ground.</li> <li>Measure the voltage from the 5-volt reference circuit to a good ground with a DMM. Refer to <i>Circuit Testing</i>.</li> </ol> Is the voltage within the specified range?	4.8–5.2 V	Go to Step 5	Go to Step 6
5	<ol style="list-style-type: none"> <li>Remove the test lamp from the jumper wire.</li> <li>Connect another jumper wire to the signal circuit of the CMP sensor wire harness electrical connector.</li> <li>Turn ON the ignition, with the engine OFF.</li> <li>Monitor the CMP active counter parameter with a scan tool.</li> <li>Momentarily connect the two ends of the jumper wires together several times.</li> </ol> Does the CMP sensor active counter number increment?	—	Go to Step 10	Go to Step 7

6	<p>Test the CMP 5-volt reference circuit between the CMP sensor and the engine control module (ECM) for the following conditions:</p> <ul style="list-style-type: none"> <li>• An open</li> <li>• High resistance</li> <li>• A short to ground</li> </ul> <p>Refer to <i>Circuit Testing and Wiring Repairs</i>. Did you find and correct the condition?</p>	—	Go to Step 12	Go to Step 9
7	<p>Test the CMP low reference circuit between the CMP sensor and the ECM for the following conditions:</p> <ul style="list-style-type: none"> <li>• An open</li> <li>• High resistance</li> <li>• A short to ground</li> <li>• A short to voltage</li> </ul> <p>Refer to <i>Circuit Testing and Wiring Repairs</i>. Did you find and correct the condition?</p>	—	Go to Step 12	Go to Step 8
8	<p>Test the CMP signal circuit between the CMP sensor and the ECM for the following conditions:</p> <ul style="list-style-type: none"> <li>• An open</li> <li>• High resistance</li> <li>• A short to ground</li> <li>• A short to voltage</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 12	Go to Step 9
9	<p>Test for shorted terminals and poor connections at the ECM wire harness electrical connector. Refer to <i>Testing for Intermittent Conditions and Poor Connections and Connector Repairs</i>. Did you find and correct the condition?</p>	—	Go to Step 12	Go to Step 11
10	<p>Replace the CMP sensor. Refer to <i>Camshaft Position (CMP) Sensor Replacement</i>. Did you complete the replacement?</p>	—	Go to Step 12	—
11	<p>Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?</p>	—	Go to Step 12	—
12	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> <li>4. Operate the vehicle within the Conditions for Running the DTC.</li> </ol> <p>Did the DTC fail this ignition?</p>	—	Go to Step 2	Go to Step 13
13	<p>Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?</p>	—	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK

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## Diagnostic Information and Procedures

SPN 65570 FMI 3 Cam Phaser W Short High

SPN 65570 FMI 4 Cam Phaser W Short Low

SPN 65570 FMI 5 Cam Phaser W Open

SPN 65570 FMI 7 Cam Phaser W Accuracy

### Circuit/System Description

The Cam Phaser system consists of a camshaft position (CMP) actuator, a CMP actuator spool valve, and a CMP actuator solenoid. For engines with a single camshaft, the Cam Phaser is identified as Cam Phaser W. (Multiple camshaft engines could also use Cam Phasers X, Y, and Z.)

The CMP actuator solenoid is controlled by the engine control module (ECM). The ECM sends a 12 volt, pulse width modulated (PWM) signal to the CMP actuator solenoid. The CMP actuator solenoid positions the CMP actuator spool valve to control the amount of pressurized engine oil, which enters into the CMP actuator assembly. A low reference wire circuit between the CMP actuator solenoid and the ECM completes the electrical circuit. The frequency of the pulse width modulated signal is fixed at 150Hz. The ECM can only command the CMP actuator to retard the valve timing from the camshaft park position, or advance the valve timing back to the park position. The total range of valve timing command is 31 degrees as measured at the camshaft, or 62 degrees as measured at the crankshaft.

### DTC Descriptors

This diagnostic procedure supports the following DTCs:

SPN 65570 FMI 3 Cam Phaser W Short High

SPN 65570 FMI 4 Cam Phaser W Short Low

SPN 65570 FMI 5 Cam Phaser W Open

SPN 65570 FMI 7 Cam Phaser W Accuracy



## Conditions for Running the DTC

SPN 65570 FMI 3, SPN 65570 FMI 4, SPN 65570 FMI 5:

- The ignition switch is in the crank or run position.
- The system voltage is between 9–18 volts.
- The CMP actuator is command ON.
- DTC P0010 runs continuously when the above conditions are met.

SPN 65570 FMI 7:

- The engine is running.
- The system voltage is between 9–18 volts.
- The CMP actuator is enabled.
- The rate of change in the camshaft position is less than 7.5 degrees in 3.35 seconds.

## Conditions for Setting the DTC

SPN 65570 FMI 3, SPN 65570 FMI 4, SPN 65570 FMI 5:

The ECM detects that the state of the high side driver and the state of the CMP solenoid control circuit does not match. The ECM will detect an open, high resistance, short to ground, or a short to voltage on the CMP solenoid control circuit, or an open on the low reference circuit, if the condition is present for more than 6 seconds.

SPN 65570 FMI 7:

- The ECM detects resistance greater than 2 ohms on the low reference circuit.
- The ECM detects that the CMP Angle position is more than 8 degrees difference than the Desired CMP position.

## Action Taken When the DTC Sets

The CMP actuator is commanded to the park position.

## Conditions for Clearing the DTC

Clear the MIL and the DTC with a scan tool.

## Diagnostic Aids

This test procedure requires that the vehicle battery has passed a load test and is completely charged.

## Circuit/System Verification

**Important:** Incorrect engine oil viscosity, aftermarket engine oil additives, or engine oil that overdue for changing, can greatly affect the performance of the camshaft actuator.

1. Observe the engine oil level. The engine oil level should be within the operating range on the oil indicator stick.
2. Start the engine. Allow the engine to reach normal operating temperature.
3. Monitor the engine oil pressure parameter value with the scan tool or pressure gauge. The engine oil pressure must be at or above the minimum hot oil pressure specification.
4. Using the output control function of the scan tool, command the CMP actuator solenoid to 25 degrees. The CMP Desired parameter value should match the CMP Angle parameter value.
5. If the vehicle passes the Circuit/System Verification, then operate the vehicle within the conditions for running the DTC.

## Circuit/System Testing

**Important:** You must perform the Circuit/System Verification before proceeding with Circuit/System Testing.

A fault in the Camshaft Position (CMP) sensor circuit (SPN 723 FMI 2) or in the Crankshaft Position (CKP) sensor circuit (SPN 636 FMI 2) may also cause SPN 65570 FMI 7 to set.

Step	Action	Values	Yes	No
<b>Schematic Reference:</b> Engine Controls Schematics <b>Connector End View Reference:</b> Engine Control Module (ECM) Connector End Views or Engine Controls Component Views				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to Diagnostic System Check
2	Did you perform the "Circuit/System Verification"?		Go to Step 3	Go to Circuit/System Verification
3	1. Turn the ignition OFF. 2. Disconnect the Camshaft Position (CMP) actuator solenoid and the Camshaft Position (CMP) sensor by separating the 5 pin connector located near the crankshaft vibration damper. 3. Check the resistance between the low reference circuit terminal E, on the ECM side of the 5 pin connector, and ground. Is the resistance greater than the specified value?	2 ohms	Go to Step 4	Go to Step 5
4	1. Remove connector J2 from the ECM. 2. Test the low reference circuit, from terminal E to the ECM connector, for an open or high resistance. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
5	1. Connect a test lamp between the CMP actuator solenoid control circuit terminal D, on the ECM side of the 5 pin connector, and the low reference circuit terminal E, on the ECM side of the 5 pin connector. 2. Turn the ignition ON. 3. Using the scan tool, command the CMP actuator solenoid from 0 to 25 degrees. 4. The test lamp should turn ON and OFF when changing between commanded states. Does the test lamp turn ON and OFF as described?	—	Go to Step 10	Go to Step 6
6	Is the test lamp always ON?	—	Go to Step 7	Go to Step 8
7	1. Turn the ignition OFF. 2. Remove connector J2 from the ECM. 3. Test the solenoid control circuit, between terminal D and the ECM connector, for a short to voltage. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
8	Is the test lamp always OFF?	—	Go to Step 9	—
9	1. Turn the ignition OFF. 2. Remove connector J2 from the ECM. 3. Test the solenoid control circuit, between terminal D and the ECM connector, for an open/high resistance or a short to ground. Did you find and correct the condition?	—	Go to Step 16	Go to Step 15
10	Inspect and test the remaining CMP actuator solenoid wire harness, from the 5 pin connector to the CMP actuator solenoid, for an open/high resistance, or a short to ground. Note: It may be necessary to remove the water pump in order to access this harness. Did you find and correct the condition?	—	Go to Step 16	Go to Step 11
11	Was the original fault SPN 65570 FMI 3, FMI 4, or FMI 5?	—	Go to Step 12	Go to Step 13
12	Replace the CMP actuator solenoid. Did you complete the replacement?	—	Go to Step 16	—

