



**VANGUARD**



# REPAIR MANUAL

EFI-ETC Diagnostic and Repair  
M440000/M490000/M610000

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## **Foreword**

This manual was written to assist engine technicians and service personnel with the troubleshooting and repair procedures for Briggs & Stratton® and Vanguard® engines equipped with Electronic Fuel Injection (EFI). It assumes that persons using this manual have been properly trained and are familiar with the service procedures for these products, including the correct use of required tools and the application of appropriate safety practices. Persons untrained or unfamiliar with these procedures or products should not attempt to do this work.

Proper repair is important to safe, reliable operation of all engines and engine-driven systems. The troubleshooting and repair procedures described in this manual are appropriate for the Briggs & Stratton and Vanguard engines described herein. Alternative methods or procedures can create risks to both personal safety and engine reliability and are not endorsed or recommended by Briggs & Stratton.

All information, illustrations, and specifications in this manual were based on the data available at the time of publication. Briggs & Stratton reserves the right to change, alter, or otherwise improve the product or the product manuals at any time without prior notice.

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This engine troubleshooting and repair manual includes the following EFI equipped engine models:

- MODEL 440000
- MODEL 490000
- MODEL 610000

**NOTE: Some models have limited service parts. Review the *Illustrated Parts List* for part availability before conducting any service work.**

**NOTE: The images in this document are representative and can differ according to model.**

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

The basic steps of any diagnosis are as follows:

1. Observe the Malfunction Indicator Lamp (MIL) with engine running. If MIL is illuminated, then current Diagnostic Trouble Codes (DTCs) are present.
2. Read DTC(s) using the Diagnostic Tool.
3. To diagnose system problem(s), go to the applicable Diagnostic Table(s) in SECTION 2 - TROUBLESHOOTING DTCs of this manual.
4. Once the problem is located and corrected through repair or replacement of faulty components, clear DTC(s) using the Diagnostic Tool.

**NOTE:** For information on the location or replacement of specific components, see SECTION 5 - REMOVAL/INSTALLATION of this manual.

5. Start and run engine to validate repairs. Observe MIL to verify that no DTCs are set.
6. If no DTCs are set, but engine performance issues exist, see SECTION 4 - SYMPTOMS of this manual.

## Diagnostic Trouble Codes (DTCs)

The ECM receives voltage signals from multiple sensors. Each sensor functions within an established set of parameters.

When a malfunction or fault condition occurs, a change in the signal voltage alerts the ECM that the sensor is functioning outside its operating "window," a DTC is set and stored in ECM memory, and the MIL is illuminated.

A default value temporarily replaces the erroneous sensor value to restore engine performance until the problem is corrected.

## Suspect Parameter Number (SPN) and Failure Mode Indicator (FMI)

The J1939 protocol transmits each DTC in a number of parts, two of which are the Suspect Parameter Number (SPN) and the Failure Mode Indicator (FMI).

While the SPN indicates the source of the problem, such as a specific electrical circuit or electrical component, the FMI indicates the type of condition or event that has occurred.

An analogy that will help is to view the SPN as a zip code which brings you to the problem area, while the FMI is the street address. For example, SPN 105 indicates that an issue exists with the Manifold Air Temperature (MAT) Sensor, while FMI 3 indicates that the sensor signal voltage is high/open.

For a list of all DTCs and their respective SPN/FMI components, see *DIAGNOSTIC TROUBLE CODES (DTCs)* in SECTION 2 - TROUBLESHOOTING DTCs of this manual.

## Malfunction Indicator Lamp (MIL)

As a bulb and diagnostic system check, the MIL illuminates at Ignition ON, Engine OFF. When the engine is started, the MIL is extinguished if no current fault condition exists.

If the MIL remains illuminated, it is an indication that a current DTC is stored. If the fault should correct itself, as in an intermittent condition, the MIL is extinguished after a ten second delay. The DTC remains stored in ECM memory as a historic code until cleared by the technician. The MIL does not indicate the existence of only historic codes.

## Data Link Connector (DLC)

See Figure 1. The DLC provides for direct communication with the ECM. By plugging the Diagnostic Tool into the 6-pin connector in the EFI wire harness, the DTCs stored in ECM memory can be read and cleared.



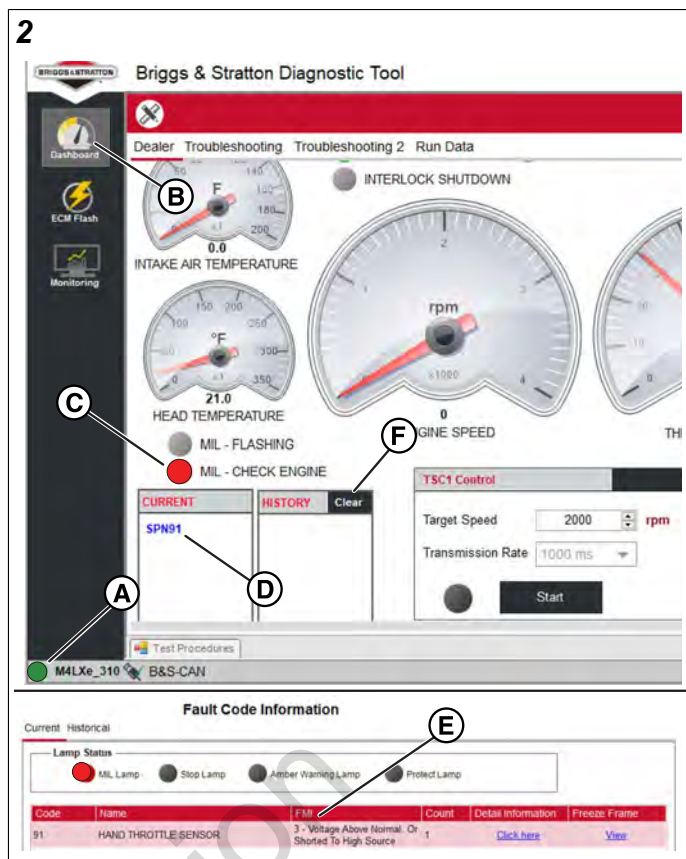
## Use Diagnostic Tool to Read/Clear DTCs

1. Go to [www.thepowerportal.com](http://www.thepowerportal.com). Be sure that you have a good internet connection.
2. Enter Login and Password.
3. From the home page, select the Briggs & Stratton black diamond engine logo tab.
4. Open the Briggs & Stratton Diagnostic Tool Application by selecting the icon on the desktop.

5. After entering the User Name and Password, click Log In.
6. Obtain Briggs & Stratton Diagnostic Tool (Part No. 19636) with USB and Interface cables.
7. Connect one end of the USB cable to the Diagnostic Tool and the other end to the USB port on the laptop.
8. Connect one end of the Interface cable to the Diagnostic Tool and the other end to the DLC on the EFI harness.
9. Turn Ignition ON, Engine OFF.

**NOTE:** See Figure 2. The Diagnostic Tool can take up to 30 seconds to connect to the engine. Once established, the connection indicator light (A) becomes solid green and the word **Connected** is displayed.

10. Select the **Dashboard** icon (B) to view the **Dealer** tab.
11. The **CHECK ENGINE** light (C) is red if a current fault code is present.
12. Observe the **Current** codes display. Hover the cursor over the blue hyperlink (D) to display a description of the SPN fault code. Click on the hyperlink to read the associated FMI (E).
13. Click **Clear** (F) to erase both current and historic DTCs.
14. Turn Ignition OFF.
15. Wait ten seconds, and then disconnect the Diagnostic Tool cables and power supply.



**NOTE:** While the Diagnostic Tool provides “live” data for analysis, it is not a standalone diagnostic tool for resolving DTCs, but must be used in conjunction with the Diagnostic Tables in this manual for the most efficient and effective diagnosis.

**NOTE:** See the Briggs & Stratton EFI Diagnostic Tool Software User Manual for more information.

## Back Probe Connector Terminals

**NOTE:** Do not insert probes into terminals on the mating side of any connector. The diameter of the test probes can damage terminals.

1. Obtain Briggs & Stratton Back Probe Wire Set (Part No. 19625).
2. Carefully slide metal pin on probe between the rubber seal and wire insulation on the back side (wire end) of the connector.
3. Gently push the pin in until it stops. Stop pushing when the pin “bottoms out,” or when the plastic sheath is very close to the connector housing.

**DO NOT** force the pin into the connector as terminal and/or probe pin damage can occur. Probe travel may be stopped by contact with insulation or core crimps. Try again after removing and re-positioning probe pin.

**IMPORTANT:**

- Use care to avoid deforming connector terminals, either by forcing the probe too far into the cavity or by using a probe that is too large. If terminal damage is suspected, test for proper terminal contact.
- A deformed terminal can cause a poor connection resulting in intermittent problems or even complete component failure. Do not use paper clips or other substitute devices as they also can damage terminals.
- Do not probe through connector seals, wire insulation, secondary ignition wires, boots, etc. Damage can occur that is not readily apparent and tiny holes can result in water intrusion, which leads to corrosion and eventual component failure.

## Avoid ECM Damage



### CAUTION

**A surge in voltage, current or both, is called a voltage spike. Voltage spikes can cause major damage to the ECM.**

1. To avoid ECM failure due to accidentally induced voltage spikes, always observe the following precautions:
  - Do not start engine if battery cable connections are loose.
  - Do not use a battery charger to start engine.

- Turn Ignition OFF before disconnecting and/or connecting battery cables.
- When disconnecting battery, always disconnect battery negative (-) cable first.
- When connecting battery, always connect battery positive (+) cable first.
- When charging battery, turn Ignition OFF and remove battery negative cable (black) from battery negative (-) terminal.
- If electric welding on vehicle, remove battery negative cable (black) from battery negative (-) terminal, and disconnect the ECM electrical connector(s).

## Special Tools

The following special tools are required:

1. Briggs & Stratton Spark Tester (Part No. 19368).
2. Briggs & Stratton Digital Volt Ohmmeter Extech Ma220 (Part No. 19602).
3. Briggs & Stratton Noid Light (Part No. 19623).
4. Briggs & Stratton BIG BLOCK™ Fuel Pressure Test Adapter (Part No. 19624).
5. Briggs & Stratton Back Probe Wire Set (Part No. 19625).
6. Briggs & Stratton Fuel Pressure Gauge (Part No. 19627).
7. Briggs & Stratton Diagnostic Tool Kit (Part No. 19636).

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## DIAGNOSTIC TROUBLE CODES (DTCS)

SPN	Component	FMI	Description
51	Throttle Position Sensor (TPS)	2	Intermittent Fail
		3	Signal Voltage High
		4	Signal Voltage Low/Open
		7	Signal Voltage Out of Range
		10	TPS Difference
91	Pedal Value	3	Signal Voltage High
		4	Signal Voltage Low/Open
100	Low Oil Pressure	1	Switch Closed/Low
102	Manifold Absolute Pressure (MAP) Sensor	3	Signal Voltage High
		4	Signal Voltage Low/Open
105	Manifold Air Temperature (MAT) Sensor	2	Intermittent Fail
		3	Signal Voltage High/Open
		4	Signal Voltage Low
110	Engine Head Temperature (EHT) Sensor	2	Intermittent Fail
		3	Signal Voltage High/Open
		4	Signal Voltage Low
158	Ignition Key Voltage	3	Voltage High
		4	Voltage Low
168	Battery Voltage	3	Voltage High
		4	Voltage Low
190	Engine Over Speed Detection	15	Over Speed Detected
636	Crankshaft Wrong Tooth Number	2	Additional Edges Detected
		8	Missing or Additional Tooth Detected
637	Crankshaft Loss of Synchronization	2	Gap Position Incorrect
		7	Missing Crankshaft Sensor Signal
		8	Crankshaft Fail During Valid Teeth Phase
639	CAN Bus Offline	19	Data Error
651	Cylinder 1 Fuel Injector	3	Signal Voltage High
		4	Signal Voltage Low/Open
652	Cylinder 2 Fuel Injector	3	Signal Voltage High
		4	Signal Voltage Low/Open
724	Oxygen Sensor	3	Sensor Shorted High
		4	Sensor Shorted Low
		5	Sensor Open
818	Voltage Protection	3	5V Supply Shorted High
		4	5V Supply Shorted Low
		16	Over Temperature
1268	Cylinder 1 Ignition Coil	3	Signal Voltage High
		4	Signal Voltage Low/Open
1269	Cylinder 2 Ignition Coil	3	Signal Voltage High
		4	Signal Voltage Low/Open
1347	Electric Lift Fuel Pump Failure	3	Circuit Shorted High
		4	Circuit Shorted Low
		5	Circuit Open

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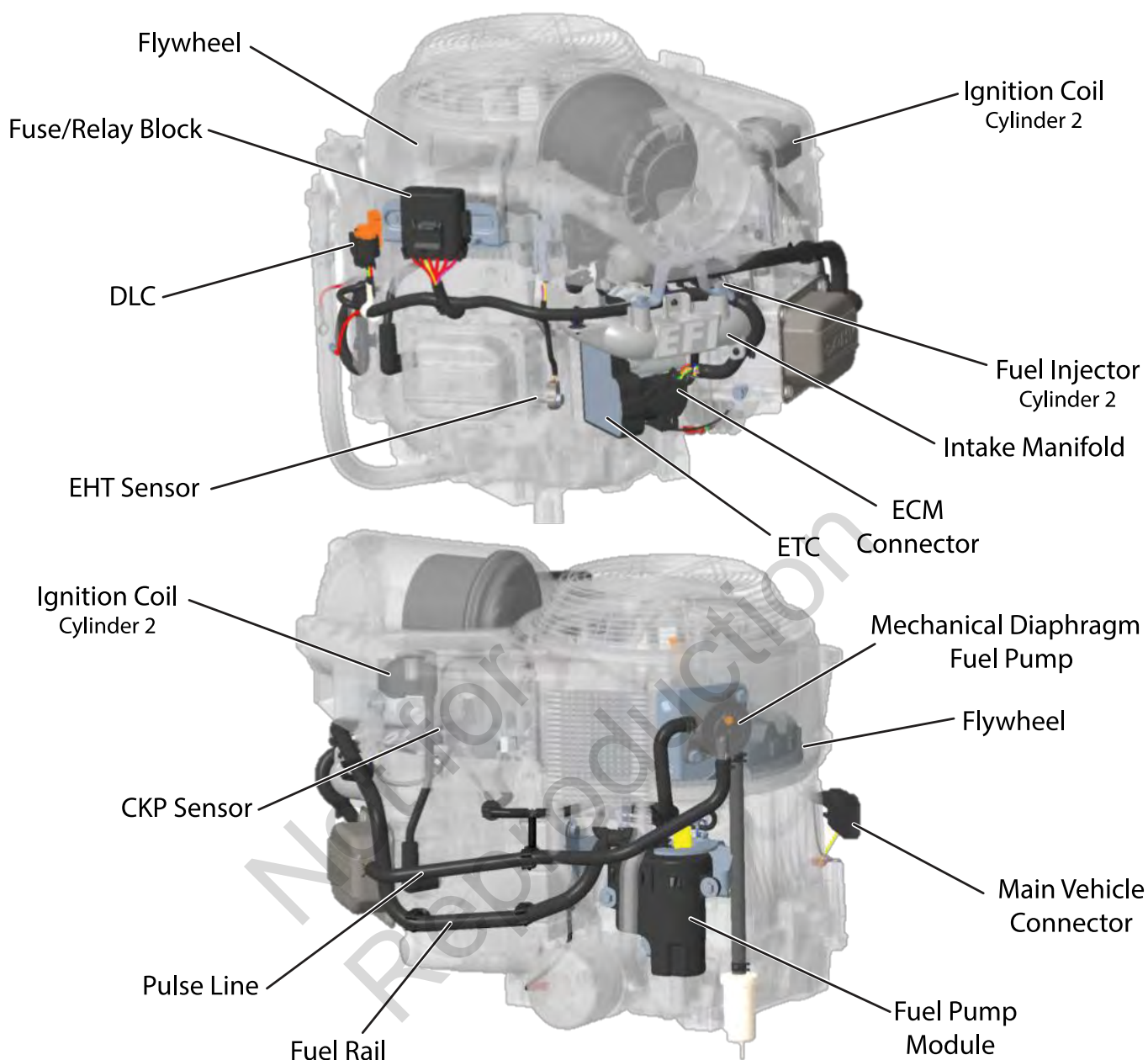


SPN	Component	FMI	Description
1485	Main Relay	3	Circuit Shorted High
		4	Circuit Shorted Low
		5	Circuit Open
1569	Engine Over Temperature Diagnosis	0	Head Temp Sensor Over THD3
		15	Head Temp Sensor Over THD1
		16	Head Temp Sensor Over THD2
1695	Oxygen Sensor Control	4	Lean Air/Fuel Ratio
		20	Sensor Correction Too High
		21	Sensor Correction Too Low
5419	Electronic Throttle Control (ETC)	3	Driver Pin Shorted High
		4	Driver Pin Shorted Low
		5	Driver Circuit Open
		6	Driver Shorted Between Pins 1 & 2
		8	Pulse Width Modulation Out of Range
		15	Driver Over Temperature WARNING
		16	Driver Over Temperature
5871	Oxygen Sensor Heater	3	Heater Shorted High
		4	Heater Shorted Low
		5	Heater Circuit Open

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## MODELS 440000/490000 EFI COMPONENT LOCATIONS

2

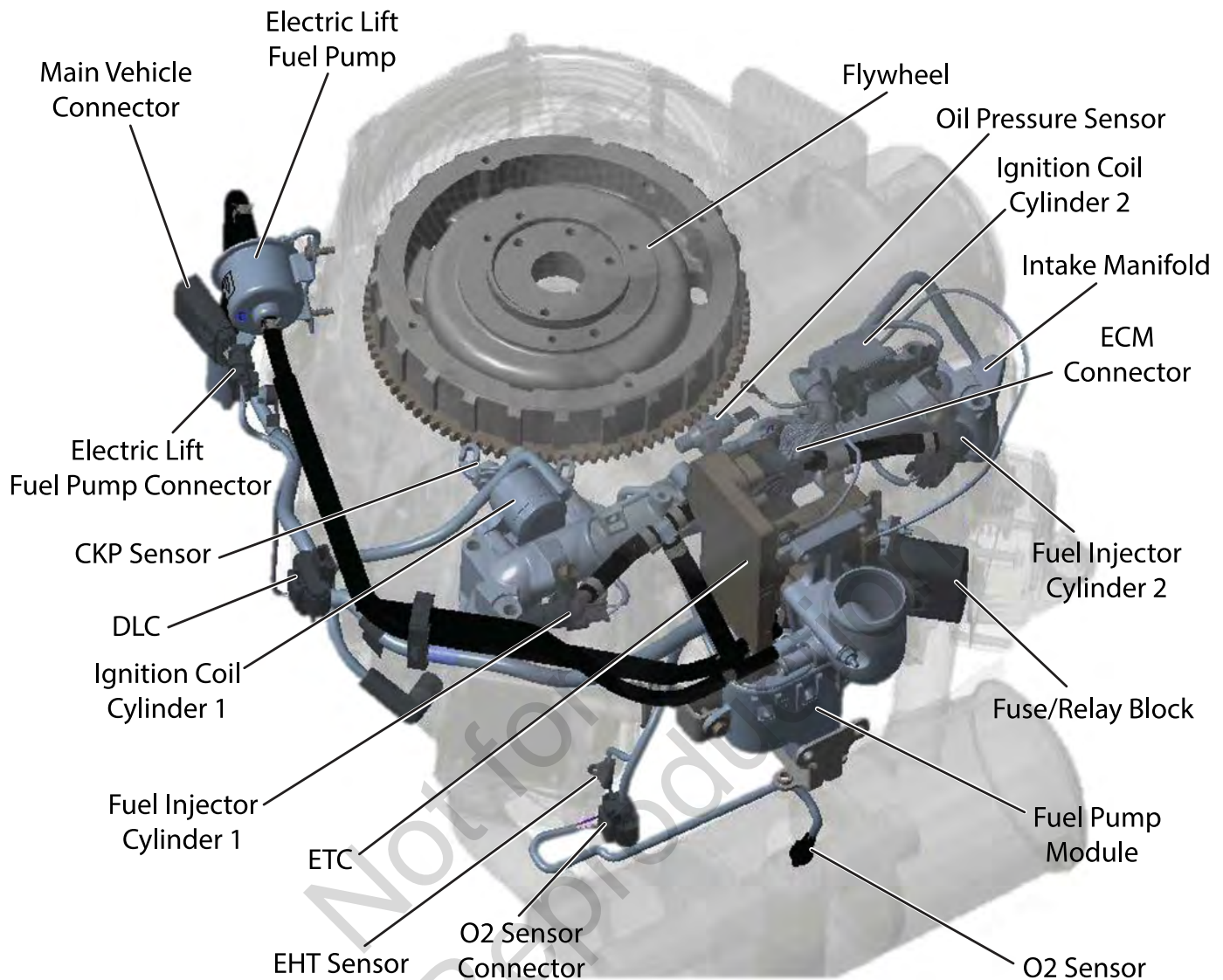


Removal Required for Back Probing Connector (x) or Replacing Component (o)		
To Access	Air Cleaner Assembly	Blower Housing
ETC/ECM	xo	o
Ignition Coil	xo	o
Mechanical Diaphragm Fuel Pump		
Fuel Pump Module		
Fuel Injectors	xo	o
CKP Sensor	xo	xo
Fuse/Relay Block		

**NOTE:** See SECTION 5 - REMOVAL/INSTALLATION of this manual for instructions.

## MODEL 610000 EFI COMPONENT LOCATIONS

2



Removal Required for Back Probing Connector (x) or Replacing Component (o)			
To Access	Side Cover	Air Cleaner Assembly/Top Cover	Blower Housing
ETC/ECM	xo	xo	
Ignition Coil	xo	xo	xo
Electric Lift Fuel Pump			
Fuel Pump Module	xo		
Fuel Injectors	xo	xo	xo
CKP Sensor	xo	xo	xo
(H)O <sub>2</sub> Sensor	xo		
Fuse/Relay Block	xo		

**NOTE:** See SECTION 5 - REMOVAL/INSTALLATION of this manual for instructions.

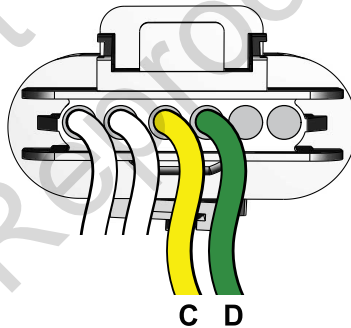
# CAN BUS TROUBLESHOOTING

Troubleshooting DTCs may not always get to the real source of the problem, as there can be instances where the problem originates with the CAN bus. Bad connections can result in faulty communications with the ECM resulting in a faulty diagnosis.

## Check Voltages

2

Step	Action
1	<ol style="list-style-type: none"><li>1. Turn Ignition OFF.</li><li>2. Back probe CAN Hi terminal C (Yellow wire) at the DLC.</li><li>3. Connect terminal C back probe to red meter test lead on DVOM.</li><li>4. Connect black meter test lead on DVOM to ground.</li><li>5. Turn Ignition ON, Engine OFF.</li><li>6. Compare voltage to table below.</li></ol>
2	<ol style="list-style-type: none"><li>1. Turn Ignition OFF.</li><li>2. Back probe CAN Lo terminal D (Green wire) at the DLC.</li><li>3. Connect terminal D back probe to red meter test lead on DVOM.</li><li>4. Connect black meter test lead on DVOM to ground.</li><li>5. Turn Ignition ON, Engine OFF.</li><li>6. Compare voltage to table below.</li></ol>



DLC

Can Bus Circuits	Sleep	Idle (Recessive) KOEO	Active Bus	CAN Lo Short to Ground	CAN Hi Short to Ground	CAN Lo Short to Power	CAN Hi Short to Power	CAN Hi Short to CAN Lo
CAN Lo (-)	0 VDC	2.5 VDC	1.5 VDC – 2.5 VDC	0 VDC	0-0.5 VDC	5-12 VDC	Below 0.75 VDC	2.45 VDC
CAN Hi (+)	0 VDC	2.5 VDC	2.5 VDC – 3.5 VDC	0-0.5 VDC	0 V	Below 0.75 VDC	5-12 VDC	2.45 VDC
Resistance Test	120 Ohms: Between both CAN HI and LO							

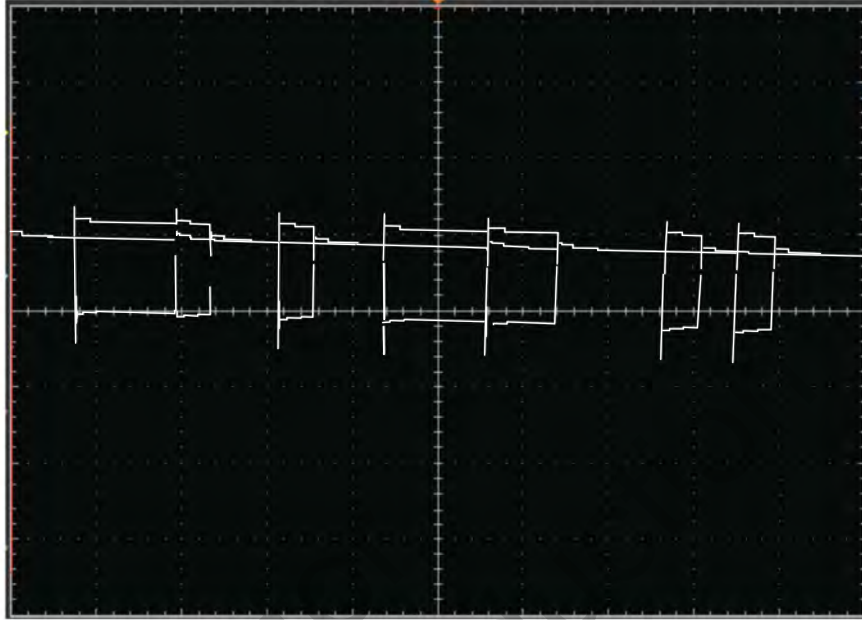
## Check Waveforms

It is generally recommended that an overall bus check be done using an oscilloscope. An inexpensive oscilloscope, and a simple multi-meter using the ohmmeter option can give valuable information on the health of the CAN bus.

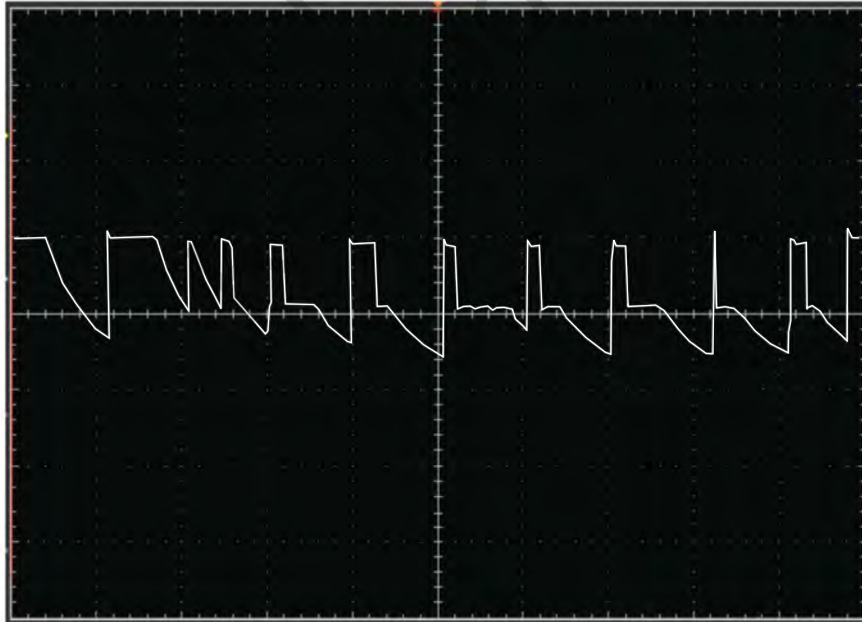
The CAN electrical signals can be viewed by connecting the oscilloscope to terminal C (CAN Hi) and terminal D (CAN Lo) on the DLC. Healthy CAN signal waveforms will appear similar to that shown in **A** of the figure below. A CAN bus with a corrupted signal is shown in **B**.

2

**A**



**B**





## OPEN LOOP VS. CLOSED LOOP OPERATION

---

Fuel injection systems operate in two modes which control fuel delivery, "Open Loop" and "Closed Loop."

### Open Loop System

In an open-loop system, fuel delivery is based on pre-determined values programmed in the ECM calibration. The ECM controls the fuel delivery based on this set of operating instructions and makes adjustments to the fuel injector duty cycle based on the input from the MAP, MAT, and EHT sensors. Fuel delivery is calculated based on information about the air entering the engine.

### Closed Loop System

In a closed loop system, fuel delivery is further enhanced with the inclusion of an O<sub>2</sub> sensor. The O<sub>2</sub> sensor measures the oxygen level in the exhaust gas and allows the ECM to make quick and precise adjustments to fuel

delivery. These adjustments happen in real time and can be used to improve engine efficiency, emissions, and power. Fuel delivery is calculated based on information about the air and exhaust exiting the engine.

### Operation

On engines equipped with an O<sub>2</sub> sensor, the ECM operates in open loop during initial starting and warm-up. The ECM calibration determines the correct fuel delivery until the engine and O<sub>2</sub> sensor reach an optimal operating temperature. Once the engine and O<sub>2</sub> sensor reach operating temperature (125° F or 52° C), the ECM enters closed loop operation and uses the O<sub>2</sub> sensor input for real time adjustments to fuel delivery

On engines NOT equipped with an O<sub>2</sub> sensor, the ECM operates only in open loop.

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## TEST PROCEDURES

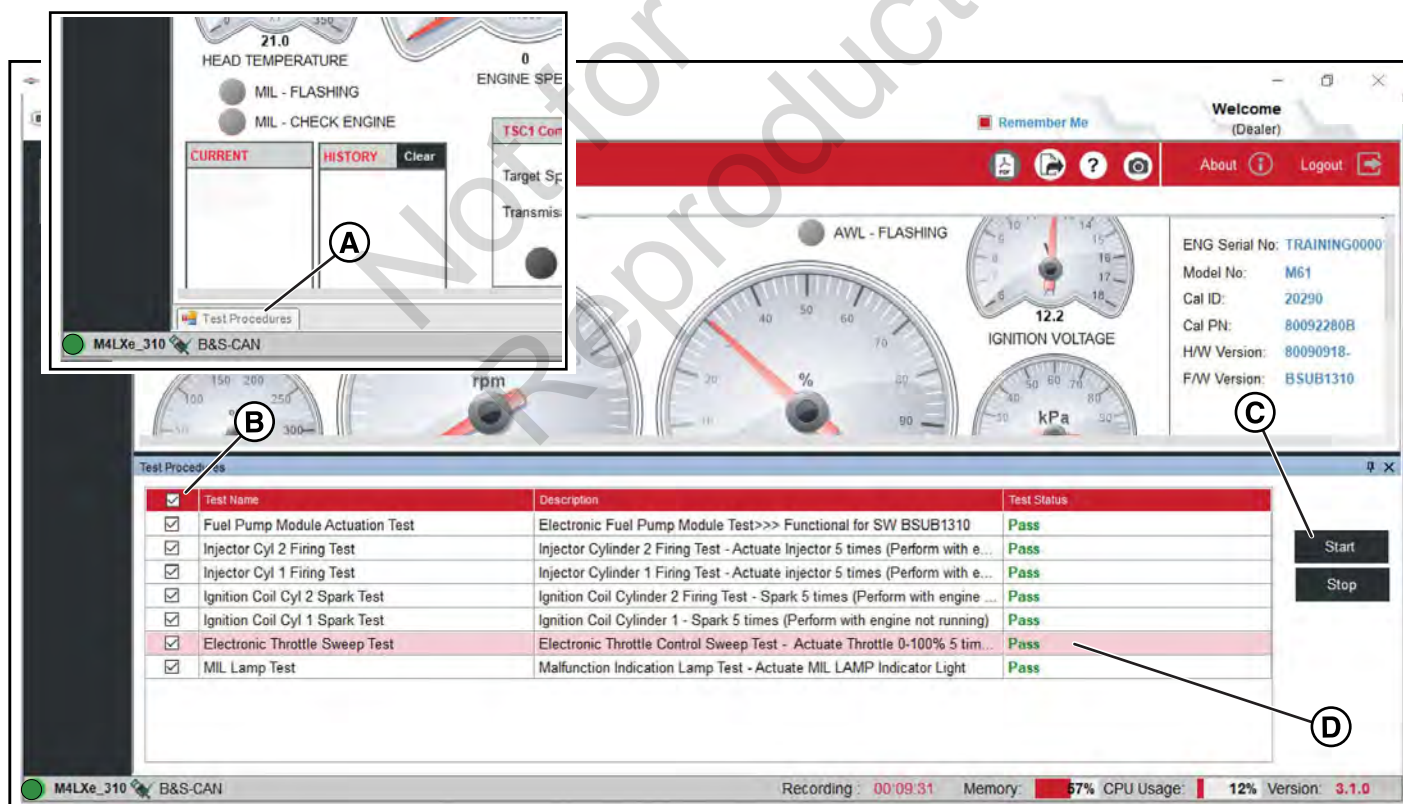
The Diagnostic Tool (Part No. 19636) can be used to do a series of tests to check the general health of the engine, or to confirm the existence of certain DTCs.

1. Connect the Diagnostic Tool and proceed to the Dealer tab. See **SECTION 1 - DIAGNOSTIC INTRODUCTION**, *Use Diagnostic Tool to Read/Clear DTCs*, of this manual, steps 1-10.
2. Select the Test Procedures tab **(A)** in the lower left corner of the screen as shown in the inset of the figure below.
3. To ascertain the general health of the engine, check the box in the header **(B)** to the left of Test Name. This action will cause all the succeeding boxes to be checked. Press Start **(C)** to automatically do each test in the sequence shown.

If addressing one particular SPN, only check the box of the applicable test, as follows:

DTC	Test
SPN 1347	Fuel Pump Module Actuation Test
SPN 652	Fuel Injector Cylinder 2 Firing Test
SPN 651	Fuel Injector Cylinder 1 Firing Test
SPN 1269	Ignition Coil Cylinder 2 Spark Test
SPN 1268	Ignition Coil Cylinder 1 Spark Test
SPN 51	Electronic Throttle Sweep Test
SPN 5419	Electronic Throttle Sweep Test

4. When the test procedure is finished, the system will display either Pass or Fail **(D)**. If the test passes then no problem currently exists. If the test fails, proceed to the appropriate diagnostic section for more information.



# VERIFY ECM POWERS UP

## Circuit Description

Since all EFI components are dependent on proper operation of the ECM, any diagnosis must include checking ECM power and grounds.

Remove and clean battery terminals. While terminals may appear clean, corrosion on the inner surfaces can cause a poor connection to ground.

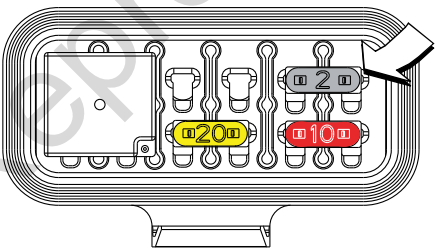
**NOTE:** When the ECM is powered up, you may hear the fuel pump module prime for two seconds. This is not definitive proof that the ECM is getting proper voltage.

2

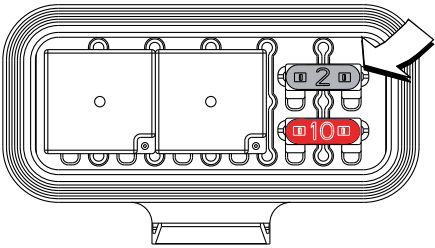
## Check ECM Power and Grounds

Step	Action	Yes	No
1	<div>1. Turn Ignition OFF.</div> <div>2. See <i>ECM Connector Loom Cover Removal</i>.</div> <div>3. Back probe terminal E3 (Violet wire) of ECM connector.</div> <div>4. Connect terminal E3 back probe to red meter test lead on DVOM.</div> <div>5. Connect black meter test lead on DVOM to a known good ground.</div> <div>6. Set DVOM to read volts DC.</div> <div>7. Turn Ignition ON, Engine OFF.</div> <div>8. Observe voltage on DVOM.</div> <div>9. Is reading 12.2-14.5 volts DC?</div>	Go to step 2.	<div>Look for open or short to ground in battery (B+) feed circuit.</div> <div>Do a visual and continuity check of 2 amp Ignition fuse (Grey).</div>
Continued...			

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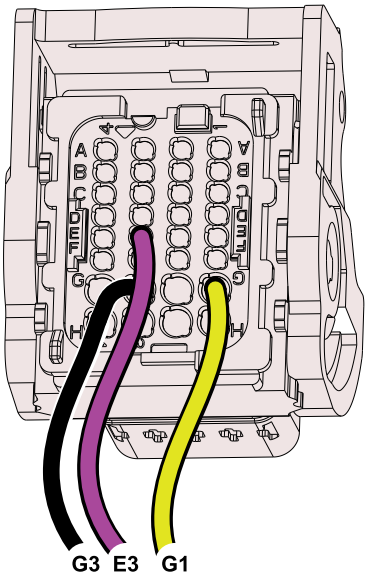


M440000/M490000



M610000

Fuse/Relay Block

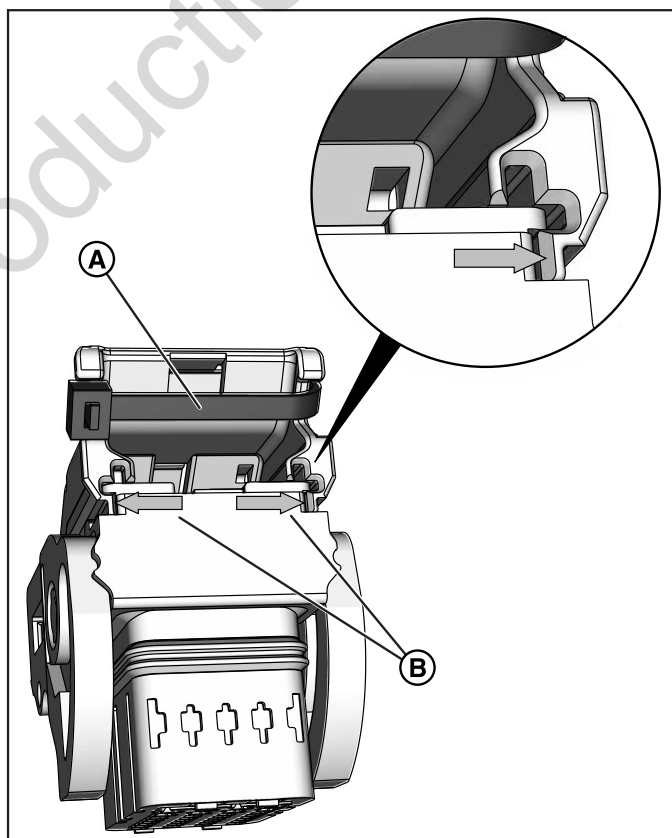


ECM Connector

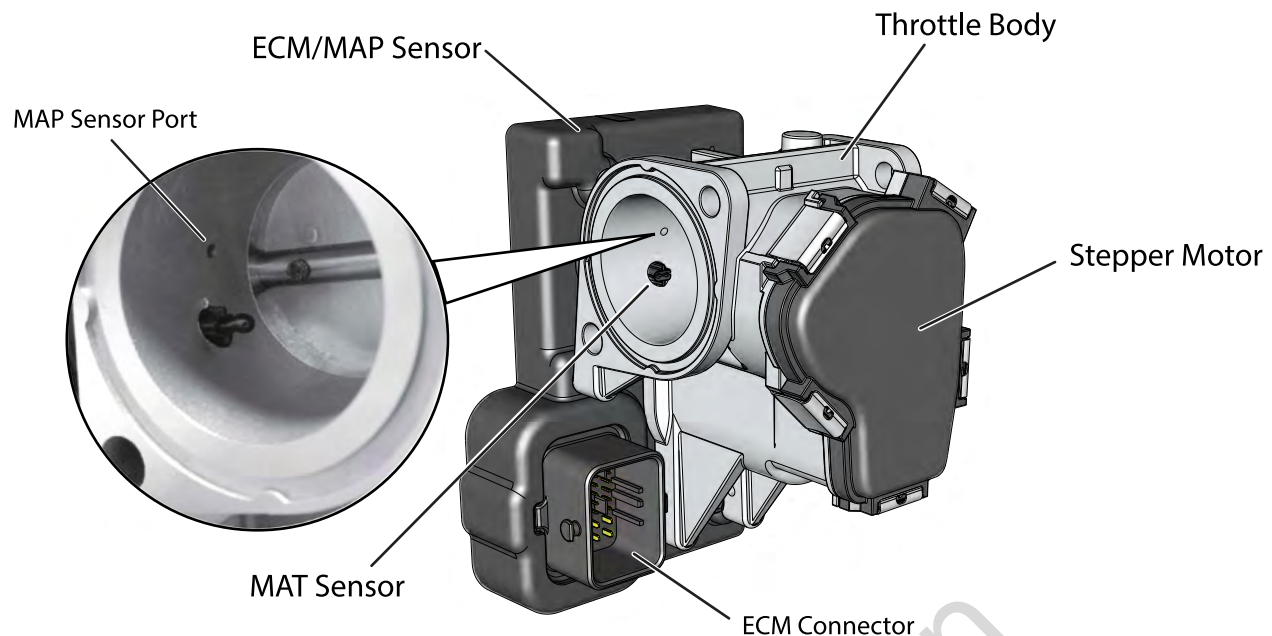
Step	Action	Yes	No
2	1. Turn Ignition OFF. 2. Remove probe from terminal E3, and back probe terminal G1 (Yellow wire) of ECM connector. 3. Connect terminal G1 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to a known good ground. 5. Turn Ignition ON, Engine OFF. 6. Observe voltage on DVOM. 7. Is reading 12.2-14.5 volts DC?	Go to step 3.	Look for open or short to ground in ignition feed circuit.
3	1. Turn Ignition OFF. 2. Remove probe from terminal G1, and back probe terminal G3 (Black wire) of ECM connector. 3. Connect terminal G3 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to a known good ground. 5. Set DVOM to read resistance. 6. Observe reading on DVOM. 7. Is resistance 1.0 ohm or less?	-	Look for open or short in ECM ground circuit.

### ECM Connector Loom Cover Removal

Cut and remove cable strap (A). Lightly push loom cover towards terminal end of connector. While maintaining light pressure on the loom cover, use a small flat blade screwdriver to push latch (B) on each side of terminal end of connector outward away from connector body. Do not release pressure on the loom cover or latches will close. Loom cover will slide off connector body after the second latch is released.



## SPN 51 THROTTLE POSITION SENSOR (TPS)



### ETC (Electronic Throttle Control)

#### Circuit Description

The TPS is used for engine control and governing. The TPS monitors and helps control the throttle position under all operating conditions.

Whenever any SPN 51 FMI is detected, the power to the Electronic Throttle Control (ETC) motor is removed and the ETC is disabled. When this occurs, the throttle plate closes to its "rest" position which is fully closed thus the engine will quit running.