13	The original fault was SPN 65570 FMI 7. Perform the Component Testing for the CMP actuator solenoid. Did you find and correct the condition?	—	Go to Step 16	Go to Step 14
14	Refer to “Camshaft Position Actuator Magnet Cleaning” 9-26 and “Camshaft Position Actuator Solenoid Valve Inspection” 9-27. Did you find and correct the condition?	—	Go to Step 16	Go to Step 1
15	Replace the ECM. Did you complete the replacement?	—	Go to Step 16	—
16	1. Turn the ignition OFF. 2. Reconnect all electrical connectors. 3. Turn the ignition ON. 4. Clear DTCs with a scan tool. 5. Turn OFF the ignition for 30 seconds. 6. Start the engine. 7. Operate the engine within the Conditions For Running the DTC. Did the DTC fail this ignition?	—	Go to Step 1	Go to Step 17
17	Are there any DTCs that have not been diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List	System OK

## Component Testing

**Important:** You must perform the Circuit/System Testing before proceeding with Component Testing.

### Static Test

Test for 5.9–6.9 ohms of resistance at 20°C, or 68°F between the solenoid control terminal 2 and the low reference terminal 1 at the CMP actuator solenoid.

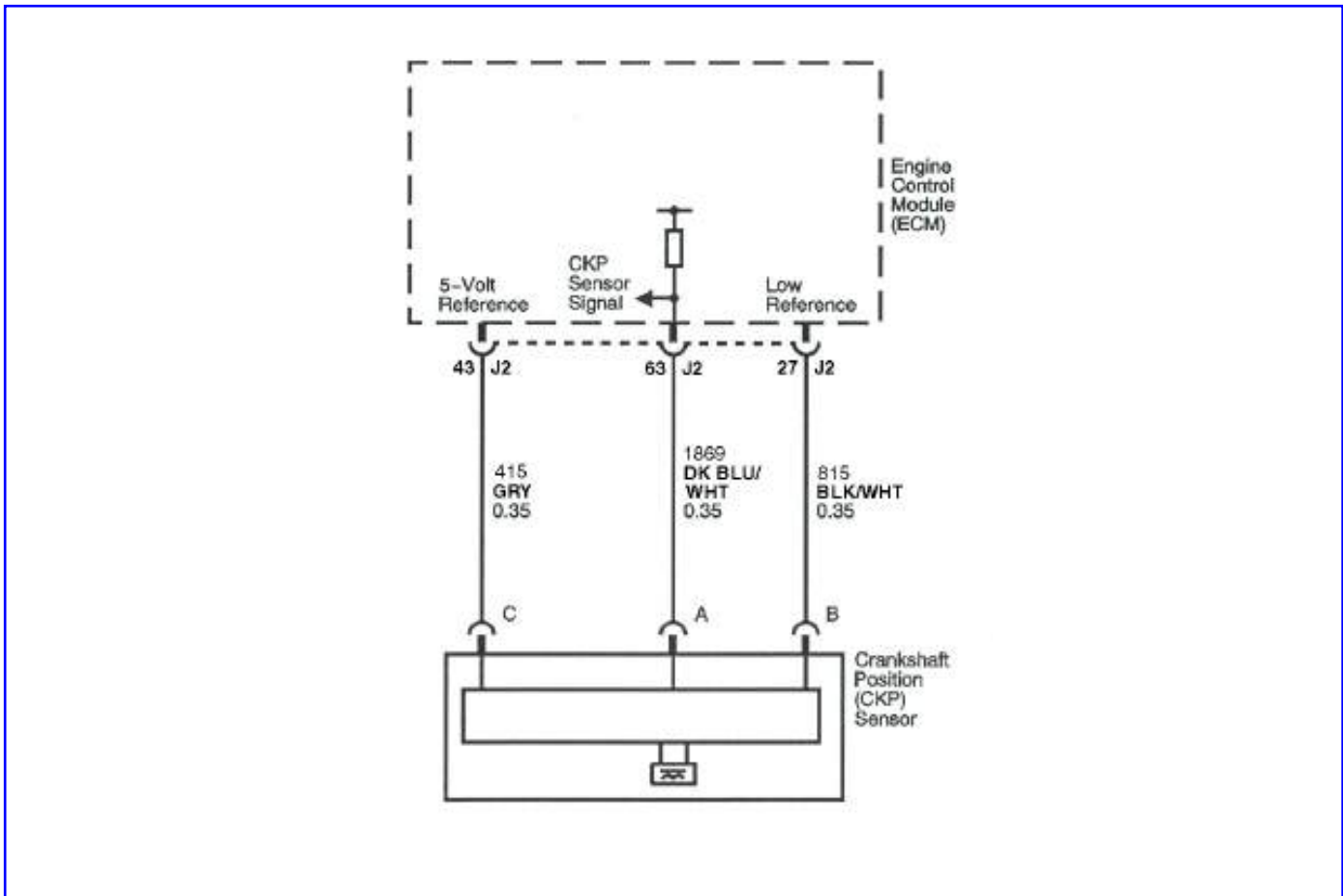
If the resistance is not within the specified range, then replace the CMP actuator solenoid. Refer to Camshaft Position Actuator Magnet Replacement 9-29.

### Dynamic Test

**Important:** Do not allow electrical current to flow through the CMP actuator solenoid for more than 1–2 seconds, or damage to the solenoid may occur.

Point the CMP actuator solenoid vertically, towards a shop towel. Connect one end of a fused jumper wire to the CMP actuator solenoid control circuit terminal 2 and 12 volts. Connect a second jumper wire to the low reference circuit terminal 1 and momentarily connect to ground. The CMP actuator solenoid should immediately extend.

If the CMP actuator solenoid pintle does not extend, then replace the CMP actuator solenoid. Refer to Camshaft Position Actuator Magnet Replacement 9-29.



## Diagnostic Information and Procedures

### SPN 636, FMI 2 Crank Signal Fault

#### Circuit/System Description

The crankshaft position (CKP) sensor circuits consist of an engine control module (ECM) supplied 5-volt reference circuit, low reference circuit and an output signal circuit. The CKP sensor is an internally magnetic biased digital output integrated circuit sensing device. The sensor detects magnetic flux changes of the teeth and slots of a 58-tooth reluctor wheel on the crankshaft. Each tooth on the reluctor wheel is spaced at 60-tooth spacing, with 2 missing teeth for the reference gap. The CKP sensor produces an ON/OFF DC voltage of varying frequency, with 58 output pulses per crankshaft revolution. The frequency of the CKP sensor output depends on the velocity of the crankshaft. The CKP sensor sends a digital signal, which represents an image of the crankshaft reluctor wheel, to the ECM as each tooth on the wheel rotates past the CKP sensor. The ECM uses each CKP signal pulse to determine crankshaft speed and decodes the crankshaft reluctor wheel reference gap to identify crankshaft position. This information is then used to sequence the ignition timing and fuel injection events for the engine. The ECM also uses CKP sensor output information to determine the crankshaft relative position to the camshaft, to detect cylinder misfire, and to control the CMP actuator if equipped.

#### DTC Descriptor

This diagnostic procedure supports the following DTC:

SPN 636, FMI 2 Crank Signal Fault (Crankshaft Position (CKP) Sensor Circuit Signal Fault)

#### Conditions for Running the DTC

- The engine is cranking or running.
- SPN 636 FMI 2 runs continuously when the above condition is met.

## Conditions for Setting the DTC

The ECM detects that there is no signal from the CKP sensor for 3 seconds.

## Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails.

## Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after consecutive ignition cycle that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

## Diagnostic Aids

SPN 636, FMI 2 will set with the ignition switch in the Start position, if the starter motor is inoperative, or the starter motor control circuit is inoperative.

## Test Description

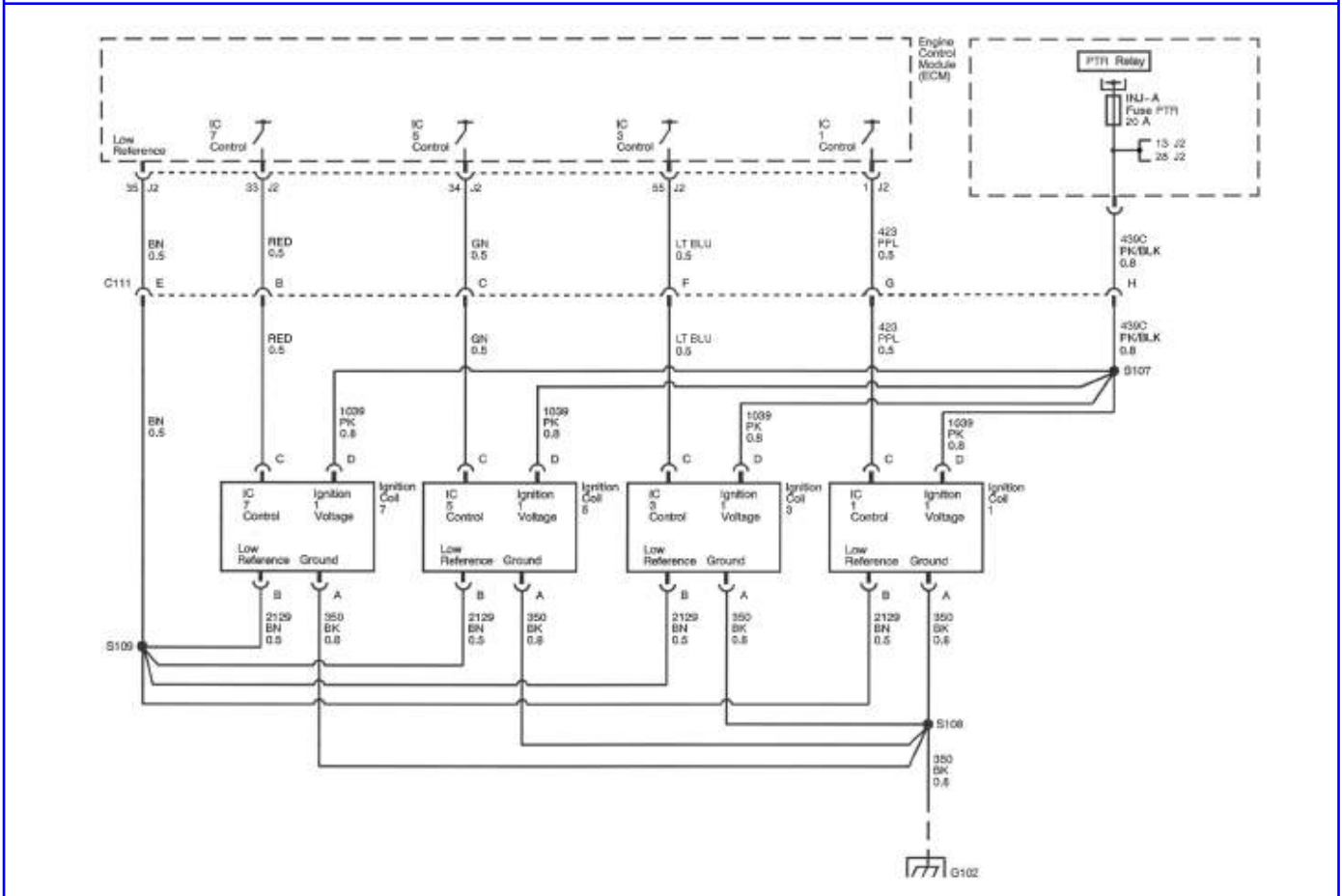
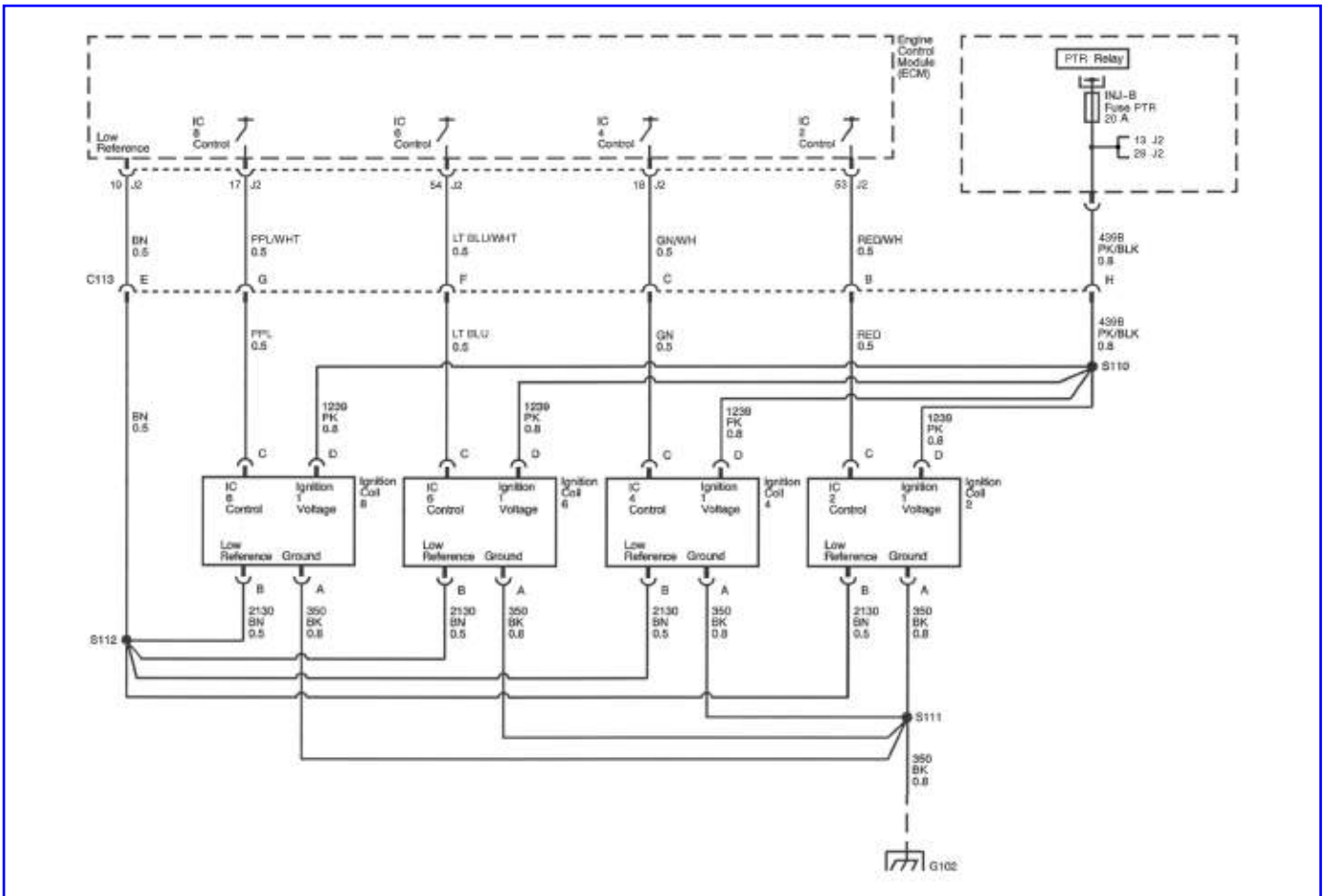
The numbers below refer to the step numbers on the diagnostic table.