#### Possible FMIs

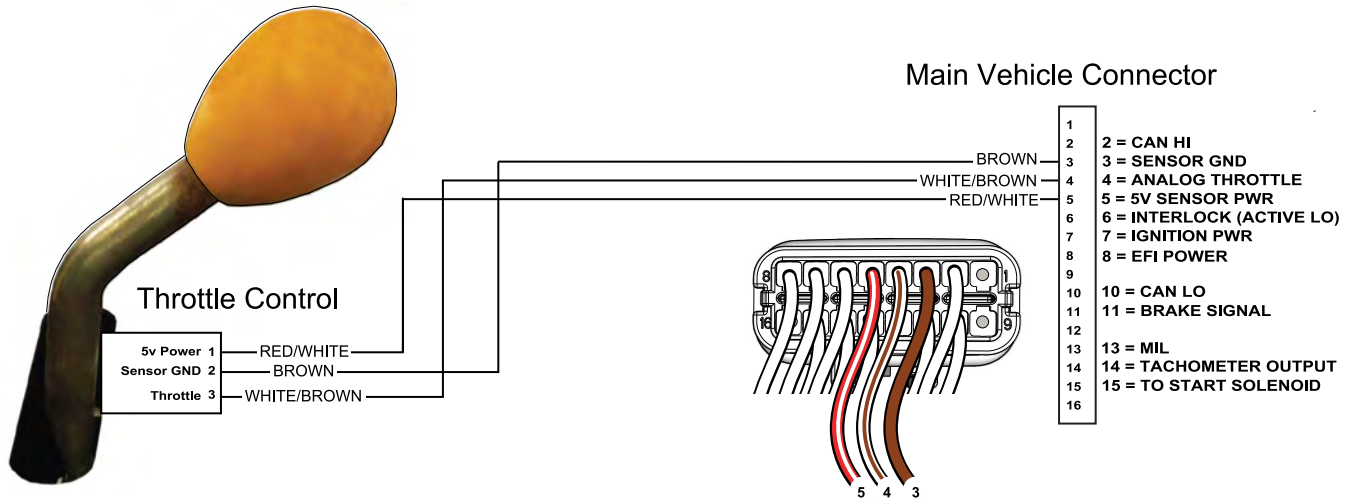
The possible FMIs for SPN 51 are as follows:

FMI	Description
2	Intermittent Fail
3	Signal Voltage High
4	Signal Voltage Low/Open
7	Signal Voltage Out of Range
10	TPS Difference

**NOTE:** The TPS is an integral part of the ETC Throttle Body, which also consists of the ECM, MAP sensor, MAT sensor, throttle body, and DC motor. The ETC components are not serviceable. If any SPN 51 FMI is present, see *TEST PROCEDURES* in this section for information on doing the Electronic Throttle Sweep Test. Replace ETC if the test fails.

## SPN 91 PEDAL VALUE

2



### Circuit Description

Via terminal 5 (Red/White wire) of the main vehicle connector, the ECM provides 5 volts power to the throttle pedal or lever on the equipment or vehicle. The throttle lever then returns a voltage through terminal 4 (White/Brown wire- analog throttle input) to the ECM that is interpreted as a commanded engine speed. If the voltage exceeds 4.9 volts DC, or drops below 0.1 volts DC, the appropriate FMI will set.

**NOTE:** The engine will default to idle if the throttle voltage is out of range.

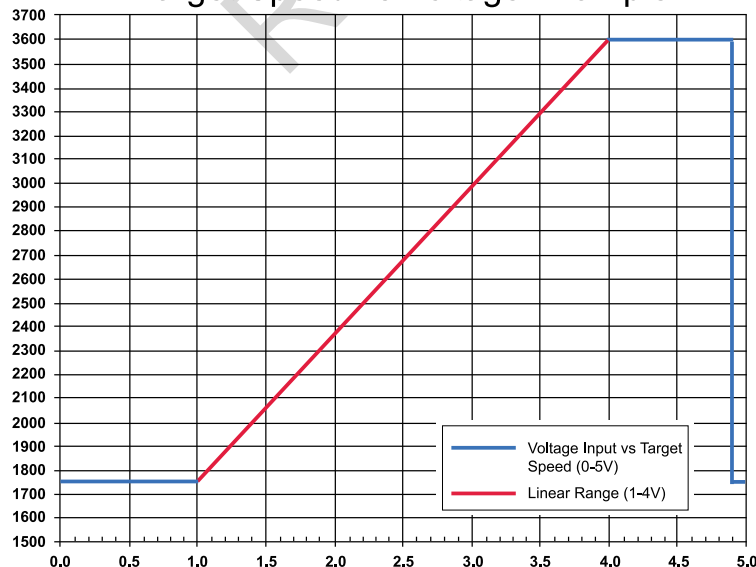
### Possible FMIs

The possible FMIs for SPN 91 are as follows:

FMI	Description
3	Signal Voltage High
4	Signal Voltage Low/Open

	MIL Range		Idle Range		Target Speed	High Range		MIL Range	
Enter Target Speeds	1750	1750	1750	1750	3200	3600	3600	1750	1750
Enter Idle and High Voltages	0	0.1	0.1	1	3.351	4	4.9	4.9	5
Target Resistor Values (Ohm)			50		508.20	1200			
Calculated Voltage Out (V)			0.83		3.351	4.14			

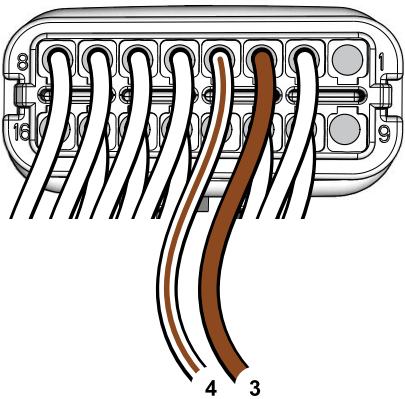
### Target Speed vs Voltage Example



Input (V)	Commanded Throttle (%)
0.00	Fault Condition
0.10	0%
1.00	0%
1.75	25%
2.50	50%
3.25	75%
4.00	100%
4.90	100%
5.00	Fault Condition

SPN 91, FMI 3: Signal Voltage High

Step	Action	Yes	No
1	<p>1. Turn Ignition OFF.</p> <p>2. Back probe terminal 4 (White/Brown wire) on engine side of the main vehicle connector.</p> <p>3. Connect terminal 4 back probe to red meter test lead on DVOM.</p> <p>4. Back probe terminal 3 (Brown wire) on engine side of the main vehicle connector.</p> <p>5. Connect terminal 3 back probe to black meter test lead on DVOM.</p> <p>6. Set DVOM to read volts DC.</p> <p>7. Turn Ignition ON, Engine OFF.</p> <p>8. Move the throttle control to low speed and take note of the voltage reading. Voltage reading should decrease.</p> <p>9. Move the throttle control to high speed and take note of the voltage reading. Voltage reading should increase.</p> <p>10. When the throttle was moved to high speed was the voltage greater than 4.9 VDC?</p>	<p>Look for throttle control problems on the equipment side.</p>	<p>No problem currently exists.</p> <p>Clear codes. While monitoring voltage, do multiple throttle sweeps to try and duplicate the failure.</p>



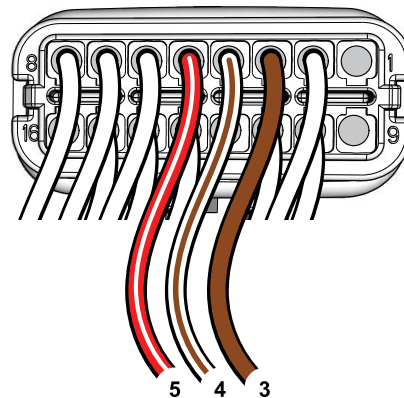
Main Vehicle Connector



## SPN 91, FMI 4: Signal Voltage Low/Open

2

Step	Action	Yes	No
1	<ol style="list-style-type: none"> <li>1. Turn Ignition OFF.</li> <li>2. Back probe terminal 4 (White/Brown wire) on engine side of the main vehicle connector.</li> <li>3. Connect terminal 4 back probe to red meter test lead on DVOM.</li> <li>4. Back probe terminal 3 (Brown wire) on engine side of the main vehicle connector.</li> <li>5. Connect terminal 3 back probe to black meter test lead on DVOM.</li> <li>6. Set DVOM to read volts DC.</li> <li>7. Turn Ignition ON, Engine OFF.</li> <li>8. DVOM should read 0.1-4.9 volts DC.</li> <li>9. Move the throttle control to high speed. Voltage reading should increase.</li> <li>10. Move the throttle control to low speed. Voltage reading should decrease.</li> <li>11. When the throttle was moved to low speed was the voltage less than 0.1 VDC?</li> </ol>	Go to step 2.	<p>No problem currently exists.</p> <p>Clear codes. While monitoring voltage, do multiple throttle sweeps to try and duplicate the failure.</p>
2	<ol style="list-style-type: none"> <li>1. Turn Ignition OFF.</li> <li>2. Remove probe from terminal 4, and back probe terminal 5 (Red/White wire) on engine side of the main vehicle connector.</li> <li>3. Turn Ignition ON, Engine OFF.</li> <li>4. Does DVOM read greater than 4.9 volts DC?</li> </ol>	Voltage is not being returned from the throttle control to the ECM. Look for throttle control problems on the equipment side.	<p>No problem currently exists.</p> <p>Clear codes. While monitoring voltage, do multiple throttle sweeps to try and duplicate the failure.</p>

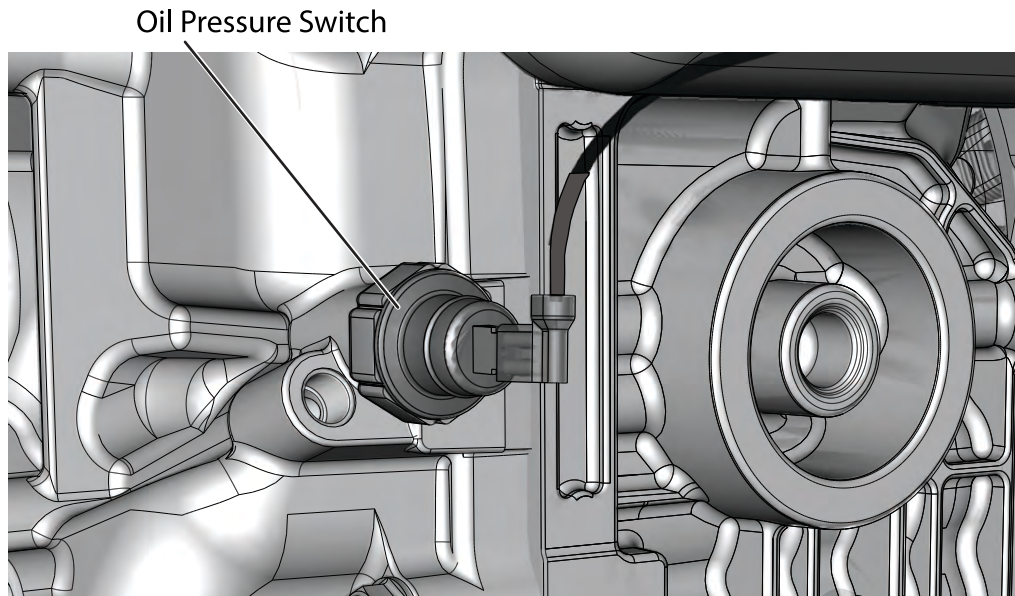


**Main Vehicle Connector**



## SPN 100 LOW OIL PRESSURE DIAGNOSIS

2



### Circuit Description

In normal operation the oil pressure switch is open. If low oil pressure is detected by the oil pressure switch, the switch is grounded and the ECM derates the engine operation and triggers a DTC. This will limit the engine RPM until the issue is resolved. To determine the cause of the low oil pressure warning check the wiring, oil level, and mechanical components to find what caused the fault.

### Possible FMIs

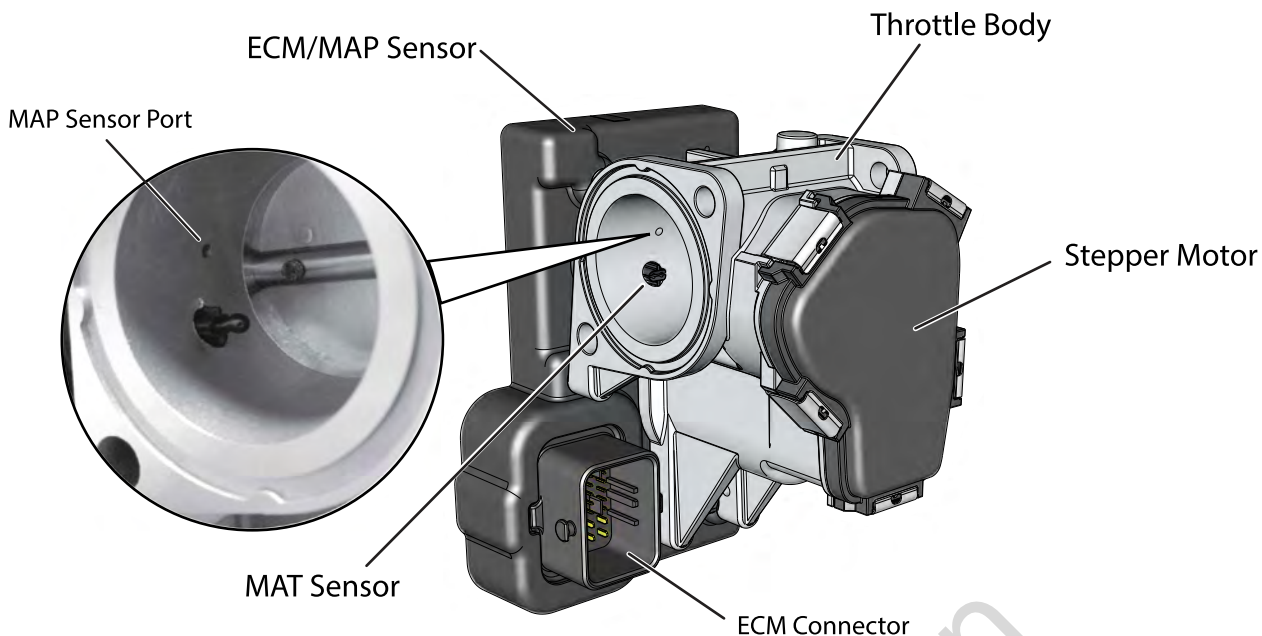
The possible FMIs for SPN 100 are as follows:

FMI	Description
1	Switch Closed/Low

**NOTE:** Operating the engine with low or no oil pressure can cause damage to the internal components. If SPN 100 is observed, cease operations until the cause of the fault is known and repaired. Use the applicable Briggs & Stratton Engine Repair Manual as a guide for inspection, troubleshooting, and replacement of components.

# SPN 102 MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

2



ETC (Electronic Throttle Control)

## Circuit Description

The MAP sensor monitors intake manifold pressure to interpret engine work load to provide accurate fuel and spark delivery. The MAP sensor continuously monitors engine performance. It also reads ambient atmospheric pressure the moment the key is turned on. This barometric pressure reference is stored in case the MAP sensor fails during operation. The system will default to the stored value in the occurrence of a failure. This barometric pressure is also used to judge ambient elevation to provide seamless engine operation at various elevations.

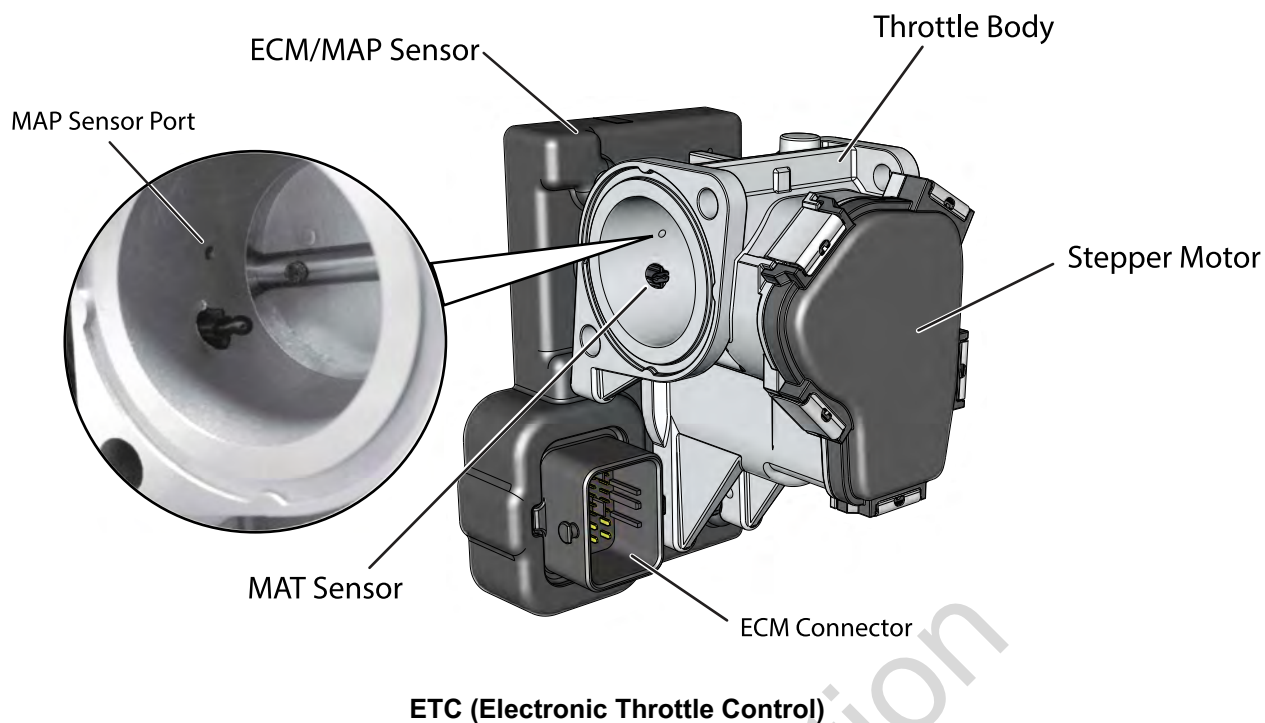
## Possible FMIs

The possible FMIs for SPN 102 are as follows:

FMI	Description
3	Signal Voltage High
4	Signal Voltage Low/Open

**NOTE:** The MAP sensor is an integral part of the ETC, which also consists of the ECM, MAT sensor, TPS, throttle body, and stepper motor. The ETC is not serviceable and can not be physically tested. If any SPN 102 FMI is present, replace the ETC.

## SPN 105 MANIFOLD AIR TEMPERATURE (MAT) SENSOR



### Circuit Description

The MAT sensor is used to monitor incoming air temperature to make dynamic changes to fuel and spark based on ambient temperature conditions. The MAT sensor thermistor is visible in the throttle body bore.

### Possible FMIs

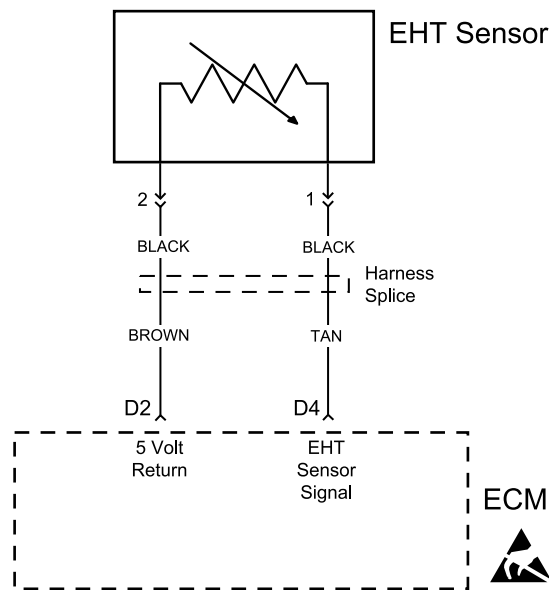
The possible FMIs for SPN 105 are as follows:

FMI	Description
2	Intermittent Fail
3	Signal Voltage High/Open
4	Signal Voltage Low

**NOTE:** The MAT sensor is an integral part of the ETC, which also consists of the ECM, MAP sensor, TPS, throttle body, and stepper motor. The ETC components are not serviceable and cannot be physically tested. If any SPN 105 FMI is present, replace the ETC.

# SPN 110 ENGINE HEAD TEMPERATURE (EHT) SENSOR

2



## Circuit Description

The EHT sensor uses a thermistor to control signal voltage to the ECM. The ECM applies 5 volts on the sensor circuit. Sensor resistance changes as ambient temperature changes, which in turn affects the voltage return to the ECM.

## Possible FMIs

The possible FMIs for SPN 110 are as follows:

FMI	Description
2	Intermittent Fail
3	Signal Voltage High/Open
4	Signal Voltage Low

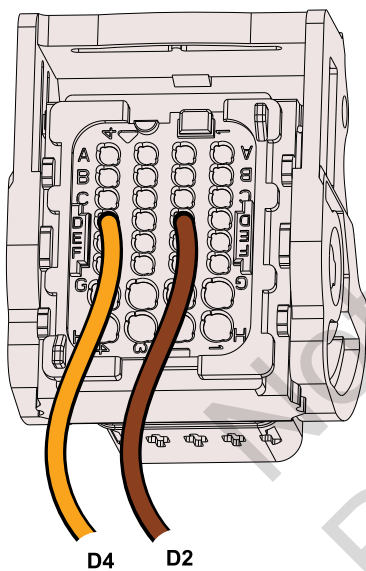
**FMI 2:** ECM has detected intermittent failure due to large changes in the EHT Sensor signal. The problem can be the wiring harness and/or connections from EHT Sensor to ECM or EHT Sensor Damage.

**FMI 3 and 4:** ECM monitors voltage from the EHT sensor if sensor voltage is < 0.537V Sensor voltage low is triggered and FMI 4 is set. Likewise for voltage high / open if sensor voltage is > 4.9756 then FMI 3 is set.

SPN 110, FMI 3: Signal Voltage High/Open

Step	Action	Yes	No
1	<div>1. Turn Ignition OFF.</div> <div>2. Back probe terminal D4 (Tan wire) of ECM connector.</div> <div>3. Connect terminal D4 back probe to red meter test lead on DVOM.</div> <div>4. Back probe terminal D2 (Brown wire) of ECM connector.</div> <div>5. Connect terminal D2 back probe to black meter test lead on DVOM.</div> <div>6. Set DVOM to read volts DC.</div> <div>7. Turn Ignition ON, Engine OFF.</div> <div>8. Observe voltage on DVOM.</div> <div>9. Is reading 0.5-4.5 volts DC?</div>	EHT sensor OK.	<div>Reading is above 4.5 volts DC. EHT sensor is bad.</div> <div>Replace EFI wire harness.</div> <div><b>NOTE:</b> EHT sensor is an integral part of the EFI wire harness and is not sold separately.</div>

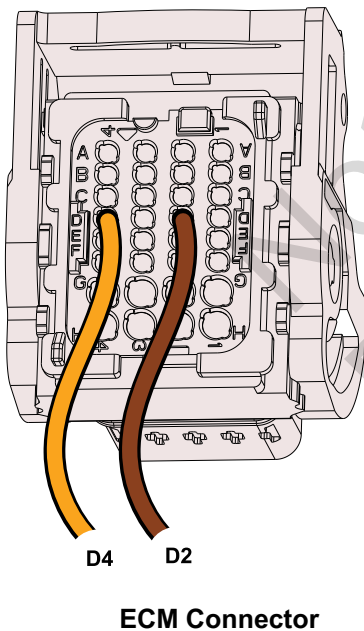
2



ECM Connector

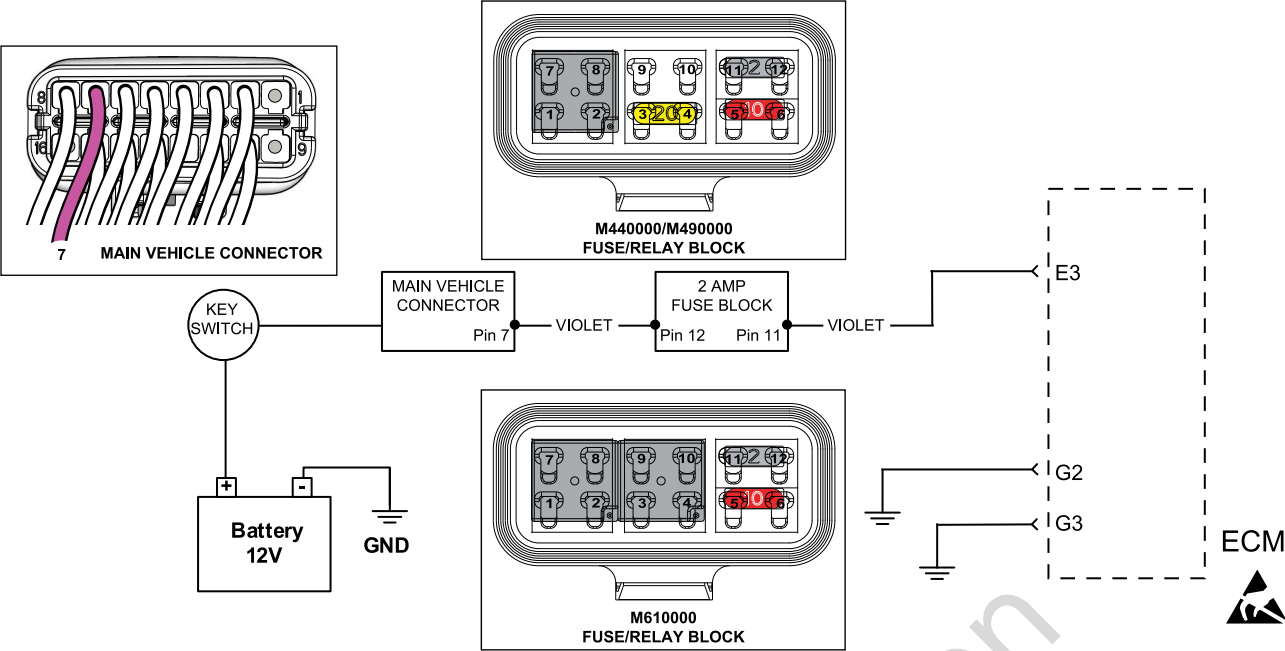
SPN 110, FMI 4: Signal Voltage Low

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Back probe terminal D4 (Tan wire) of ECM connector. 3. Connect terminal D4 back probe to red meter test lead on DVOM. 4. Back probe terminal D2 (Brown wire) of ECM connector. 5. Connect terminal D2 back probe to black meter test lead on DVOM. 6. Set DVOM to read volts DC. 7. Turn Ignition ON, Engine OFF. 8. Observe voltage on DVOM. 9. Is reading 0.5-4.5 volts DC?	EHT sensor OK.	Go to step 2.
2	1. Reading is below 0.5 volts DC. 2. Is ECM connector fully mated?	EHT sensor is bad. Replace EFI wire harness.  <b>NOTE:</b> EHT sensor is an integral part of the EFI wire harness and is not sold separately.	Connect connector.



# SPN 158 IGNITION KEY VOLTAGE

2



## Circuit Description

The ignition key circuit detects a malfunction if the ignition voltage signal is above 18V (setting FMI 3) or below 8V (setting FMI 4) for extended periods of time. Check for a low or weak battery condition. Defective, loose, or corroded battery voltage connections to the ignition key circuit can also cause a malfunction.

To further diagnose system voltage faults, see the applicable section of your Briggs & Stratton Engine Repair Manual.

## Possible FMIs

The possible FMIs for SPN 158 are as follows:

FMI	Description
3	Voltage High
4	Voltage Low

SPN 158, FMI 3: Voltage High

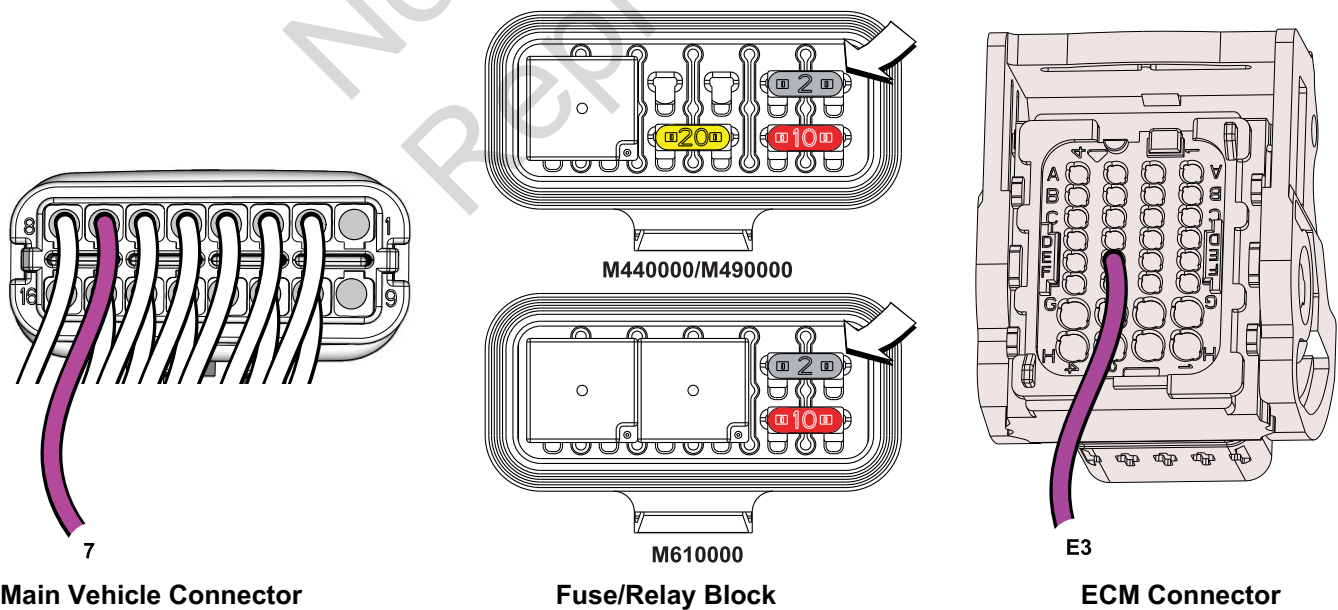
Step	Action	Yes	No
1	1. Connect red meter test lead on DVOM to battery positive (+) post. 2. Connect black meter test lead on DVOM to battery negative (-) post. 3. Set DVOM to read volts DC. 4. Start and run engine at full speed (3600 RPM). 5. Observe voltage on DVOM. 6. Is reading 12.2-14.5 volts DC?	System voltage OK.	Reading is above 15 volts. Check charging system.  See the applicable Briggs & Stratton Engine Repair Manual.

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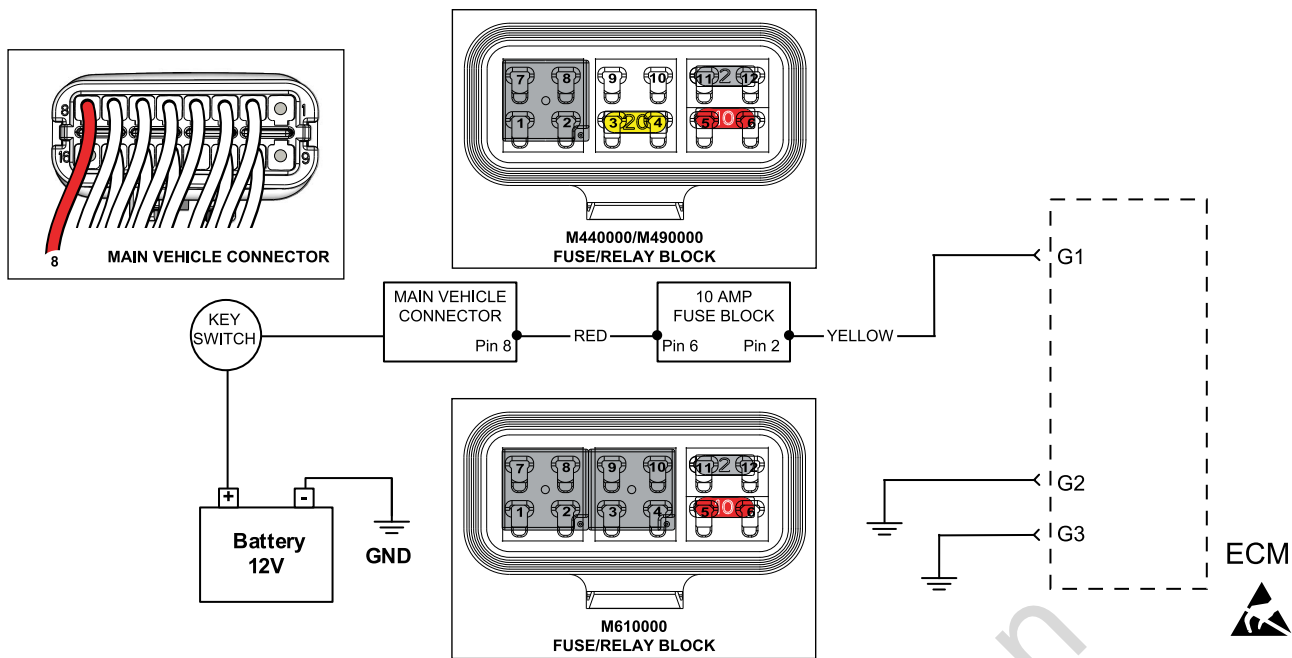
SPN 158, FMI 4: Voltage Low

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Set DVOM to read volts DC. 3. Connect red meter test lead on DVOM to battery positive (+) post. 4. Connect black meter test lead on DVOM to ground. 5. Turn Ignition ON, Engine OFF. 6. Does DVOM read 12+ volts DC?	Go to step 2.	Charge or replace battery.
2	1. Turn Ignition OFF. 2. Back probe terminal 7 (Violet wire) at the main vehicle connector. 3. Connect terminal 7 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to ground. 5. Turn Ignition ON, Engine OFF. 6. Does DVOM read 12+ volts DC?	Go to step 3.	Check vehicle or equipment side for problems.
3	1. Check condition of 2 amp fuse in the fuse block. Is fuse OK?	Go to step 4.	Replace fuse and retest.
4	1. Turn Ignition OFF. 2. Back probe terminal E3 (Violet wire) at ECM connector. 3. Connect terminal E3 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to ground. 5. Turn Ignition ON, Engine OFF. 6. Does DVOM read 12+ volts DC?	No problem currently exists.	Inspect EFI wire harness between the main vehicle connector and terminal E3 (Violet wire) at ECM connector.



# SPN 168 BATTERY VOLTAGE

2



## Circuit Description

The EFI system operates with a battery voltage of 9-16 volts. If the system voltage drops below 6.2 volts the ECM will reset. During normal operation, the MIL is illuminated if the voltage is above 18 volts (setting FMI 3) or below 8 volts (setting FMI 4) for a specified amount of time.

To determine the system voltage to the ECM, take a voltage measurement at terminal G1. If the voltage is not within 0.01 volt of the measurement obtained at the battery (12-14.5 volts DC) measuring between the positive (+) and negative (-) posts with a DVOM, determine the fault associated with the ignition circuit.

To further diagnose system voltage faults, see the applicable section of your Briggs & Stratton Engine Repair Manual.

## Possible FMIs

The possible FMIs for SPN 168 are as follows:

FMI	Description
3	Voltage High
4	Voltage Low

SPN 168, FMI 3: Voltage High

Step	Action	Yes	No
1	1. Connect red meter test lead on DVOM to battery positive (+) post. 2. Connect black meter test lead on DVOM to battery negative (-) post. 3. Set DVOM to read volts DC. 4. Start and run engine at full speed (3600 RPM). 5. Observe voltage on DVOM. 6. Is reading 12.2-14.5 volts DC?	System voltage OK.	Reading is above 15 volts. Check charging system.  See the applicable section of your Briggs & Stratton Engine Repair Manual.

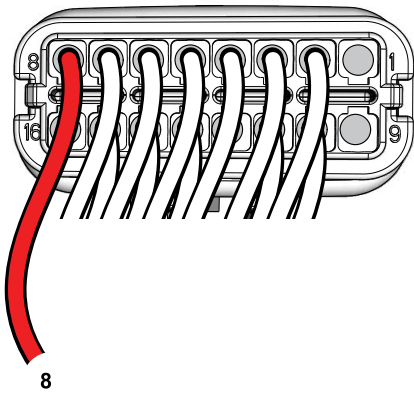
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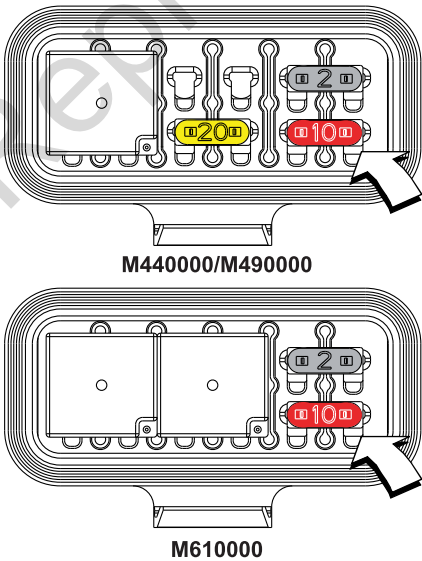
SPN 168, FMI 4: Voltage Low

2

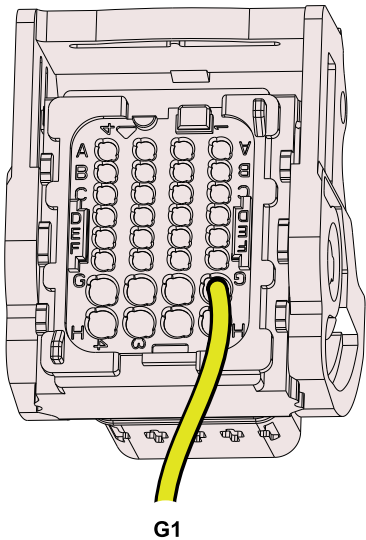
Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Set DVOM to read volts DC. 3. Connect red meter test lead on DVOM to battery positive (+) post. 4. Connect black meter test lead on DVOM to ground. 5. Turn Ignition ON, Engine OFF. 6. Does DVOM read 12+ volts DC?	Go to step 2.	Charge or replace battery.
2	1. Turn Ignition OFF. 2. Back probe terminal 8 (Red wire) at the main vehicle connector. 3. Connect terminal 8 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to ground. 5. Turn Ignition ON, Engine OFF. 6. Does DVOM read 12+ volts DC?	Go to step 3.	Check vehicle or equipment side for problems.
3	1. Check condition of 10 amp fuse in the fuse block. Is fuse OK?	Go to step 4.	Replace fuse and retest.
4	1. Turn Ignition OFF. 2. Back probe terminal G1 (Yellow wire) at ECM connector. 3. Connect terminal G1 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to ground. 5. Turn Ignition ON, Engine OFF. 6. Does DVOM read 12+ volts DC?	No problem currently exists.	Inspect EFI wire harness between the main vehicle connector and terminal G1 (Yellow wire) at ECM connector.



Main Vehicle Connector



Fuse/Relay Block



ECM Connector

## SPN 190 ENGINE OVER SPEED DETECTION

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### Possible FMIs

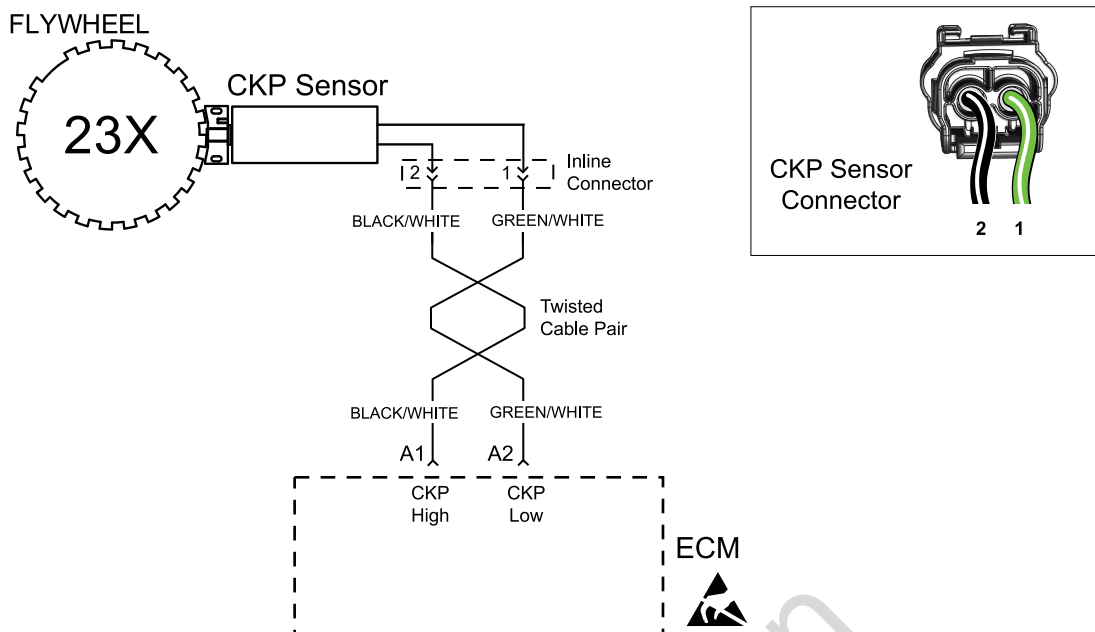
The possible FMIs for SPN 190 are as follows:

FMI	Description
15	Over Speed Detected

**FMI 15:** The ECM checks engine speed after each four stroke cycle and sets the code if top no load rpm speed is not exceeded. Verify the engine high speed range is set to top no load speed as specified by the calibration. If throttle is stuck open and engine over speed diagnostic is active, replace ETC. If engine over speed problem persists, replace ETC.

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## SPN 636 CRANKSHAFT WRONG TOOTH NUMBER



### Circuit Description

The CKP sensor works in conjunction with the 23X reluctor target wheel on the flywheel. Each tooth on the reluctor wheel is equally spaced with 1 tooth missing for the reference sync pulse. As the crankshaft rotates, the reluctor target wheel interrupts a magnetic field produced by an internal sensor magnet. The CKP sensor internal circuitry detects this interruption, and produces an ON/OFF AC voltage of varying frequency. The frequency of the CKP sensor output signal is dependent upon crankshaft speed. The ECM uses each CKP sensor output signal to determine crankshaft speed and identify crankshaft position.

With the spark under control of the ECM, the engine will not run if the CKP sensor signal is lost. The ECM will not be able to determine which stroke the pistons are on.

### Possible FMIs

The possible FMIs for SPN 636 are as follows:

FMI	Description
2	Additional Edges Detected
8	Missing or Additional Tooth Detected

**FMI 2:** Erratic signal possibly caused by excessive air gap or electronic noise.

**FMI 8:** Abnormal frequency due to excessive air gap or metallic debris on sensor.

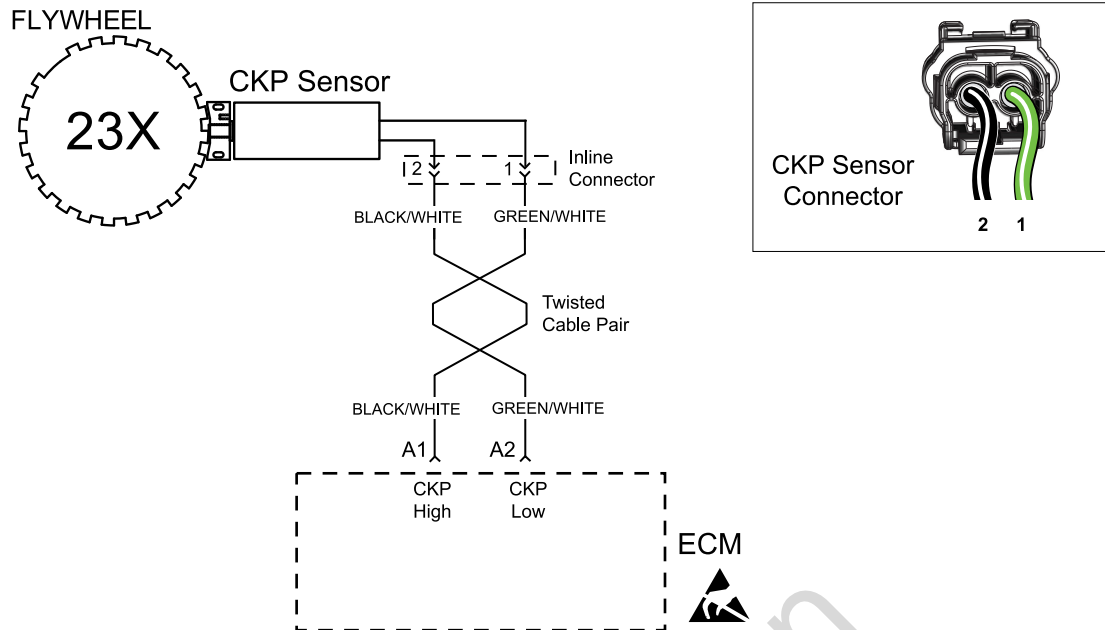
## SPN 636, FMI 2: Additional Edges Detected

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Check CKP sensor air gap. 3. Is CKP sensor air gap set at 0.010 inches (0.254 mm)? <b>NOTE:</b> If air gap is too large, engine will likely backfire during cranking.	Go to step 2.	Adjust as necessary.
2	1. Obtain two Briggs & Stratton Spark Testers (Part No. 19368). 2. Install spark testers in line with high tension leads and spark plugs. 3. Look for spark in tester windows while cranking engine. 4. Is spark observed?	Go to step 3.	Repair or replace spark plugs and/or high tension lead/ignition coil.
3	1. Turn Ignition OFF. 2. Check valve lash adjustment. 3. Is valve lash within specification?	Go to step 4.	Adjust as necessary.
4	1. Replace CKP sensor. 2. Is problem corrected?	-	Repair or replace EFI wire harness.