3. This step determines if the fault is present.
6. This step simulates a CKP sensor signal to the ECM. If the ECM receives the signal, the fuel pump will operate for about 3 seconds.

Step	Action	Values	Yes	No
<b>Schematic Reference: <i>Engine Controls Schematics</i></b> <b>Connector End View Reference: <i>Engine Control Module (ECM) Connector End Views</i> or <i>Engine Controls Connector End Views</i></b>				
1	Did you perform the "On-Board Diagnostic" (OBD) System Check?	—	Go to Step 2	Go to <i>Diagnostic System Check</i>
2	Attempt to start the engine. Does the engine start and continue to run?	—	Go to Step 3	Go to Step 4
3	1. Observe Conditions for Running this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the engine within the conditions for Running the DTC. Did the DTC fail this ignition?	—	Go to Step 4	Go to <i>Testing for Intermittent Conditions and Poor Connections</i>
4	1. Disconnect the crankshaft position (CKP) sensor connector. 2. Turn ON the ignition, with the engine OFF. 3. Measure the voltage from the 5-volt reference circuit of the crankshaft position (CKP) sensor to a good ground with a DMM. Refer to <i>Troubleshooting with a Digital Multi-meter</i> Does the voltage measure above the specified value?	4.8 V	Go to Step 5	Go to Step 7
5	Measure the voltage between the 5-volt reference circuit of the CKP sensor and the low reference circuit of the CKP sensor with a DMM. Does the voltage measure above the specified value?	4.8 V	Go to Step 6	Go to Step 8
6	Momentarily connect a test lamp between the CKP sensor signal circuit and the 5-volt reference of the CKP sensor. Does the fuel pump operate when the test lamp is applied to the CKP sensor signal circuit?	—	Go to Step 10	Go to Step 9

7	<p>Test the 5-volt reference circuit for the following conditions:</p> <ul style="list-style-type: none"> <li>• An open</li> <li>• A short to ground</li> <li>• High resistance</li> </ul> <p>Refer to <i>Circuit Testing and Wiring Repairs</i>. Did you find and correct condition?</p>	—	Go to Step 16	Go to Step 12
8	<p>Test the low reference circuit for the following conditions:</p> <ul style="list-style-type: none"> <li>• An open</li> <li>• A short to voltage</li> <li>• High resistance</li> </ul> <p>Refer to <i>Circuit Testing and Wiring Repairs</i>. Did you find and correct the condition?</p>	—	Go to Step 16	Go to Step 12
9	<p>Test the CKP sensor signal circuit for the following conditions:</p> <ul style="list-style-type: none"> <li>• An open</li> <li>• A short to ground</li> <li>• A short to voltage</li> <li>• High resistance</li> </ul> <p>Refer to <i>Circuit Testing and Wiring Repairs</i>. Did you find and correct the condition?</p>	—	Go to Step 16	Go to Step 12
10	<ol style="list-style-type: none"> <li>1. Remove the CKP sensor. Refer to <i>Crankshaft Position (CKP) Sensor Replacement</i>.</li> <li>2. Visually inspect the CKP sensor for the following conditions: <ul style="list-style-type: none"> <li>• Physical damage</li> <li>• Loose or improper installation</li> <li>• Wiring routed too closely to the secondary ignition components</li> </ul> </li> <li>3. The following conditions may cause this DTC to set: <ul style="list-style-type: none"> <li>• Excessive air gap between the CKP sensor and the reluctor wheel</li> <li>• The CKP sensor coming in contact with the reluctor wheel</li> <li>• Foreign material passing between the CKP sensor and the reluctor wheel</li> </ul> </li> </ol> <p>Did you find and correct the condition?</p>	—	Go to Step 16	Go to Step 11
11	<p>Visually inspect the CKP sensor reluctor wheel for the following conditions:</p> <ul style="list-style-type: none"> <li>• Loose or improper installation</li> <li>• Physical damage</li> <li>• Excessive end play or looseness</li> </ul> <p>Did you find and correct the condition?</p>	—	Go to Step 16	Go to Step 14
12	<p>Test for poor connections at the CKP sensor. Refer to <i>Testing for Intermittent Conditions and Poor Connections and Wiring Repairs</i>. Did you find and correct the condition?</p>	—	Go to Step 16	Go to Step 13
13	<p>Test for poor connections at the engine control module (ECM). Refer to <i>Testing for Intermittent Conditions and Poor Connections and Wiring Repairs</i>. Did you find and correct the condition?</p>	—	Go to Step 16	Go to Step 15
14	<p>Replace the CKP sensor. Refer to <i>Crankshaft Position (CKP) Sensor Replacement</i>. Did you complete the replacement?</p>	—	Go to Step 16	—

15	Replace the ECM. Refer to <i>Control Module References</i> for replacement, setup, and programming. Did you complete the replacement?	—	Go to Step 16	—
16	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> <li>4. Operate the engine within the Conditions for Running the DTC.</li> </ol> Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 17
17	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	—	Go to <i>Diagnostic Trouble Code (DTC) List</i>	System OK





## Diagnostic Information and Procedures

### SPN 65541 – SPN 65548 , FMI 3, 4, 5

#### Circuit Description

The ignition system on this engine uses an individual ignition coil for each cylinder. The engine control module (ECM) controls the spark event for each cylinder through 8 individual ignition control (IC) circuits. When the ECM commands the IC circuit ON, electrical current will flow through the primary winding of the ignition coil, creating a magnetic field. When a spark event is requested, the ECM will command the IC circuit OFF, interrupting current flow through the primary winding. The magnetic field created by the primary winding will collapse across the secondary coil winding, producing a high voltage across the spark plug electrodes. The ECM uses information from the crankshaft position (CKP) and the camshaft position (CMP) sensor for sequencing and timing of the spark events. Each ignition coil/module has the following circuits:

- An ignition 1 voltage circuit
- A ground circuit
- An IC circuit
- A low reference circuit

If the ECM detects that the IC circuit has an incorrect voltage level, SPN 65541 – SPN 65548 will set.

#### DTC Descriptors

This diagnostic procedure supports the following DTCs:

- SPN 65541 FMI 3 EST 1 Short High
- SPN 65541 FMI 4 EST 1 Short Low
- SPN 65541 FMI 5 EST 1 Open
- SPN 65542 FMI 3 EST 2 Short High
- SPN 65542 FMI 4 EST 2 Short Low
- SPN 65542 FMI 5 EST 2 Open
- SPN 65543 FMI 3 EST 3 Short High
- SPN 65543 FMI 4 EST 3 Short Low
- SPN 65543 FMI 5 EST 3 Open
- SPN 65544 FMI 3 EST 4 Short High
- SPN 65544 FMI 4 EST 4 Short Low
- SPN 65544 FMI 5 EST 4 Open
- SPN 65545 FMI 3 EST 5 Short High
- SPN 65545 FMI 4 EST 5 Short Low
- SPN 65545 FMI 5 EST 5 Open
- SPN 65546 FMI 3 EST 6 Short High
- SPN 65546 FMI 4 EST 6 Short Low
- SPN 65546 FMI 5 EST 6 Open
- SPN 65547 FMI 3 EST 7 Short High
- SPN 65547 FMI 4 EST 7 Short Low
- SPN 65547 FMI 5 EST 7 Open
- SPN 65548 FMI 3 EST 8 Short High
- SPN 65548 FMI 4 EST 8 Short Low
- SPN 65548 FMI 5 EST 8 Open

#### Conditions for Running the DTC

- The engine is running.

- SPN 65541 – SPN 65548 runs continuously when the above condition is met.

### Conditions for Setting the DTC

The ECM detects the IC circuit is grounded, open, or shorted to voltage.

### Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL).

### Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

### Test Description

The numbers below refer to the step numbers on the diagnostic table.

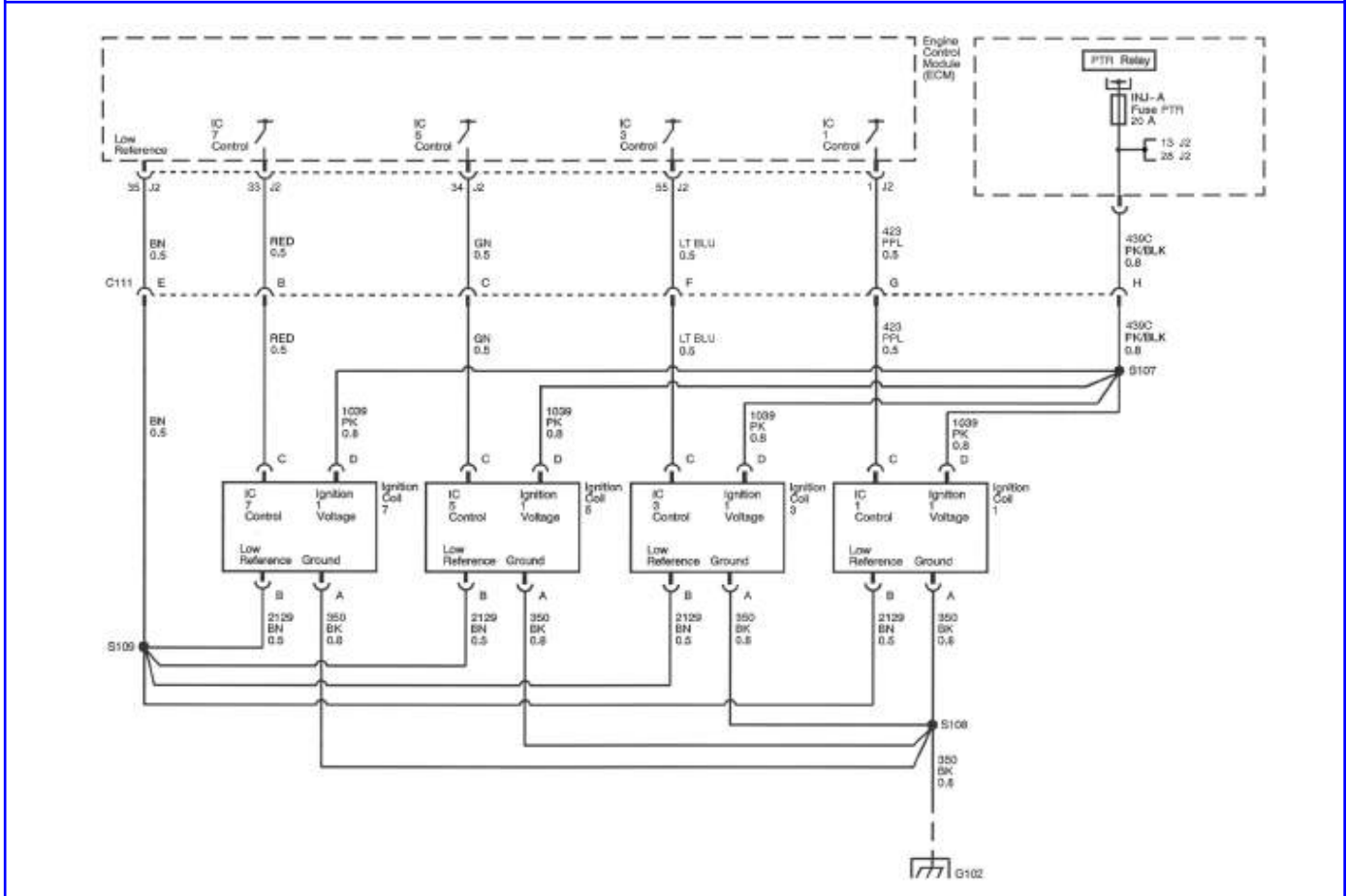
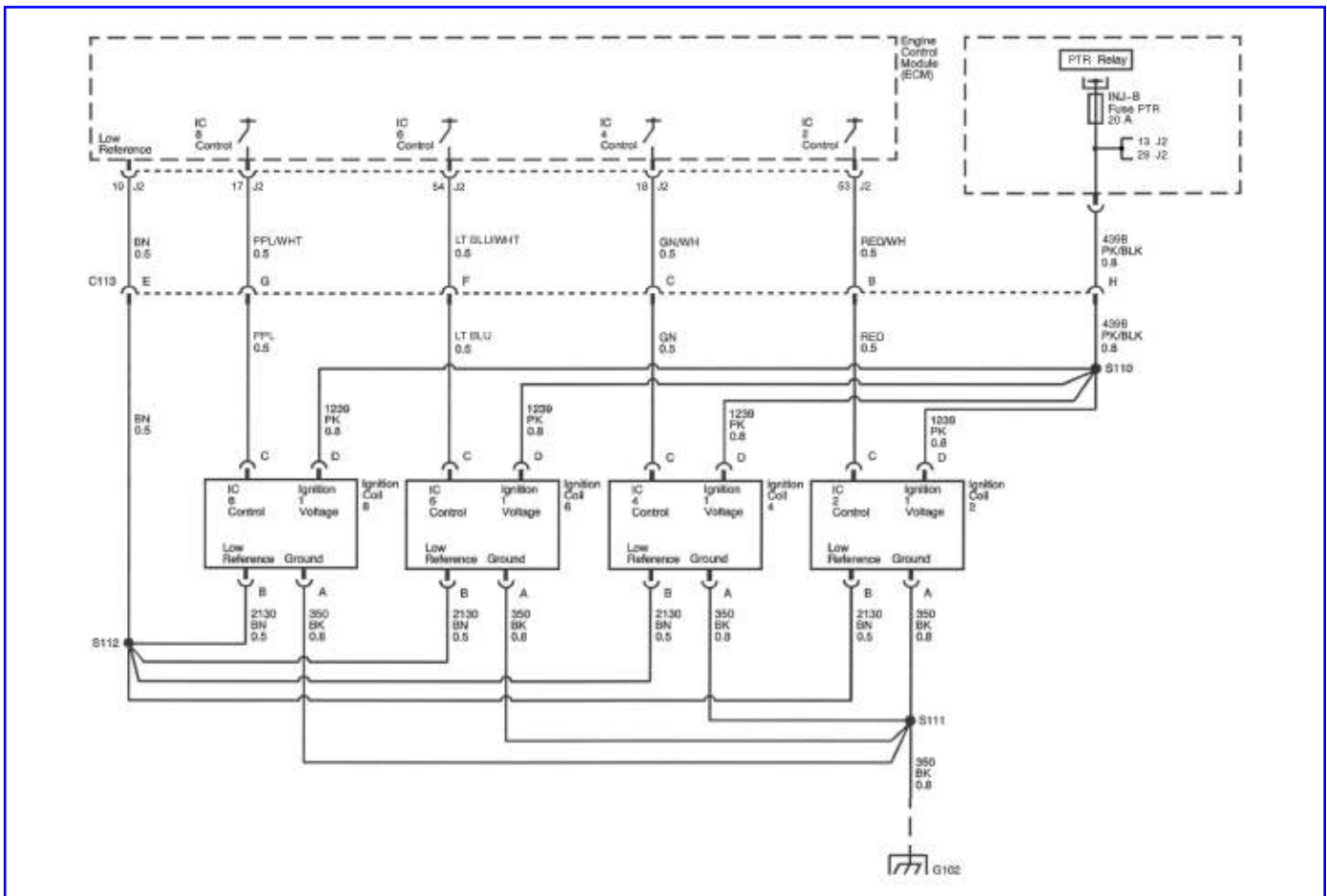
3. This step verifies the integrity of the IC circuit and the ECM output.
4. This step tests for a short to voltage on the IC circuit.