**Spark Tester (Part No. 19368)**

## SPN 637 CRANKSHAFT LOSS OF SYNCHRONIZATION



### Circuit Description

The CKP sensor works in conjunction with the 23X reluctor target wheel on the flywheel. Each tooth on the reluctor wheel is equally spaced with 1 tooth missing for the reference sync pulse. As the crankshaft rotates, the reluctor target wheel interrupts a magnetic field produced by an internal sensor magnet. The CKP sensor internal circuitry detects this interruption, and produces an ON/OFF AC voltage of varying frequency. The frequency of the CKP sensor output signal is dependent upon crankshaft speed. The ECM uses each CKP sensor output signal to determine crankshaft speed and identify crankshaft position.

With the spark under control of the ECM, the engine will not run if the CKP sensor signal is lost. The ECM will not be able to determine which stroke the pistons are on.

### Possible FMIs

The possible FMIs for SPN 637 are as follows:

FMI	Description
2	Gap Position Incorrect
7	Missing Crankshaft Sensor Signal
8	Crankshaft Fail During Valid Teeth Phase

**FMI 2:** Erratic signal possibly caused by excessive air gap or electronic noise.

**FMI 8:** Abnormal frequency due to excessive air gap or metallic debris on sensor.



## SPN 637, FMI 2: Gap Position Incorrect

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Disconnect cylinder 1 fuel injector connector. 3. Install Briggs & Stratton Noid Light (Part No. 19623). 4. Observe Noid Light while cranking engine. 5. Does Noid Light flash?	Go to step 2.	Go to step 2.
2	1. Turn Ignition OFF. 2. Obtain two Briggs & Stratton Spark Testers (Part No. 19368). 3. Install spark testers in line with high tension leads and spark plugs. 4. Look for spark in tester windows while cranking engine. 5. Is spark observed?	Check CKP sensor connections.	Go to step 3.
3	1. Turn Ignition OFF. 2. Check CKP sensor air gap. 3. Is CKP sensor air gap set at 0.010 inches (0.254 mm)? <b>NOTE:</b> If air gap is too large, engine will likely backfire during cranking.	Go to step 4.	Adjust as necessary.
4	1. Turn Ignition OFF. 2. Replace CKP sensor. 3. Is problem corrected?		Repair or replace EFI wire harness.



**Noid Light (Part No. 19623)**



**Spark Tester (Part No. 19368)**

## SPN 637, FMI 7: Missing Crankshaft Sensor Signal

2

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Disconnect and connect CKP sensor connector. 3. Attempt to start engine. Does engine start?	Problem corrected.	Go to step 2.
2	1. Turn Ignition OFF. 2. Check CKP sensor air gap. 3. Is CKP sensor air gap set at 0.010 inches (0.254 mm)?  <b>NOTE:</b> If air gap is too large, engine will likely backfire during cranking.	Go to step 3.	Adjust as necessary.  Go to step 3 if engine still does not start.
3	1. Turn Ignition OFF. 2. Replace CKP sensor and set air gap at 0.010 inches (0.254 mm). 3. Is problem corrected?	-	Repair or replace EFI wire harness.

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# SPN 639 CAN BUS OFFLINE

## Circuit Description

The The ECM monitors CAN Bus network and messages. If 120 occurrences of being offline are detected the code is set. Inspect the CAN bus wires for breakage, damage or loose wiring connections. If the cause of the fault is not determined, examine CAN BUS with an oscilloscope.

## Possible FMIs

The possible FMIs for SPN 639 are as follows:

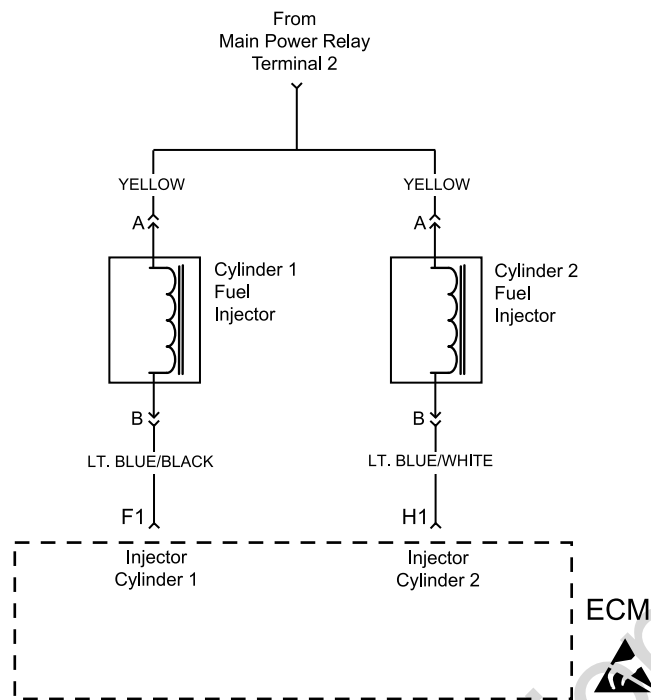
FMI	Description
19	Network CAN Bus is not Detected

2

Not for  
Reproduction

# SPN 651 CYLINDER 1 FUEL INJECTOR

2



## Circuit Description

The ECM controls each fuel injector by grounding the control circuit via a solid state device called a driver. If the ECM detects an unacceptable difference in resistance, a fuel injector control DTC is set.

Although the DTC indicates which fuel injector is faulty, the technician must determine if the fault is in the ground circuit or the +12v circuit from the main power relay.

**NOTE:** Injector resistance between terminals A and B should be 11.5-13.5 ohms.

**NOTE:** If an ignition coil fault code is active, the fuel injector for the same cylinder is turned off.

## Possible FMIs

The possible FMIs for SPN 651 are as follows:

FMI	Description
3	Signal Voltage High
4	Signal Voltage Low/Open

SPN 651, FMI 3: Signal Voltage High

Step	Action	Yes	No
1	1. Do the Injector Cylinder 1 Firing Test. See <i>TEST PROCEDURES</i> in this section.  2. Did the test Pass?	Problem does not currently exist.	Go to step 2.
2	1. Turn Ignition OFF.  2. Disconnect fuel injector connector.  3. Install Briggs & Stratton Noid Light (Part No. 19623).  4. Start and run engine.  5. Does Noid Light flash?	Replace fuel injector.	Go to step 3.
3	1. Turn Ignition OFF.  2. Remove Noid Light and connect fuel injector connector.  3. Back probe (using fused patch cord) terminal A (Yellow wire) of fuel injector connector.  4. Connect terminal A back probe to red meter test lead on DVOM.  5. Connect black meter test lead to a known good ground.  6. Set DVOM to read volts DC.  7. Turn Ignition ON, Engine OFF.  8. Does DVOM read 12.2-13.5 volts DC?	Go to step 4.	Reading is below 12.2 volts DC.  Do a visual and continuity check of the Main Power Relay and 10 amp Battery fuse (Red).
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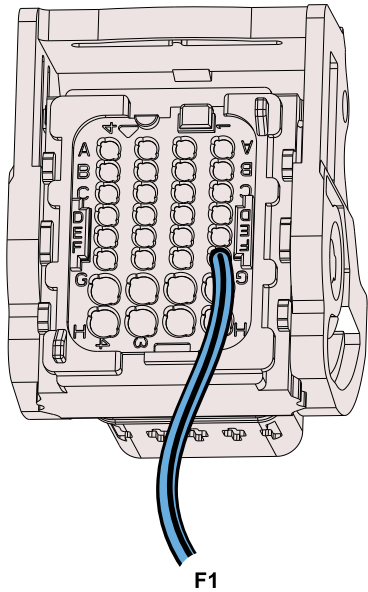
2



Noid Light  
(Part No. 19623)



Fuel Injector Connector  
Cylinder 1



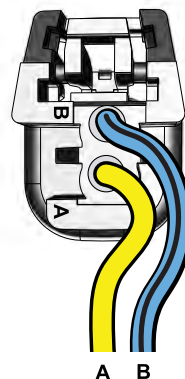
ECM Connector

Step	Action	Yes	No
4	<ol style="list-style-type: none"><li>1. Turn Ignition OFF.</li><li>2. Disconnect fuel injector connector.</li><li>3. Disconnect ECM connector.</li><li>4. Back probe terminal B (Lt. Blue/Black wire) of fuel injector connector.</li><li>5. Connect terminal B back probe to red meter test lead on DVOM.</li><li>6. Back probe terminal F1 (Lt. Blue/Black wire) of ECM connector.</li><li>7. Connect terminal F1 back probe to black meter test lead on DVOM.</li><li>8. Set DVOM to read resistance.</li><li>9. Does DVOM read less than 0.5 ohms?</li></ol>	Control circuit is OK.	<p>Reading is above 0.5 ohms. Check terminals for corrosion or replace EFI wire harness.</p> <p><b>NOTE:</b> If DTC still present after replacement of EFI wire harness, then replace ECM due to failed injector driver.</p>

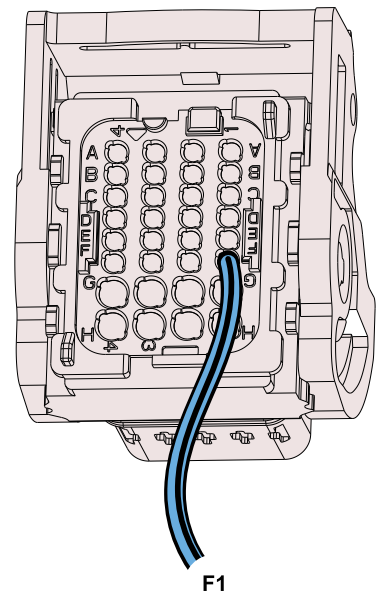
Not for  
Reproduction

## SPN 651, FMI 4: Signal Voltage Low/Open

Step	Action	Yes	No
1	1. Do the Injector Cylinder 1 Firing Test. See <i>TEST PROCEDURES</i> in this section.  2. Did the test Pass?	Problem does not currently exist.	Go to step 2.
2	1. Turn Ignition OFF.  2. Back probe terminal F1 (Lt. Blue/Black wire) of ECM connector.  3. Connect terminal F1 back probe to red meter test lead on DVOM.  4. Connect black meter test lead to a known good ground.  5. Set DVOM to read volts DC.  6. Turn Ignition ON, Engine OFF.  7. Does DVOM read 12.2-13.5 volts DC?	No problem.	Go to step 3.
3	1. Turn Ignition OFF.  2. Back probe (using fused patch cord) terminal A (Yellow wire) of fuel injector connector.  3. Connect terminal A back probe to black meter test lead on DVOM.  4. Set DVOM to read resistance.  5. Turn Ignition ON, Engine OFF.  6. Does DVOM read open line O/L (no continuity)?	Go to step 4.	Repair or replace wire between ECM and fuel injector, or replace EFI wire harness.
4	1. Turn Ignition OFF.  2. Remove back probe from terminal F1 of ECM connector.  3. Back probe terminal B (Lt. Blue/Black wire) of fuel injector connector.  4. Connect terminal B back probe to red meter test lead on DVOM.  5. Turn Ignition ON, Engine OFF.  6. Does DVOM read open line O/L (no continuity)?	Injector OK.	Replace Injector



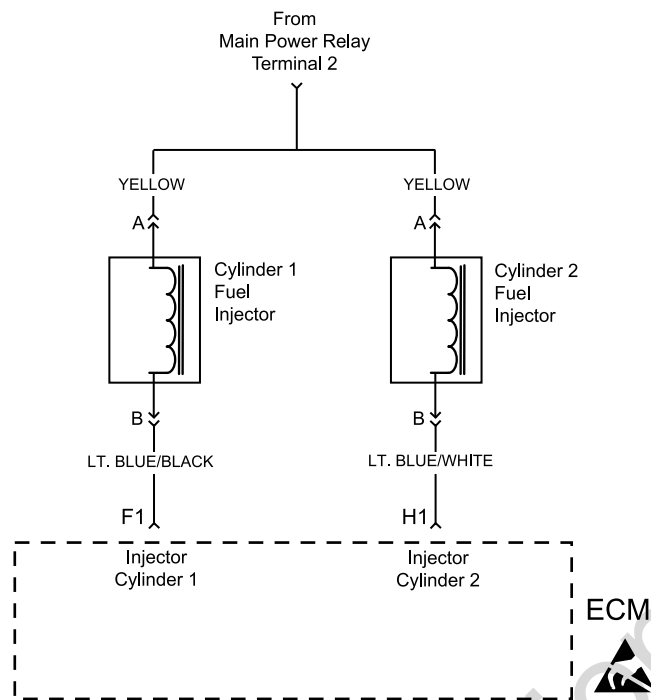
**Fuel Injector Connector  
Cylinder 1**



**ECM Connector**

# SPN 652 CYLINDER 2 FUEL INJECTOR

2



## Circuit Description

The ECM controls each fuel injector by grounding the control circuit via a solid state device called a driver. If the ECM detects an unacceptable difference in resistance, a fuel injector control DTC is set.

Although the DTC indicates which fuel injector is faulty, the technician must determine if the fault is in the ground circuit or the +12v circuit from the main power relay.

**NOTE:** Injector resistance between terminals A and B should be 11.5-13.5 ohms.

**NOTE:** If an ignition coil fault code is active, the fuel injector for the same cylinder is turned off.

## Possible FMIs

The possible FMIs for SPN 652 are as follows:

FMI	Description
3	Signal Voltage High
4	Signal Voltage Low/Open



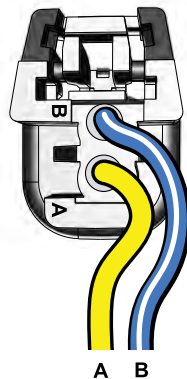
SPN 652, FMI 3: Signal Voltage High

Step	Action	Yes	No
1	1. Do the Injector Cylinder 2 Firing Test. See <i>TEST PROCEDURES</i> in this section.  2. Did the test Pass?	Problem does not currently exist.	Go to step 2.
2	1. Turn Ignition OFF.  2. Disconnect fuel injector connector.  3. Install Briggs & Stratton Noid Light (Part No. 19623).  4. Start and run engine.  5. Does Noid Light flash?	Replace fuel injector.	Go to step 3.
3	1. Turn Ignition OFF.  2. Remove Noid Light and connect fuel injector connector.  3. Back probe (using fused patch cord) terminal A (Yellow wire) of fuel injector connector.  4. Connect terminal A back probe to red meter test lead on DVOM.  5. Connect black meter test lead to a known good ground.  6. Set DVOM to read volts DC.  7. Turn Ignition ON, Engine OFF.  8. Does DVOM read 12.2-13.5 volts DC?	Go to step 4.	Reading is below 12.2 volts DC.  Do visual and continuity checks of the Main Power Relay and the 10 amp Battery fuse (Red).
Continued...			

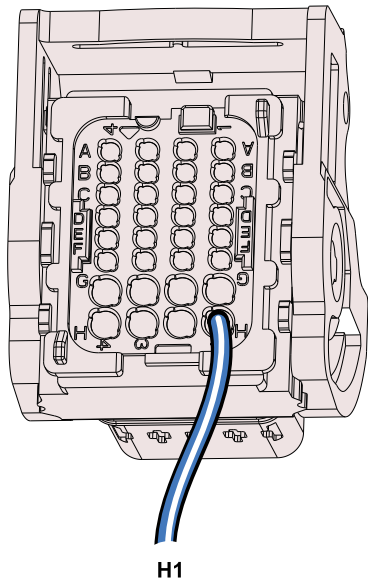
2



Noid Light  
(Part No. 19623)



Fuel Injector Connector  
Cylinder 2



ECM Connector

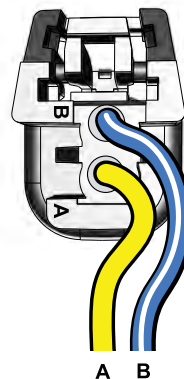
Step	Action	Yes	No
4	<ol style="list-style-type: none"><li>1. Turn Ignition OFF.</li><li>2. Disconnect fuel injector connector.</li><li>3. Disconnect ECM connector.</li><li>4. Back probe terminal B (Lt. Blue/White wire) of fuel injector connector.</li><li>5. Connect terminal B back probe to red meter test lead on DVOM.</li><li>6. Back probe terminal H1 (Lt. Blue/White wire) of ECM connector.</li><li>7. Connect terminal H1 back probe to black meter test lead on DVOM.</li><li>8. Set DVOM to read resistance.</li><li>9. Does DVOM read less than 0.5 ohms?</li></ol>	Control circuit is OK.	<p>Reading is above 0.5 ohms. Check terminals for corrosion or replace EFI wire harness.</p> <p><b>NOTE:</b> If DTC still present after replacement of EFI wire harness, then replace ECM due to failed injector driver.</p>

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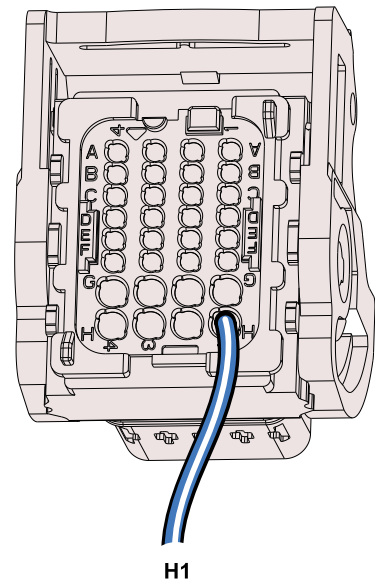
## SPN 652, FMI 4: Signal Voltage Low/Open

Step	Action	Yes	No
1	<ol style="list-style-type: none"> <li>1. Do the Injector Cylinder 2 Firing Test. See <i>TEST PROCEDURES</i> in this section.</li> <li>2. Did the test Pass?</li> </ol>	Problem does not currently exist.	Go to step 2.
2	<ol style="list-style-type: none"> <li>1. Turn Ignition OFF.</li> <li>2. Back probe terminal H1 (Lt. Blue/White wire) of ECM connector.</li> <li>3. Connect terminal H1 back probe to red meter test lead on DVOM.</li> <li>4. Connect black meter test lead to a known good ground.</li> <li>5. Set DVOM to read volts DC.</li> <li>6. Turn Ignition ON, Engine OFF.</li> <li>7. Does DVOM read 12.2-13.5 volts DC?</li> </ol>	No problem.	Go to step 3.
3	<ol style="list-style-type: none"> <li>1. Turn Ignition OFF.</li> <li>2. Back probe (using fused patch cord) terminal A (Yellow wire) of fuel injector connector.</li> <li>3. Connect terminal A back probe to black meter test lead on DVOM.</li> <li>4. Set DVOM to read resistance.</li> <li>5. Turn Ignition ON, Engine OFF.</li> <li>6. Does DVOM read open line O/L (no continuity)?</li> </ol>	Go to step 4.	Repair or replace wire between ECM and fuel injector, or replace EFI wire harness.
4	<ol style="list-style-type: none"> <li>1. Turn Ignition OFF.</li> <li>2. Remove back probe from terminal H1 of ECM connector.</li> <li>3. Back probe terminal B (Lt. Blue/White wire) of fuel injector connector.</li> <li>4. Connect terminal B back probe to red meter test lead on DVOM.</li> <li>5. Turn Ignition ON, Engine OFF.</li> <li>6. Does DVOM read open line O/L (no continuity)?</li> </ol>	Injector OK.	Replace Injector

2

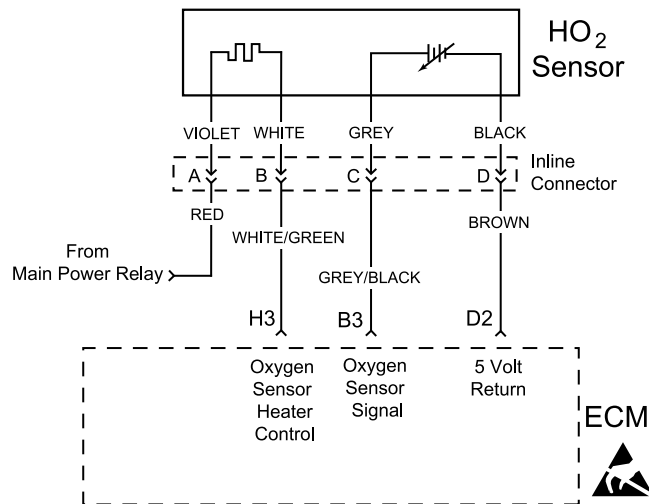


**Fuel Injector Connector  
Cylinder 2**



**ECM Connector**

## SPN 724 OXYGEN (O2) SENSOR



### Circuit Description

The oxygen sensor supplies voltage signal feedback to the ECM to help control engine fueling. The narrowband oxygen sensor operates in a narrow voltage range from 0 - 1 V. The circuit voltage is monitored to detect oxygen sensor issues. A oxygen sensor heater supplies faster sensor warm-up and improved sensor operation. If oxygen sensor diagnostics are active, the engine ECM reverts to open loop fueling operation and continues to function. The oxygen sensor can be replaced if the oxygen sensor diagnostics are active.

The oxygen sensor voltage varies from about 1.0 volt if the exhaust is rich down to about 0.1 volt if the exhaust is lean. The ECM applies about 3.5 volts to this circuit for diagnostics when the ignition is on or the engine is running. Default operation is in an open loop that is maintained until engine head temperature is above 130 °F (54 °C) and the engine load is low to moderate. Only then will closed loop operation become available. The oxygen sensor heater provides for faster sensor warm-up. This allows the sensor to become active in a shorter period of time and remain active during a long extended idle.

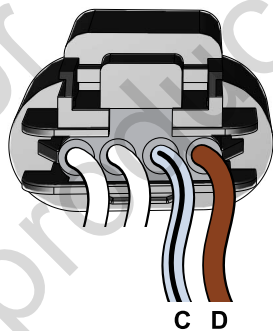
### Possible FMIs

An active or current SPN 724 code indicates that the circuit is experiencing a problem and is operating in Open Loop mode by default. The possible FMIs for SPN 724 are as follows:

FMI	Description
3	Circuit Voltage Returned to ECM is Too High
4	Circuit Voltage Returned to ECM is Too Low or Shorted to Ground
5	Circuit from O <sub>2</sub> Sensor to ECM is Open

SPN 724, FMI 3: Sensor Shorted High

Step	Action	Yes	No
1	<div>1. Turn Ignition OFF.</div> <div>2. Back probe (using fused patch cord) terminal C (Grey/Black wire) on engine side of O<sub>2</sub> sensor connector.</div> <div>3. Connect terminal C back probe to red meter test lead on DVOM.</div> <div>4. Back probe terminal D (Brown wire) on engine side of O<sub>2</sub> sensor connector.</div> <div>5. Connect terminal D back probe to black meter test lead on DVOM.</div> <div>6. Set DVOM to read volts DC.</div> <div>7. Turn Ignition ON, Engine Off.</div> <div>8. Observe voltage on DVOM.</div> <div>9. Is reading 2.5-4.0 volts DC?</div>	<div>Go to step 2.</div>	<div>Ensure probe connectivity.</div>
2	<div>1. Start and run engine.</div> <div>2. Observe voltage on DVOM.</div> <div>3. Within 30 seconds, does voltage reading drop to less than 1000 millivolts, and then continue to drop?</div>	<div>O<sub>2</sub> sensor OK.</div> <div>Clear codes and retest.</div>	<div>Replace O<sub>2</sub> sensor.</div>

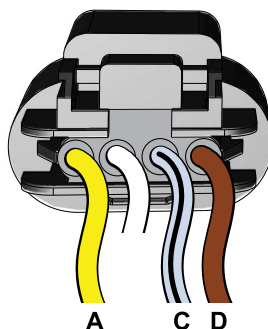


O<sub>2</sub> Sensor Connector

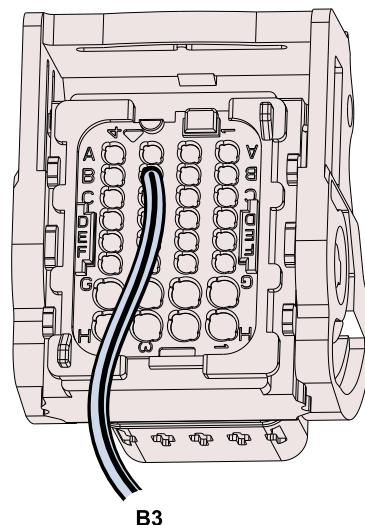
## SPN 724, FMI 4: Sensor Shorted Low

2

Step	Action	Yes	No
1	<ol style="list-style-type: none"> <li>Turn Ignition OFF.</li> <li>Back probe (using fused patch cord) terminal A (Yellow wire) on engine side of O<sub>2</sub> sensor connector.</li> <li>Connect terminal A back probe to red meter test lead on DVOM.</li> <li>Back probe terminal D (Brown wire) on engine side of O<sub>2</sub> sensor connector.</li> <li>Connect terminal D back probe to black meter test lead on DVOM.</li> <li>Set DVOM to read volts DC.</li> <li>Turn Ignition ON, Engine Off.</li> <li>Does DVOM read 2.5-4.0 volts DC?</li> </ol>	Go to step 2.	Do a visual and continuity check of Main Power Relay and 10 amp Battery fuse (Red).
2	<ol style="list-style-type: none"> <li>Turn Ignition OFF.</li> <li>Remove probe from terminal A, and back probe terminal C (Grey/Black wire) on engine side of O<sub>2</sub> sensor connector.</li> <li>Turn Ignition ON, Engine OFF.</li> <li>Does DVOM read 2.5-4.0 volts DC?</li> </ol>	Go to step 3.	Replace O <sub>2</sub> sensor.
3	<ol style="list-style-type: none"> <li>Turn Ignition OFF.</li> <li>Remove probe from terminal C, and back probe ECM connector terminal B3 (Grey/Black wire).</li> <li>Connect terminal B3 back probe to red meter test lead on DVOM.</li> <li>Turn Ignition ON, Engine OFF.</li> <li>Does DVOM read 2.5-4.0 volts DC?</li> </ol>	Both EFI wire harness and O <sub>2</sub> sensor are good.	Go to step 4.
4	Are both O <sub>2</sub> sensor and ECM connectors fully mated?	Repair or replace EFI wire harness.	Connect connectors.



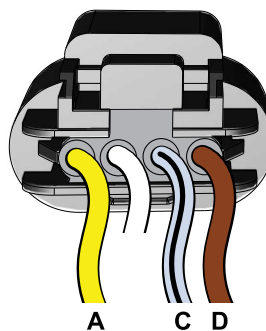
O<sub>2</sub> Sensor Connector



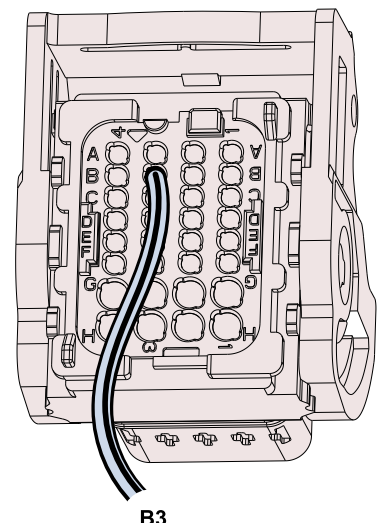
ECM Connector

## SPN 724, FMI 5: Sensor Open

Step	Action	Yes	No
1	<ol style="list-style-type: none"> <li>1. Turn Ignition OFF.</li> <li>2. Back probe (using fused patch cord) terminal A (Yellow wire) on engine side of O<sub>2</sub> sensor connector.</li> <li>3. Connect terminal A back probe to red meter test lead on DVOM.</li> <li>4. Back probe terminal D (Brown wire) on engine side of O<sub>2</sub> sensor connector.</li> <li>5. Connect terminal D back probe to black meter test lead on DVOM.</li> <li>6. Set DVOM to read volts DC.</li> <li>7. Turn Ignition ON, Engine Off.</li> <li>8. Does DVOM read 2.5-4.0 volts DC?</li> </ol>	Go to step 2.	Do a visual and continuity check of Main Power Relay and 10 amp Battery fuse (Red).
2	<ol style="list-style-type: none"> <li>1. Turn Ignition OFF.</li> <li>2. Remove probe from terminal A, and back probe terminal C (Grey/Black wire) on engine side of O<sub>2</sub> sensor connector.</li> <li>3. Turn Ignition ON, Engine OFF.</li> <li>4. Does DVOM read 2.5-4.0 volts DC?</li> </ol>	Go to step 3.	Replace O <sub>2</sub> sensor.
3	<ol style="list-style-type: none"> <li>1. Turn Ignition OFF.</li> <li>2. Remove probe from terminal C, and back probe ECM connector terminal B3 (Grey/Black wire).</li> <li>3. Connect terminal B3 back probe to red meter test lead on DVOM.</li> <li>4. Turn Ignition ON, Engine OFF.</li> <li>5. Does DVOM read 2.5-4.0 volts DC?</li> </ol>	Both EFI wire harness and O <sub>2</sub> sensor are good.	Go to step 4.
4	Are both O <sub>2</sub> sensor and ECM connectors fully mated?	Repair or replace EFI wire harness.	Connect connectors.



O<sub>2</sub> Sensor Connector



ECM Connector

## SPN 818 VOLTAGE PROTECTION

---

### Circuit Description

2

The ECM uses a 5 volt reference system for various sensor functions. The ECM also monitors performance of the 5 volt system, and detects if the system has been shorted to ground, or shorted to battery voltage. The system is current limited, so damage will not occur in either event. However, the system temperature may increase causing FMI 16 to set.

### Possible FMIs

The possible FMIs for SPN 818 are as follows:

FMI	Description
3	5V Supply High
4	5V Supply Low or Shorted to Ground
16	Over Temperature

**FMI 16:** Over temperature of the 5 volt voltage regulator.

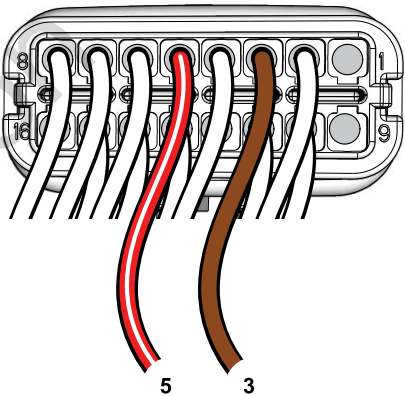
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SPN 818, FMI 3: 5V Supply Shorted High

Step	Action	Yes	No
1	<div>1. Turn Ignition OFF.</div> <div>2. Back probe terminal 5 (Red/White wire) at the main vehicle connector.</div> <div>3. Connect terminal 5 back probe to red meter test lead on DVOM.</div> <div>4. Back probe terminal 3 (Brown wire) at the main vehicle connector.</div> <div>5. Connect terminal 3 back probe to black meter test lead on DVOM.</div> <div>6. Set DVOM to read volts DC.</div> <div>7. Turn Ignition ON, Engine OFF.</div> <div>8. Does DVOM read greater than 5 volts DC?</div>	<div>Replace EFI wire harness, or locate and repair 5 volt wire shorted to battery voltage.</div> <div>Disconnect main vehicle connector from equipment to see if any change occurs.</div>	<div>No current issue.</div>

2

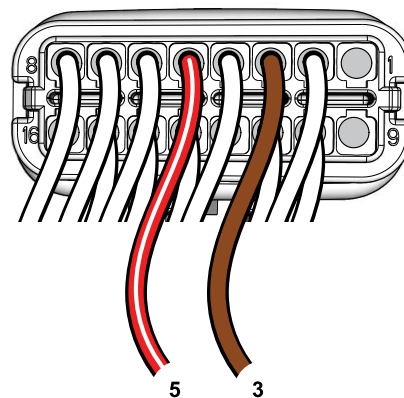


Main Vehicle Connector

## SPN 818, FMI 4: 5V Supply Shorted Low

2

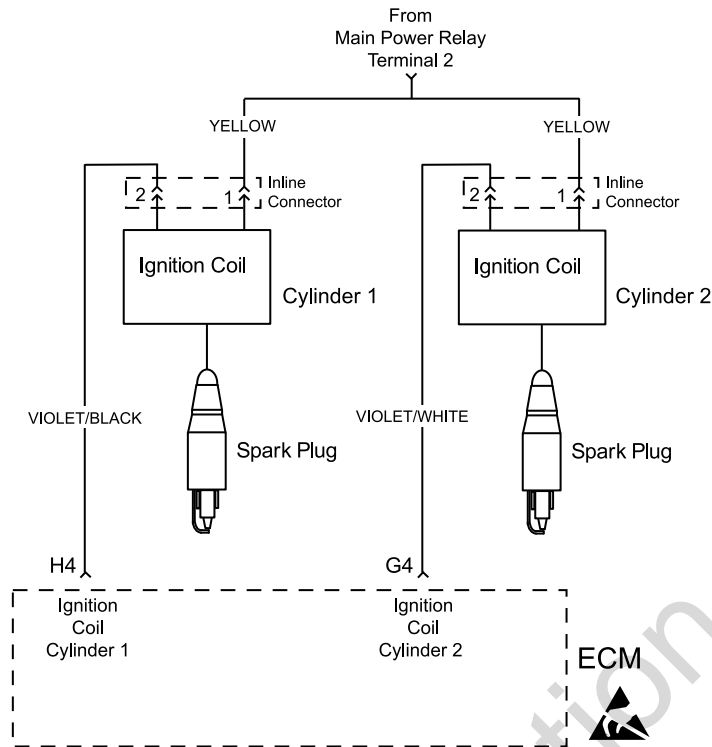
Step	Action	Yes	No
1	<ol style="list-style-type: none"> <li>1. Turn Ignition OFF.</li> <li>2. Back probe terminal 5 (Red/White wire) at the main vehicle connector.</li> <li>3. Connect terminal 5 back probe to red meter test lead on DVOM.</li> <li>4. Back probe terminal 3 (Brown wire) at the main vehicle connector.</li> <li>5. Connect terminal 3 back probe to black meter test lead on DVOM.</li> <li>6. Set DVOM to read volts DC.</li> <li>7. Turn Ignition ON, Engine OFF.</li> <li>8. Does DVOM read 5 volts DC?</li> </ol>	No current issue.	Go to step 2.
2	<ol style="list-style-type: none"> <li>1. Turn Ignition OFF.</li> <li>2. Disconnect main vehicle connector from equipment.</li> <li>3. Turn Ignition ON, Engine OFF.</li> <li>4. Does DVOM read 0 volts DC?</li> </ol>	Go to step 3.	Locate and correct problem on equipment side.
3	<ol style="list-style-type: none"> <li>1. Turn Ignition OFF.</li> <li>2. Disconnect ECM connector.</li> <li>3. Set DVOM to read resistance.</li> <li>4. Remove back probe from terminal 3. Connect black meter test lead on DVOM to battery negative terminal.</li> <li>5. Is resistance found (and <b>not</b> O/L)?</li> </ol>	Replace EFI wire harness, or locate and repair short to ground.	Replace ECM.



Main Vehicle Connector

## SPN 1268 CYLINDER 1 IGNITION COIL

2



### Circuit Description

Each ignition coil has an ignition (B+ voltage) and a ground circuit. The ECM controls the ignition coil by completing the ground circuit as needed.

The DTC's indicate which ignition coil circuit has an issue. The issue may be in the circuit itself with loose or damaged wiring or in the ignition coil for the respective cylinder. When an ignition circuit fault is set the ECM also shuts down the fuel injector for the same cylinder.

The engine continues to run on one cylinder if no fault is set for the opposite cylinder.

### Possible FMIs

The possible FMIs for SPN 1268 are as follows:

FMI	Description
3	Signal Voltage High
4	Signal Voltage Low/Open

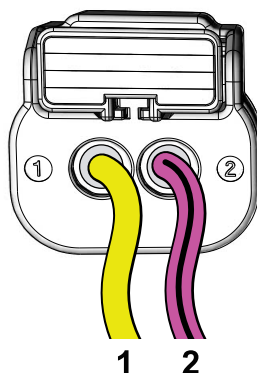
## SPN 1268, FMI 3: Signal Voltage High

2

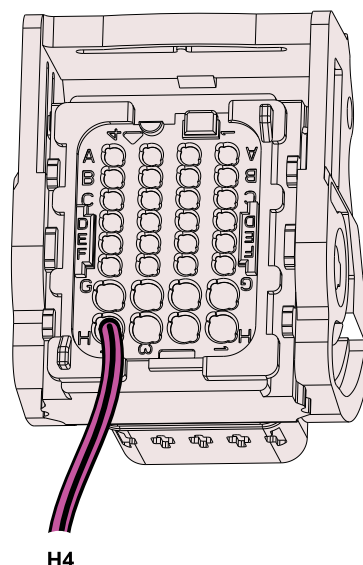
Step	Action	Yes	No
1	1. Do the Ignition Coil Cylinder 1 Spark Test. See <i>TEST PROCEDURES</i> in this section. 2. Did the test Pass?	Problem does not currently exist.	Go to step 2.
2	1. Turn Ignition OFF. 2. Obtain two Briggs & Stratton Spark Testers (Part No. 19368). 3. Install spark testers in line with high tension leads and spark plugs. 4. Look for spark in tester windows while cranking engine. 5. Is spark observed?	No current problem.	Go to step 3.
3	1. Turn Ignition OFF. 2. Back probe (using fused patch cord) terminal 1 (Yellow wire) of ignition coil connector. 3. Connect terminal 1 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to a known good ground. 5. Set DVOM to read volts DC. 6. Turn Ignition ON, Engine OFF. 7. Does DVOM read 12.2-13.5 volts DC?	Go to step 4.	Reading is below 12.2 volts DC.  Do a visual and continuity check of Main Power Relay and 10 amp Battery fuse (Red).
4	1. Turn Ignition OFF. 2. Remove probe from terminal 1, and back probe terminal 2 (Violet/Black wire) of ignition coil connector. 3. Disconnect ECM connector. 4. Back probe terminal H4 (Violet/Black wire) of ECM connector. 5. Connect terminal H4 back probe to black meter test lead on DVOM. 6. Set DVOM to read resistance. 7. Does DVOM read 0.5 ohms or less?	Replace ignition coil.	Resistance reading is above 0.5 ohms.  Repair or replace EFI wire harness.



**Spark Tester  
(Part No. 19368)**



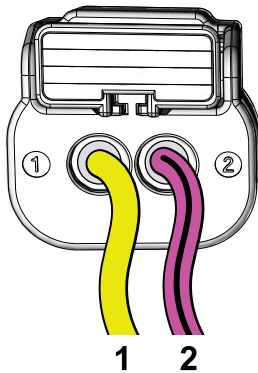
**Ignition Coil Connector  
Cylinder 1**



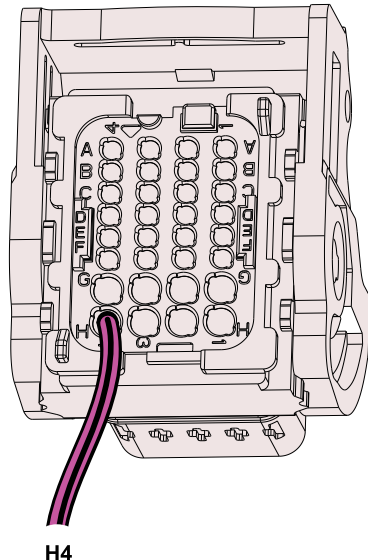
**ECM Connector**

SPN 1268, FMI 4: Signal Voltage Low/Open

Step	Action	Yes	No
1	1. Do the Ignition Coil Cylinder 1 Spark Test. See <i>TEST PROCEDURES</i> in this section.  2. Did the test Pass?	Problem does not currently exist.	Go to step 2.
2	1. Turn Ignition OFF.  2. Back probe terminal H4 (Violet/Black wire) of ECM connector.  3. Connect terminal H4 back probe to red meter test lead on DVOM.  4. Connect black meter test lead to a known good ground.  5. Set DVOM to read volts DC.  6. Turn Ignition ON, Engine OFF.  7. Does DVOM read 12.2-13.5 volts DC?	No problem.	Go to step 3.
3	1. Turn Ignition OFF.  2. Back probe (using fused patch cord) terminal A (Yellow wire) of ignition coil connector.  3. Connect terminal A back probe to black meter test lead on DVOM.  4. Set DVOM to read resistance.  5. Turn Ignition ON, Engine OFF.  6. Does DVOM read open line O/L (no continuity)?	Go to step 4.	Repair or replace wire between ECM and ignition coil, or replace EFI wire harness.
4	1. Turn Ignition OFF.  2. Remove back probe from terminal H4 of ECM connector.  3. Back probe terminal B (Violet/Black wire) of ignition coil connector.  4. Connect terminal B back probe to red meter test lead on DVOM.  5. Turn Ignition ON, Engine OFF.  6. Does DVOM read open line O/L (no continuity)?	Ignition coil OK.	Replace ignition coil.



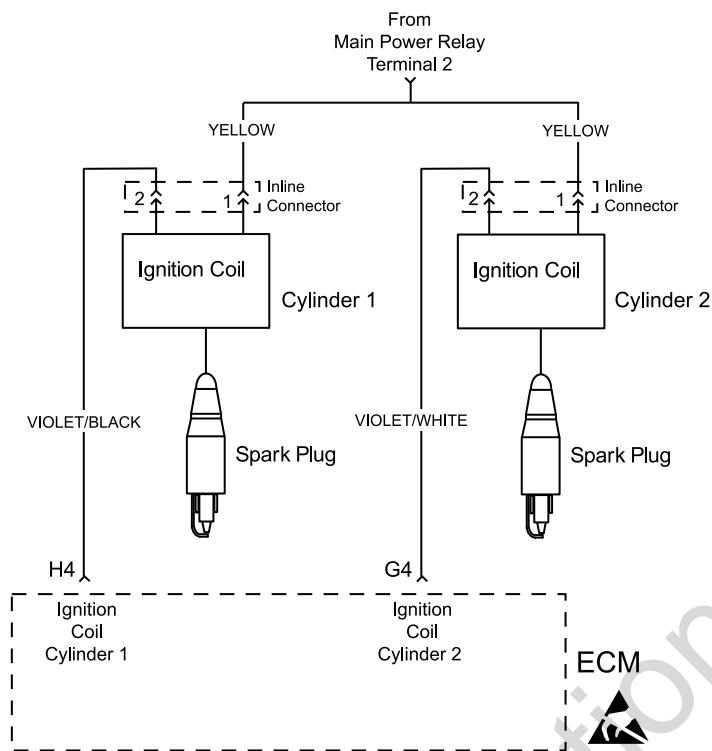
Ignition Coil Connector  
Cylinder 1



ECM Connector

## SPN 1269 CYLINDER 2 IGNITION COIL

2



### Circuit Description

Each ignition coil has an ignition (B+ voltage) and a ground circuit. The ECM controls the ignition coil by completing the ground circuit as needed.