Step	Action	Values	Yes	No
<b>Schematic Reference: <i>Engine Controls Schematics</i></b> <b>Connector End View Reference: <i>Engine Control Module (ECM) Connector End Views or Engine Controls Connector End Views</i></b>				
1	Did you perform the Diagnostic System Check – Vehicle?	—	Go to Step 2	Go to Diagnostic System Check - Vehicle
2	1. Observe the Conditions for Running this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vessel within the Conditions for Running the DTC. You may also operate the vessel within the conditions you observed when the DTC was set. Did the DTC fail this ignition?	—	Go to Step 3	Go to Testing for Intermittent Conditions and Poor Connections
3	1. Turn OFF the engine. 2. Disconnect the respective ignition coil electrical connector. 3. Disconnect the respective fuel injector electrical connector. 4. Start the engine. 5. Measure the frequency at the ignition (IC) circuit with the DMM set to AC Hertz. Is the frequency within the specified range?	3–20 Hz	Go to Step 7	Go to Step 4
4	1. Turn ON the ignition, with the engine OFF. 2. Measure the voltage from the IC circuit of the ignition coil to a good ground with a DMM. Is the voltage more than the specified value?	1 V	Go to Step 13	Go to Step 5

5	1. Turn OFF the ignition. 2. Disconnect the engine control module (ECM) connector. 3. Test the IC circuit between the ignition coil connector and the ECM connector for continuity with the DMM. Does the DMM indicate continuity?	—	Go to Step 6	Go to Step 14
6	Test the respective IC circuit for a short to ground. Refer to Testing for Short to Ground . Did you find and correct the condition?	—	Go to Step 17	Go to Step 10
7	1. Turn ON the ignition, with the engine OFF. 2. Probe the ignition 1 voltage circuit of the ignition coil with a test lamp that is connected to battery ground. Refer to Troubleshooting with a Test Lamp . Does the test lamp illuminate?	—	Go to Step 8	Go to Step 11
8	Probe the ground circuit of the ignition coil with a test lamp connected to battery voltage. Refer to Troubleshooting with a Test Lamp . Does the test lamp illuminate?	—	Go to Step 9	Go to Step 12
9	Test for an intermittent and for a poor connection at the ignition coil. Refer to Testing for Intermittent Conditions and Poor Connections and Connector Repairs . Did you find and correct the condition?	—	Go to Step 17	Go to Step 15
10	Test for an intermittent and for a poor connection at the ECM. Refer to Testing for Intermittent Conditions and Poor Connections and Connector Repairs . Did you find and correct the condition?	—	Go to Step 17	Go to Step 16
11	Repair the open or high resistance in the ignition 1 voltage circuit. Refer to Wiring Repairs . Did you complete the repair?	—	Go to Step 17	—
12	Repair the open or high resistance in the ground circuit for the ignition coil. Refer to Wiring Repairs . Did you complete the repair?	—	Go to Step 17	—
13	Repair the IC circuit for a short to voltage. Refer to Wiring Repairs . Did you complete the repair?	—	Go to Step 17	—
14	Repair the open or high resistance in the IC circuit. Refer to Wiring Repairs . Did you complete the repair?	—	Go to Step 17	—
15	Replace the ignition coil. Refer to Ignition Coil(s) Replacement . Did you complete the replacement?	—	Go to Step 17	—
16	Replace the ECM. Refer to Control Module References for replacement, setup, and programming. Did you complete the replacement?	—	Go to Step 17	—

17	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> <li>4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed when the DTC was set.</li> </ol> Did the DTC fail this ignition?	—	Go to Step 2	Go to Step 18
18	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List - Vehicle	System OK

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## Diagnostic Information and Procedures

### SPN 65590-65598

#### System Description

The engine control module (ECM) uses information from the crankshaft position (CKP) sensor and the camshaft position (CMP) sensor to determine when an engine misfire is occurring. By monitoring variations in the crankshaft rotation speed for each cylinder, the ECM is able to detect individual misfire events. A misfire rate that is high enough can cause the catalytic converters (if equipped) to overheat under certain operating conditions. If the ECM detects a misfire rate sufficient to cause emission levels to exceed mandated standards, SPN 65590 FMI 7 will set. In some applications, the ECM is able to determine that a specific cylinder is misfiring, and will set a corresponding SPN 65591 - 65598 for that cylinder.

#### DTC Descriptors

- SPN 65590 FMI 7: Misfire
- SPN 65591 FMI 7: Cylinder 1 Misfire
- SPN 65592 FMI 7: Cylinder 2 Misfire
- SPN 65593 FMI 7: Cylinder 3 Misfire
- SPN 65594 FMI 7: Cylinder 4 Misfire
- SPN 65595 FMI 7: Cylinder 5 Misfire
- SPN 65596 FMI 7: Cylinder 6 Misfire
- SPN 65597 FMI 7: Cylinder 7 Misfire
- SPN 65598 FMI 7: Cylinder 8 Misfire

#### Conditions for Running the DTC

- The engine speed is between 600–6,000 RPM.
- The ignition voltage is between 9–18 volts.
- The throttle angle is steady or does not vary by more than approximately 5 percent.
- The ECM is not in fuel shut-off or decel fuel cut-off mode.
- SPN 65590-65598 run continuously when the above conditions are met.

#### Conditions for Setting the DTC

The ECM is detecting a crankshaft rotation speed variation indicating a misfire sufficient to cause emission levels to exceed mandated standards, or misfiring enough to cause damage to the catalytic converter (if equipped).

#### Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) after the diagnostic runs and fails.
- The diagnostic may fail for approximately 30 seconds prior to illuminating the MIL.

#### Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 25 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

#### Diagnostic Aids

- Excessive vibration from sources other than the engine could cause SPN 65590-65598 to set. The following are possible sources of vibration:
  - Excessive driveline vibration
  - Worn or damaged accessory drive belt
- There may be more or less cylinders actually misfiring than indicated by the scan tool.

- Spray water on the secondary ignition components using a spray bottle. Look and listen for arcing or misfiring.
- If there are multiple misfires on only one bank, inspect the fuel injector and ignition coil, power and ground circuits for that bank. Refer to *Engine Controls Schematics* .

## Test Description

The number below refers to the step number on the diagnostic table.

2. If the actual CKP variation values are not within the learned values, the misfire counters may increment.

Step	Action	Values	Yes	No
1	Did you perform the Diagnostic System Check - Vehicle?	—	Go to Step 2	Go to Diagnostic System Check
2	1. Start the engine. 2. Allow the engine to idle or operate within the conditions for running the DTC. 3. Monitor all of the Misfire counters with the scan tool. Are any of the Misfire current counters incrementing?	—	Go to Step 3	Go to Diagnostic Aids
3	Are any DTCs other than SPN 65590-65598 set?	—	Go to Diagnostic Trouble Code (DTC) List - Vehicle	Go to Step 4
4	Can any abnormal engine noise be heard?	—	Go to Symptoms - Engine Mechanical	Go to Step 5
5	Does the scan tool indicate that the heated oxygen sensor (HO2S) A1 or HO2S B1 voltage parameters are below the specified value?	200 mV	Go to SPN 65561 FMI 1 SPN 65563 FMI 1	Go to Step 6
6	Does the scan tool indicate that the HO2S A1 or HO2S B1 voltage parameters are fixed above the specified value?	900 mV	Go to SPN 65561 FMI 0 SPN 65563 FMI 0	Go to Step 7
7	Inspect the following components: <ul style="list-style-type: none"> <li>• The vacuum hoses and seals for splits, restrictions, and improper connections.</li> <li>• The throttle body and intake manifold for vacuum leaks</li> <li>• The crankcase ventilation system for vacuum leaks.</li> <li>• The engine control module (ECM) grounds for corrosion and loose connections.</li> <li>• The exhaust system for restrictions.</li> <li>• The fuel for contamination.</li> </ul> Did you find and correct the condition?	—	Go to Step 19	Go to Step 8