The DTC's indicate which ignition coil circuit has an issue. The issue may be in the circuit itself with loose or damaged wiring or in the ignition coil for the respective cylinder. When an ignition circuit fault is set the ECM also shuts down the fuel injector for the same cylinder.

The engine continues to run on one cylinder if no fault is set for the opposite cylinder.

### Possible FMIs

The possible FMIs for SPN 1269 are as follows:

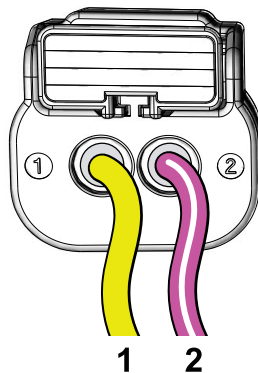
FMI	Description
3	Signal Voltage High
4	Signal Voltage Low/Open

## SPN 1269, FMI 3: Signal Voltage High

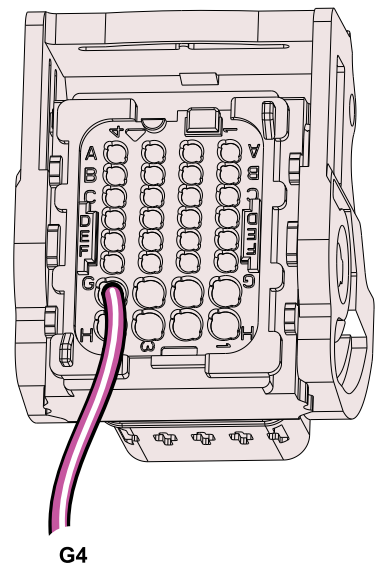
Step	Action	Yes	No
1	1. Do the Ignition Coil Cylinder 2 Spark Test. See <i>TEST PROCEDURES</i> in this section. 2. Did the test Pass?	Problem does not currently exist.	Go to step 2.
2	1. Turn Ignition OFF. 2. Obtain two Briggs & Stratton Spark Testers (Part No. 19368). 3. Install spark testers in line with high tension leads and spark plugs. 4. Look for spark in tester windows while cranking engine. 5. Is spark observed?	No current problem.	Go to step 3.
3	1. Turn Ignition OFF. 2. Back probe (using fused patch cord) terminal 1 (Yellow wire) of ignition coil connector. 3. Connect terminal 1 back probe to red meter test lead on DVOM. 4. Connect black meter test lead on DVOM to a known good ground. 5. Set DVOM to read volts DC. 6. Turn Ignition ON, Engine OFF. 7. Does DVOM read 12.2-13.5 volts DC?	Go to step 4.	Reading is below 12.2 volts DC.  Do visual and continuity checks of the Main Power Relay and the 10 amp Battery fuse (Red).
4	1. Turn Ignition OFF. 2. Remove probe from terminal 1, and back probe terminal 2 (Violet/White wire) of ignition coil connector. 3. Disconnect ECM connector. 4. Back probe terminal G4 (Violet/Black wire) of ECM connector. 5. Connect terminal G4 back probe to black meter test lead on DVOM. 6. Set DVOM to read resistance. 7. Does DVOM read 0.5 ohms or less?	Replace ignition coil.	Resistance reading is above 0.5 ohms.  Repair or replace EFI wire harness.



**Spark Tester  
(Part No. 19368)**



**Ignition Coil Connector  
Cylinder 2**

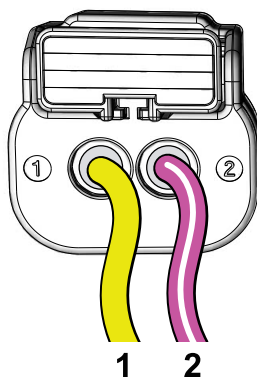


**ECM Connector**

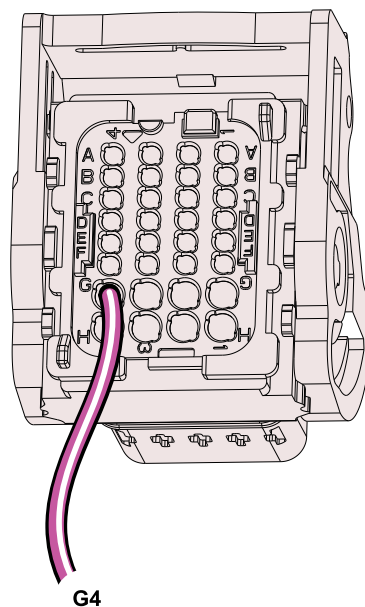
## SPN 1269, FMI 4: Signal Voltage Low/Open

2

Step	Action	Yes	No
1	1. Do the Ignition Coil Cylinder 2 Spark Test. See <i>TEST PROCEDURES</i> in this section.  2. Did the test Pass?	Problem does not currently exist.	Go to step 2.
2	1. Turn Ignition OFF.  2. Back probe terminal G4 (Violet/White wire) of ECM connector.  3. Connect terminal G4 back probe to red meter test lead on DVOM.  4. Connect black meter test lead to a known good ground.  5. Set DVOM to read volts DC.  6. Turn Ignition ON, Engine OFF.  7. Does DVOM read 12.2-13.5 volts DC?	No problem.	Go to step 3.
3	1. Turn Ignition OFF.  2. Back probe (using fused patch cord) terminal A (Yellow wire) of ignition coil connector.  3. Connect terminal A back probe to black meter test lead on DVOM.  4. Set DVOM to read resistance.  5. Turn Ignition ON, Engine OFF.  6. Does DVOM read open line O/L (no continuity)?	Go to step 4.	Repair or replace wire between ECM and ignition coil, or replace EFI wire harness.
4	1. Turn Ignition OFF.  2. Remove back probe from terminal G4 of ECM connector.  3. Back probe terminal B (Violet/White wire) of ignition coil connector.  4. Connect terminal B back probe to red meter test lead on DVOM.  5. Turn Ignition ON, Engine OFF.  6. Does DVOM read open line O/L (no continuity)?	Ignition coil OK.	Replace ignition coil.



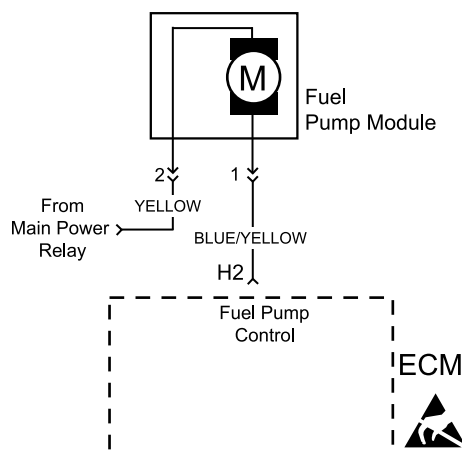
Ignition Coil Connector  
Cylinder 2



ECM Connector



## SPN 1347 ELECTRICAL FUEL PUMP FAILURE



### Circuit Description

The fuel pump is controlled by the ECM via the ground circuit of the fuel pump plug. If resistance is unacceptable in that circuit the fuel pump DTC is set.

When the ignition switch is turned ON, the ECM activates the electric fuel pump module. The fuel pump module remains ON as long as the ECM receives reference pulses from the CKP sensor. If there are no reference pulses, the ECM turns the fuel pump relay OFF after about 2 seconds. This shuts off the fuel pump. The fuel pump module delivers fuel to the fuel rail and fuel injectors.

### Possible FMIs

The possible FMIs for SPN 1347 are as follows:

FMI	Description
3	Circuit Shorted High
4	Circuit Shorted Low
5	Circuit Open

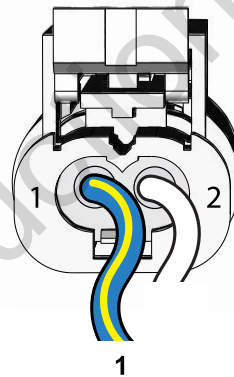
**FMI 3:** Indicates that higher than expected voltage is seen on the circuit, which means that the fuel pump is not providing enough resistance or is turning too slowly.

**FMI 4:** Shows that the signal voltage is low, which indicates voltage is lost to the pump, high circuit resistance, or open connection.

**FMI 5:** Indicates that the circuit is broken.

## SPN 1347, FMI 3: Circuit Shorted High

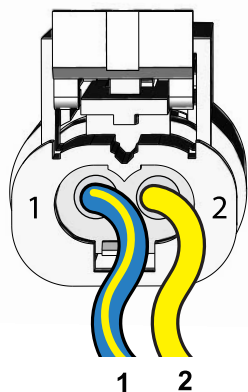
Step	Action	Yes	No
1	1. Do the Fuel Pump Module Actuation Test. See <i>TEST PROCEDURES</i> in this section.  2. Did the test Pass?	Problem does not currently exist.	Go to step 2.
2	1. Turn Ignition OFF.  2. Back probe terminal 1 (Blue/Yellow wire) of fuel pump module connector.  3. Connect terminal 1 back probe to red meter test lead on DVOM.  4. Connect black meter test lead on DVOM to a known good ground.  5. Set DVOM to read volts DC.  6. Attempt to start engine while observing voltage on DVOM.  7. Is reading below 1.0 volts DC?  <b>NOTE:</b> It is OK if engine starts.	System is operating OK.	Reading is above 1.0 volts DC.  Replace fuel pump module.



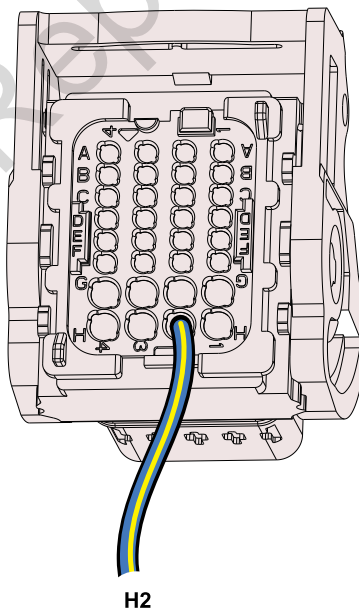
**Fuel Pump Module Connector**

SPN 1347, FMI 4: Circuit Shorted Low

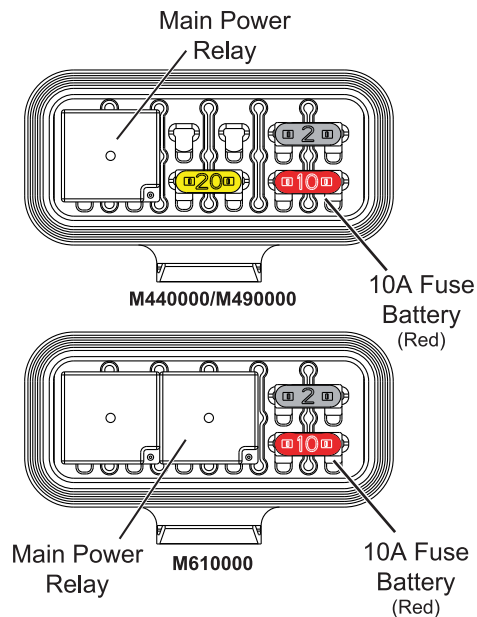
Step	Action	Yes	No
1	1. Do the Fuel Pump Module Actuation Test. See <i>TEST PROCEDURES</i> in this section.  2. Did the test Pass?	Problem does not currently exist.	Go to step 2.
2	1. Turn Ignition OFF, and then back ON.  2. Does fuel pump run for 5 seconds?	Fuel pump module OK.	Go to step 3.
3	1. Turn Ignition OFF.  2. Back probe terminal 2 (Yellow wire) of fuel pump module connector.  3. Connect terminal 2 back probe to red meter test lead on DVOM.  4. Connect black meter test lead on DVOM to a known good ground.  5. Set DVOM to read volts DC.  6. Turn Ignition ON, Engine OFF.  7. Does DVOM read 12.2-13.5 volts DC?	Go to step 4.	Do a visual and continuity check of Main Power Relay (Terminal 2) and 10 amp Battery fuse (Red).
4	1. Turn Ignition OFF.  2. Disconnect fuel pump module connector.  3. Remove probe from terminal 2, and back probe terminal 1 (Blue/Yellow wire) of fuel pump module connector.  4. Disconnect ECM connector.  5. Back probe terminal H2 (Blue/Yellow wire) of ECM connector.  6. Connect terminal H2 back probe to black meter test lead on DVOM.  7. Set DVOM to read resistance.  8. Does DVOM read 0.5 ohm or less?	Replace fuel pump module.	Resistance reading is above 0.5 ohm.  Check terminals for corrosion or replace EFI wire harness.



Fuel Pump Module Connector



ECM Connector

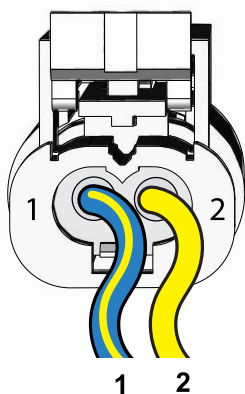


Fuse/Relay Block

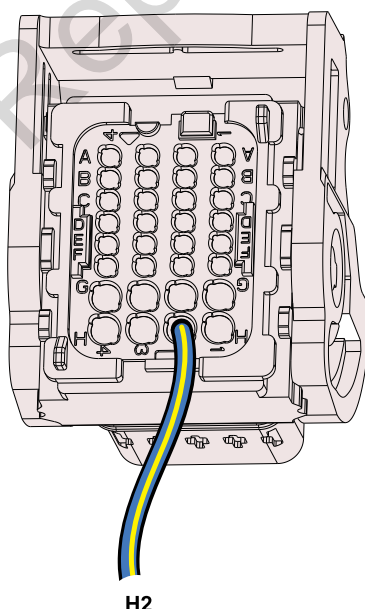
## SPN 1347, FMI 5: Circuit Open

2

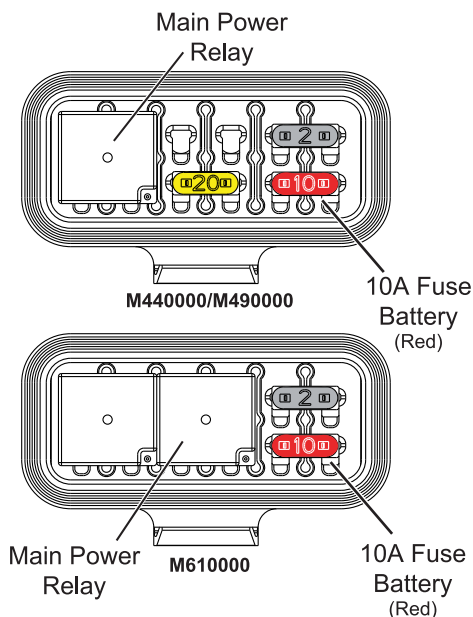
Step	Action	Yes	No
1	1. Do the Fuel Pump Module Actuation Test. See <i>TEST PROCEDURES</i> in this section.  2. Did the test Pass?	Problem does not currently exist.	Go to step 2.
2	1. Turn Ignition OFF, and then back ON.  2. Does fuel pump run for 5 seconds?	Fuel pump module OK.	Go to step 3.
3	1. Turn Ignition OFF.  2. Back probe terminal 2 (Yellow wire) of fuel pump module connector.  3. Connect terminal 2 back probe to red meter test lead on DVOM.  4. Connect black meter test lead on DVOM to a known good ground.  5. Set DVOM to read volts DC.  6. Turn Ignition ON, Engine OFF.  7. Does DVOM read 12.2-13.5 volts DC?	Go to step 4.	Do a visual and continuity check of Main Power Relay (Terminal 2) and 10 amp Battery fuse (Red).
4	1. Turn Ignition OFF.  2. Disconnect fuel pump module connector.  3. Remove probe from terminal 2, and back probe terminal 1 (Blue/Yellow wire) of fuel pump module connector.  4. Disconnect ECM connector.  5. Back probe terminal H2 (Blue/Yellow wire) of ECM connector.  6. Connect terminal H2 back probe to black meter test lead on DVOM.  7. Set DVOM to read resistance.  8. Does DVOM read 0.5 ohm or less?	Replace fuel pump module.	Resistance reading is above 0.5 ohm.  Check terminals for corrosion or replace EFI wire harness.



Fuel Pump Module Connector

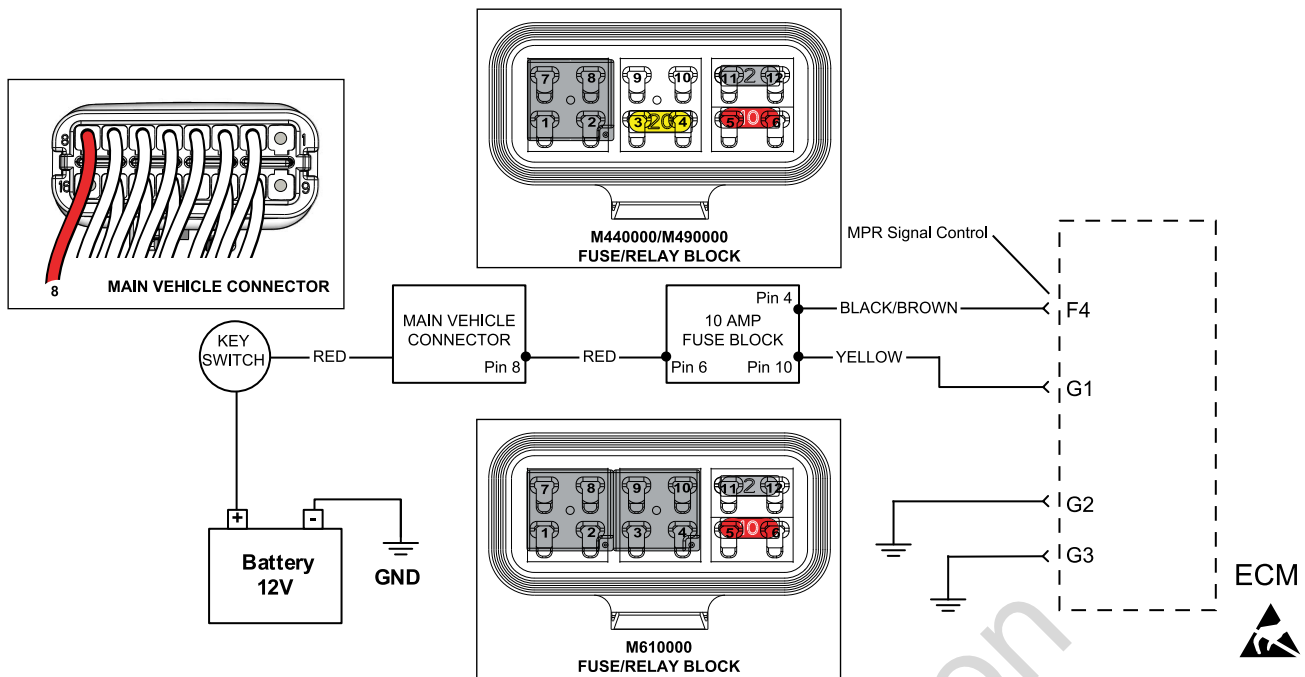


ECM Connector



Fuse/Relay Block

## SPN 1485 MAIN RELAY



### Circuit Description

The ECM monitors main power relay performance by voltage input on ECM terminal G1.

### Possible FMIs

The possible FMIs for SPN 1485 are as follows:

FMI	Description
3	Circuit Shorted High
4	Circuit Shorted Low
5	Circuit Open

**FMI 3:** Voltage input at ECM terminal G1 exceeds 16 volts DC.

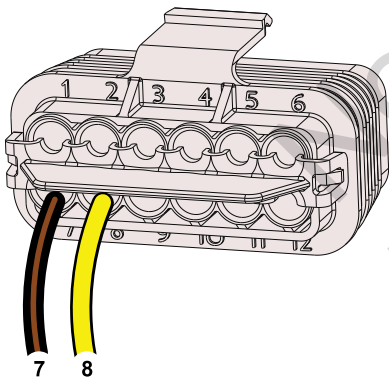
**FMI 4:** Main power relay fails to operate.

**FMI 5:** Main power relay fails to power up the ECM G1 circuit at start up.

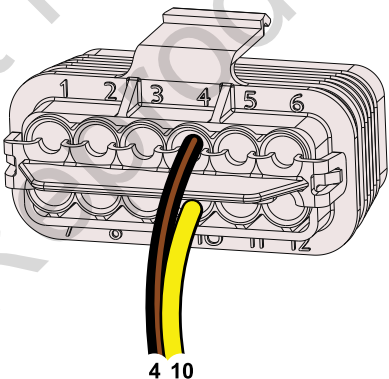
SPN 1485, FMI 3: Circuit Shorted High

2

Step	Action	Yes	No
1	<div>1. Turn Ignition OFF.</div> <div>2. Using fused patch cord), back probe terminal 8 (Yellow wire) of fuse block on M44/M49 models, or terminal 10 (Yellow wire) on M61 model.</div> <div>3. Connect back probe to red meter test lead on DVOM.</div> <div>4. Connect black meter test lead on DVOM to battery negative terminal.</div> <div>5. Set DVOM to read volts DC.</div> <div>6. Turn Ignition ON, Engine OFF.</div> <div>7. Does DVOM read 12.2-13.2 volts DC?</div>	Go to step 2.	Check battery connections/ voltage and 10 amp Battery fuse (Red).
2	<div>1. Turn Ignition OFF.</div> <div>2. Remove back probe (with fused patch cord), and back probe terminal 7 (Black/Brown wire) of fuse block on M44/M49 models, or terminal 4 (Black/ Brown wire) on M61 model.</div> <div>3. Connect black meter test lead on DVOM to battery negative terminal.</div> <div>4. Turn Ignition ON, Engine OFF.</div> <div>5. Does DVOM read 12.2-13.2 volts DC?</div>	Replace Main Power Relay.	Problem does not currently exist. Placing a finger on the body of the Main Power Relay, toggle the Ignition ON and OFF. The relay should be felt and heard as it clicks ON.



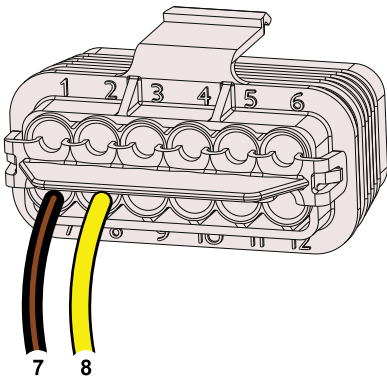
Fuse/Relay Block  
Models M440000/M490000



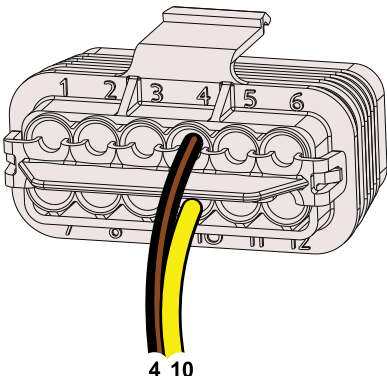
Fuse/Relay Block  
Model M610000

SPN 1485, FMI 4: Circuit Shorted Low

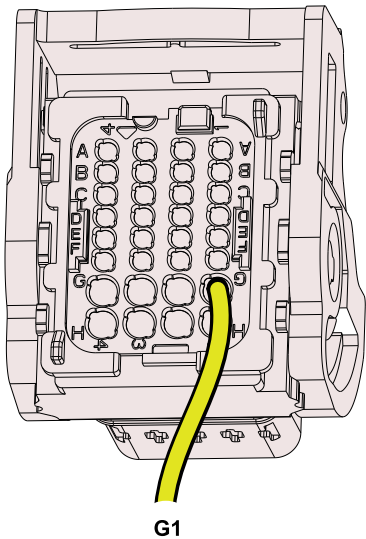
Step	Action	Yes	No
1	<p>1. Turn Ignition OFF.</p> <p>2. Using fused patch cord, back probe terminal 8 (Yellow wire) of fuse block on M44/M49 models, or terminal 10 (Yellow wire) on M61 model.</p> <p>3. Connect back probe to red meter test lead on DVOM.</p> <p>4. Connect black meter test lead on DVOM to battery negative terminal.</p> <p>5. Set DVOM to read volts DC.</p> <p>6. Turn Ignition ON, Engine OFF.</p> <p>7. Does DVOM read 12.2-13.2 volts DC?</p>	Go to step 2.	Check battery connections/ voltage, and 10 amp Battery fuse (Red).
2	<p>1. Turn Ignition OFF.</p> <p>2. Remove back probe (with fused patch cord), and back probe terminal 7 (Black/Brown wire) of fuse block on M44/M49 models, or terminal 4 (Black/ Brown wire) on M61 model.</p> <p>3. Connect black meter test lead on DVOM to battery negative terminal.</p> <p>4. Turn Ignition ON, Engine OFF.</p> <p>5. Does DVOM read 0 volts DC?</p>	Go to step 3.  Placing a finger on the body of the Main Power Relay, toggle the Ignition ON and OFF. The relay should be felt and heard as it clicks ON. If neither is sensed, replace the relay and retest.	If reading battery voltage, check the back probe for correct terminal location.
3	<p>1. Turn Ignition OFF.</p> <p>2. Remove back probe (with fused patch cord) from fuse block.</p> <p>3. Back probe terminal G1 (Yellow wire) of ECM connector.</p> <p>4. Connect terminal G1 back probe to red meter test lead on DVOM.</p> <p>5. Connect black meter test lead on DVOM to battery negative terminal.</p> <p>6. Turn Ignition ON, Engine OFF.</p> <p>7. Does DVOM read 12.2-13.2 volts DC?</p>	Replace EFI wire harness or locate and repair short or break between fuse block and ECM connector.	If 10 amp Battery fuse (Red) is intact and proper voltage is still not seen at ECM terminal G1, then replace the ECM.



Fuse/Relay Block  
Models M440000/M490000



Fuse/Relay Block  
Model M610000

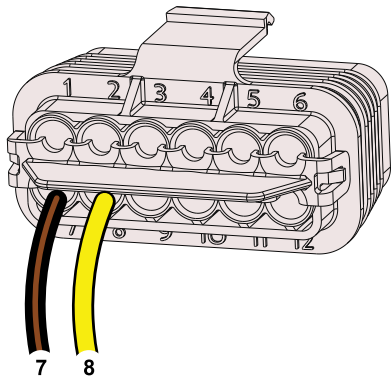


ECM Connector

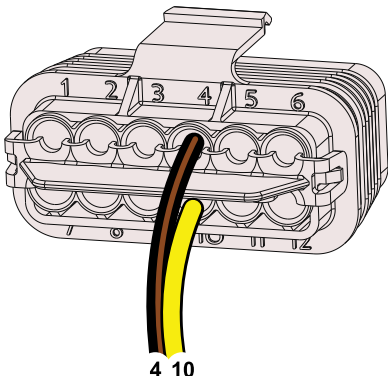
SPN 1485, FMI 5: Circuit Open

2

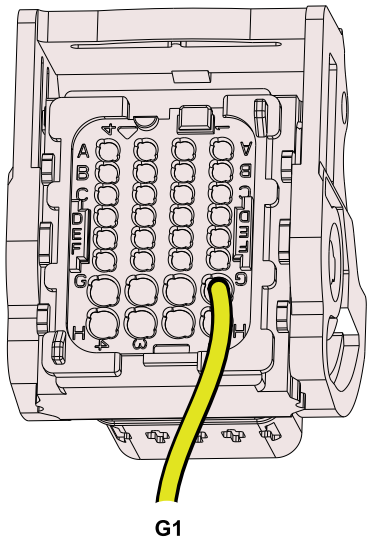
Step	Action	Yes	No
1	<p>1. Turn Ignition OFF.</p> <p>2. Using fused patch cord, back probe terminal 8 (Yellow wire) of fuse block on M44/M49 models, or terminal 10 (Yellow wire) on M61 model.</p> <p>3. Connect back probe to red meter test lead on DVOM.</p> <p>4. Connect black meter test lead on DVOM to battery negative terminal.</p> <p>5. Set DVOM to read volts DC.</p> <p>6. Turn Ignition ON, Engine OFF.</p> <p>7. Does DVOM read 12.2-13.2 volts DC?</p>	Go to step 2.	Check battery connections/voltage, and 10 amp Battery fuse (Red).
2	<p>1. Turn Ignition OFF.</p> <p>2. Remove back probe (with fused patch cord), and back probe terminal 7 (Black/Brown wire) of fuse block on M44/M49 models, or terminal 4 (Black/Brown wire) on M61 model.</p> <p>3. Connect black meter test lead on DVOM to battery negative terminal.</p> <p>4. Turn Ignition ON, Engine OFF.</p> <p>5. Does DVOM read 0 volts DC?</p>	<p>Go to step 3.</p> <p>Placing a finger on the body of the Main Power Relay, toggle the Ignition ON and OFF. The relay should be felt and heard as it clicks ON. If neither is sensed, replace the relay and retest.</p>	If reading battery voltage, check the back probe for correct terminal location.
3	<p>1. Turn Ignition OFF.</p> <p>2. Remove back probe (with fused patch cord) from fuse block.</p> <p>3. Back probe terminal G1 (Yellow wire) of ECM connector.</p> <p>4. Connect terminal G1 back probe to red meter test lead on DVOM.</p> <p>5. Connect black meter test lead on DVOM to battery negative terminal.</p> <p>6. Turn Ignition ON, Engine OFF.</p> <p>7. Does DVOM read 12.2-13.2 volts DC?</p>	Replace EFI wire harness or locate and repair short or break between fuse block and ECM connector.	If 10 amp Battery fuse (Red) is intact and proper voltage is still not seen at ECM terminal G1, then replace the ECM.



Fuse/Relay Block  
Models M440000/M490000

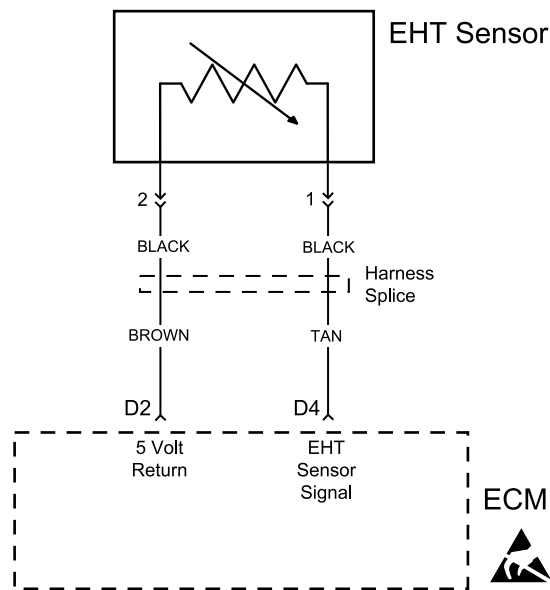


Fuse/Relay Block  
Model M610000



ECM Connector





## Circuit Description

The Head Temperature sensor measures the cylinder head in an specific location and helps the ECM make adjustments for engine performance based on the temperature. Three levels of engine over temperature diagnosis help protect the engine in extreme cases where cooling of the engine is not adequate and causes an overheat condition. If over-temperature diagnosis has occurred, turn off the engine and allow it to cool down. Then, inspect and clean out any unwanted material that would prevent cooling air to reach the engine. Check openings and clean out those areas too.

## Possible FMIs

The possible FMIs for SPN 110 are as follows:

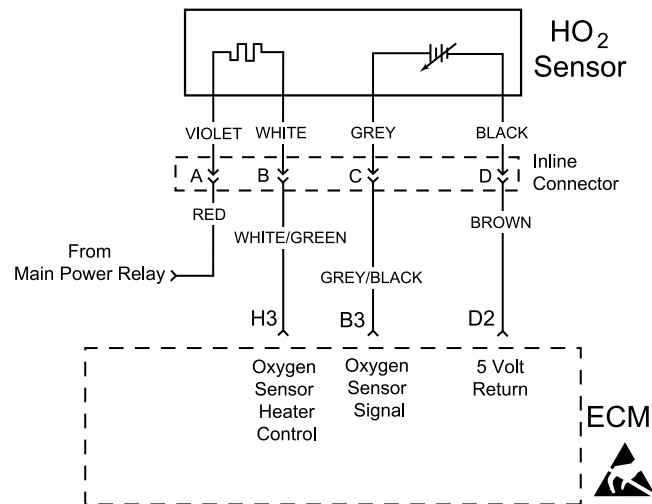
FMI	Description
0	Head Temp Sensor Over THD3
15	Head Temp Sensor Over THD1
16	Head Temp Sensor Over THD2

**FMI 0:** A temperature-related fault. The engine will derate at a temperature > 205C.

**FMI 15:** A temperature-related fault. The engine will derate at a temperature > 195C.

**FMI 16:** A temperature-related fault. The engine will derate at a temperature > 200C.

## SPN 1695 OXYGEN SENSOR CONTROL



### Circuit Description

The oxygen sensor, when in closed loop mode, monitors how the engine is using the given air/fuel ratio. When there is a deviation from the target air/fuel ratio, fuel trimming will take over to bring the air/fuel ratio back to target. If the correction goes to the maximum in either direction to achieve the target, the code will be set.

### Possible FMIs

The possible FMIs for SPN 1695 are as follows:

FMI	Description
4	Lean Air/Fuel Ratio (Under Load)
20	Sensor Correction Too High (Lean Air/Fuel Ratio)
21	Sensor Correction Too Low (Rich Air/Fuel Ratio)

**FMI 4:** Indicates that the oxygen sensor sees a lean condition (below 0.1025 volts) in open loop mode under moderate to heavy load.

**FMI 20:** Indicates a corrected increase in fuel delivery has gone to maximum (+15%).

**FMI 21:** Indicates a corrected reduction in fuel delivery has gone to maximum (-15%).

## SPN 1695, FMI 4: Lean Engine Detected

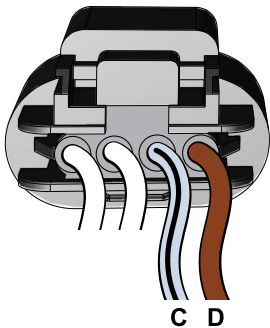
Step	Action	Yes	No
1	1. Check fuel filter and fuel lines for dirt, debris or other restriction. 2. Is a problem found?	Repair.	Go to step 2.
2	1. Check fuel pressure. See <i>CHECK/RELIEVE FUEL SYSTEM PRESSURE</i> in <i>SECTION 5 - REMOVAL/INSTALLATION</i> of this manual. 2. Is fuel pressure 38-43 psi (262-296 kPa)?	Fuel pressure OK.	Go to step 3.
3	1. Verify that fuel filter is not clogged or restricted, and that fuel pump is operating properly (see <i>Mechanical Diaphragm Fuel Pump</i> or <i>Electric Lift Fuel Pump, Volumetric Test</i> , in <i>SECTION 5 - REMOVAL/INSTALLATION</i> of this manual. 2. Is a problem found?	Repair.	Go to step 4.
4	1. Check for vacuum and exhaust leaks. 2. Is a leak found?	Repair.	Go to step 5.
5	1. Check for faulty fuel injectors. 2. Are faulty fuel injectors found?	Repair.	Go to step 6.
6	1. Replace faulty HO <sub>2</sub> sensor. 2. Is problem corrected?	-	Contact engine manufacturer.

Not for  
Reproduction

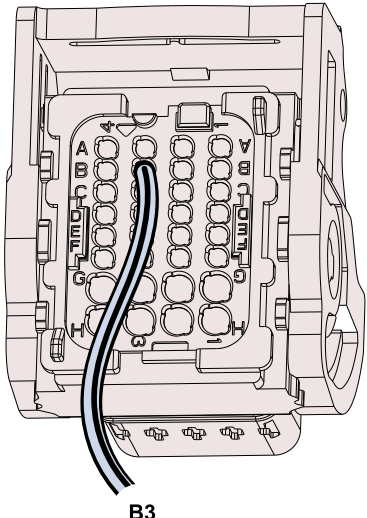
SPN 1695, FMI 20: Correction Too High

2

Step	Action	Yes	No
1	<div>1. Turn Ignition OFF.</div> <div>2. Back probe terminal C (Grey/Black wire) of HO<sub>2</sub> sensor connector.</div> <div>3. Connect terminal C back probe to red meter test lead on DVOM.</div> <div>4. Back probe terminal D (Brown wire) of HO<sub>2</sub> sensor connector.</div> <div>5. Connect terminal D back probe to black meter test lead on DVOM.</div> <div>6. Set DVOM to read volts DC.</div> <div>7. Start and run engine for at least 2 minutes.</div> <div>8. With engine running, observe voltage on DVOM.</div> <div>9. Is reading 600 – 950 millivolts DC?</div>	HO <sub>2</sub> sensor OK.	Go to step 2.
2	<div>1. Turn Ignition OFF.</div> <div>2. Remove probe from terminal C, and back probe ECM connector terminal B3 (Grey/Black wire).</div> <div>3. Connect terminal B3 back probe to red meter test lead on DVOM.</div> <div>4. Start and run engine.</div> <div>5. Observe voltage on DVOM.</div> <div>6. Is reading 600 – 950 millivolts DC?</div>	HO <sub>2</sub> sensor OK.	<div>Verify that both HO<sub>2</sub> sensor and ECM connectors are fully mated.</div> <div><b>NOTE:</b> If reading is above 950 millivolts DC, replace HO<sub>2</sub> sensor or identify overly rich running condition.</div>



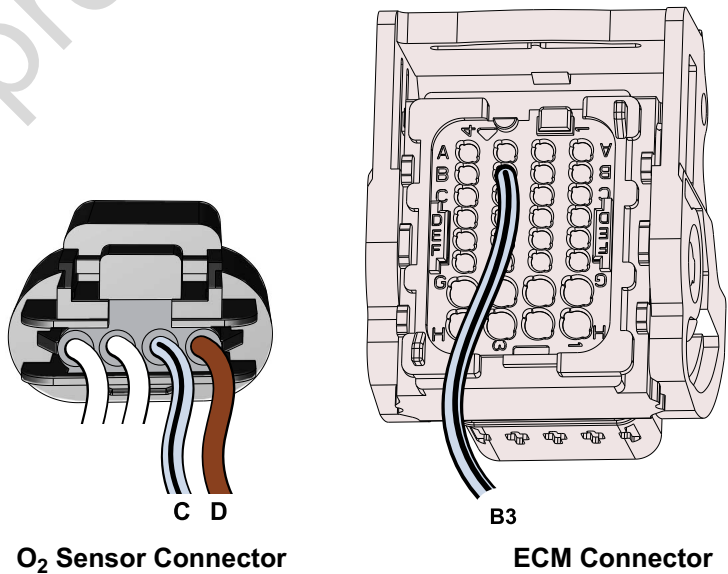
O<sub>2</sub> Sensor Connector



ECM Connector

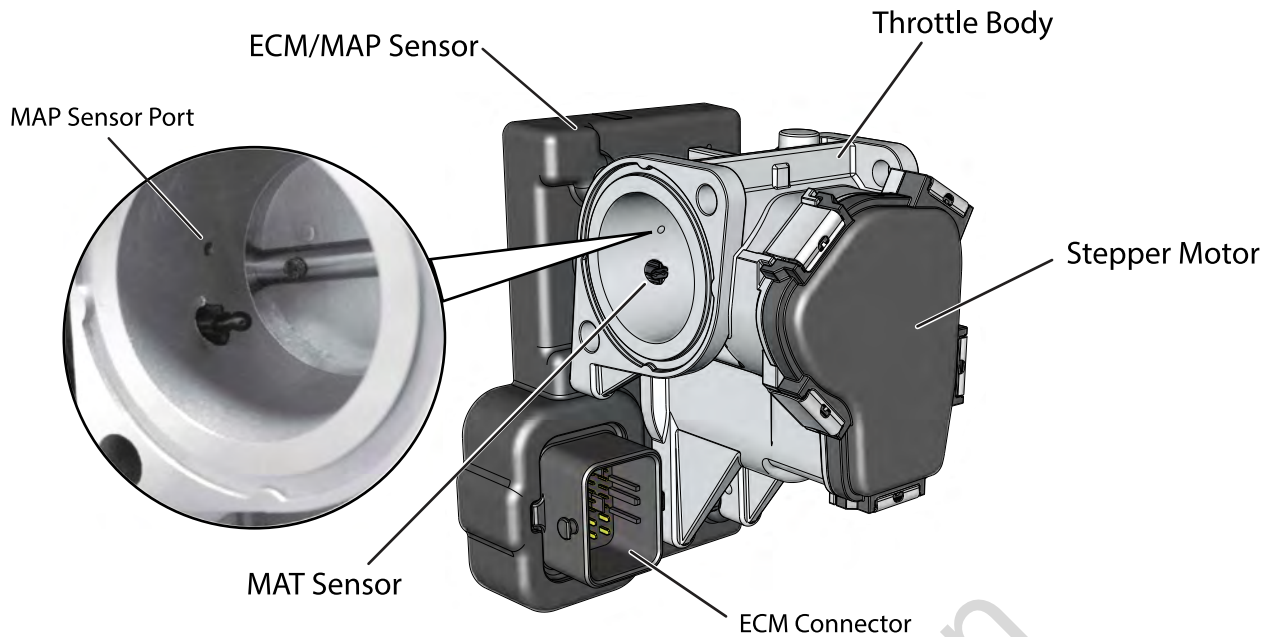
SPN 1695, FMI 21: Correction Too Low

Step	Action	Yes	No
1	<div>1. Turn Ignition OFF.</div> <div>2. Back probe terminal C (Grey/Black wire) of HO<sub>2</sub> sensor connector.</div> <div>3. Connect terminal C back probe to red meter test lead on DVOM.</div> <div>4. Back probe terminal D (Brown wire) of HO<sub>2</sub> sensor connector.</div> <div>5. Connect terminal D back probe to black meter test lead on DVOM.</div> <div>6. Set DVOM to read volts DC.</div> <div>7. Start and run engine for at least 2 minutes.</div> <div>8. With engine running, observe voltage on DVOM.</div> <div>9. Is reading 600 – 950 millivolts DC?</div>	HO <sub>2</sub> sensor OK.	Go to step 2.
2	<div>1. Turn Ignition OFF.</div> <div>2. Remove probe from terminal C, and back probe ECM connector terminal B3 (Grey/Black wire).</div> <div>3. Connect terminal B3 back probe to red meter test lead on DVOM.</div> <div>4. Start and run engine.</div> <div>5. Observe voltage on DVOM.</div> <div>6. Is reading 600 – 950 millivolts DC?</div>	HO <sub>2</sub> sensor OK.	<div>Verify that both HO<sub>2</sub> sensor and ECM connectors are fully mated.</div> <div><b>NOTE:</b> If reading is below 300 millivolts DC, inspect exhaust system for cracks or leaks between muffler and cylinder head (gaskets). If everything is OK, replace HO<sub>2</sub> sensor.</div>



## SPN 5419 ELECTRONIC THROTTLE CONTROL (ETC)

2



ETC (Electronic Throttle Control)

### Circuit Description

The ETC controls engine speed with a stepper motor built into the throttle body. The stepper motor movement is very precise and computer controlled. The ECM maintains engine speed and adjusts throttle plate angle instantaneously to maintain target engine speed.

**NOTE:** When Ignition is ON, an audible humming noise can be heard from the ETC stepper motor. This is normal operation.

### Mechanical

Look for excessive carbon buildup between the throttle plate and throttle body bore, or debris inhibiting movement of the throttle plate.

Are either of these conditions found?