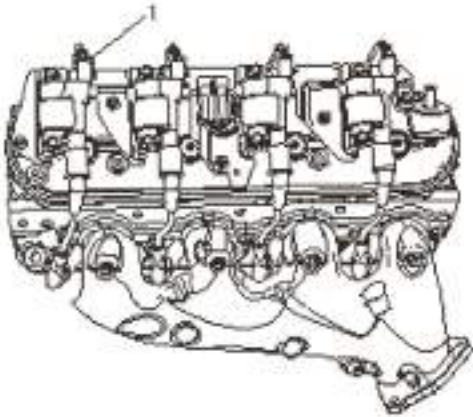


8	<p>Important: An erratic or inconsistent spark is considered a no spark.</p> <ol style="list-style-type: none"> <li>1. Turn OFF the ignition.</li> <li>2. Disconnect the spark plug wire from the spark plug that corresponds to the affected cylinder.</li> <li>3. Install the J 26792 Spark Tester.</li> <li>4. Start the engine.</li> </ol> <p>Does the spark jump the tester gap?</p>	—	Go to Step 10	Go to Step 9
9	<ol style="list-style-type: none"> <li>1. Remove the spark plug wire for the affected cylinders.</li> <li>2. Inspect the spark plug wire.</li> <li>3. Measure the resistance of the spark plug wire with a DMM.</li> </ol> <p>Is the resistance within the specified value?</p>	188–312	Go to Electronic Ignition (EI) System Diagnosis	Go to Step 18
10	<ol style="list-style-type: none"> <li>1. Remove the spark plug from the cylinder that indicated a misfire.</li> <li>2. Inspect the spark plug.</li> </ol> <p>Does the spark plug appear to be OK?</p>	—	Go to Step 11	Go to Step 12
11	<ol style="list-style-type: none"> <li>1. Exchange the suspected spark plug with another cylinder that is operating properly.</li> <li>2. Operate the vehicle under the same conditions that the misfire occurred.</li> </ol> <p>Did the misfire move with the spark plug?</p>	—	Go to Step 17	Go to Step 15
12	Is the spark plug oil or coolant fouled?	—	Go to Symptoms - Engine Mechanical	Go to Step 13
13	Is the spark plug gas fouled?	—	Go to Step 16	Go to Step 14
14	Did the spark plug show any signs of being cracked, worn, or improperly gapped?	—	Go to Step 17	Go to Step 15
15	Perform the fuel injector coil test. Did you find and correct the condition?	—	Go to Step 19	Go to Symptoms - Engine Mechanical
16	Perform the fuel system diagnosis. Did you find and correct the condition?	—	Go to Step 19	Go to Symptoms - Engine Mechanical
17	Replace the faulty spark plug. Did you complete the replacement?	—	Go to Step 19	—
18	Replace the faulty spark plug wires. Did you complete the replacement?	—	Go to Step 19	—
19	<ol style="list-style-type: none"> <li>1. Clear the DTCs with a scan tool.</li> <li>2. Turn OFF the ignition for 30 seconds.</li> <li>3. Start the engine.</li> <li>4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that were observed when the DTC was set.</li> </ol> <p>Did the DTC fail this ignition?</p>	—	Go to Step 2	Go to Step 22
20	Observe the Capture Info with a scan tool. Are there any DTCs that have not been diagnosed?	—	Go to Diagnostic Trouble Code (DTC) List - Vehicle	System OK

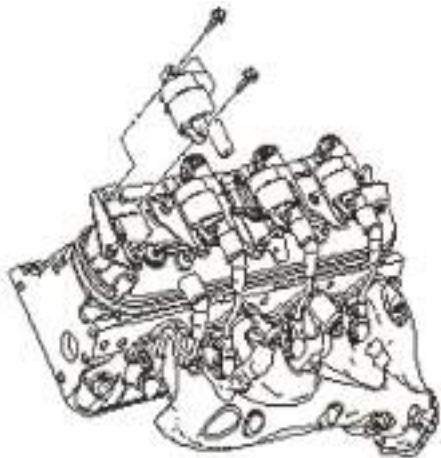
## Removal & Replacement Instructions

### Ignition Coil Replacement

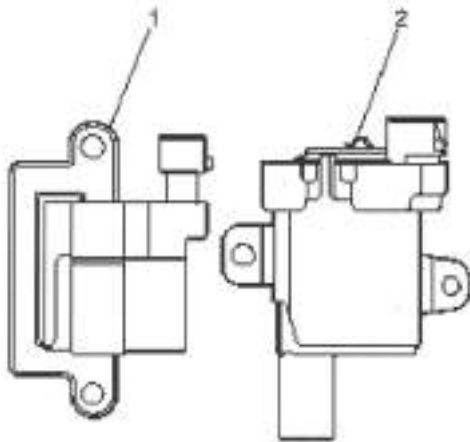
*Ignition:Coils Replacement:Engine Controls*



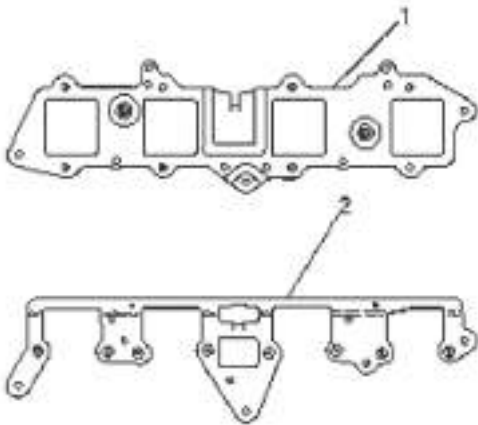
### Removal Procedure



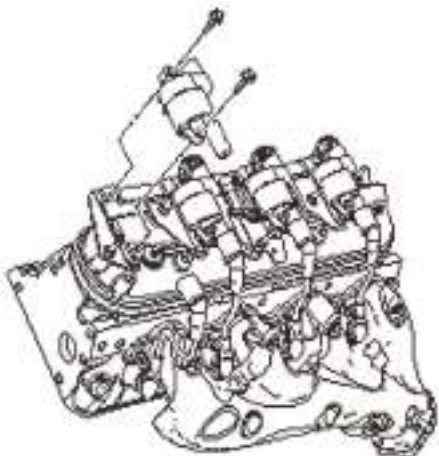
1. Remove the intake manifold sight shield. Refer to *Upper Intake Manifold Sight Shield Replacement* .
2. Disconnect the ignition coil wiring harness electrical connector (1) from the ignition coil.
3. Remove the spark plug wire from the ignition coil.
  - Twist the spark plug wire boot a 1/2 turn.
  - Pull only on the boot in order to remove the wire from the ignition coil.



4. Remove the ignition coil bolts.
5. Remove the ignition coil from the bracket. (left side shown, right side similar).
6. There are 2 different manufacturers for the ignition coils and coil brackets. They are as follows:



7. The Melco® (1) ignition coil is a square design.
8. The Delphi® (2) ignition coil is a round design.
9. The Melco® ignition coil bracket (1) is a square design.
10. The Delphi® ignition coil bracket (2) is a round design.



## Installation Procedure

1. Position the ignition coil to the ignition coil bracket. (left side shown, right side similar).

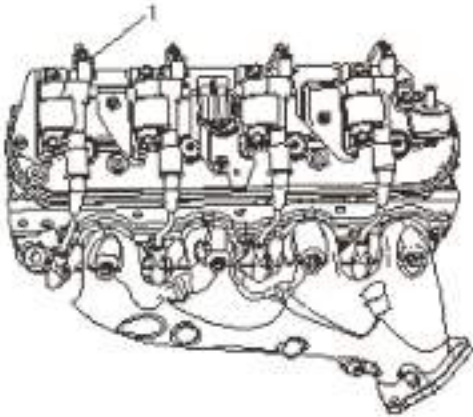
**Notice: Refer to *Fastener Notice*.**

2. Install the ignition coil bolts.

**Tighten:** Tighten the bolts to 10N·m (89lb in).

3. Install the spark plug wire to the ignition coil.

4. Inspect the spark plug wire for proper installation:



- Push sideways on each boot in order to inspect the seating.
- Reinstall any loose boot.