**Yes-** Clean and retest.

**No-** Replace ETC.

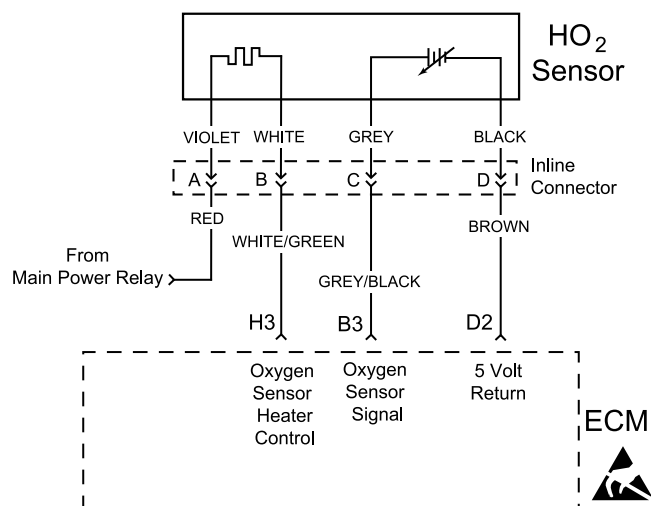
### Possible FMIs

The possible FMIs for SPN 5419 are as follows:

FMI	Description
3	Driver Pin 1 Shorted High
4	Driver Pin 1 Shorted Low
5	Driver Circuit Open
6	Driver Shorted Between Pins 1 and 2
8	Pulse Width Modulation Out of Range
15	Driver Over Temperature
16	Driver Over Temperature WARNING

**NOTE:** The ETC consists of the TPS, ECM, MAP sensor, MAT sensor, throttle body, and stepper motor. The ETC is not serviceable and can not be physically tested. If any SPN 5419 FMI is present, see *TEST PROCEDURES* in this section for information on doing the Electronic Throttle Sweep Test. Replace ETC if test fails.

## SPN 5871 OXYGEN SENSOR HEATER



### Circuit Description

The oxygen sensor, when in closed loop mode, monitors how the engine is using the given air/fuel ratio. A heater is built into the oxygen sensor and is controlled by the ECM. If the ECM detects that the heater circuit has faulted high, low, or open for longer than one second, SPN 5871 will set with the appropriate FMI. The engine will default to open loop operation until the fault is corrected.

### Possible FMIs

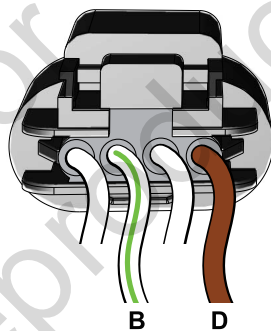
The possible FMIs for SPN 5871 are as follows:

FMI	Description
3	Heater Shorted High
4	Heater Shorted Low
5	Heater Circuit Open

## SPN 5871, FMI 3: Heater Shorted High

2

Step	Action	Yes	No
1	<ol style="list-style-type: none"> <li>1. Turn Ignition OFF.</li> <li>2. Back probe (using fused patch cord) terminal B (White/Green wire) on engine side of O<sub>2</sub> sensor connector.</li> <li>3. Connect terminal B back probe to red meter test lead on DVOM.</li> <li>4. Back probe terminal D (Brown wire) on engine side of O<sub>2</sub> sensor connector.</li> <li>5. Connect terminal D back probe to black meter test lead on DVOM.</li> <li>6. Set DVOM to read volts DC.</li> <li>7. Turn Ignition ON, Engine Off.</li> <li>8. Observe voltage on DVOM.</li> <li>9. Is reading 12.2-13.5 volts DC?</li> </ol>	Go to step 2.	Ensure probe connectivity.
2	<ol style="list-style-type: none"> <li>1. Start and run engine.</li> <li>2. Observe voltage on DVOM.</li> <li>3. Within 30 seconds, does voltage reading drop below 11.6 volts DC?</li> </ol>	<p>O<sub>2</sub> sensor OK.</p> <p>Clear codes and retest.</p>	Replace O <sub>2</sub> sensor.

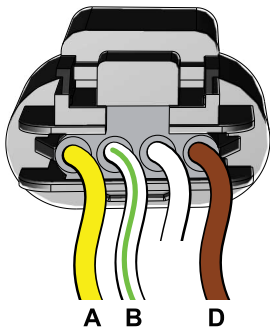


O<sub>2</sub> Sensor Connector

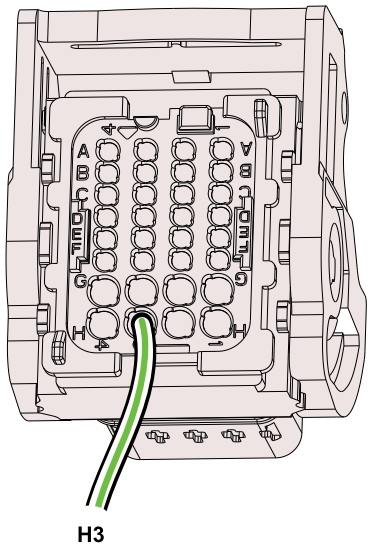


SPN 5871, FMI 4: Heater Shorted Low

Step	Action	Yes	No
1	1. Turn Ignition OFF. 2. Back probe (using fused patch cord) terminal A (Yellow wire) on engine side of O <sub>2</sub> sensor connector. 3. Connect terminal A back probe to red meter test lead on DVOM. 4. Back probe terminal D (Brown wire) on engine side of O <sub>2</sub> sensor connector. 5. Connect terminal D back probe to black meter test lead on DVOM. 6. Set DVOM to read volts DC. 7. Turn Ignition ON, Engine Off. 8. Does DVOM read 12.2-13.5 volts DC?	Go to step 2.	Do a visual and continuity check of Main Power Relay and 10 amp Battery fuse (Red).
2	1. Turn Ignition OFF. 2. Remove probe from terminal A, and back probe terminal B (White/Green wire) on engine side of O <sub>2</sub> sensor connector. 3. Turn Ignition ON, Engine OFF. 4. Does DVOM read 12.2-13.5 volts DC?	Go to step 3.	Replace O <sub>2</sub> sensor.
3	1. Turn Ignition OFF. 2. Remove probe from terminal B, and back probe ECM connector terminal H3 (White/Green wire). 3. Connect terminal H3 back probe to red meter test lead on DVOM. 4. Turn Ignition ON, Engine OFF. 5. Does DVOM read 12.2-13.5 volts DC?	Both EFI wire harness and O <sub>2</sub> sensor are good.	Go to step 4.
4	Are both O <sub>2</sub> sensor and ECM connectors fully mated?	Repair or replace EFI wire harness.	Connect connectors.



O<sub>2</sub> Sensor Connector

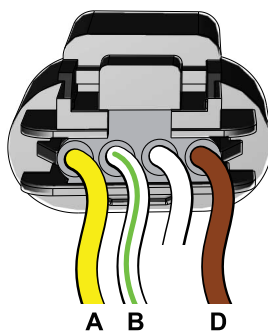


ECM Connector

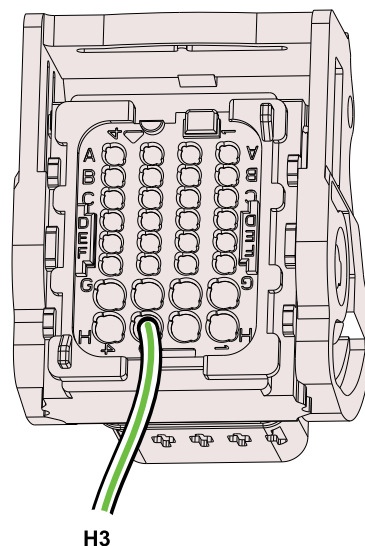
## SPN 5871, FMI 5: Heater Open

2

Step	Action	Yes	No
1	<ol style="list-style-type: none"> <li>Turn Ignition OFF.</li> <li>Back probe (using fused patch cord) terminal A (Yellow wire) on engine side of O<sub>2</sub> sensor connector.</li> <li>Connect terminal A back probe to red meter test lead on DVOM.</li> <li>Back probe terminal D (Brown wire) on engine side of O<sub>2</sub> sensor connector.</li> <li>Connect terminal D back probe to black meter test lead on DVOM.</li> <li>Set DVOM to read volts DC.</li> <li>Turn Ignition ON, Engine Off.</li> <li>Does DVOM read 12.2-13.5 volts DC?</li> </ol>	Go to step 2.	Do a visual and continuity check of Main Power Relay and 10 amp Battery fuse (Red).
2	<ol style="list-style-type: none"> <li>Turn Ignition OFF.</li> <li>Remove probe from terminal A, and back probe terminal B (White/Green wire) on engine side of O<sub>2</sub> sensor connector.</li> <li>Turn Ignition ON, Engine OFF.</li> <li>Does DVOM read 12.2-13.5 volts DC?</li> </ol>	Go to step 3.	Replace O <sub>2</sub> sensor.
3	<ol style="list-style-type: none"> <li>Turn Ignition OFF.</li> <li>Remove probe from terminal B, and back probe ECM connector terminal H3 (White/Green wire).</li> <li>Connect terminal H3 back probe to red meter test lead on DVOM.</li> <li>Turn Ignition ON, Engine OFF.</li> <li>Does DVOM read 12.2-13.5 volts DC?</li> </ol>	Both EFI wire harness and O <sub>2</sub> sensor are good.	Go to step 4.
4	Are both O <sub>2</sub> sensor and ECM connectors fully mated?	Repair or replace EFI wire harness.	Connect connectors.



O<sub>2</sub> Sensor Connector



ECM Connector

**SECTION 3 - WIRE SCHEMATICS AND PIN-OUTS**

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ECM CONNECTOR PIN-OUT -----86

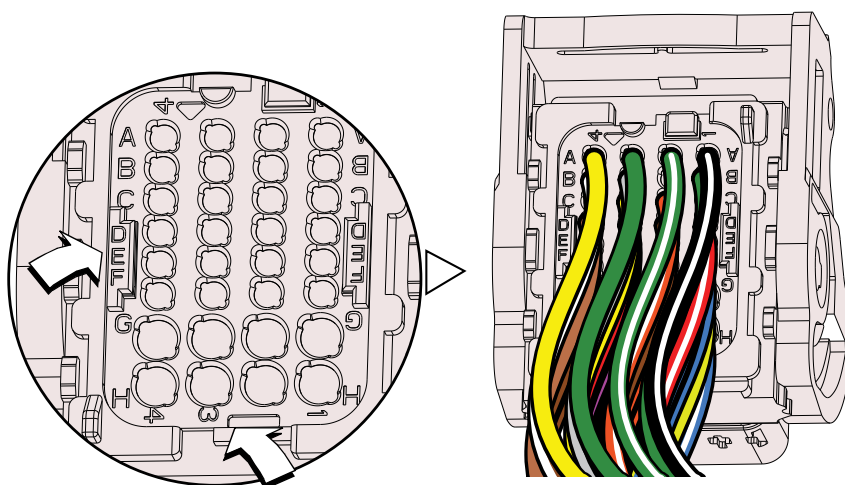
M440000/M490000/M610000 WIRING DIAGRAM -----88

MODELS 440000/490000/610000 FUSE/RELAY BLOCK -----90

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## ECM CONNECTOR PIN-OUT

3



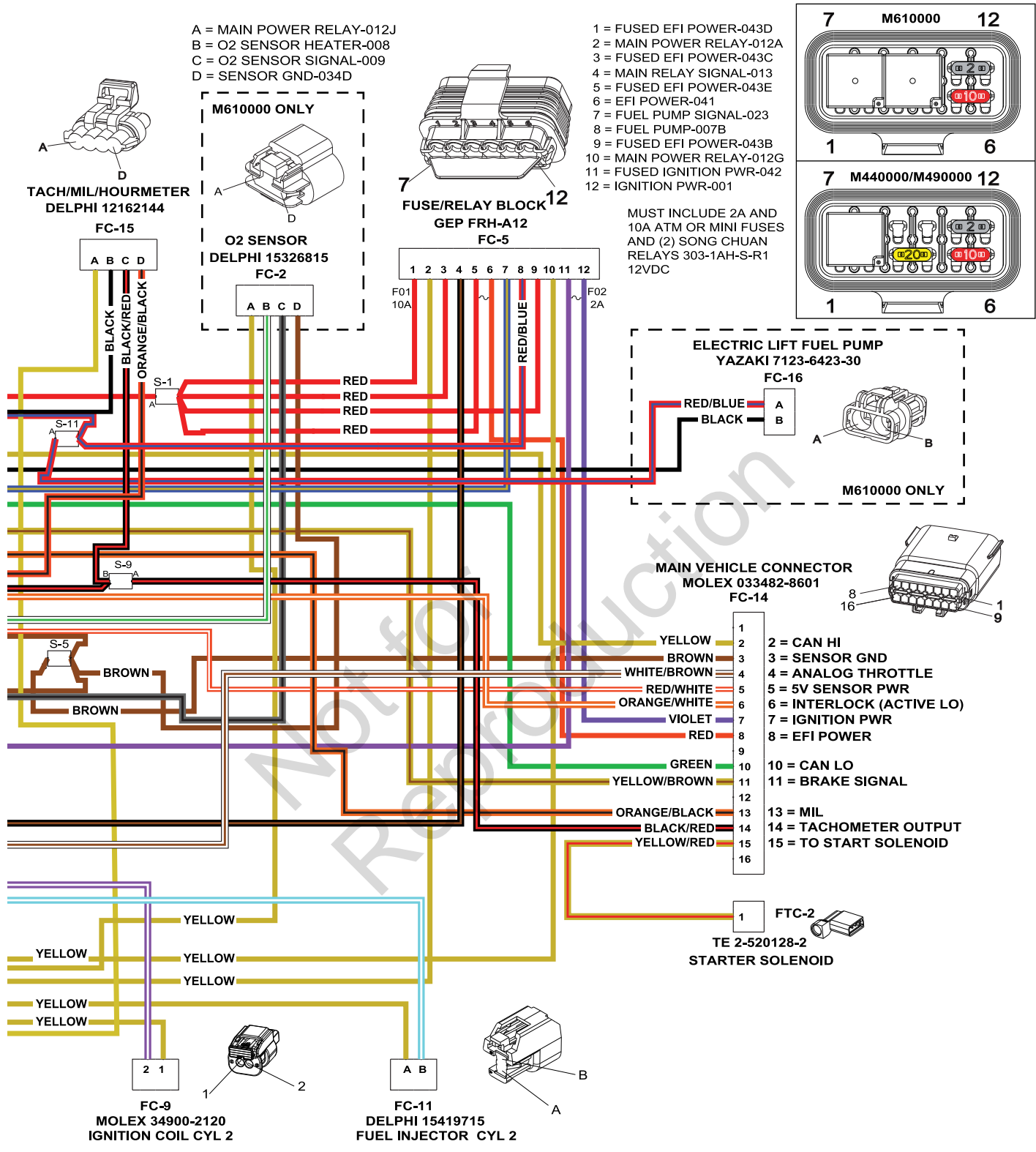
Connector-Pin Number	Wire Color	Function
A1	Black/White	CPS (+)
A2	Green/White	CPS (-)
A3	Green	CAN LO
A4	Yellow	CAN HI
B1	Green	Oil Pressure Sensor
B2	NOT USED	
B3	Gray/Black	Oxygen Sensor Signal
B4	White/Brown	Analog Throttle
C1	NOT USED	
C2	Orange/White	Interlock (Active LO)
C3	Yellow/Brown	Brake Signal
C4	NOT USED	
D1	Red/White	5V Sensor Power
D2	Brown	Sensor Ground
D3	Black/Red	Tachometer Output
D4	Tan	Head Temperature Sensor
E1	NOT USED	
E2	NOT USED	
E3	Violet	Fused Ignition Power
E4	NOT USED	
F1	Light Blue/Black	Injector Cylinder 1
F2	Orange/Black	MIL
F3	NOT USED	
F4	Black/Brown	Main Relay Signal
G1	Yellow	Main Power Relay
G2	Black	Ground
G3	Black	Ground

Connector-Pin Number	Wire Color	Function
G4	Violet/White	Ignition Coil Cylinder 2
H1	Light Blue/Whit2	Injector Cylinder 1
H2	Blue/Yellow	Fuel Pump Signal
H3	White/Green	Oxygen Sensor Heater
H4	Violet/Black	Ignition Coil Cylinder 1

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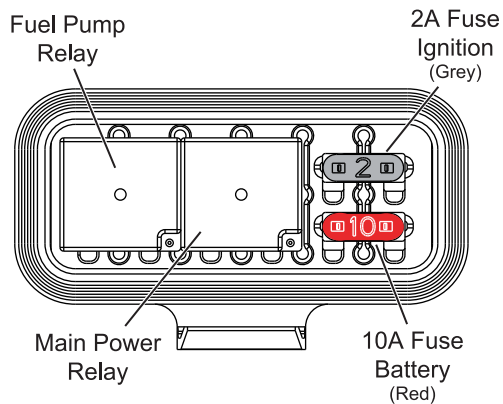
## 3



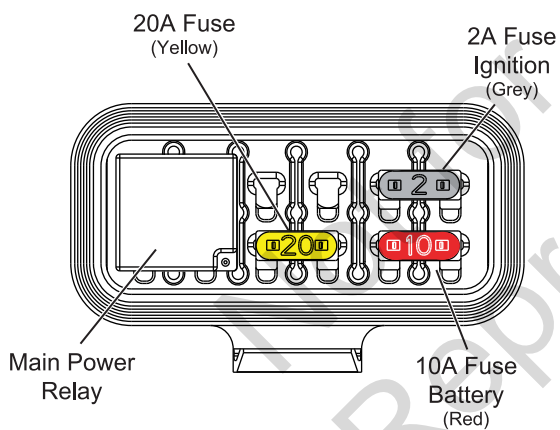
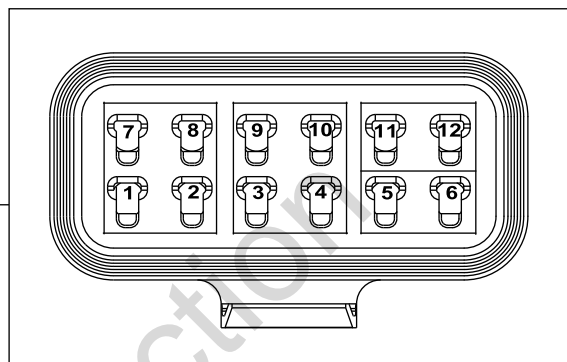


## MODELS 440000/490000/610000 FUSE/RELAY BLOCK

3



**M610000**



**M440000/M490000**



## SECTION 4 - SYMPTOMS

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# INTRODUCTION

## Verify Customer Complaint

Verify customer complaint and then move to the Diagnostic Table that best describes the problem.

- Engine does not crank.
- Engine cranks but does not start.
- Engine exhibits hard start symptoms.
- Engine power output low.
- Engine hunts and surges.

## 4

## Visual Checks

Each Diagnostic Table contains an instruction to do a careful visual check. These checks must include the following:

- Verify that ECM grounds and sensor connections are clean, tight and in their proper location.
- Thoroughly check for any type of vacuum leak or restriction.
- Look for air leaks at the throttle body mounting and intake manifold sealing surfaces.
- Inspect ignition wires for cracks, hardness, improper routing and carbon tracking.
- Inspect wires for kinks, cuts, burns, abraded insulation, and other damage.
- Look for moisture in primary or secondary ignition circuit connections.
- Look for salt corrosion on electrical connections and exposed throttle body linkages.

Check electrical connectors for the following:

- Poor mating of connector halves, or a terminal not fully seated in the connector body (backed out or loose).

- Improperly formed or damaged terminals and/or connectors.
- Improper contact tension of connector pin and socket terminals in the problem circuit.
- Poor terminal to wire connection (both core and insulation crimps).

## Intermittents

**IMPORTANT:** Intermittents may not cause the MIL to illuminate or set a DTC. DO NOT use the DTC Tables to diagnose intermittent problems. The fault condition must be present to locate the problem. Many intermittent problems are caused by faulty electrical connections or wiring.

The engine may be operated with a DVOM connected to the suspect circuit. If an abnormal voltage is observed when a malfunction occurs, it is a good indication that there is a fault in the circuit. The Diagnostic Tool also may be used to help detect intermittents.

An intermittent MIL with no stored DTC may be caused by one or more of the following conditions:

- Ignition coil is shorted to ground and arcing is present at ignition wires or plugs.
- MIL wire to ECM is shorted to ground.
- Poor ECM grounds.
- An electrical system interference caused by a sharp electrical surge. The problem normally occurs when the faulty component is operated.
- Secondary ignition components are shorted to ground, or there is an open in the ignition coil ground.
- Engine components, such as starters, alternators or relays, are internally shorted to ground.

## ENGINE DOES NOT CRANK

Step	Action	Yes	No
1	Do an OBD System Check.  Are any DTCs found?	Go to applicable DTC Table.	Go to step 2.
2	Do a careful visual check.  Is a problem found?	Repair	Go to step 3.
3	Check battery as follows: <ul style="list-style-type: none"> <li>• Look for loose or corroded terminals.</li> <li>• Verify battery voltage is 12.2-13.5 volts.</li> </ul> Is a problem found?	Repair	Go to step 4.
4	Verify PTO clutch is not engaged.  Is PTO clutch engaged?	Disengage PTO clutch.	Go to step 5.
5	Verify safety interrupt is NOT active or faulty, if equipped.  Is a problem found?	Repair	Go to step 6.
6	Verify ignition switch is working properly. See the applicable section of your Briggs & Stratton Engine Repair Manual.  Is a problem found?	Repair	Go to step 7.
7	Verify starter is operating properly. See Section 6 of the Intek V-Twin Cylinder OHV Repair Manual.  Is a problem found?	Repair	Go to step 8.
8	Review diagnostic procedures in this table. If all steps have been completed and no problems have been found, proceed as follows: <ul style="list-style-type: none"> <li>• Repeat visual check.</li> <li>• Review Diagnostic Tool/Code Reader data.</li> <li>• Check all electrical connections within the suspect circuit and/or system.</li> </ul> Is a problem found?	Repair	Contact engine manufacturer.

## ENGINE CRANKS BUT DOES NOT START

4

Step	Action	Yes	No
1	Do an OBD System Check.  Are any DTCs found?	Go to applicable DTC Table.	Go to step 2.
2	Do a careful visual check.*  Is a problem found?	Repair	Go to step 3.
3	Verify fuel in tank(s).  Is there insufficient fuel in tank(s)?	Add fuel.	Go to step 4.
4	Check fuel shut off valve, if equipped.  Is fuel shut off valve closed?	Open fuel shut off valve.	Go to step 5.
5	Check the following fuel system components for dirt, water, or other contaminants.  <ul style="list-style-type: none"> <li>• Fuel tanks</li> <li>• Fuel filter</li> <li>• Fuel lines</li> <li>• Fuel pumps</li> </ul> Is a problem found?	Repair	Go to step 6.
6	Verify that fuel pressure is 38-43 psi (262-296 kPa). See <i>CHECK/RELIEVE FUEL SYSTEM PRESSURE</i> in SECTION 5 - REMOVAL/INSTALLATION of this manual.  Is a problem found?	Repair	Go to step 7.
7	Verify safety interrupt is NOT active or faulty, if equipped.  Is a problem found?	Repair	Go to step 8.
8	Check battery as follows:  <ul style="list-style-type: none"> <li>• Look for loose or corroded terminals.</li> <li>• Verify battery voltage is 12.2-13.5 volts.</li> </ul> Is a problem found?	Repair	Go to step 9.
9	Verify that each cylinder is getting spark. See the applicable section of your Briggs & Stratton Engine Repair Manual.  Is a problem found?	Repair	Go to step 10.
10	See <i>VERIFY ECM POWERS UP</i> in SECTION 2 - TROUBLESHOOTING DTCs of this manual  Is a problem found?	Repair	Go to step 11.
<b>Continued...</b>			

\* **NOTE:** Verify that the fuel pump primes for approximately two seconds when the ECM is powered up. If fuel pump primes for only 1/2 second, then the Safety Circuit is the likely problem.

Step	Action	Yes	No
11	<p>Check engine for the following mechanical problems:</p> <ul style="list-style-type: none"> <li>• Low compression.</li> <li>• Leaking cylinder head gaskets.</li> <li>• Proper valve set up.</li> </ul> <p>See the applicable Briggs &amp; Stratton Engine Repair Manual.</p> <p>Is a problem found?</p>	Repair	Go to step 12.
12	<p>Review diagnostic procedures in this table. If all steps have been completed and no problems have been found, proceed as follows:</p> <ul style="list-style-type: none"> <li>• Repeat visual check.</li> <li>• Review Diagnostic Tool/Code Reader data.</li> <li>• Check all electrical connections within the suspect circuit and/or system.</li> </ul> <p>Is a problem found?</p>	Repair	Contact engine manufacturer.

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## ENGINE EXHIBITS HARD START SYMPTOMS

**Definition:** Engine cranks OK, but does not start for a long time. Engine does run, or may start but immediately die.

Step	Action	Yes	No
1	Do an OBD System Check.  Are any DTCs found?	Go to applicable DTC Table.	Go to step 2.
2	Do a careful visual check.  Is a problem found?	Repair	Go to step 3.
3	Check the following fuel system components for dirt, water, or other contaminants.  <ul style="list-style-type: none"> <li>Fuel tanks</li> <li>Fuel filter</li> <li>Fuel lines</li> <li>Fuel pumps</li> </ul> Is a problem found?	Repair	Go to step 4.
4	Verify that fuel pressure is 38-43 psi (262-296 kPa). See <i>CHECK/RELIEVE FUEL SYSTEM PRESSURE</i> in SECTION 5 - REMOVAL/INSTALLATION of this manual.  Is a problem found?	Repair	Go to step 5.
5	Check battery as follows: <ul style="list-style-type: none"> <li>Look for loose or corroded terminals.</li> <li>Verify battery voltage is 12.2-13.5 volts.</li> </ul> Is a problem found?	Repair	Go to step 6.
6	Check engine for the following mechanical problems: <ul style="list-style-type: none"> <li>Low compression.</li> <li>Leaking cylinder head gaskets.</li> <li>Proper valve set up.</li> </ul> See the applicable Briggs & Stratton Engine Repair Manual.  Is a problem found?	Repair	Go to step 7.
7	Review diagnostic procedures in this table. If all steps have been completed and no problems have been found, proceed as follows: <ul style="list-style-type: none"> <li>Repeat visual check.</li> <li>Review Diagnostic Tool/Code Reader data.</li> <li>Check all electrical connections within the suspect circuit and/or system.</li> </ul> Is a problem found?	Repair	Contact engine manufacturer.

## ENGINE POWER OUTPUT LOW

4

Step	Action	Yes	No
1	<p>Do an OBD System Check.</p> <p>Are any DTCs found?</p>	Go to applicable DTC Table.	Go to step 2.
2	<p>Do a careful visual check.</p> <p>Is a problem found?</p>	Repair	Go to step 3.
3	<p>Check the following fuel system components for dirt, water, or other contaminants.</p> <ul style="list-style-type: none"> <li>Fuel tanks</li> <li>Fuel filter</li> <li>Fuel lines</li> <li>Fuel pumps</li> </ul> <p>Is a problem found?</p>	Repair	Go to step 4.
4	<p>Verify that fuel pressure is 38-43 psi (262-296 kPa). See <i>CHECK/RELIEVE FUEL SYSTEM PRESSURE</i> in SECTION 5 - REMOVAL/INSTALLATION of this manual.</p> <p>Is a problem found?</p>	Repair	Go to step 5.
5	<p>Verify crankcase oil is at the correct level.</p> <p>Is a problem found?</p>	Add crankcase oil.	Go to step 6.
6	<p>Verify air filter element is clean and dry.</p> <p>Is a problem found?</p>	Replace air filter element.	Go to step 7.
7	<p>Verify engine is not supporting a greater load than intended for its application? Check for the following:</p> <ul style="list-style-type: none"> <li>Damaged drive belt.</li> <li>For mowers, verify blades are not restricted by debris.</li> <li>Faulty pulley bearing(s).</li> </ul> <p>Is a problem found?</p>	Repair	Go to step 8.
8	<p>Verify spark plugs are:</p> <ul style="list-style-type: none"> <li>Gapped properly.</li> <li>Not gas fouled.</li> <li>Not excessively worn.</li> </ul> <p>Is a problem found?</p>	Repair	Go to step 9.
9	<p>Verify exhaust is not restricted.</p> <p>Is a problem found?</p>	Repair	Go to step 10.
Continued...			

Step	Action	Yes	No
10	<p>Check engine for the following mechanical problems:</p> <ul style="list-style-type: none"> <li>• Low compression.</li> <li>• Leaking cylinder head gaskets.</li> <li>• Proper valve set up.</li> </ul> <p>See the applicable Briggs &amp; Stratton Engine Repair Manual..</p> <p>Is a problem found?</p>	Repair	Go to step 11.
11	<p>Review diagnostic procedures in this table. If all steps have been completed and no problems have been found, proceed as follows:</p> <ul style="list-style-type: none"> <li>• Repeat visual check.</li> <li>• Review Diagnostic Tool/Code Reader data.</li> <li>• Check all electrical connections within the suspect circuit and/or system.</li> </ul> <p>Is a problem found?</p>	Repair	Contact engine manufacturer.

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## ENGINE HUNTS AND SURGES

Step	Action	Yes	No
1	Do an OBD System Check.  Are any DTCs found?	Go to applicable DTC Table.	Go to step 2.
2	Do a careful visual check.  Is a problem found?	Repair	Go to step 3.
3	Check the following fuel system components for dirt, water, or other contaminants.  <ul style="list-style-type: none"> <li>• Fuel tanks</li> <li>• Fuel filter</li> <li>• Fuel lines</li> <li>• Fuel pumps</li> </ul> Is a problem found?	Repair	Go to step 4.
4	Verify that fuel pressure is 38-43 psi (262-296 kPa). See <i>CHECK/RELIEVE FUEL SYSTEM PRESSURE</i> in <i>SECTION 5 - REMOVAL/INSTALLATION</i> in this manual.  Is a problem found?	Repair	Go to step 5.
5	Check battery as follows: <ul style="list-style-type: none"> <li>• Look for loose or corroded terminals.</li> <li>• Verify battery voltage is 12.2-13.5 volts.</li> </ul> Is a problem found?	Repair	Go to step 6.
6	Verify crankcase oil is at the correct level.  Is a problem found?	Add crankcase oil.	Go to step 7.
7	Verify air filter element is clean and dry.  Is a problem found?	Replace air filter element.	Go to step 8.
8	Review diagnostic procedures in this table. If all steps have been completed and no problems have been found, proceed as follows: <ul style="list-style-type: none"> <li>• Repeat visual check.</li> <li>• Review Diagnostic Tool/Code Reader data.</li> <li>• Check all electrical connections within the suspect circuit and/or system.</li> </ul> Is a problem found?	Repair	Contact engine manufacturer.

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## CHECK/RELIEVE FUEL SYSTEM PRESSURE

### Safety Precautions

Always observe the following safety precautions before removing any fuel system components.



- Wear proper eye protection.
- Relieve fuel system pressure.
- Be sure there is no open flame or potential ignition sources in the area.
- When removing a fuel hose or fitting, cover with a shop towel to catch any fuel leakage.
- Collect any fuel and/or shop towels in approved containers and dispose of properly.
- Exercise care to keep dirt and debris out of fuel lines and fuel pump.
- Keep a dry chemical fire extinguisher on hand in case of emergencies.



The fuel in the fuel rail is under high pressure. To avoid an uncontrolled discharge or spray of fuel, and to reduce the risk of fire and personal injury, always relieve fuel system pressure before servicing.

Proceed as follows:

**NOTE:** Do all of the steps if checking fuel system pressure. If only relieving fuel system pressure, do steps 1-5.

1. Turn Ignition OFF.
2. To access the fuel pump module on Model 610000, see *MODEL 610000 - VERTICAL SHAFT* or *MODEL 610000 - HORIZONTAL SHAFT, Fuel Pump Module, Removal*.
3. Pull out grey secondary lock and press to disconnect fuel pump module connector.
4. Turn Ignition ON, Engine ON.
5. Start and run engine until it stalls. If it does not start, crank engine a few times to relieve fuel system pressure.
6. Obtain the following tools:

- Briggs & Stratton Fuel Pressure Gauge (Part No. 19627).
- Briggs & Stratton BIG BLOCK Fuel Pressure Test Adapter (Part No. 19624).

7. Squeeze two tabs on quick disconnect fitting to release fuel rail from fuel outlet port of fuel pump module.

**NOTE:** Wrap shop towel around fitting to catch any fuel leakage.

8. Install fuel pressure test adapter between fuel rail and fuel pump module.
9. Remove protective cap from Schrader valve on fuel pressure test adapter and install fuel pressure gauge.
10. Connect fuel pump module connector. Push in grey secondary lock to secure.
11. Turn Ignition ON to pressurize fuel system.
12. Note the reading of the fuel pressure gauge. Fuel pressure should remain steady at **38-43 psi** (262-296 kPa).
13. Turn Ignition OFF.
14. Position the clear bleed tube in an approved container and press the pressure relief button on the gauge assembly to relieve fuel system pressure. Fully depress and hold the pressure relief button until pointer on the dial face is resting on the stop pin.
15. Remove fuel pressure gauge from Schrader valve on fuel pressure test adapter.

**NOTE:** A small amount of gasoline may drain from the Schrader valve when the gauge is removed. Wrap a shop towel around the valve fitting to catch any fuel leakage.

16. Install protective cap on Schrader valve.
17. Remove fuel pressure test adapter between fuel rail and fuel pump module.
18. Firmly push quick disconnect fitting on fuel rail onto fuel outlet port of fuel pump module. Gently tug on fitting to verify that it is properly seated and secure.
19. Turn ignition switch ON for two seconds, and then OFF for 10 seconds. Turn the ignition switch back to ON and check for fuel leaks.
20. To reinstall the Model 610000 engine components, see *MODEL 610000 - VERTICAL SHAFT* or *MODEL 610000 - HORIZONTAL SHAFT, Fuel Pump Module, Installation*.

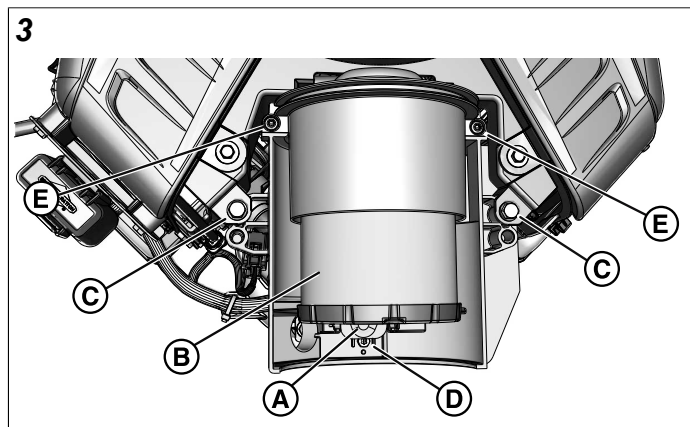
## Air Cleaner Assembly

### Removal

1. Loosen two thumbscrews to release air cleaner cover.
2. See Figure 3. Rotate retention latch (A) 90° and remove air filter element (B).
3. Remove two hex flange screws (C) to release air cleaner base from blower housing.
4. Remove T20 TORX screw (D) to release air cleaner base from intake manifold bracket.
5. Remove two T20 TORX screws (E) to release air cleaner base from intake elbow.
6. Remove air cleaner base.

### Installation

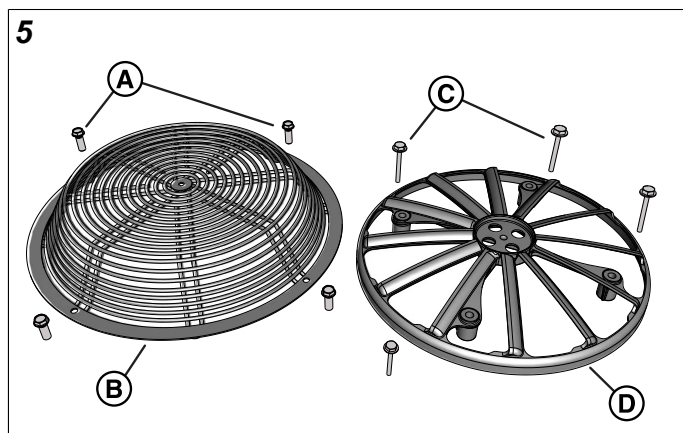
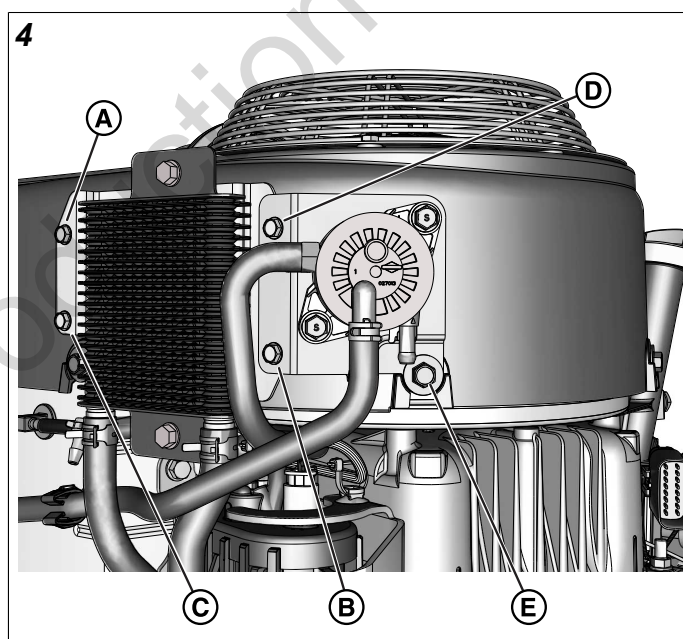
1. See Figure 3. Install air cleaner base.
2. Install two T20 TORX self tapping screws (E) to fasten air cleaner base to intake elbow. Tighten screws to **20-30 lb-in** (2.3-3.4 N-m).
3. Install T20 TORX machine screw (D) to fasten air cleaner base to intake manifold bracket. Tighten screw to **30-35 lb-in** (3.4-4.0 N-m).
4. Install two hex flange screws (C) to fasten air cleaner base to blower housing. Tighten screws to **30-36 lb-in** (3.4-4.1 N-m).
5. Install air filter element (B).
6. Rotate retention latch (A) 90° to secure air filter element. Latch will snap in place if filter is fully installed.
7. Install air cleaner cover and tighten two thumbscrews until snug.

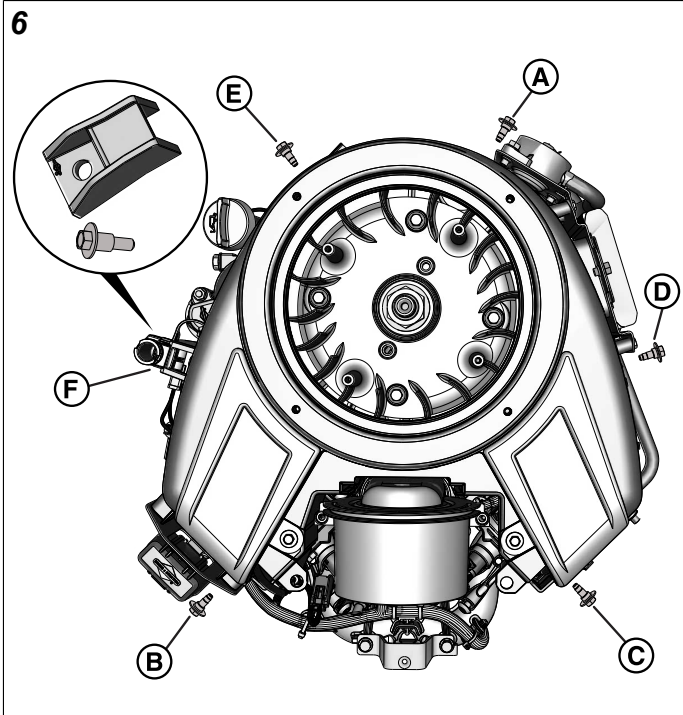


## Blower Housing

### Removal

1. See *Air Cleaner Assembly, Removal*.
2. See Figure 4. Remove four hex flange screws (A-D) and one blower housing alignment screw (E) to release mechanical diaphragm fuel pump bracket and oil cooler bracket from blower housing.
3. Disconnect fuse/relay block from cover.
4. Remove high tension leads from spark plug terminals on both cylinder 1 and cylinder 2. On cylinder 1, high tension lead runs inside of EFI wire harness, so move lead forward to prevent spark plug boot from being caught by EFI wire harness when blower housing is removed.
5. See Figure 5. Remove four hex flange screws (A) to release static guard (B) from blower housing.



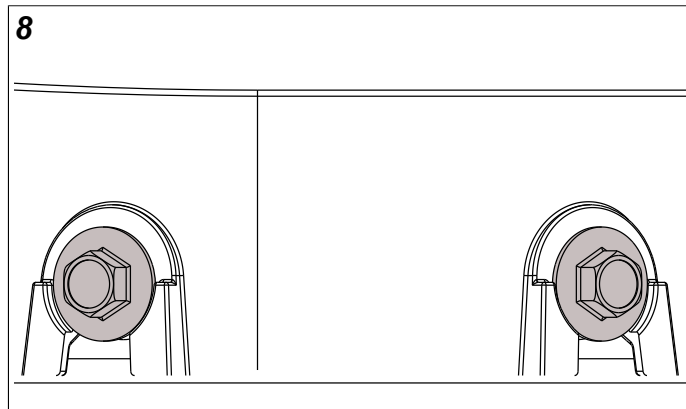
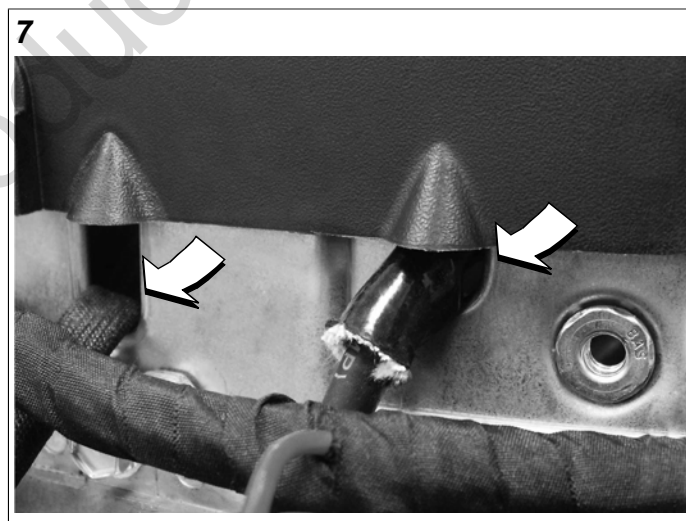


6. Remove four hex flange screws (C) to release debris screen (D) from posts on fan blades.
7. See Figure 6. Loosen or remove the four remaining standard alignment screws (B-E) around perimeter of blower housing. The first screw (A) was removed with the mechanical diaphragm fuel pump bracket.
8. Remove oil drain hose from clip. Remove special alignment screw (F) to release oil drain hose clip from blower housing.
9. Disconnect cylinder 1 ignition coil connector. Pull out red secondary lock, and then press and hold tab before pulling apart connector halves.
10. Squeeze anchor on connector clip of cylinder 2 ignition coil connector and push anchor through hole in shield. Use a needle nose pliers for best results.
11. Raise blower housing and disconnect cylinder 2 ignition coil connector. Pull out red secondary lock, and then press and hold tab before pulling apart connector halves.
12. Remove blower housing from engine.

### Installation

1. Position blower housing on engine.
2. Connect cylinder 2 ignition coil connector. Push in red secondary lock to secure. From inside blower housing, push anchor on pin housing into hole in cylinder 2 shield.
3. Connect cylinder 1 ignition coil connector. Push in red secondary lock to secure. From outside blower housing, push anchor on pin housing into hole in cylinder 1 shield, if removed.

4. See Figure 7. Verify that cylinder 1 high tension lead and voltage regulator wiring are routed through slots in shield. Move high tension lead inside of EFI wire harness.
5. Verify that cylinder 2 high tension lead is routed through slot in shield.
6. See Figure 6. Start four standard alignment screws (B-E) around perimeter of blower housing (this excludes the standard alignment screw (A) to be installed with the mechanical diaphragm fuel pump bracket and the special alignment screw (F) used for installation of the oil drain hose clip).
7. Apply downward pressure to front of blower housing and tighten the two front alignment screws (B and C) to **75-95 lb-in (8.5-10.7 N-m)**.
8. Apply downward pressure to rear of blower housing and tighten the two rear alignment screws (D and E) to **75-95 lb-in (8.5-10.7 N-m)**.
9. Start the special alignment screw (F) to fasten oil drain hose clip to blower housing. Tighten screw to **75-95 lb-in (8.5-10.7 N-m)**. Install oil drain hose onto clip.
10. Connect fuse/relay block to cover.





11. Install high tension leads onto spark plug terminals of both cylinder 1 and cylinder 2.
12. See Figure 5. Start four hex flange screws (C) to fasten debris screen (D) to posts on fan blades. Alternately tighten screws to **40-48 lb-in** (4.5-5.4 N-m).
13. Start four hex flange screws (A) to fasten static guard (B) to blower housing. Alternately tighten screws to **20-30 lb-in** (2.3-3.4 N-m).
14. See Figure 4. Positioned so that the mechanical diaphragm fuel pump bracket overlaps the oil cooler bracket, start four hex flange screws (A-D) to fasten brackets to blower housing. Alternately tighten screws to **25-30 lb-in** (2.8-3.4 N-m) in the sequence shown.
15. Capturing corner tab of mechanical diaphragm fuel pump bracket, install the last alignment screw (E) into the blower housing. Tighten screw to **75-95 lb-in** (8.5-10.7 N-m).
16. See *Air Cleaner Assembly, Installation*.

## ETC

**NOTE:** The ETC consists of the ECM, MAP sensor, MAT sensor, TPS, throttle body, and stepper motor. The ETC is not serviceable, and must be replaced if any component fails.

## Removal

1. See *Blower Housing, Removal*.
2. See Figure 10. Release fuel rail hose from three clips (A and B) anchored in holes of cylinder 2 shield.
3. Press two green tabs on quick disconnect fitting (C) to release fuel rail from fuel pump module.

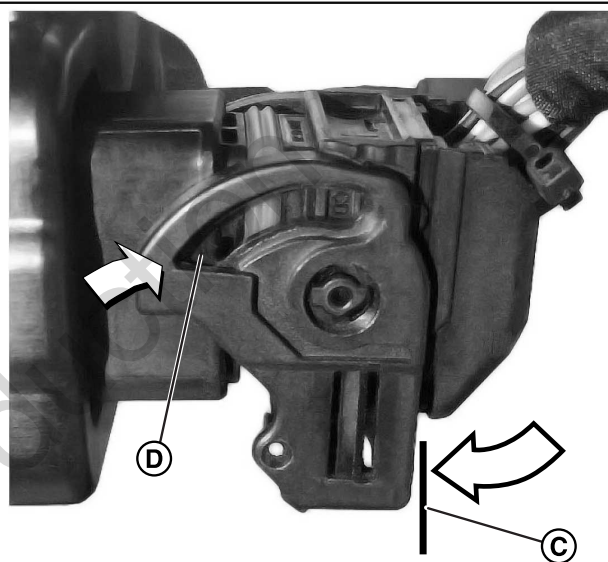
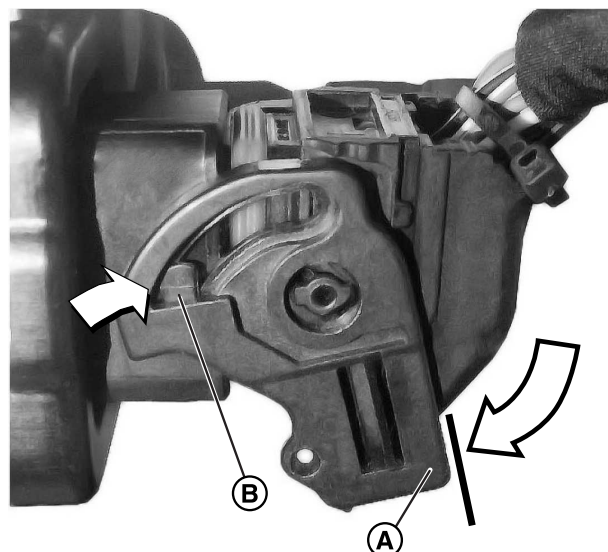
**NOTE:** Wrap shop towel around fitting to catch any fuel leakage.

4. Squeeze anchor on connector clip (D) to release pin housing of cylinder 1 ignition coil connector from hole in shield. Use needle nose pliers for best results. Repeat step on cylinder 2 ignition coil connector (E), if installed.
5. Remove hex flange screw to release EHT sensor (F) from cylinder 1 head.
6. Remove hex flange screw to release throttle body ground wire ring terminal (G) from cylinder 2 head.
7. Disconnect ECM connector.

**NOTE:** See Figure 9. Push tab and rotate cam lock (A) in a clockwise direction until post (B) contacts opposite end of slot. Rotate cam lock to the completely vertical position (C) to disengage post from slot (D). Remove connector.

8. See Figure 10. Gently pull crankcase breather tube (H) from hole at back of intake elbow. At same location, remove fuel pump module vacuum hose from EVAP elbow fitting.

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9. To avoid pulling or stretching the EFI wire harness during removal of the intake manifold/ETC/air intake elbow assembly, add some slack to the harness as follows:

- A. Remove wire harness clip (I) above valve cover on cylinder 1 shield. For best results, squeeze anchor using a needle nose pliers and push through hole.
- B. Remove wire harness clip (J) from top of corner tab on valley shield.

**NOTE:** Forcefully removing the fir tree style clip may bend the shield. For best results, use the Briggs & Stratton Fuel Line Removal Tool (Part No. 19620) to gently pry the clip from the anchor hole. If the clip is broken during removal, be sure to remove all plastic debris from the engine.

- C. Disconnect CKP sensor connector (K).

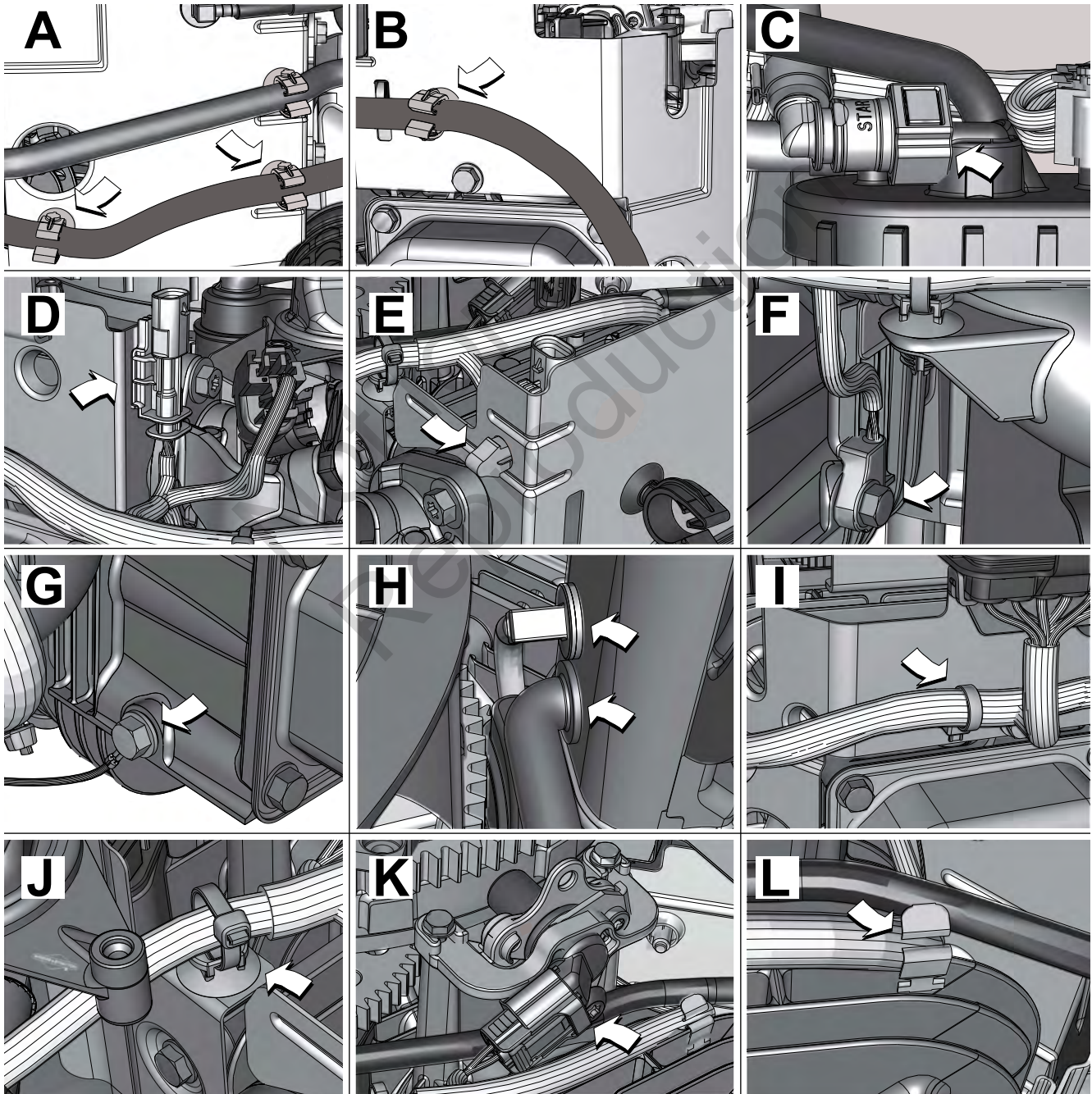


- D. Release wire harness from metal form clip (L) attached to fin of cylinder 2.
10. Remove four hex flange screws to release intake manifold. Gently tap intake manifold with a rubber mallet to loosen, if necessary.
  11. Slowly raise the intake manifold/ETC/air intake elbow assembly straight up to remove it from the engine. Release any part of the wire harness that could get caught by the assembly as this task is being done. Avoid pulling or stretching the wire harness.
  12. See Figure 11. Remove two hex flange nuts (A) to release air intake elbow (B) and ETC (C) from intake manifold studs (D).

**NOTE:** With the ends of the studs pointing down, turn nuts in a clockwise direction. Inadvertently turning the nuts in the wrong direction may crack the plastic construction of the air intake elbow.

13. Remove old gaskets from intake manifold and cylinder head flanges. Discard gaskets.
14. Start bottom intake manifold flange screws into cylinder heads, if removed. Engage bottom slots in intake manifold flanges with screws to temporarily seat intake manifold. Do not allow intake manifold to hang by the wire harness or damage may occur.

10



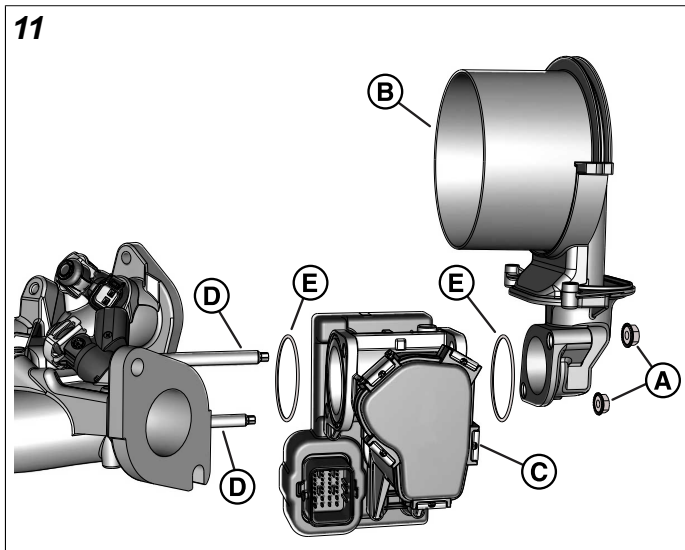
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## Installation

1. See Figure 11. Verify that O-rings (**E**) on each side of the throttle body are not damaged or deformed. Install **new** O-rings if necessary.
2. Slowly raise the intake manifold straight up. Exercise care to avoid pulling or stretching the wire harness or damage may occur.
3. Slide ETC (**C**) and air intake elbow (**B**) onto intake manifold studs (**D**). Start two hex flange nuts (**A**) onto studs and tighten to **40-60 lb-in** (4.5-6.8 N-m).
4. Verify that intake manifold and cylinder head flanges are clean and dry. Install **new** gaskets onto intake manifold flanges.
5. Engage bottom slots in intake manifold flanges with screws installed in cylinder heads.
6. Start two top hex flange screws into intake manifold flanges.
7. Alternately tighten four intake manifold flange screws to **90-110 lb-in** (10.2-12.4 N-m) using a crosswise pattern.
8. See Figure 10. Capture wire harness in metal clip (**L**) attached to fin of cylinder 2.
9. Connect CKP sensor connector (**K**).
10. Install wire harness clip (**J**) into hole at top of corner tab on valley shield.

**NOTE:** If fir tree style clip was broken during removal, obtain a **new** fir tree (or rosebud) style clip, and use the imprint left on the wire harness as a guide for correct location.

11. Install wire harness clip (**I**) into hole in cylinder 1 shield (above valve cover).
12. At back of air intake elbow, install vacuum hose from fuel pump module onto EVAP elbow fitting (**H**). At same location, install crankcase breather tube.
13. Connect ECM connector.



**NOTE:** Push in connector until post engages slot in cam lock. Rotate cam lock in a counter-clockwise direction until post is at the opposite end of slot and cam lock locks in the horizontal position.

14. Install hex flange screw to fasten throttle body ground wire ring terminal (**G**) to cylinder 2 head. Tighten screw to **40-50 lb-in** (4.5-5.7 N-m).
15. Install hex flange screw to fasten EHT sensor (**F**) to cylinder 1 head. Tighten screw to **40-50 lb-in** (4.5-5.7 N-m).
16. Push anchor on pin housing of cylinder 2 ignition coil connector (**E**) into inside hole in shield.
17. Push anchor on pin housing of cylinder 1 ignition coil connector (**D**) into outside hole in shield.
18. Route fuel rail hose (terminating in quick disconnect fitting) toward the fuel pump module. When between the oil cooler inlet/outlet hoses, run hose behind the mechanical diaphragm fuel pump hose, and then up to top of fuel pump module.
19. Firmly push quick disconnect fitting (**C**) onto fuel pump module fitting. Gently tug on quick disconnect fitting to verify that it is properly seated and secured.
20. Capture fuel rail hose into three clips (**B** and **A**) anchored in holes of cylinder 2 shield.
21. See *Blower Housing, Installation*.

## Mechanical Diaphragm Fuel Pump

### Removal

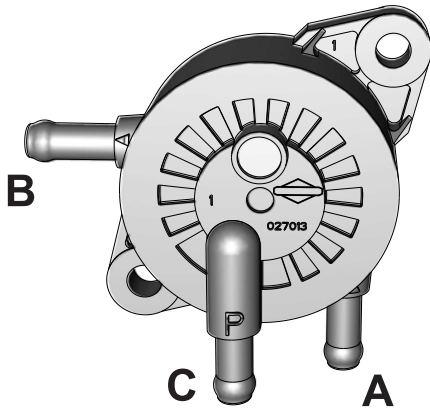
1. See Figure 12. Squeeze tangs and move hose clamp away from fuel inlet fitting (**A**). Remove hose from fitting.

**NOTE:** Wrap shop towel around fittings to catch any fuel leakage.

2. Squeeze tangs and move hose clamp away from fuel outlet fitting (**B**). Remove hose from fitting.
3. Squeeze tangs and move hose clamp away from pulse line fitting (**C**). Remove hose from fitting.
4. Remove two hex flange screws to release fuel pump from bracket.

### Installation

1. See Figure 12. Orient **new** fuel pump with the pulse line and fuel inlet fittings pointing down.
2. Install two hex flange screws to fasten fuel pump to bracket. Alternately tighten screws to **40-50 lb-in** (4.5-5.7 N-m).
3. Install hose from fuel filter onto fuel inlet fitting (**A**). Squeeze tangs and move hose clamp about **1/8 inch** (3 mm) from end of hose.
4. Install hose to fuel pump module onto fuel outlet fitting (**B**). Squeeze tangs and move hose clamp about **1/8 inch** (3 mm) from end of hose.



5. Install crankcase vacuum hose from cylinder 2 valve cover onto pulse line fitting (C). Squeeze tangs and move hose clamp about **1/8 inch** (3 mm) from end of hose. Verify that hose is captured in clip anchored on cylinder 2 shield.
6. Turn ignition switch ON for two seconds, and then OFF for 10 seconds. Turn the ignition switch back to ON and check for fuel leaks.

## Fuel Pump Module

### Removal

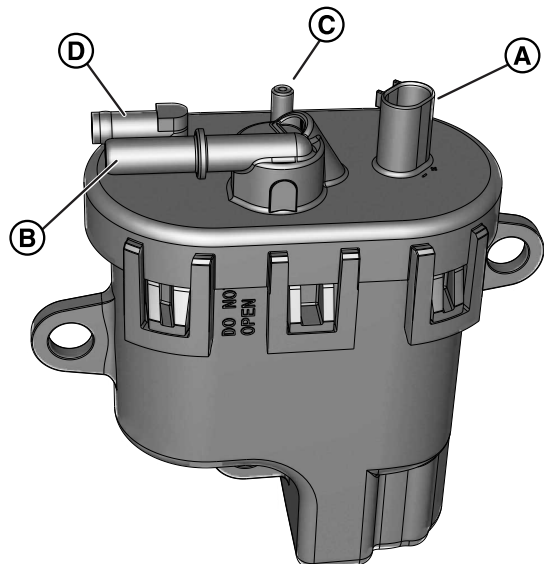
1. See *CHECK/RELIEVE FUEL SYSTEM PRESSURE* in this section.
  2. See Figure 13. Disconnect fuel pump module connector (A). Pull out gray secondary lock, and then press and hold tab before pulling apart connector halves.
  3. Remove three hex flange screws to release fuel pump module from bracket.
  4. Release fuel rail hose from three clips anchored in holes of cylinder 2 shield.
  5. Press two green tabs on quick disconnect fitting to release fuel rail from fuel outlet fitting (B).
- NOTE:** Wrap shop towel around fittings to catch any fuel leakage.
6. See Figure 4. Remove four hex flange screws (A-D) and one blower housing alignment screw (E) to release mechanical diaphragm fuel pump bracket and oil cooler bracket from blower housing.
  7. See Figure 13. Squeeze tangs and move hose clamp away from EVAP fitting (C). Remove hose from fitting.
  8. Squeeze tangs and move hose clamp away from fuel inlet fitting (D). Remove hose from fitting.

**NOTE:** Fuel pump module may contain a small quantity of fuel. Hold fuel pump module with inlet and

outlet fittings pointing upward until fuel can be drained into a suitable container.

### Installation

1. See Figure 13. Install hose from mechanical diaphragm fuel pump onto fuel inlet fitting (D). Squeeze tangs and move hose clamp about **1/8 inch** (3 mm) from end of hose. Be sure tangs are at the top of the hose or they may interfere with installation of the quick disconnect fitting.
2. Install hose to intake elbow onto EVAP fitting (C). Route hose through loop formed by installation of the fuel inlet hose installed in step 1. Squeeze tangs and move hose clamp to end of hose.
3. Align three holes in fuel pump module with holes in bracket. Start three hex flange screws to fasten fuel pump module to bracket. Alternately tighten screws to **60-70 lb-in** (6.8-8 N-m).
4. See Figure 4. Positioned so that the mechanical diaphragm fuel pump bracket overlaps the oil cooler bracket, start four hex flange screws to fasten brackets to blower housing. Alternately tighten screws (A-D) to **25-30 lb-in** (2.8-3.4 N-m) in the sequence shown.
5. Capturing corner tab of mechanical diaphragm fuel pump bracket, install the alignment screw (E) into the blower housing. Tighten screw to **75-95 lb-in** (8.5-10.7 N-m).
6. Route fuel rail hose (terminating in quick disconnect fitting) toward the fuel pump module. When between the oil cooler inlet/outlet hoses, run hose behind the mechanical diaphragm fuel pump hose (to pulse line fitting), and then up to top of fuel pump module.





7. See Figure 13. Firmly push quick disconnect fitting onto fuel outlet fitting (B). Gently tug on fitting to verify that it is properly seated and secured.
8. Capture fuel rail hose into three clips anchored in holes of cylinder 2 shield.
9. Connect fuel pump module connector (A). Push in grey secondary lock to secure.
10. Turn ignition switch ON for two seconds, and then OFF for 10 seconds. Turn the ignition switch back to ON and check for fuel leaks.

## Fuel Filter

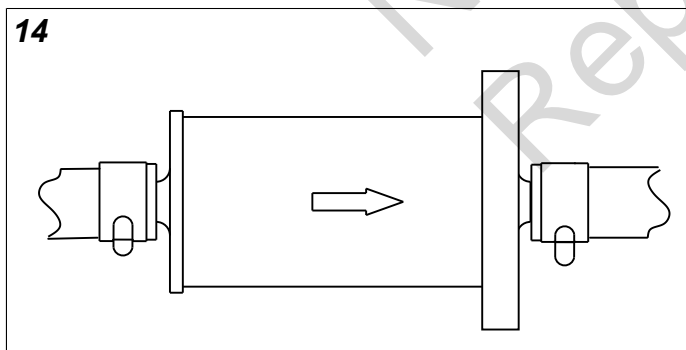
### Removal

1. See *CHECK/RELIEVE FUEL SYSTEM PRESSURE* in this section.
2. Squeeze tangs and move hose clamps away from fuel inlet and outlet fittings. Remove fuel inlet and outlet hoses from fuel filter fittings.

**NOTE:** Wrap shop towel around fuel filter fittings to catch any fuel leakage.

### Installation

1. See Figure 14. With the arrow pointing in the direction of fuel flow, install **new** fuel filter between fuel inlet and outlet hoses. Squeeze tangs and move hose clamps about **1/8 inch** (3 mm) from end of each hose.
2. Turn ignition switch ON for two seconds, and then OFF for 10 seconds. Turn the ignition switch back to ON and check for fuel leaks.

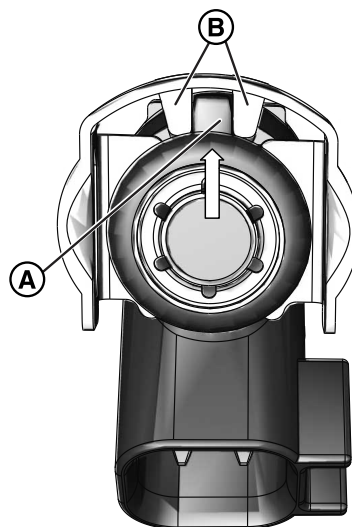


## Fuel Injectors/Fuel Rail

### Removal

1. See *CHECK/RELIEVE FUEL SYSTEM PRESSURE* in this section.
2. See *Blower Housing, Removal*.
3. Disconnect cylinder 1 and cylinder 2 fuel injector connectors. Pull out white secondary lock, and then press and hold tab before pulling apart connector halves.

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4. Remove two T30 TORX screws to release fuel injector cap flanges from intake manifold.
5. Remove retaining clips and then remove fuel injector caps from fuel injectors.
6. Remove fuel injectors from intake manifold.
7. To remove fuel rail, proceed as follows:
  - A. Release fuel rail hose from three clips anchored in holes of cylinder 2 shield.
  - B. Squeeze two green tabs on quick disconnect fitting to release fuel rail from fuel pump module fitting.

**NOTE:** Wrap shop towel around fitting to catch any fuel leakage.

### Installation

1. Lightly lubricate fuel injector O-rings with clean engine oil.
2. Install fuel injectors into intake manifold.
3. Install fuel injector caps onto fuel injectors.
4. Install retaining clips to secure fuel injector caps to fuel injectors.

**NOTE:** See Figure 15. Be sure retaining clips are properly installed. Side slots on clip engage lip on cap, while tab (A) on fuel injector body is captured between prongs (B) on clip.

5. Install two T30 TORX screws to fasten fuel injector cap flanges to intake manifold. Tighten screws to **50-60 lb-in** (5.7-6.8 N-m).
6. Gently rotate cylinder 1 fuel injector (black) outward until it makes light contact with the intake manifold. Rotate cylinder 2 fuel injector (gray) inward until it makes light contact with the throttle body.

7. Connect fuel injector connectors. Push in white secondary locks to secure.
8. To install fuel rail, proceed as follows:
  - A. Route fuel rail hose (terminating in quick disconnect fitting) toward the fuel pump module. When between the oil cooler inlet/outlet hoses, run hose behind the mechanical diaphragm fuel pump hose (from pulse line fitting), and then up to the fuel pump module fitting.
  - B. Firmly push quick disconnect fitting onto fuel pump module fitting. Gently tug on fitting to verify that it is properly seated and secured.
  - C. Capture fuel rail hose into three clips anchored in holes of cylinder 2 shield.
9. Turn ignition switch ON for two seconds, and then OFF for 10 seconds. Turn the ignition switch back to ON and check for fuel leaks.
10. See *Blower Housing, Installation*.

## Ignition Coil

### Removal

1. See *Blower Housing, Removal*.
2. Remove two hex flange screws to release ignition coil from blower housing.

### Installation

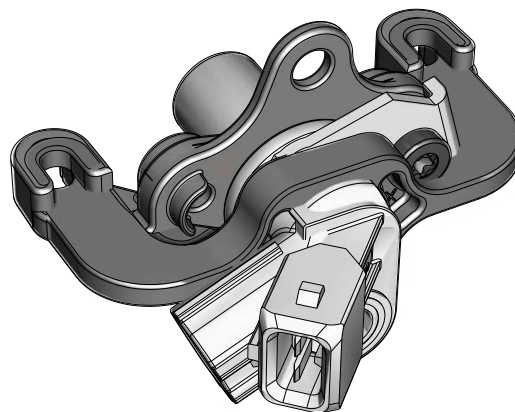
1. Install two hex flange screws to fasten ignition coil to blower housing. Tighten screws to **20-30 lb-in** (2.3-3.4 N-m).
2. Route cylinder 1 ignition coil connector through opening in blower housing.
3. See *Blower Housing, Installation*.

## CKP Sensor

### Removal

1. See *Blower Housing, Removal*.
2. Disconnect CKP sensor connector.
3. Loosen or remove two hex flange screws to release CKP sensor bracket from cylinder mounting bosses.

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### Installation

1. If installing **new** CKP sensor, start two **new** hex flange screws to fasten CKP sensor bracket to cylinder mounting bosses.
2. Move bracket toward flywheel, so that gap between CKP sensor and flywheel tooth is **0.010 inches** (0.254 mm).
3. Alternately tighten CKP sensor bracket screws to **20-30 lb-in** (2.3-3.4 N-m).
4. Connect CKP sensor connector.
5. See *Blower Housing, Installation*.

### EHT Sensor

**NOTE:** The EHT sensor is an integral part of the EFI wire harness and is not sold separately. Replace EFI wire harness if EHT sensor is bad.

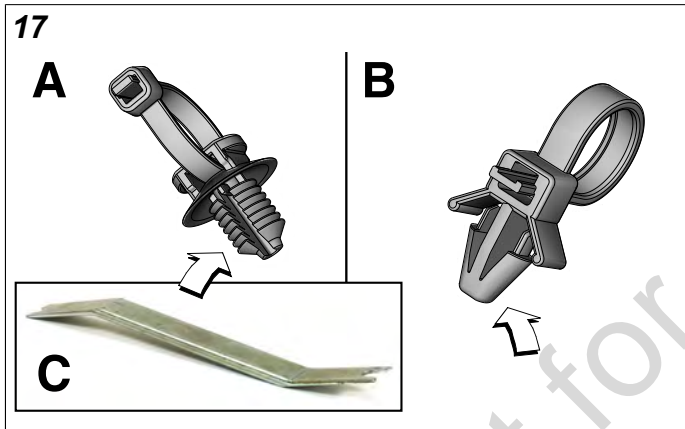
## EFI Wire Harness

### Removal

**NOTE:** While a variety of devices are used to retain the wire harness, the two most common can be distinguished by the type of anchor featured, as shown in Figure 17.

The anchor on the fir tree style clip (**A**) resembles an upside down fir tree. Due to the rib configuration, the anchor is a very tight fit, and often cannot be removed without damage to the clip unless special care is taken.

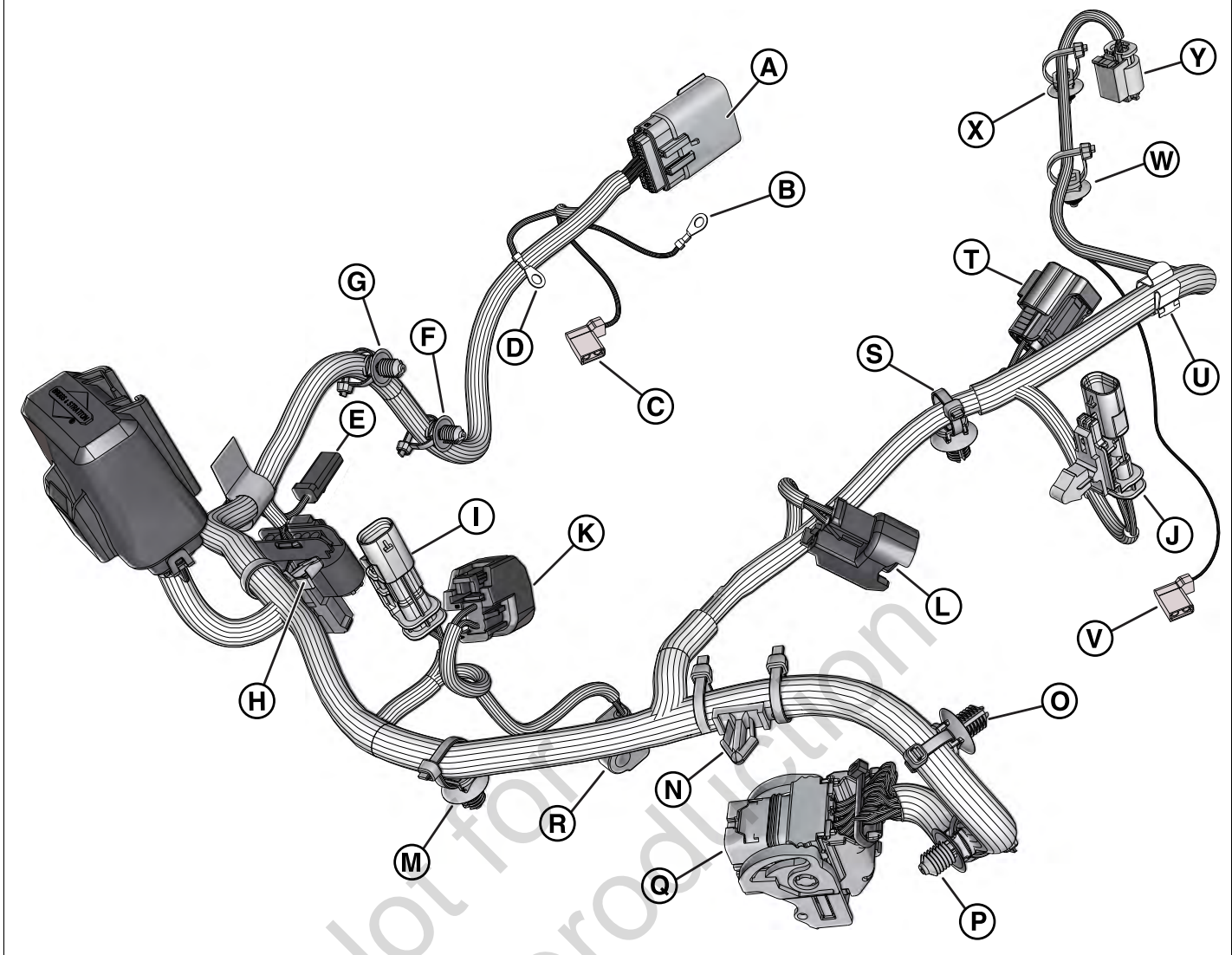
Conversely, the anchor on the rosebud style clip (**B**), which also resembles its namesake, is easily removed by gently squeezing the anchor with a needle nose pliers, and then pushing it through the anchor hole.



**NOTE:** When removing the fir tree style clips, avoid damage to the clips and/or engine components by using the Briggs & Stratton Fuel Line Removal Tool (Part No. 19620) (**C**) to gently pry the clip from the anchor hole. If the clip is broken during removal, be sure to remove all plastic debris from the engine.

1. See *Blower Housing, Removal*.
2. See Figure 18. Starting on cylinder 1 side, and moving in a counter-clockwise direction around the engine, press tab and disconnect main vehicle connector (**A**), if connected.
3. Rotate hex to remove threaded stud from crankcase. Remove engine ground wire ring terminal (**B**) from stud.
4. Remove yellow wire elbow spade socket terminal (**C**) from starter solenoid spade contact.

5. Remove hex nut to release red wire ring terminal (**D**) from starter solenoid post.
  6. Remove wire harness from clip on dipstick oil tube.
  7. Disconnect one-place voltage regulator connector (**E**).
  8. Remove two wire harness clips (**F** and **G** in Figure 19) from cylinder 1 shield next to voltage regulator.
  9. Remove wire harness clip (**H** in Figure 19) from cylinder 1 shield above valve cover.
  10. Squeeze anchor on connector clip to release pin housing (**I**) of cylinder 1 ignition coil connector from hole in shield. Use needle nose pliers for best results. Repeat step on cylinder 2 ignition coil connector (**J**), if installed.
  11. Disconnect cylinder 1 and cylinder 2 fuel injector connectors (**K** and **L**). Pull out white secondary lock, and then press and hold tab before pulling apart connector halves.
  12. Remove wire harness clip (**M** in Figure 19) at top of intake manifold (cylinder 1 side).
  13. Remove double-sided wire harness clip (**N** in Figure 19) at top center of intake manifold.
  14. Remove two wire harness clips (**O** and **P** in Figure 19) at top and bottom of intake manifold (cylinder 2 side).
  15. Disconnect ECM connector (**Q**).
- NOTE:** See Figure 9. Push tab and rotate cam lock in a clockwise direction until post contacts opposite end of slot. Rotate cam lock to the completely vertical position to disengage post from slot. Remove connector.
16. Remove hex flange screw to release EHT sensor (**R**) from cylinder 1 head.
  17. Remove wire harness clip (**S** in Figure 19) from top of corner tab on valley shield on cylinder 2 side.
  18. Disconnect CKP sensor connector (**T**).
  19. Release wire harness from metal form clip (**U** in Figure 19) attached to fin of cylinder 2.
  20. Remove elbow spade socket terminal (**V**) from oil pressure switch spade contact.
  21. Remove two wire harness clips (**W** and **X** in Figure 19) at top of fuel pump module bracket.
  22. Disconnect fuel pump module connector (**Y**). Pull out grey secondary lock, and then press and hold tab before pulling apart connector halves.
  23. Remove EFI wire harness from the engine.



### Installation

1. Place **new** EFI wire harness in its approximate position on the engine.
2. See Figure 18. Starting on cylinder 1 side, and moving in a counter-clockwise direction around the engine, connect main vehicle connector (A).
3. Install engine ground wire ring terminal (B) (and ground wire ring terminal from starter solenoid) onto threaded stud. Install stud in crankcase and tighten to **125-135 lb-in** (14.1-15.3 N-m).
4. Install yellow wire elbow spade socket terminal (C) onto starter solenoid spade contact.
5. Install red wire ring terminal (D) onto starter solenoid post. Install hex nut and tighten to **10-15 lb-in** (1.1-1.7 N-m).
6. Install wire harness into clip on dipstick oil tube.
7. Connect one-place voltage regulator connector (E).
8. Install two wire harness clips (F and G in Figure 19) into cylinder 1 shield next to voltage regulator.
9. Install wire harness clip (H in Figure 19) into cylinder 1 shield above valve cover.
10. Push anchor on pin housing of cylinder 1 ignition coil connector (I) into hole on outside of shield.
11. Push anchor on pin housing of cylinder 2 ignition coil connector (J) into hole on inside of shield.
12. Connect cylinder 1 and cylinder 2 fuel injector connectors (K and L). Push in white secondary locks to secure.
13. Install wire harness clip (M in Figure 19) at top of intake manifold (cylinder 1 side).
14. Install double-sided wire harness clip (N in Figure 19) at top center of intake manifold.
15. Install two wire harness clips (O and P in Figure 19) at top and bottom of intake manifold (cylinder 2 side).
16. Connect ECM connector (Q).
17. Install hex flange screw to fasten EHT sensor (R) to cylinder 1 head and tighten to **40-50 lb-in** (4.5-5.7 N-m).



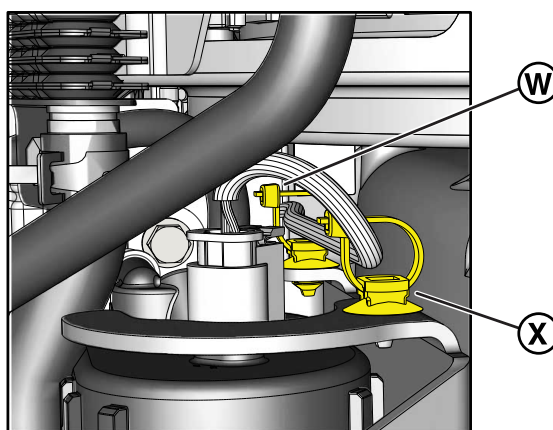
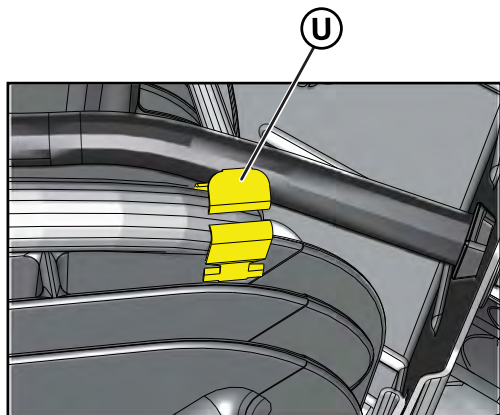
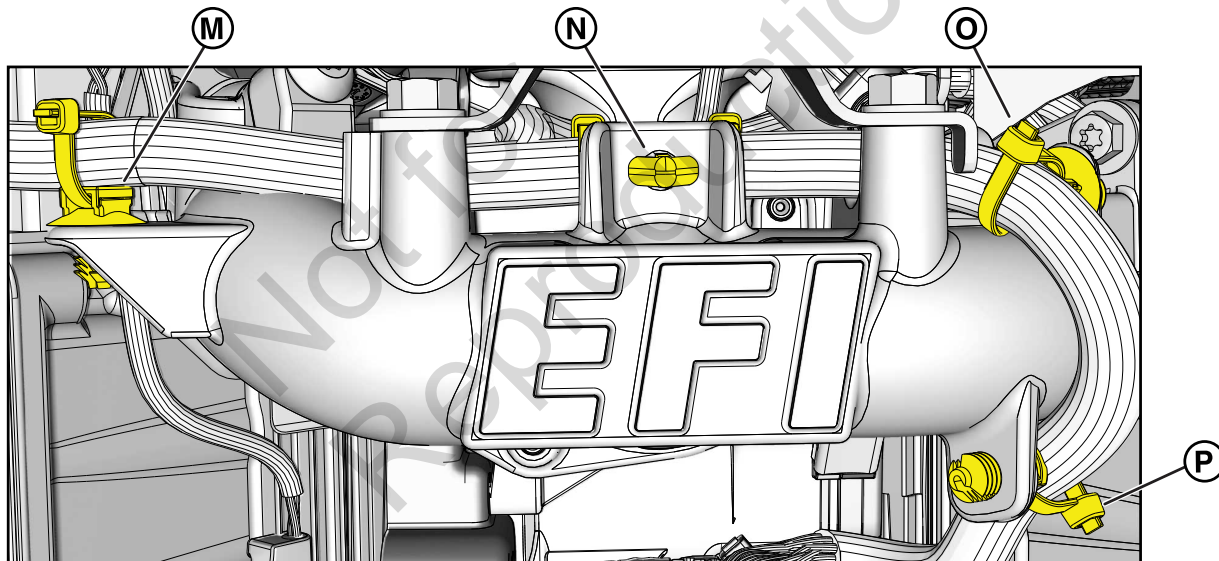
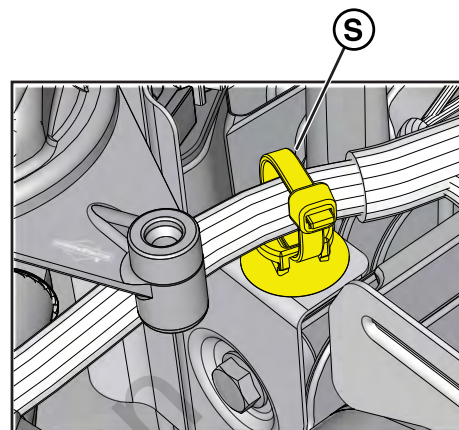
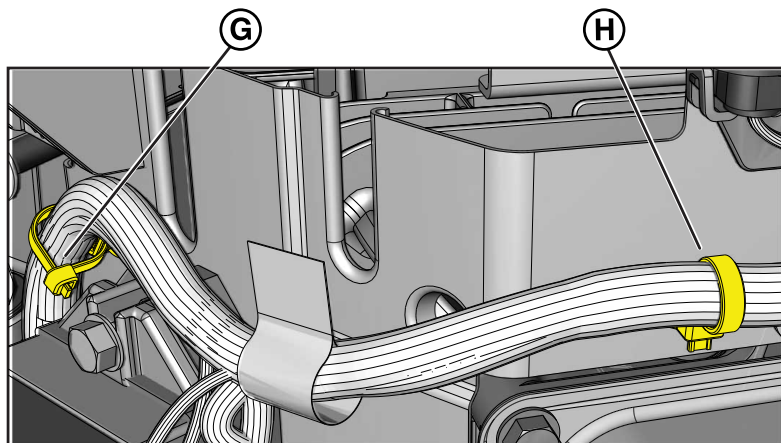
18. Install wire harness clip (**S** in Figure 19) into top of corner tab on valley shield on cylinder 2 side.
19. Connect CKP sensor connector (**T**).
20. Install wire harness into metal form clip (**U** in Figure 19) attached to fin of cylinder 2.
21. Route wire harness under EVAP tube, and then downward between shield and oil filter to oil pressure

switch. Install elbow spade socket terminal onto oil pressure switch spade contact (**V**).

22. Route free end of wire harness outside of shield, and install two wire harness clips (**W** and **X** in Figure 19) at top of fuel pump module bracket.
23. Connect fuel pump module connector (**Y**). Push in grey secondary lock to secure.
24. See *Blower Housing, Installation*.

19

5





## Side Cover

### Removal

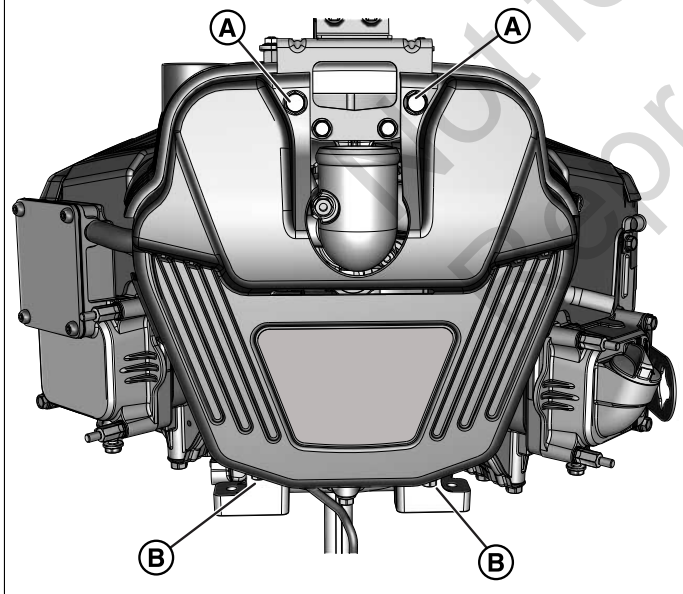
1. See Figure 20. Remove two hex flange screws (A) to release top of side cover from air cleaner bracket.
2. Remove two hex flange screws (B) to release bottom of side cover from fuel pump module bracket.