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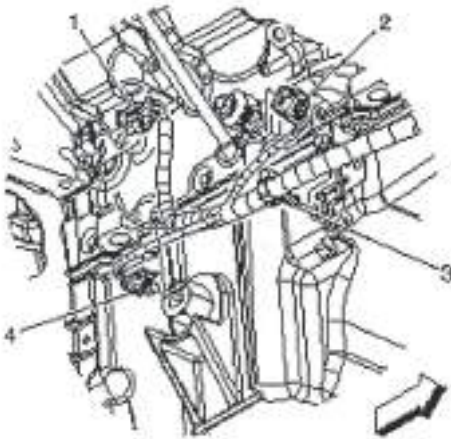
## Removal & Replacement Instructions

### Crankshaft Position Sensor Replacement

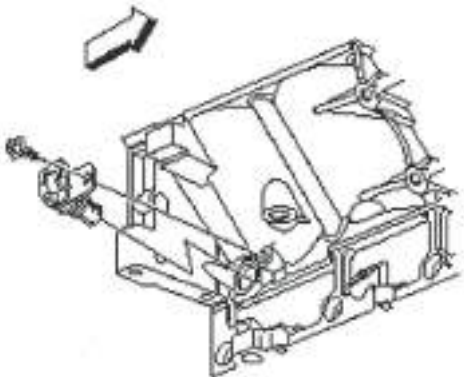
*Crankshaft Position Sensor:Replacement:Engine Controls*

#### Removal Procedure

**Important:** Perform the *Crankshaft Position System Variation Learn* whenever the crankshaft position sensor is removed or replaced.

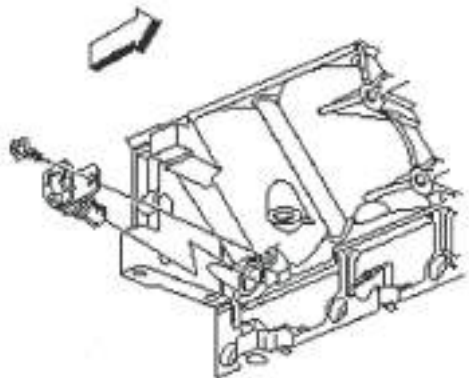


1. Remove the starter. Refer to *Starter Motor Replacement*.
2. Disconnect the engine wiring harness electrical connector (1) from the crankshaft position (CKP) sensor.



3. Clean the area around the CKP sensor before removal in order to avoid debris from entering the engine.
4. Remove the CKP sensor bolt.
5. Remove the CKP sensor.

## Installation Procedure

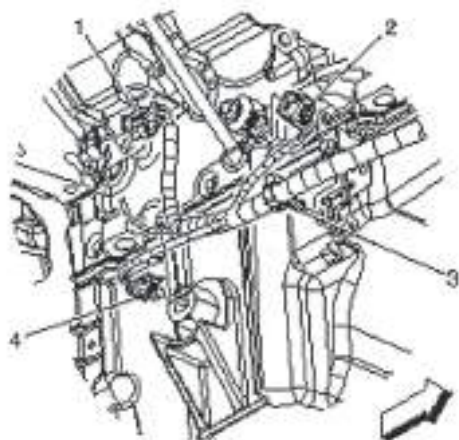


1. Install the CKP sensor.

**Notice:** Refer to *Fastener Notice* .

2. Install the CKP sensor bolt.

**Tighten:** Tighten the bolt to 25 N·m (18 lb ft).



3. Connect the engine wiring harness electrical connector (1) to the CKP sensor.

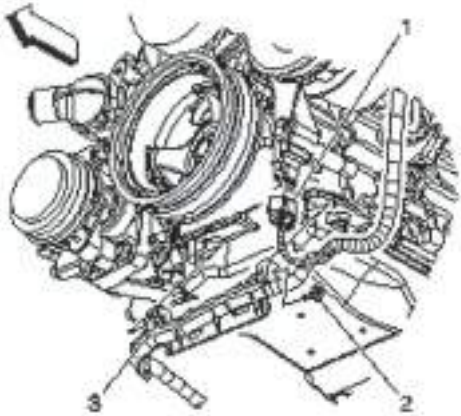
## Removal & Replacement Instructions

### Camshaft Position Sensor Replacement

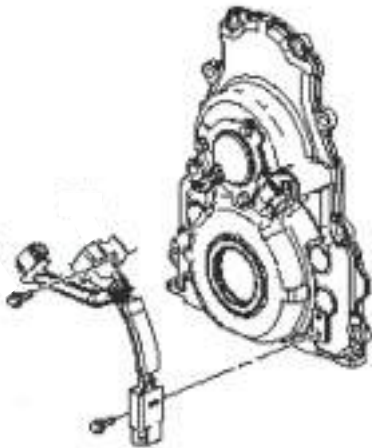
*Camshaft Position (CMP) Sensor: Replacement: Engine Controls - 6.0L*

#### Removal Procedure

**Important:** Clean the area around the camshaft position (CMP) sensor before removal in order to prevent debris from entering the engine.

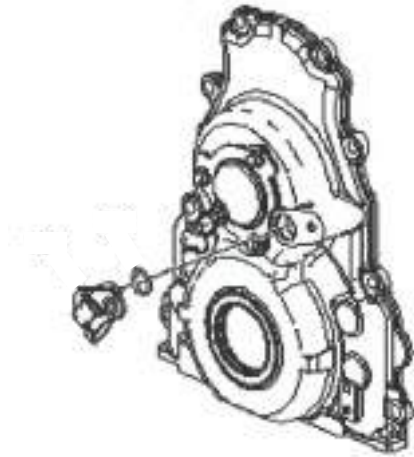


1. Disconnect the engine wiring harness electrical connector (1) from the CMP sensor wire harness.
2. Remove the 3 CMP sensor wire harness bolts.

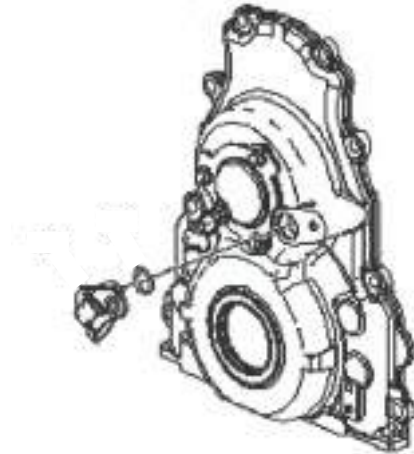


3. Disconnect the CMP sensor wire harness electrical connectors from the CMP sensor and the CMP actuator magnet.



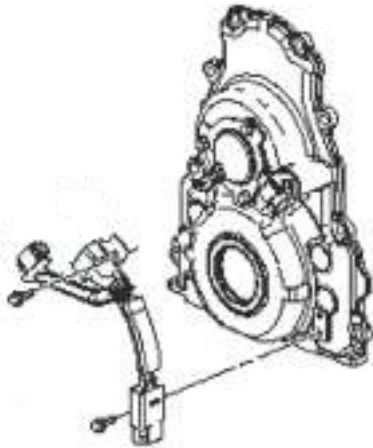


4. Remove the CMP sensor wire harness.
5. Remove the CMP sensor and O-ring seal.



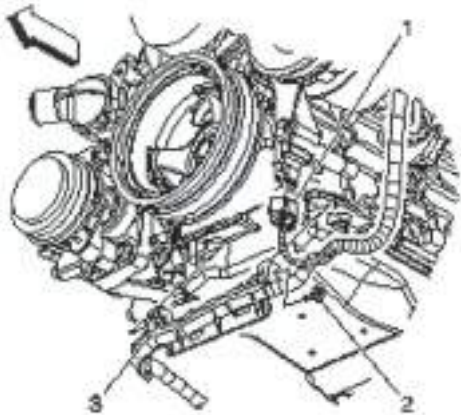
### Installation Procedure

1. Inspect the CMP O-ring seal for cuts or damage. If the seal is not cut or damaged, it may be used again.
2. Lubricate the O-ring seal with clean engine oil.



3. Install the O-ring seal onto the sensor.
4. Install the CMP sensor to the front cover.
5. Install the CMP sensor wire harness.
6. Connect the CMP sensor wire harness electrical connectors to the CMP sensor and the CMP actuator magnet.

**Notice:** Refer to *Fastener Notice* .



7. Install the 3 CMP sensor wire harness bolts.  
**Tighten:** Tighten the bolts to 12N·m (106lb in).
8. Connect the engine wiring harness electrical connector (1) to the CMP sensor wire harness.

Note: If this manual wears out from normal use, Indmar will replace it at no charge. Call 901-353-9930 for replacement.

**SMP0503-07**

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