### Installation

1. See Figure 20. Install side cover on engine.
2. Start two short hex flange screws (B) to fasten bottom of side cover to fuel pump module bracket.
3. Start two long hex flange screws (A) to fasten top of side cover to air cleaner bracket.
4. Alternately tighten four hex flange screws to **80-100 lb-in** (9.0-11.3 N-m).

**NOTE:** Be sure low oil pressure switch conduit is not pinched as cover is tightened, but is routed through opening next to upper valve cover screw.

20

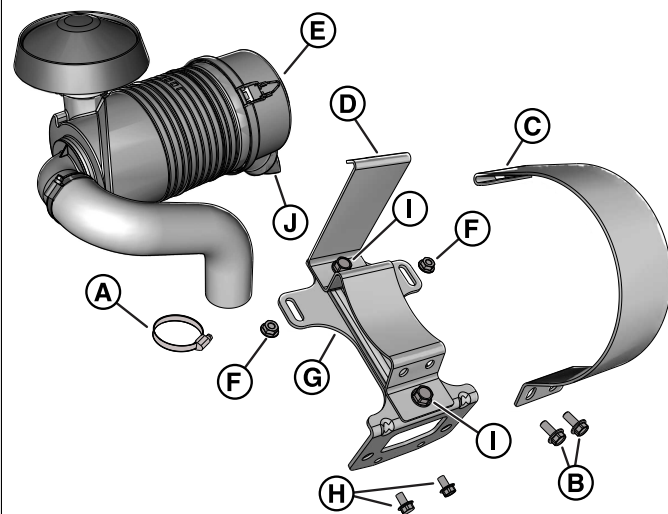


## Air Cleaner Assembly

### Removal

1. See *Side Cover, Removal*.
2. See Figure 21. Loosen band clamp (A) and remove hose from air intake elbow.

21



5

3. Remove two hex flange screws (B) and disengage hook on air cleaner strap (C) from lip on air cleaner top bracket (D).
4. Remove air cleaner assembly (E).
5. Remove two hex flange nuts (F) to release air cleaner bottom bracket (G) from air cleaner studs.
6. Remove two hex flange screws (H) to release air cleaner bottom bracket from air intake elbow.

### Installation

1. Place air cleaner bottom bracket (G) over two air cleaner studs.
2. Start two hex flange screws (H) to fasten air cleaner bottom bracket to air intake elbow. Tighten screws **80-100 lb-in** (9.0-11.3 N-m).
3. Install two hex flange nuts (F) to fasten air cleaner bottom bracket to air cleaner studs. Tighten nuts to **80-100 lb-in** (9.0-11.3 N-m).
4. If removed, install two hex flange screws (I) to fasten air cleaner top bracket (D) to air cleaner bottom bracket. Tighten screws to **125-150 lb-in** (14.1-17.0 N-m).
5. Position air cleaner assembly (E) on air cleaner top bracket with the duckbill air valve (J) pointing down.

**NOTE:** Replace duckbill air valve if damaged or missing. Engine operation without the duckbill air valve can reduce filter efficiency.

6. Engage hook on air cleaner strap (C) with lip on air cleaner top bracket.

7. Install two hex flange screws (**B**) to fasten air cleaner strap to air cleaner top bracket. Tighten screws to **80-100 lb-in** (9.0-11.3 N-m).
8. If detached, install hose onto air outlet elbow with the paint mark on top. Install band clamp at end of hose and tighten to **15-20 lb-in** (1.7- 2.3 N-m).
9. Loosely install band clamp (**A**) at opposite end of hose, and install hose onto air intake elbow. Tighten band clamp to **15-20 lb-in** (1.7-2.3 N-m).
10. See *Side Cover, Installation*.

## Top Cover

### Removal

1. See *Air Cleaner Assembly, Removal*.
2. See Figure 22. Remove two Phillips screws (**A**) with retaining washers (**B**) to release top cover (**C**) from blower housing. If equipped, disconnect MIL/tachometer/hourmeter connector at back of top cover.

### Installation

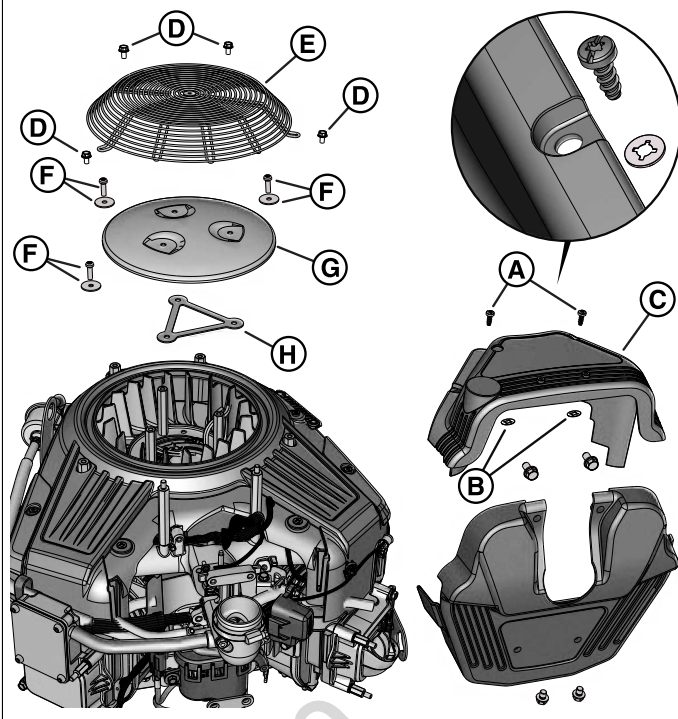
1. If equipped, connect MIL/tachometer/hourmeter connector at back of top cover.
2. See Figure 22. Insert two Phillips screws (**A**) into top cover (**C**), and finger tighten retaining washers (**B**) onto screws. Start screws into blower housing and tighten to **25-35 lb-in** (2.8-4.0 N-m).
3. See *Air Cleaner Assembly, Installation*.

## Blower Housing

### Removal

1. See *Air Cleaner Assembly, Removal*.
2. See *Top Cover, Removal*.
3. See Figure 22. Remove four hex flange screws (**D**) to release wire guard (**E**) from coupling nuts at top of blower housing.
4. Remove three T30 TORX screws with flat washers (**F**) to release debris screen (**G**) and triangular spacer (**H**) from ring mounting studs.
5. See Figure 23. Starting at cylinder 2 (oil filter side) and working in a counter-clockwise direction around the engine, remove oil pressure switch conduit clip (**A**) from blower housing.
6. Remove hex flange screw (**B**) to release oil pressure switch conduit clip, air guide, and blower housing from intake manifold.
7. Remove Phillips screw (**C**) to release oil cooler (or finger guard) top bracket from blower housing.
8. Remove two Phillips screws (**D**) to release electric lift fuel pump bracket from blower housing.
9. Remove hex flange screw (**E**) to release EFI wire harness clip, air guide, and blower housing from intake manifold.

22



10. Remove four coupling nuts (**F**) from cylinder posts at top of blower housing.
11. Remove blower housing from engine.

### Installation

1. Loosely install blower housing onto engine, so that holes in housing engage four cylinder posts.
2. Verify that high tension leads are routed through slots in shield on both sides of engine.
3. Verify that hose from fuel lift pump, EVAP hose, and EFI wire harness stacked behind cylinder 1 valve cover breather are not pinched, crushed, or kinked as blower housing is tightened.
4. See Figure 23. Start four coupling nuts (**F**) onto cylinder posts, but do not tighten.
5. Starting at cylinder 1 (starter motor side) and working in a clockwise direction around the engine, install hex flange screw (**E**) to fasten EFI wire harness clip, air guide, and blower housing to intake manifold. Tighten screw to **80-100 lb-in** (9.0-11.3 N-m).
6. Install two Phillips screws (**D**) to fasten electric lift fuel pump bracket to blower housing. Tighten screws to **35-45 lb-in** (4.0-5.1 N-m).
7. Install Phillips screw (**C**) to fasten oil cooler (or finger guard) top bracket to blower housing. Tighten screw to **35-45 lb-in** (4.0-5.1 N-m). If removed, install two hex flange screws to fasten bottom bracket to back plate. Tighten screws to **80-100 lb-in** (9.0-11.3 N-m).
8. Install hex flange screw (**B**) to fasten oil pressure switch conduit clip, air guide, and blower housing

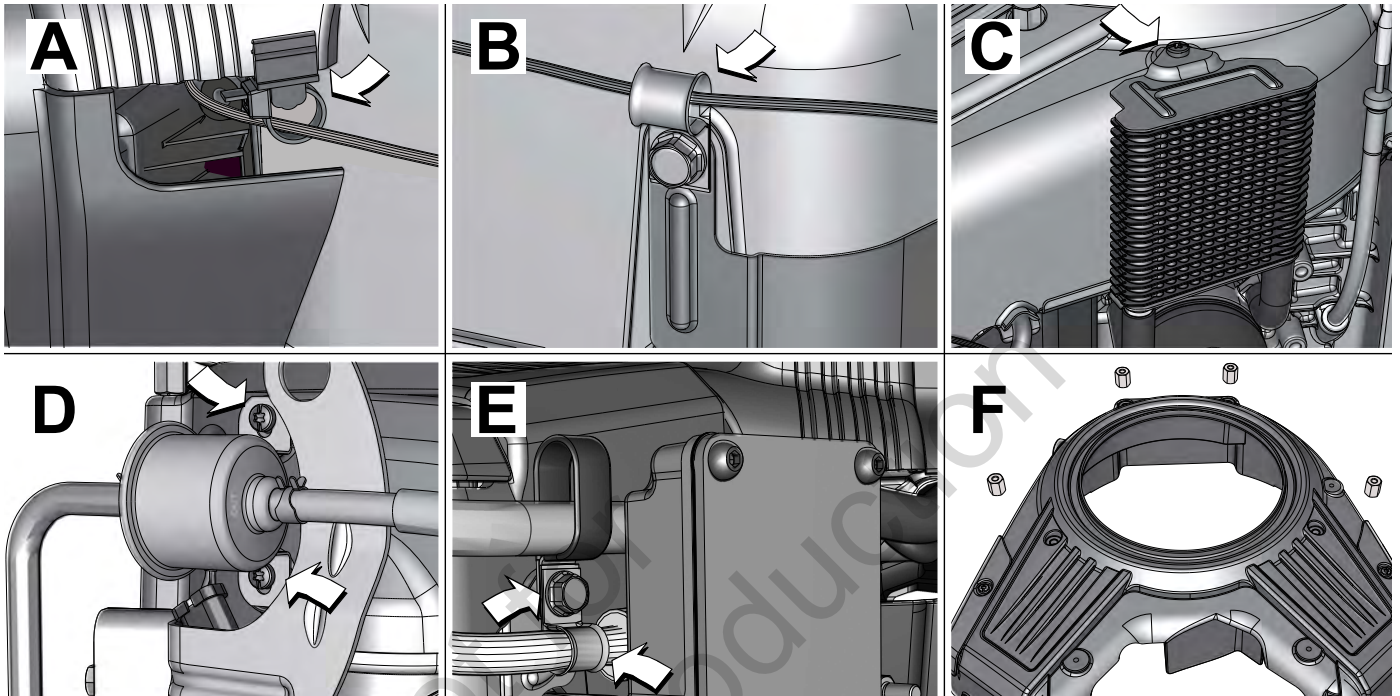
to intake manifold. Tighten screw to **80-100 lb-in** (9.0-11.3 N-m).

9. Attach oil pressure switch conduit clip (A) to blower housing.
10. Alternately tighten four coupling nuts to **80-100 lb-in** (9.0-11.3 N-m) in a crosswise pattern.
11. See Figure 22. Position triangular spacer (H) on top of ring mounting studs. Install debris screen (G) and start three T30 TORX screws with flat washers (F).

Alternately tighten screws to **80-100 lb-in** (9.0-11.3 N-m) in a crosswise pattern.

12. Install four hex flange screws (D) to fasten wire guard (E) to coupling nuts. Alternately tighten screws to **80-100 lb-in** (9.0-11.3 N-m) in a crosswise pattern.
13. See *Top Cover, Installation*.
14. See *Air Cleaner Assembly, Installation*.

23



5

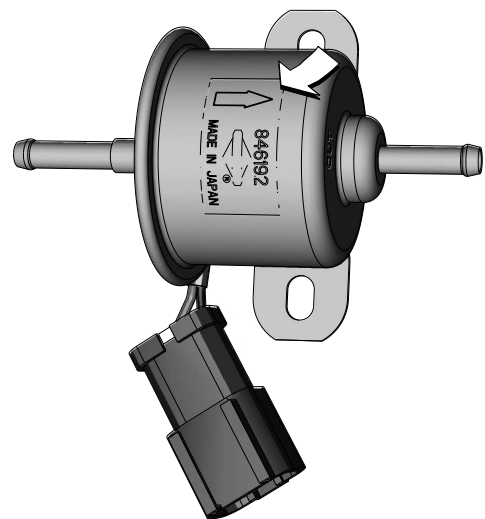
## Electric Lift Fuel Pump

### Removal

1. See *CHECK/RELIEVE FUEL SYSTEM PRESSURE* in this section.
2. See Figure 24. Remove two Phillips screws to release electric lift fuel pump bracket from blower housing.
3. Disconnect fuel pump connector.
4. Squeeze tangs and move hose clamps away from fuel inlet and outlet fittings. Remove fuel inlet and outlet hoses from pump.

**NOTE:** Wrap shop towel around fuel filter fittings to catch any fuel leakage.

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## Installation

1. See Figure 24. With the arrow pointing in the direction of fuel flow, install **new** electric lift fuel pump between fuel inlet and outlet hoses. Squeeze tangs and move hose clamps about **1/8 inch** (3 mm) from end of each hose.
2. Connect fuel pump connector.
3. Install two Phillips screws to fasten pump bracket to blower housing. Tighten screws to **35-45 lb-in** (4.0-5.1 N-m).
4. Turn ignition switch ON for two seconds, and then OFF for 10 seconds. Turn the ignition switch back to ON and check for fuel leaks.

## Fuel Pump Module

### 5

### Removal

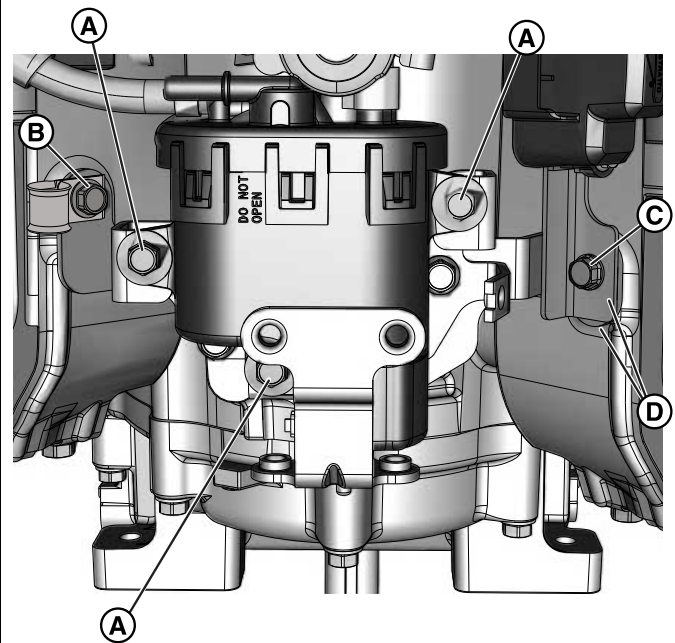
1. See *CHECK/RELIEVE FUEL SYSTEM PRESSURE* in this section.
2. See *Side Cover, Removal*.
3. See Figure 25. Remove three hex flange screws (A) to release fuel pump module from bracket.
4. On cylinder 1 (starter motor) side, remove hex flange screw (B) to release fuel pump module bracket and wire harness clip (capturing O<sub>2</sub> sensor and EHT sensor conduit) from cylinder head.
5. On opposite side, remove hex flange screw (C) to release fuel pump module bracket and fuse/relay block bracket from cylinder head. Note that bracket is positioned inside (D) of fuse/relay block bracket.
6. Remove fuel pump module from bracket.
7. See Figure 26. Disconnect fuel pump module connector (A). Pull out gray secondary lock, and then press and hold tab before pulling apart connector halves.
8. Press two tabs on quick disconnect fitting to release fuel rail from fuel outlet fitting (B).

**NOTE:** Wrap shop towel around fittings to catch any fuel leakage.

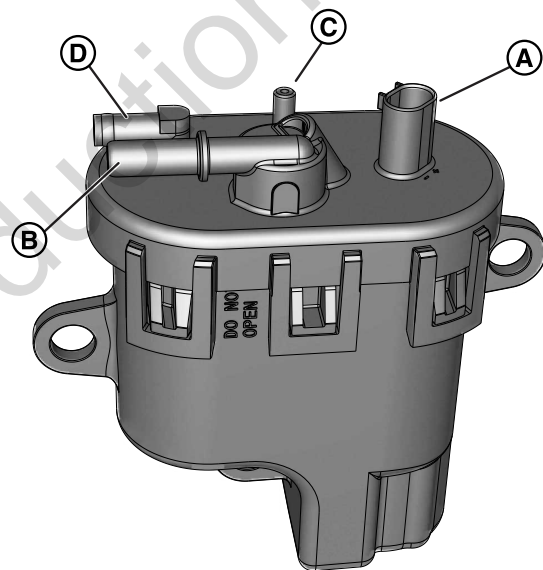
9. Squeeze tangs and move hose clamp away from EVAP fitting (C). Remove hose from fitting.
10. Squeeze tangs and move hose clamp away from fuel inlet fitting (D). Remove hose from fitting.

**NOTE:** Fuel pump module may contain a small quantity of fuel. Hold fuel pump module with inlet and outlet fittings pointing upward until fuel can be drained into a suitable container.

25



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## Installation

1. See Figure 26. Install hose from fuel lift pump onto fuel inlet fitting (D). Squeeze tangs and move hose clamp about **1/8 inch** (3 mm) from end of hose.
2. Install hose to intake elbow onto EVAP fitting (C). Squeeze tangs and move hose clamp to end of hose.
3. Firmly push quick disconnect fitting onto fuel outlet fitting (B). Gently tug on fitting to verify that it is properly seated and secured.
4. Connect fuel pump module connector (C). Push in grey secondary lock.
5. See Figure 25. Place fuel pump module into bracket. Be sure fuel pump module flanges are positioned

outside of bracket tabs, and start three hex flange screws (A).

6. On cylinder 2 (oil filter) side, start long hex flange screw (C) to fasten fuel pump module bracket to cylinder head. Be sure that bracket is positioned inside (D) of vertical fuse/relay block bracket.
7. On opposite side, start short hex flange screw (B) to fasten fuel pump module bracket and EFI wire harness clip (capturing O<sub>2</sub> sensor and EHT sensor conduit) to cylinder head.
8. Tighten two fuel pump module bracket screws to **80-100 lb-in** (9.0-11.3 N-m).
9. Fasten fuel pump module to bracket. Alternately tighten three screws to **80-100 lb-in** (9.0-11.3 N-m).
10. Turn ignition switch ON for two seconds, and then OFF for 10 seconds. Turn the ignition switch back to ON and check for fuel leaks.
11. See *Side Cover, Installation*.

## ETC

**NOTE:** The ETC consists of the ECM, MAP sensor, MAT sensor, TPS, throttle body, and stepper motor. The ETC is not serviceable, and must be replaced if any component fails.

### Removal

1. See *Air Cleaner Assembly, Removal*.
2. See *Top Cover, Removal*.
3. Disconnect ECM connector.

**NOTE:** See Figure 9. Push tab and rotate cam lock (A) in a clockwise direction until post (B) contacts opposite end of slot. Rotate cam lock to the completely vertical position (C) to disengage post from slot (D). Remove connector.

4. Remove EVAP hose from air intake elbow.

5. Remove breather hose from air intake elbow.
6. See Figure 27. Remove hex nuts (A) from two studs (B) to release air intake elbow (C) from throttle body (D).
7. Remove Phillips screw (E) to release ECM ground wire ring terminal from throttle body.
8. Remove two studs (4 mm) to release ETC from intake manifold.

### Installation

1. See Figure 27. Verify that O-rings (F) on each side of the throttle body are not missing, damaged, or deformed. Install **new** O-rings if any of these conditions are found.
2. Insert two threaded studs (B) through throttle body (D). Install longer stud on cylinder 1 (ECM) side. Start studs into intake manifold. Alternately tighten studs (4 mm) to **80-100 lb-in** (9.0-11.3 N-m).
3. Connect ECM connector.

**NOTE:** Push in connector until post engages slot in cam lock. Rotate cam lock in a counter-clockwise direction until post is at the opposite end of slot and cam lock locks in the horizontal position.

4. Install Phillips screw (E) to fasten ECM ground wire ring terminal to throttle body. Tighten screw to **15-20 lb-in** (1.7-2.3 N-m).
5. Install air intake elbow (C) onto two studs and start hex nuts (A). Alternately tighten hex nuts to **80-100 lb-in** (9.0-11.3 N-m).
6. Install breather hose onto air intake elbow.
7. Install EVAP hose onto air intake elbow.
8. See *Top Cover, Installation*.
9. See *Air Cleaner Assembly, Installation*.

## Fuel Filter

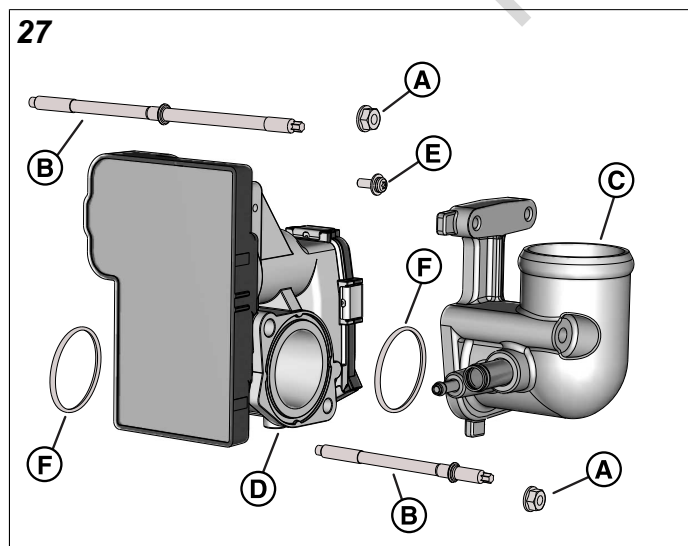
### Removal

1. See *CHECK/RELIEVE FUEL SYSTEM PRESSURE* in this section.
2. Squeeze tangs and move hose clamps away from fuel inlet and outlet fittings. Remove fuel inlet and outlet hoses from fuel filter fittings.

**NOTE:** Wrap shop towel around fuel filter fittings to catch any fuel leakage.

### Installation

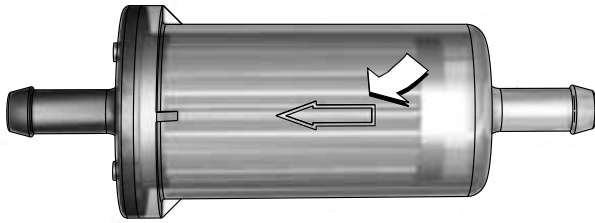
1. See Figure 28. With the arrow pointing in the direction of fuel flow, install **new** fuel filter between fuel inlet and outlet hoses. Squeeze tangs and move hose clamps about **1/8 inch** (3 mm) from end of each hose.



2. Turn ignition switch ON for two seconds, and then OFF for 10 seconds. Turn the ignition switch back to ON and check for fuel leaks.

5. Remove retaining clips and then remove fuel injector caps from fuel injectors.
6. Remove fuel injectors from intake manifold bores.
7. To remove fuel rail, proceed as follows:

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A. Cylinder 1 (Starter Motor) Side:

- See *ETC, Removal*, steps 3-8.
- Remove hex flange screw (E) to release hose clamp from intake manifold boss.
- Remove fuel rail hose from clamp.
- Squeeze two tabs on quick disconnect fitting (F) to release fuel rail from fuel pump module fitting.

**NOTE:** Wrap shop towel around fitting to catch any fuel leakage.

B. Cylinder 2 (Oil Filter) Side:

- Remove hex flange screw (G) to release fuse/relay block bracket from fuel rail hose clamp.
- Rotate fuse/relay block bracket outward.
- Remove hex flange screw (H) to release hose clamp from intake manifold boss.
- Remove fuel rail hose from clamp.

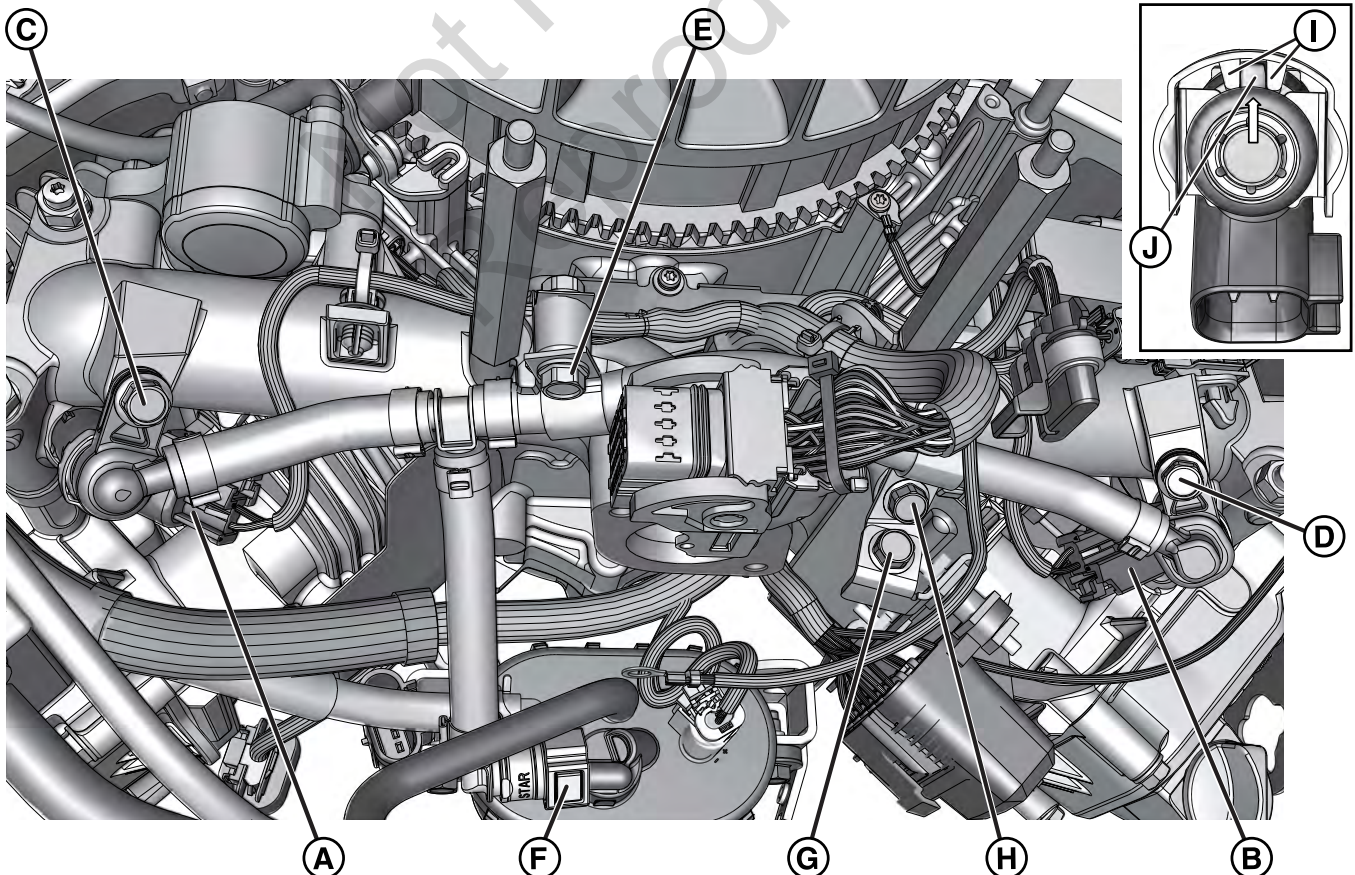
## Fuel Injectors/Fuel Rail

### Removal

5

1. See *CHECK/RELIEVE FUEL SYSTEM PRESSURE* in this section.
2. See *Blower Housing, Removal*.
3. See Figure 29. Disconnect cylinder 1 and cylinder 2 fuel injector connectors (A and B). Pull out white secondary lock, and then press and hold tab before pulling apart connector halves.
4. Remove two hex flange screws (C and D) to release fuel injector cap flanges from intake manifold.

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## Installation

**NOTE:** If only replacing fuel injectors, move to step 2.

1. To install fuel rail, proceed as follows:

A. Cylinder 2 (Oil Filter) Side:

- Place fuel rail into position, so that protective sleeve is positioned between two hose clamp bosses on the intake manifold.
- Install clamp on fuel rail hose. Verify that EFI wire harness is also captured in clamp (ignition coil, fuel injector, and ground wire ring terminal conduit).
- See Figure 29. Start short hex flange screw (**H**) to fasten clamp to intake manifold boss. Tighten screw to **80-100 lb-in** (9.0-11.3 N-m).
- Rotate fuse/relay block bracket inward to align clamp and bracket holes (clamp positioned below bracket).
- Install long hex flange screw (**G**) to fasten bracket to clamp. Tighten screw to **80-100 lb-in** (9.0-11.3 N-m).

B. Cylinder 1 (Starter Motor) Side:

- Install clamp on fuel rail hose.
- Start hex flange screw (**E**) to fasten clamp to intake manifold boss. Tighten screw to **80-100 lb-in** (9.0-11.3 N-m).
- See *ETC, Installation*, steps 1-7.
- Firmly push quick disconnect fitting (**F**) onto fuel outlet fitting. Gently tug on fitting to verify that it is properly seated and secured.

2. Lightly lubricate fuel injector O-rings with clean engine oil.
3. Install fuel injector caps onto fuel injectors.
4. Install retaining clips to secure fuel injector caps to fuel injectors.

**NOTE:** See inset of Figure 29. Be sure retaining clips are properly installed. Side slots on clip engage lip on cap, while tab (**J**) on fuel injector body is captured between prongs (**I**) on clip.

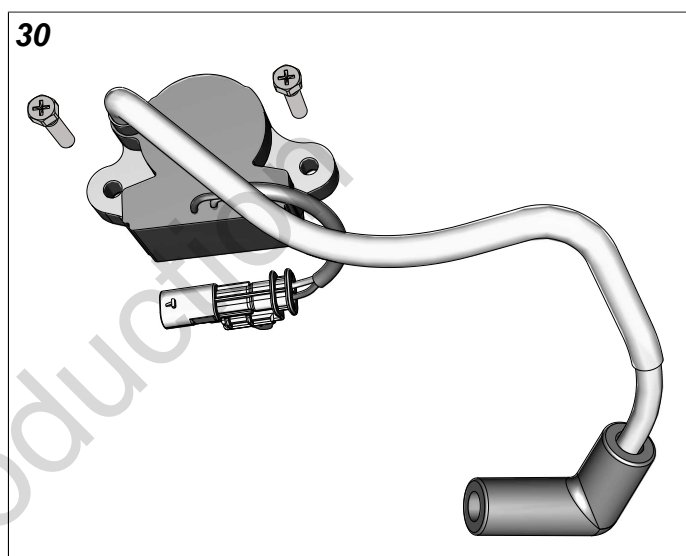
5. Install fuel injectors into intake manifold bores.
6. Install two hex flange screws (**D** and **C**) to fasten fuel injector cap flanges to intake manifold. Tighten screws to **100-120 lb-in** (11.3- 13.6 N-m).
7. Connect fuel injector connectors (**B** and **A**). Push in white secondary locks to secure.
8. Rotate each fuel injector until connector makes light contact with the intake manifold.

9. Turn ignition switch ON for two seconds, and then OFF for 10 seconds. Turn the ignition switch back to ON and check for fuel leaks.
10. See *Blower Housing, Installation*.

## Ignition Coil

### Removal

1. See *Blower Housing, Removal*.
2. Remove high tension lead from spark plug terminal.
3. Remove two hex screws to release ignition coil from intake manifold bosses.
4. Disconnect ignition coil connector. Pull out red secondary lock, and then press and hold tab before pulling apart connector halves.



### Installation

1. Start two hex screws to fasten ignition coil to intake manifold bosses. Tighten screws to **22.5-37.5 lb-in** (2.5-4.2 Nm).
2. Connect ignition coil connector. Push in red secondary lock to secure.
3. Install high tension lead onto spark plug terminal.
4. See *Blower Housing, Installation*.

## CKP Sensor

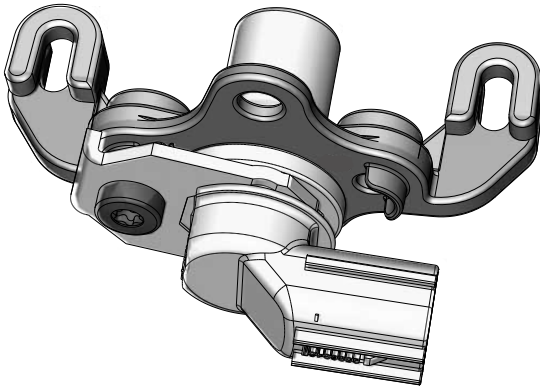
### Removal

1. See *Blower Housing, Removal*.
2. Disconnect CKP sensor connector.
3. Loosen or remove two hex flange screws to release CKP sensor bracket from cylinder mounting bosses.

## Installation

1. If installing **new** CKP sensor, start two **new** hex flange screws to fasten CKP sensor bracket to cylinder mounting bosses.
2. Move bracket toward flywheel, so that gap between CKP sensor and flywheel tooth is **0.010 inches** (0.254 mm).
3. Alternately tighten CKP sensor bracket screws to **20-25 lb-in** (2.3-2.8 N-m).
4. Connect CKP sensor connector.
5. See *Blower Housing, Installation*.

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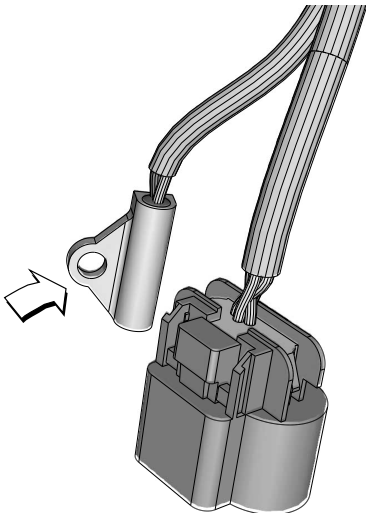


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## EHT Sensor

**NOTE:** The EHT sensor is an integral part of the EFI wire harness and is not sold separately. Replace EFI wire harness if EHT sensor is bad.

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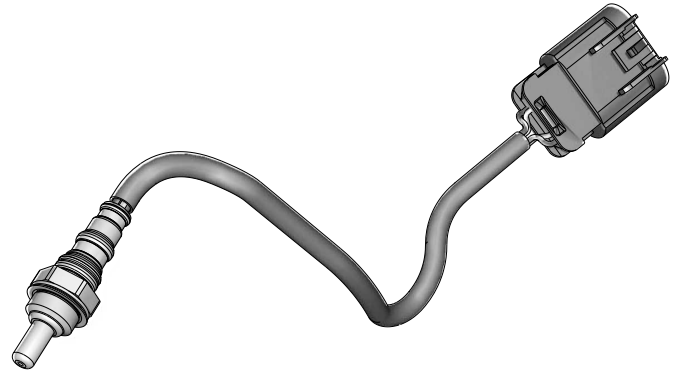


## HO<sub>2</sub> Sensor

### Removal

1. See *Side Cover, Removal*.
2. Disconnect HO<sub>2</sub> sensor connector.
3. Rotate sensor body hex counter-clockwise to release sensor from muffler.

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### Installation

1. Rotate sensor body hex clockwise to secure sensor to muffler. Tighten sensor to **146-173 lb-in** (16-19 N-m).
2. Connect HO<sub>2</sub> sensor connector.
3. See *Side Cover, Installation*.

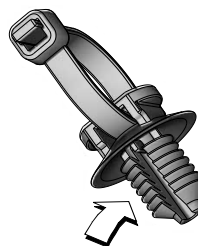
## EFI Wire Harness

### Removal

**NOTE:** See Figure 34. The anchor on the fir tree style clip (**A**) resembles an upside down fir tree. Due to the rib configuration, the anchor is a very tight fit. To avoid damage to the clips and/or engine components, use the Briggs & Stratton Fuel Line Removal Tool (Part No. 19620) (**B**) to gently pry the clip from the anchor hole. If the clip is broken during removal, be sure to remove all plastic debris from the engine.

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**A**



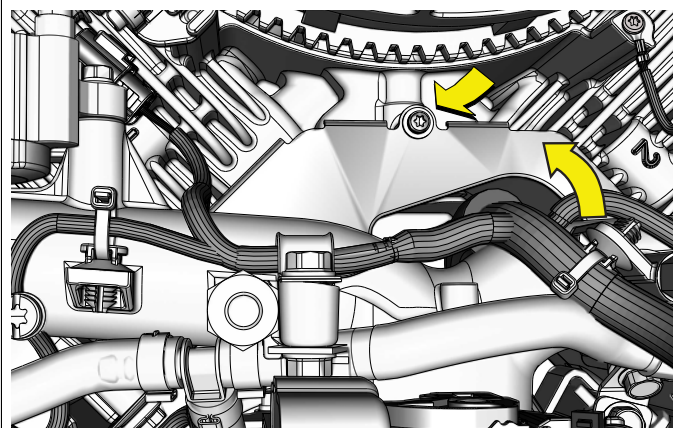
**B**

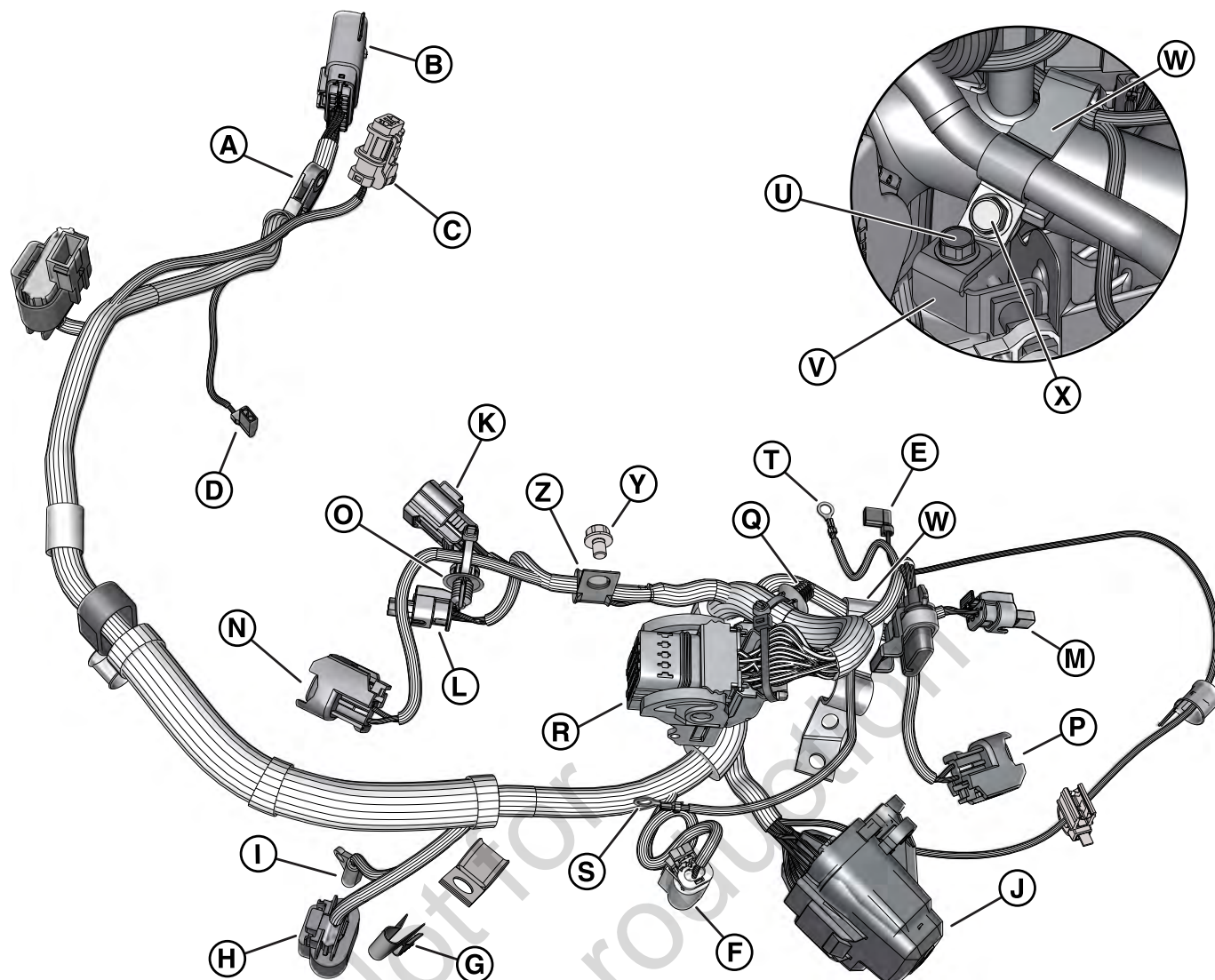




1. See *Blower Housing, Removal*.
2. See Figure 36. Starting on cylinder 1 (starter motor) side, and moving in a counter-clockwise direction around the outside of the engine, remove hex flange screw to release wire harness clip (A) from lifting bracket.
3. Press tab and disconnect main vehicle connector (B).
4. Disconnect electric lift fuel pump connector (C).
5. Remove elbow spade socket terminal (D) from starter solenoid spade contact.
6. Remove elbow spade socket terminal (E) from oil pressure switch spade contact. Remove wire harness retention clips, if attached.
7. On starter motor side, remove hex flange screw to release fuel pump module bracket and wire harness clip (capturing O<sub>2</sub> sensor and EHT sensor conduit) from cylinder head. On opposite side, remove hex flange screw to release fuel pump module bracket and fuse/relay block bracket from cylinder head.
8. Disconnect fuel pump module connector (F). Pull out gray secondary lock, and then press and hold tab before pulling apart connector halves.
9. Remove O<sub>2</sub> sensor conduit from clip (G) on fuel pump module bracket, if present.
10. Disconnect O<sub>2</sub> sensor connector (H). Press tab to remove grey secondary lock, and then press black tab to separate connector halves.
11. Remove T25 TORX screw to release EHT sensor (I) from cylinder 1 head.
12. Disconnect fuse/relay block (J) from cover.
13. At top of engine, disconnect CKP sensor connector (K).
14. Disconnect cylinder 1 ignition coil connector (L in Figure 37) after removing anchor of rosebud style clip from boss at bottom of intake manifold. Remove two screws to release ignition coil from intake manifold bosses, if necessary. Pull out red secondary lock, and then press and hold tab before pulling apart connector halves.
15. Disconnect cylinder 2 ignition coil connector (M in Figure 37) at top of intake manifold. Pull out red secondary lock, and press and hold tab before pulling apart connector halves.
16. Disconnect cylinder 1 fuel injector connector (N) after removing anchor of fir tree style clip (O in Figure 37) from boss at top of intake manifold. Pull out white secondary lock, and press and hold tab before pulling apart connector halves. Remove fuel injector cap screw if connector is caught beneath fuel rail.
17. Disconnect cylinder 2 fuel injector connector (P). Pull out white secondary lock, and press and hold tab before pulling apart connector halves. Remove fuel injector cap screw if connector is caught beneath fuel rail.
18. Remove anchor of fir tree style clip (Q in Figure 37) from hole in intake manifold boss next to air cleaner bracket stud.
19. Disconnect ECM connector (R).
20. Remove Phillips screw to release ECM ground wire ring terminal (S) from throttle body. Loosen or remove hex nuts from two studs to release air intake elbow, if necessary.
21. Remove Phillips screw to release engine ground wire ring terminal (T) from crankcase boss.
22. Proceed as follows:
  - A. Cylinder 2 (Oil Filter) Side:
    - Remove hex flange screw (U) to release fuse/relay block bracket (V) from double-sided clamp (W) at top of intake manifold.
    - Remove hex flange screw (X) to release clamp from intake manifold boss.
    - Remove wire harness from clamp.
  - B. Cylinder 1 (Starter Motor) Side:
    - Remove hex flange screw (Y) to release single-sided clamp (Z) at top of intake manifold.
    - Remove wire harness from clamp.
23. See Figure 35. Remove Phillips screw to release air block plate from crankcase. Rotate plate in a counter-clockwise direction to enlarge opening for harness removal.
24. Starting with the fuse/relay block and ending with the main vehicle connector, feed branches of wire harness up through opening next to air block plate.

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### Installation

1. See Figure 35. Starting with the main vehicle connector and ending with the fuse/relay block, feed branches of **new** wire harness down through opening next to air block plate.
2. Rotate air block plate in a clockwise direction and install Phillips screw to fasten plate to crankcase. Tighten screw to **15-20 lb-in** (1.7-2.3 N-m).
3. See Figure 36. Connect ECM connector (R).
4. Install Phillips screw to fasten ECM ground wire ring terminal (S) to throttle body. Tighten screw to **15-20 lb-in** (1.7-2.3 N-m). If loosened or removed, install hex nuts onto two studs to secure air intake elbow. Tighten nuts to **80-100 lb-in** (9.0-11.3 N-m).
5. Install Phillips screw to fasten engine ground wire ring terminal (T) to crankcase boss. Tighten screw to **40-50 lb-in** (4.5-5.7 N-m).
6. Install anchor of fir tree style clip (Q in Figure 37) capturing MIL, ECM, and ground wire ring terminal
7. Running conduit between intake manifold and fuel rail, connect cylinder 2 fuel injector connector (P). Push in white secondary lock. If removed, install fuel injector cap screw and tighten to **100-120 lb-in** (11.3-13.6 N-m).
8. Running conduit between intake manifold and fuel rail, connect cylinder 1 fuel injector connector (N). Push in white secondary lock. Install anchor of fir tree style clip (O in Figure 37) into hole in boss at top of intake manifold. If removed, install fuel injector cap screw and tighten to **100-120 lb-in** (11.3-13.6 N-m).
9. Connect cylinder 2 ignition coil connector (M in Figure 37) at top of intake manifold. Push in red secondary lock.
10. Connect cylinder 1 ignition coil connector (L in Figure 37). Push in red secondary lock. Install anchor of rosebud style clip into hole in boss at bottom of intake manifold. Install two screws to fasten ignition coil to

conduit into hole in intake manifold boss next to air cleaner bracket stud.

intake manifold bosses, if removed. Tighten screws to **22.5-37.5 lb-in** (2.5-4.2 N-m).

11. Connect CKP sensor connector (**K**).

12. Proceed as follows:

A. Cylinder 2 (Oil Filter) Side:

- Capture wire harness (ignition coil, fuel injector, and ground wire ring terminal conduit) in double-sided clamp (**W**). Opposite side of clamp captures fuel rail hose.
- Start short hex flange screw (**X**) to fasten clamp to intake manifold boss. Tighten screw to **80-100 lb-in** (9.0-11.3 N-m).
- Install long hex flange screw (**U**) to fasten fuse/relay block bracket (**V**) to clamp. Tighten screw to **80-100 lb-in** (9.0-11.3 N-m).

B. Cylinder 1 (Starter Motor) Side:

- Capture wire harness (CKP sensor, ignition coil, and fuel injector conduit) in single-sided clamp (**Z**).
- Start hex flange screw (**Y**) to fasten clamp to intake manifold boss. Tighten screw to **80-100 lb-in** (9.0-11.3 N-m).

13. Connect fuse/relay block to cover (**J**).

14. Connect fuel pump module connector (**F**). Push in grey secondary lock.

15. Start long hex flange screw to fasten fuel pump module bracket and fuse/relay block bracket to cylinder 2 head. On opposite side, start short hex flange screw to fasten fuel pump module bracket and EFI wire harness clip (capturing O<sub>2</sub> sensor and EHT sensor conduit) to cylinder head. Tighten two screws to **80-100 lb-in** (9.0-11.3 N-m).

16. Install T25 TORX screw to fasten EHT sensor (**I**) to cylinder 1 head and tighten to **35-55 lb-in** (4.0-6.2 N-m).

17. Connect O<sub>2</sub> sensor connector (**H**), and install gray secondary lock.

18. Capture O<sub>2</sub> sensor conduit in clip (**G**) attached to fuel pump module bracket, if present.

19. Connect elbow spade socket terminal (**E**) to oil pressure switch spade contact.

20. Install elbow spade socket terminal (**D**) onto starter solenoid spade contact.

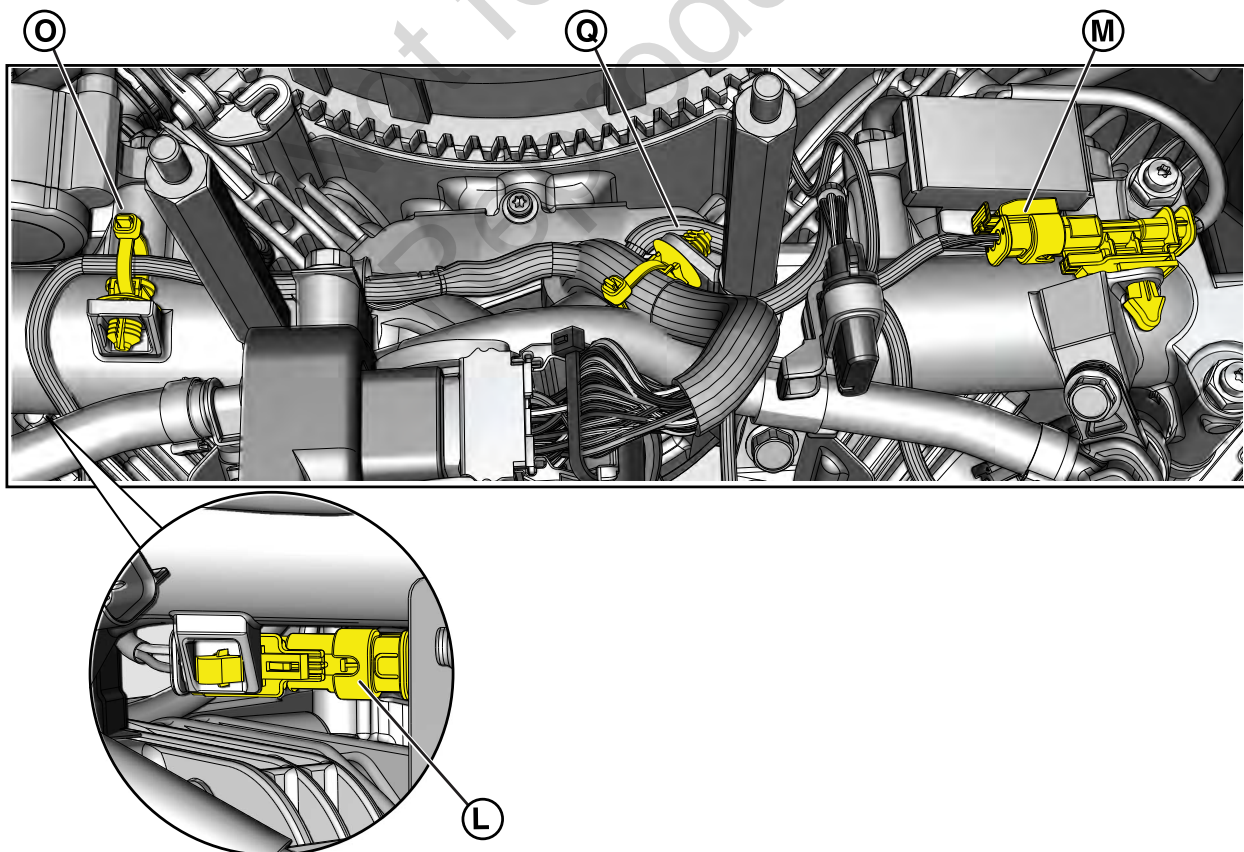
21. Connect electric lift fuel pump connector (**C**).

22. Connect main vehicle connector (**B**).

23. Install hex flange screw to fasten wire harness clip (**A**) to lifting bracket. Tighten screw to **31-36 lb-in** (3.5-4.1 N-m).

24. See *Blower Housing, Installation*.

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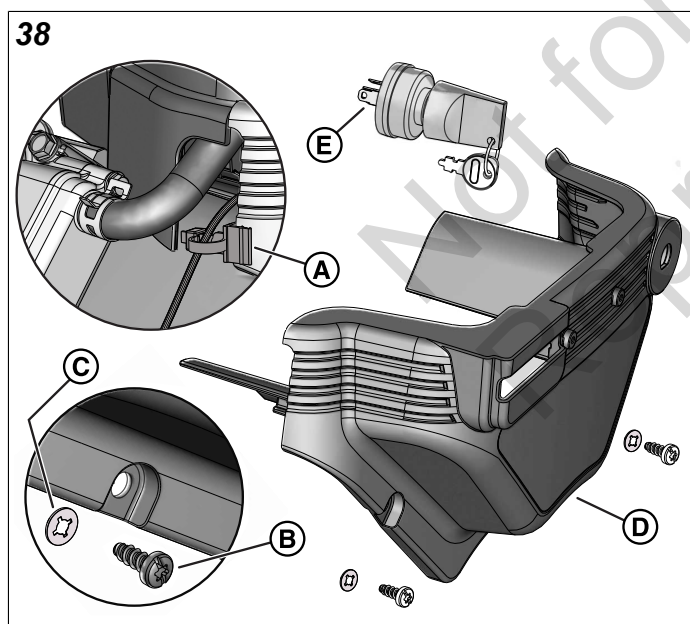
## Side Cover

### Removal

1. See Figure 38. Remove oil pressure switch conduit clip (A) from side cover.
2. Remove two Phillips screws (B) with retaining washers (C) to release side cover (D) from blower housing.
3. Disconnect ignition key switch connector (E), if equipped.

### Installation

1. Connect ignition key switch connector (E), if equipped.
2. Insert two Phillips screws (B) into side cover (D), and finger tighten retaining washers (C) onto screws. Start screws into blower housing and tighten to **25-35 lb-in** (2.8-4.0 N-m).
3. Attach oil pressure switch conduit clip (A) to side cover.

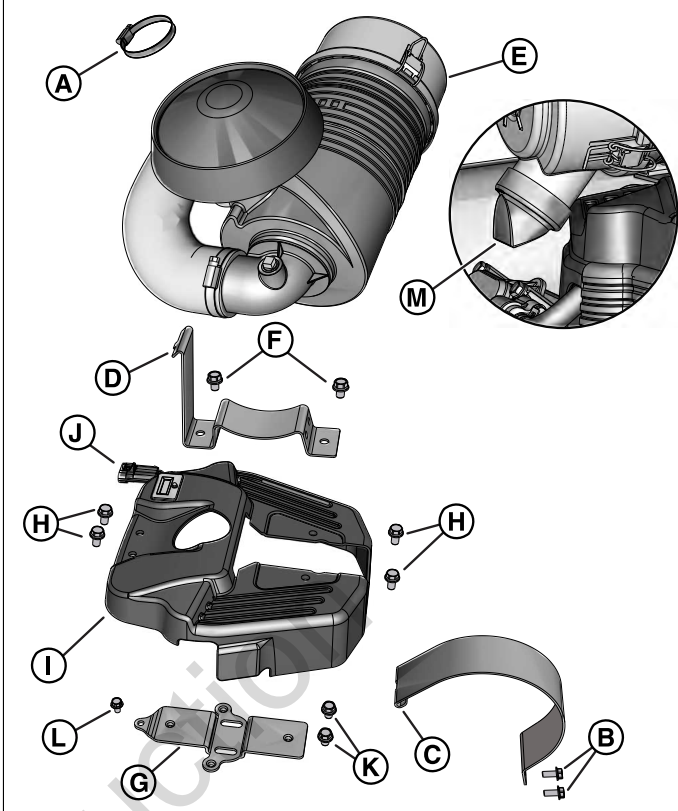


## Air Cleaner Assembly/Top Cover

### Removal

1. See *Side Cover, Removal*.
2. See Figure 39. Loosen band clamp (A) and remove hose from air intake elbow.
3. Remove two hex flange screws (B) and disengage hook on air cleaner strap (C) from lip on air cleaner top bracket (D).

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4. Remove air cleaner assembly (E).
5. Remove two hex flange screws (F) to release air cleaner top bracket from air cleaner bottom bracket (G).
6. Remove four hex flange screws (H) to release top cover (I) from air intake elbow and air cleaner bottom bracket. If equipped, disconnect MIL/ tachometer/ hourmeter connector (J) at back of top cover.
7. Remove two hex flange screws (K) to release air cleaner bottom bracket from fuel pump module bracket support.
8. Remove hex flange screw (L) to release air cleaner bottom bracket from air intake elbow.

### Installation

1. Install two hex flange screws (K) to fasten air cleaner bottom bracket (G) to fuel pump module bracket support. Tighten screws **125-150 lb-in** (14.1-17.0 N-m).
2. Install hex flange screw (L) to fasten air cleaner bottom bracket to air intake elbow. Tighten screw **80-100 lb-in** (9.0-11.3 N-m).
3. If equipped, connect MIL/tachometer/hourmeter connector (J) at back of top cover (I).

4. Install four hex flange screws (H) to fasten top cover to air intake elbow and air cleaner bottom bracket. Alternately tighten four hex flange screws to **80-100 lb-in** (9.0-11.3 N-m).
  5. Install two hex flange screws (F) to fasten air cleaner top bracket (D) to air cleaner bottom bracket. Tighten screws to **125-150 lb-in** (14.1-17.0 N-m).
  6. Position air cleaner assembly (E) on air cleaner top bracket with the duckbill air valve pointing down.
- NOTE:** Replace duckbill air valve (M) if damaged or missing. Engine operation without the duckbill air valve can reduce filter efficiency.
7. Engage hook on air cleaner strap (C) with lip on air cleaner top bracket.
  8. Install two hex flange screws (B) to fasten air cleaner strap to air cleaner top bracket. Tighten screws to **80-100 lb-in** (9.0-11.3 N-m).
  9. If detached, install hose onto air outlet elbow with the paint mark on top. Install band clamp at end of hose and tighten to **15-20 lb-in** (1.7- 2.3 N-m).
  10. Loosely install band clamp (A) at opposite end of hose, and install hose onto air intake elbow. Tighten band clamp to **15-20 lb-in** (1.7-2.3 N-m).
  11. See *Side Cover, Installation*.

## Fuel Pump Module

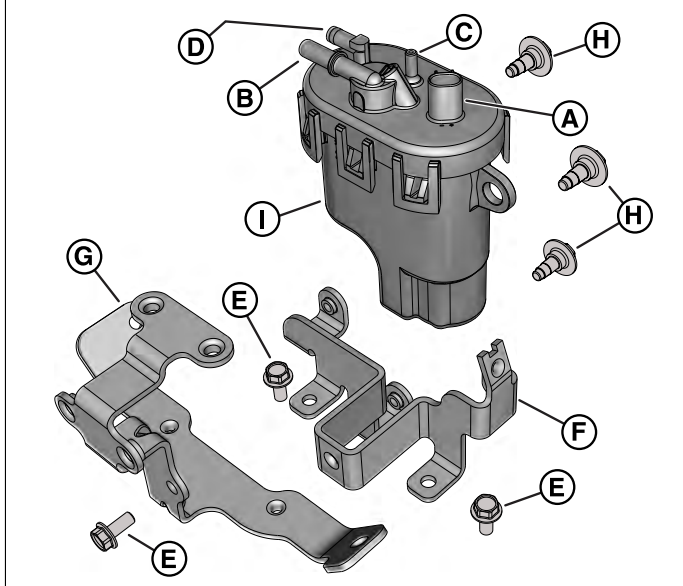
### Removal

1. See *CHECK/RELIEVE FUEL SYSTEM PRESSURE* in this section.
2. See *Air Cleaner Assembly/Top Cover, Removal*.
3. See Figure 40. Disconnect fuel pump module connector (A). Pull out gray secondary lock, and then press and hold tab before pulling apart connector halves.
4. Press two tabs on quick disconnect fitting to release fuel rail from fuel outlet fitting (B).

**NOTE:** Wrap shop towel around fittings to catch any fuel leakage.

5. Squeeze tangs and move hose clamp away from EVAP fitting (C). Remove hose (to intake elbow) from fitting.
6. Squeeze tangs and move hose clamp away from fuel inlet fitting (D). Remove hose (from fuel lift pump) from fitting.
7. Remove three hex flange screws (E) to release fuel pump module bracket (F) from fuel pump module bracket support (G).
8. Remove three hex flange screws (H) to release fuel pump module (I) from bracket.

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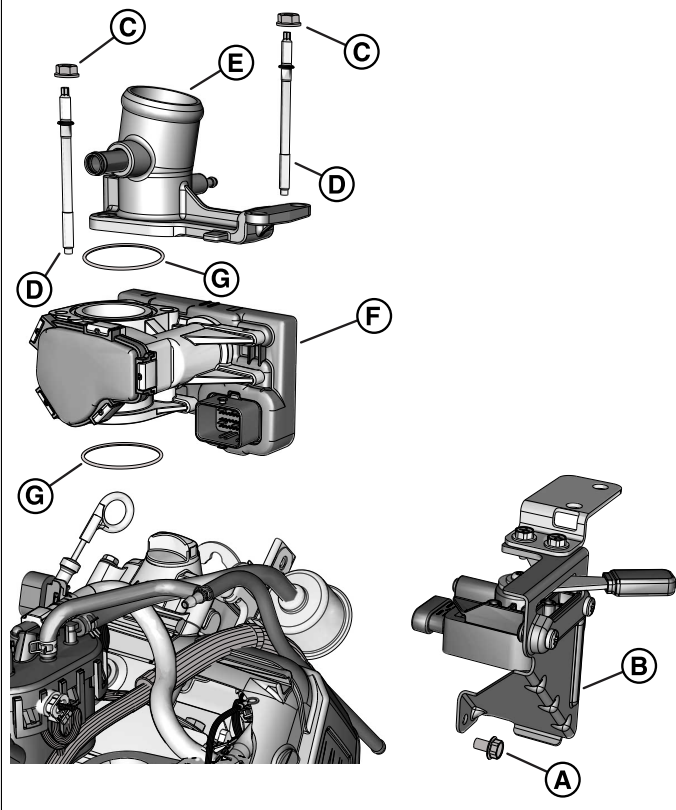
**NOTE:** Fuel pump module may contain a small quantity of fuel. Hold fuel pump module with inlet and outlet fittings pointing upward until fuel can be drained into a suitable container.

### Installation

1. See Figure 40. Install three hex flange screws (H) to fasten fuel pump module (I) to bracket (F). Tighten screws to **80-100 lb-in** (9.0-11.3 N-m).
2. Install three hex flange screws (E) to fasten fuel pump module bracket to fuel pump module bracket support (G). Tighten screws to **80-100 lb-in** (9.0-11.3 N-m).
3. Install hose from fuel lift pump onto fuel inlet fitting (D). Squeeze tangs and move hose clamp about **1/8 inch** (3 mm) from end of hose.
4. Install hose to intake elbow onto EVAP fitting (C). Squeeze tangs and move hose clamp to end of hose.
5. Firmly push quick disconnect fitting onto fuel outlet fitting (B). Gently tug on fitting to verify that it is properly seated and secured.
6. Connect fuel pump module connector (A). Push in grey secondary lock to secure.
7. Turn ignition switch ON for two seconds, and then OFF for 10 seconds. Turn the ignition switch back to ON and check for fuel leaks.
8. See *Air Cleaner Assembly/Top Cover, Installation*.

### ETC

**NOTE:** The ETC consists of the ECM, MAP sensor, MAT sensor, TPS, throttle body, and stepper motor. The ETC is not serviceable, and must be replaced if any component fails.



### Removal

1. See *Air Cleaner Assembly/Top Cover, Removal*.
2. See Figure 41. If equipped, remove hex flange screw (A) to remove throttle lever bracket (B) from intake manifold boss. Disconnect throttle lever module connector.
3. Disconnect ECM connector.
4. Remove Phillips screw to release ECM ground wire ring terminal from throttle body.
5. Remove EVAP hose from air intake elbow.
6. Remove breather hose from air intake elbow.
7. Remove hex nuts (C) from two studs (D) to release air intake elbow (E) from throttle body.
8. Remove two studs (4 mm) to release ETC (F) from intake manifold.

### Installation

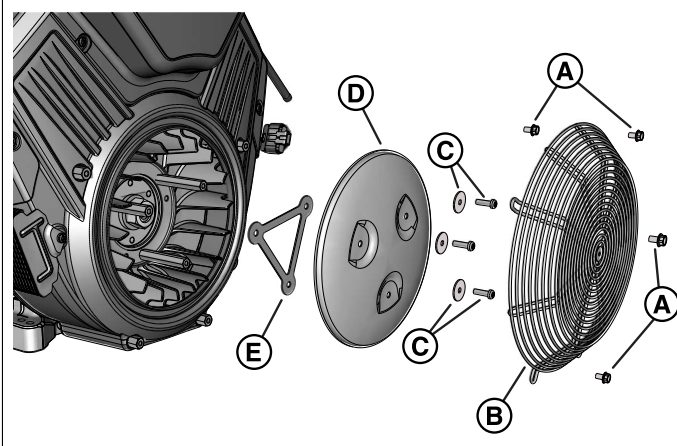
1. See Figure 41. Verify that O-rings (G) on each side of the throttle body are not missing, damaged, or deformed. Install **new** O-rings if any of these conditions are found.
2. Insert two threaded studs (D) through throttle body. Install longer stud on cylinder 1 side. Start studs into intake manifold. Alternately tighten studs (4 mm) to **80-100 lb-in** (9.0-11.3 N-m).
3. Connect ECM connector.

4. Install Phillips screw to fasten ECM ground wire ring terminal to throttle body. Tighten screw to **15-20 lb-in** (1.7-2.3 N-m).
5. Install air intake elbow (E) onto two studs and start hex nuts (C). Alternately tighten hex nuts to **80-100 lb-in** (9.0-11.3 N-m).
6. Install breather hose onto air intake elbow.
7. Install EVAP hose onto air intake elbow.
8. If equipped, connect throttle lever module connector. Install hex flange screw (A) to fasten throttle lever bracket (B) to intake manifold boss. Tighten screw to **80-100 lb-in** (9.0-11.3 N-m).
9. See *Air Cleaner Assembly/Top Cover, Installation*.

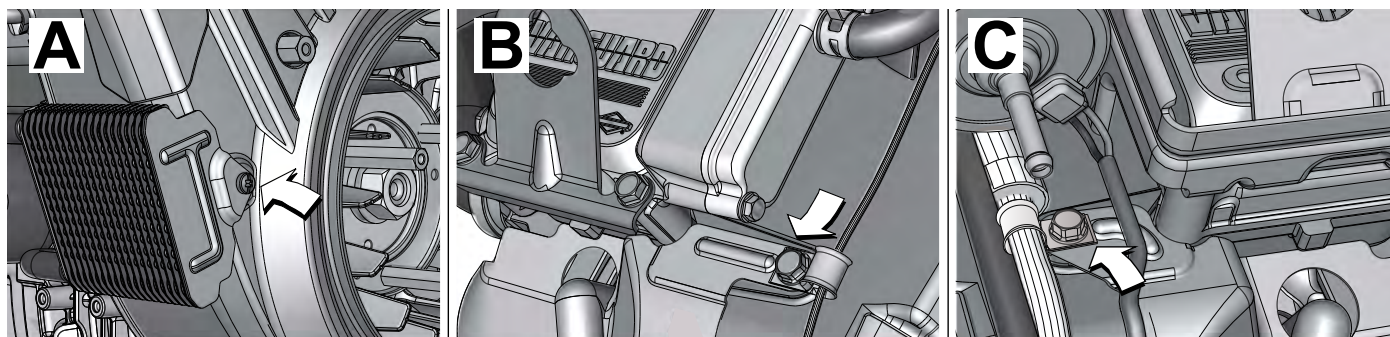
## Blower Housing

### Removal

1. See *Side Cover, Removal*.
2. See Figure 42. Remove four hex flange screws (A) to release wire guard (B) from coupling nuts.
3. Remove three T30 TORX screws with flat washers (C) to release debris screen (D) and triangular spacer (E) from ring mounting studs.
4. See Figure 43. Remove Phillips screw (A) to release oil cooler (or finger guard) bracket from blower housing. Remove two bottom hex flange screws to release bottom bracket from back plate.
5. Remove hex flange screw (B) to release oil pressure switch conduit clip, air guide, and blower housing from intake manifold.
6. On opposite side of engine, remove hex flange screw (C) to release wire harness clip, air guide, and blower housing from intake manifold.
7. See Figure 44. Remove four coupling nuts (A) from cylinder posts.
8. Remove blower housing (B) from engine.







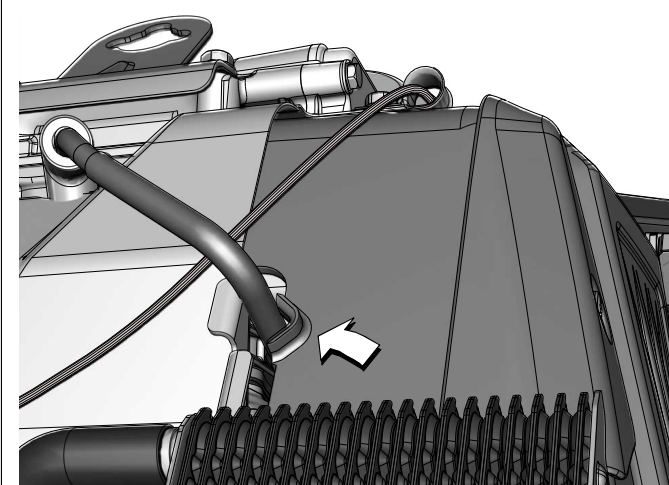
## Installation

1. See Figure 44. Loosely install blower housing (B) onto engine, so that holes in housing engage four cylinder posts.
2. Start four coupling nuts (A) onto cylinder posts, but do not tighten.
3. See Figure 45. Verify that high tension leads are routed through slots in blower housing on both sides of engine.
4. See Figure 43. Starting on starter motor side of engine, install hex flange screw (C) to fasten wire harness clip, air guide, and blower housing to intake manifold. Tighten screw to **80-100 lb-in** (9.0-11.3 N-m).
5. On opposite side of engine, install hex flange screw (B) to fasten oil pressure switch conduit clip, air guide, and blower housing to intake manifold. Tighten screw to **80-100 lb-in** (9.0-11.3 N-m).
6. Install Phillips screw (A) to fasten oil cooler (or finger guard) top bracket to blower housing. Tighten screw to **35-45 lb-in** (4.0-5.1 N-m). Install two hex flange screws to fasten bottom bracket to back plate and tighten to **80-100 lb-in** (9.0-11.3 N-m).
7. Alternately tighten four coupling nuts to **80-100 lb-in** (9.0-11.3 N-m) in a crosswise pattern.
8. See Figure 42. Position triangular spacer (E) on top of ring mounting studs. Install debris screen (D) and start three T30 TORX screws with flat washers (C). Alternately tighten screws to **80-100 lb-in** (9.0-11.3 N-m) in a crosswise pattern.
9. Install four hex flange screws (A) to fasten wire guard (B) to coupling nuts. Alternately tighten screws to **80-100 lb-in** (9.0-11.3 N-m) in a crosswise pattern.
10. See *Side Cover, Installation*.

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## Fuel Injectors/Fuel Rail

### Removal

1. See *CHECK/RELIEVE FUEL SYSTEM PRESSURE* in this section.
2. See *Air Cleaner Assembly/Top Cover, Removal*.
3. See *Blower Housing, Removal*.
4. See Figure 46. Disconnect fuel injector connectors (A and B). Pull out white secondary lock, and then press and hold tab before pulling apart connector halves.
5. Remove two hex flange screws (C and D) to release fuel injector cap flanges from intake manifold.
6. Remove retaining clips and then remove fuel injector caps from fuel injectors.
7. Remove fuel injectors from intake manifold bores.
8. To remove fuel rail, proceed as follows:

#### A. Cylinder 2 (Oil Filter) Side:

- If equipped, remove hex flange screw (E) to release throttle lever bracket (F) from intake

manifold boss. Disconnect throttle lever module connector to remove assembly.

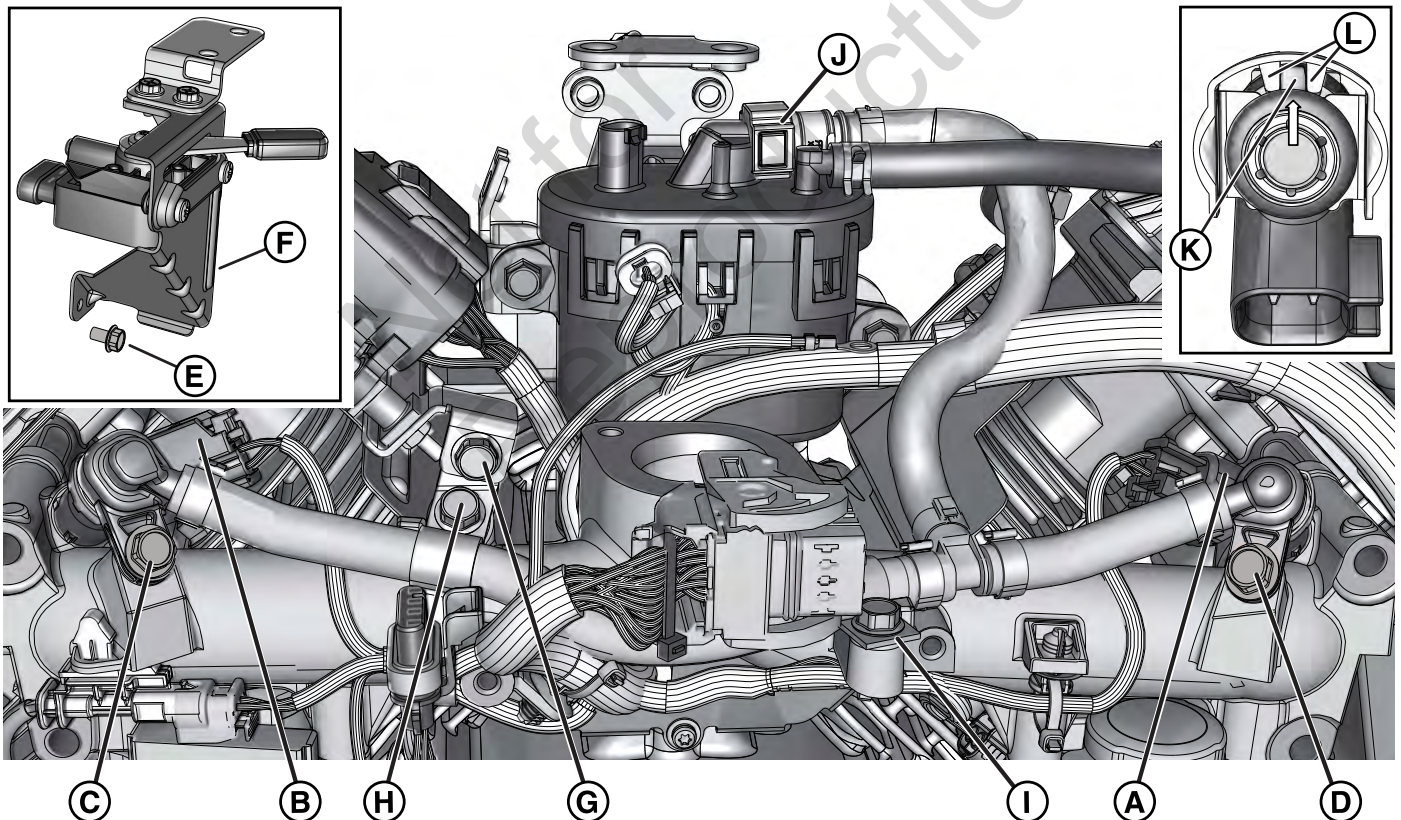
- Remove hex flange screw (G) to release fuse/relay block bracket from fuel rail hose clamp.
- Rotate fuse/relay block bracket outward.
- Remove hex flange screw (H) to release hose clamp from intake manifold boss.
- Remove fuel rail hose from clamp.

#### B. Cylinder 1 (Starter Motor) Side:

- See *ETC, Removal*, steps 3-8.
- Remove hex flange screw (I) to release hose clamp from intake manifold boss.
- Remove fuel rail hose from clamp.
- Squeeze two tabs on quick disconnect fitting (J) to release fuel rail from fuel pump module fitting.

**NOTE:** Wrap shop towel around fitting to catch any fuel leakage.

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## Installation

**NOTE:** If only replacing fuel injectors, move to step 2.

1. To install fuel rail, proceed as follows:

A. Cylinder 1 (Oil Filter) Side:

- Place fuel rail into position, so that protective sleeve is positioned between two hose clamp bosses on the intake manifold
- Install clamp on fuel rail hose.
- Start hex flange screw (**I**) to fasten clamp to intake manifold boss. Tighten screw to **80-100 lb-in** (9.0-11.3 N-m).
- See *ETC, Installation*, steps 1-7.
- See Figure 46. Firmly push quick disconnect fitting (**J**) onto fuel outlet fitting. Gently tug on fitting to verify that it is properly seated and secured.

B. Cylinder 2 (Starter Motor) Side:

- Install clamp on fuel rail hose. Verify that EFI wire harness is captured in opposite side of clamp (ignition coil, fuel injector, and ground wire ring terminal conduit).
- Start short hex flange screw (**H**) to fasten clamp to intake manifold boss. Tighten screw to **80-100 lb-in** (9.0-11.3 N-m).
- Rotate fuse/relay block bracket inward to align clamp and bracket holes (clamp positioned below bracket).
- Install long hex flange screw (**G**) to fasten bracket to clamp. Tighten screw to **80-100 lb-in** (9.0-11.3 N-m).
- If equipped, connect throttle lever module connector, and then install hex flange screw (**E**) to fasten throttle lever bracket (**F**) to intake manifold boss. Tighten screw to **80-100 lb-in** (9.0-11.3 N-m).

2. Lightly lubricate fuel injector O-rings with clean engine oil.
3. Install fuel injector caps onto fuel injectors.
4. Install retaining clips to secure fuel injector caps to fuel injectors.

**NOTE:** Be sure retaining clips are properly installed. Side slots on clip engage lip on cap, while tab (**K**) on fuel injector body is captured between prongs (**L**) on clip.

5. Install fuel injectors into intake manifold bores.
6. Install two hex flange screws (**D** and **C**) to fasten fuel injector cap flanges to intake manifold. Tighten screws to **100-120 lb-in** (11.3- 13.6 N-m).
7. Connect fuel injector connectors (**B** and **A**). Push in white secondary locks to secure.

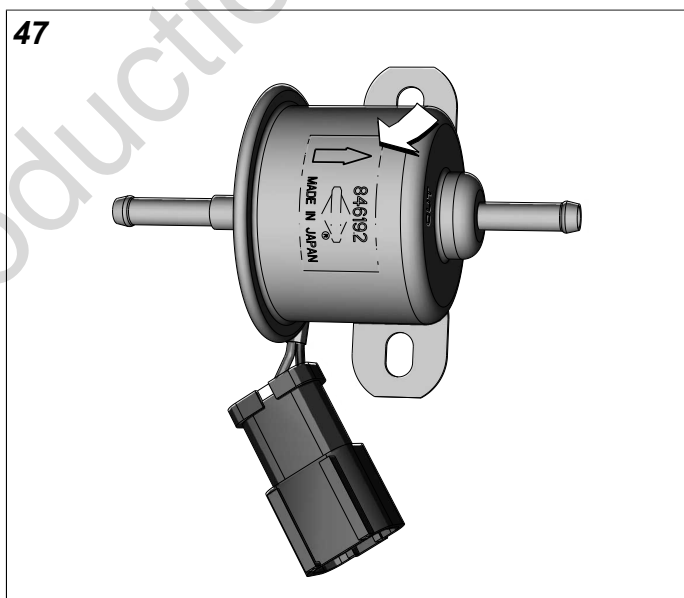
8. Rotate each fuel injector until connector makes light contact with the intake manifold.
9. Turn ignition switch ON for two seconds, and then OFF for 10 seconds. Turn the ignition switch back to ON and check for fuel leaks.
10. See *Blower Housing, Installation*.
11. See *Air Cleaner Assembly/Top Cover, Installation*.

## Electric Lift Fuel Pump

### Removal

1. See *CHECK/RELIEVE FUEL SYSTEM PRESSURE* in this section.
2. See Figure 47. Remove two hex flange screws to release electric lift fuel pump bracket from lifting bracket.
3. Disconnect fuel pump connector.
4. Squeeze tangs and move hose clamps away from fuel inlet and outlet fittings. Remove fuel inlet and outlet hoses from pump.

**NOTE:** Wrap shop towel around fuel filter fittings to catch any fuel leakage.



### Installation

1. See Figure 47. With the arrow pointing in the direction of fuel flow, install **new** electric lift fuel pump between fuel inlet and outlet hoses. Squeeze tangs and move hose clamps about **1/8 inch** (3 mm) from end of each hose.
2. Connect fuel pump connector.
3. Install two hex flange screws to fasten pump bracket to lifting bracket. Tighten screws to **80-100 lb-in** (9.0-11.3 N-m).

- Turn ignition switch ON for two seconds, and then OFF for 10 seconds. Turn the ignition switch back to ON and check for fuel leaks.

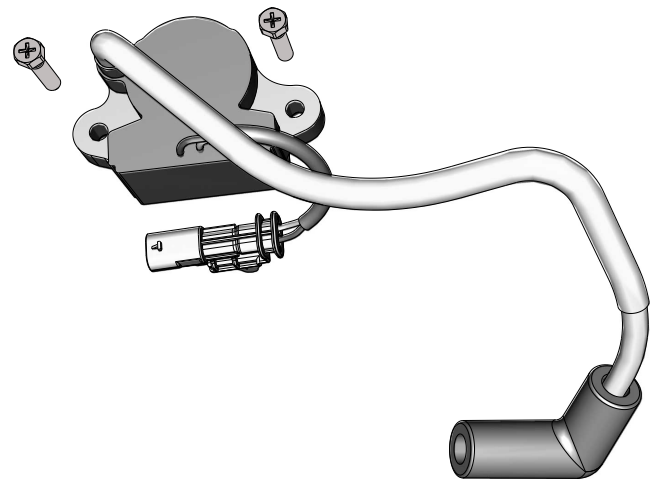
## Fuel Filter

### Removal

- See *CHECK/RELIEVE FUEL SYSTEM PRESSURE* in this section.
- Squeeze tangs and move hose clamps away from fuel inlet and outlet fittings. Remove fuel inlet and outlet hoses from fuel filter fittings.

**NOTE:** Wrap shop towel around fuel filter fittings to catch any fuel leakage.

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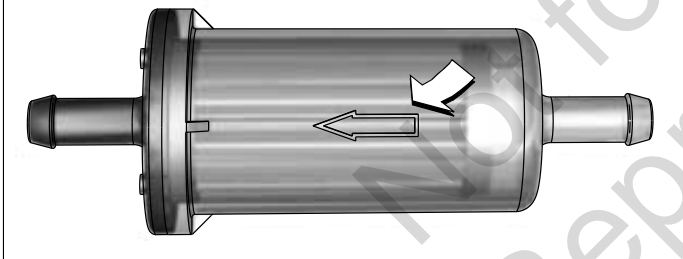


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### Installation

- See Figure 48. With the arrow pointing in the direction of fuel flow, install **new** fuel filter between fuel inlet and outlet hoses. Squeeze tangs and move hose clamps about **1/8 inch** (3 mm) from end of each hose.
- Turn ignition switch ON for two seconds, and then OFF for 10 seconds. Turn the ignition switch back to ON and check for fuel leaks.

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### Installation

- Start two hex screws to fasten ignition coil to intake manifold bosses. Tighten screws to **22.5-37.5 lb-in** (2.5-4.2 N-m).
- Connect ignition coil connector. Push in red secondary lock to secure.
- Install high tension lead onto spark plug terminal.
- See *Blower Housing, Installation*.

## CKP Sensor

### Removal

- See *Blower Housing, Removal*.
- Disconnect CKP sensor connector.
- Loosen or remove two Phillips screws to release CKP sensor bracket from cylinder mounting bosses.

## Ignition Coil

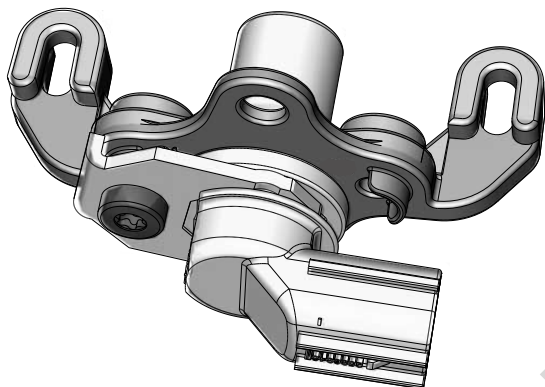
### Removal

- See *Blower Housing, Removal*.
- Remove high tension lead from spark plug terminal.
- Remove two hex screws to release ignition coil from intake manifold bosses.
- Disconnect ignition coil connector. Pull out red secondary lock, and then press and hold tab before pulling apart connector halves.

## Installation

1. If installing **new** CKP sensor, start two **new** Phillips screws to fasten CKP sensor bracket to cylinder mounting bosses.
2. Move bracket toward flywheel, so that gap between CKP sensor and flywheel tooth is **0.010 inches** (0.254 mm).
3. Alternately tighten CKP sensor bracket screws to **20-25 lb-in** (2.3-2.8 N-m).
4. Connect CKP sensor connector.
5. See *Blower Housing, Installation*.

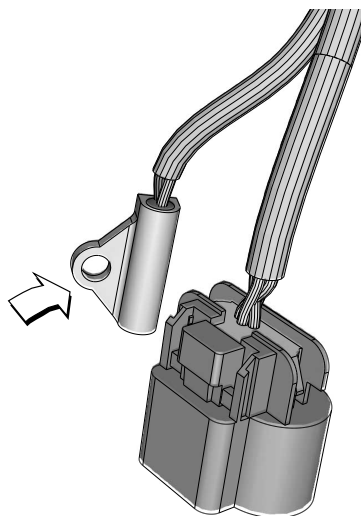
50



## EHT Sensor

**NOTE:** The EHT sensor is an integral part of the EFI wire harness and is not sold separately. Replace EFI wire harness if EHT sensor is bad.

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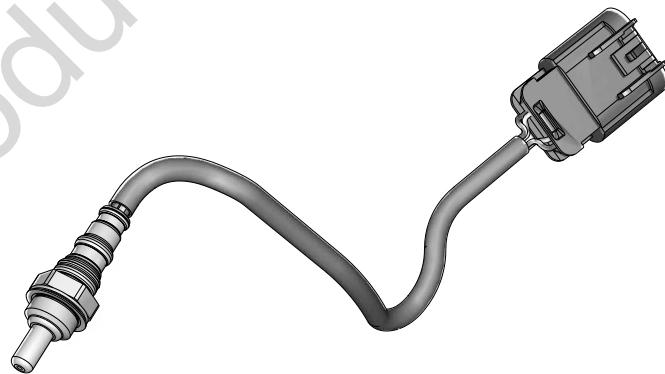


## HO<sub>2</sub> Sensor

### Removal

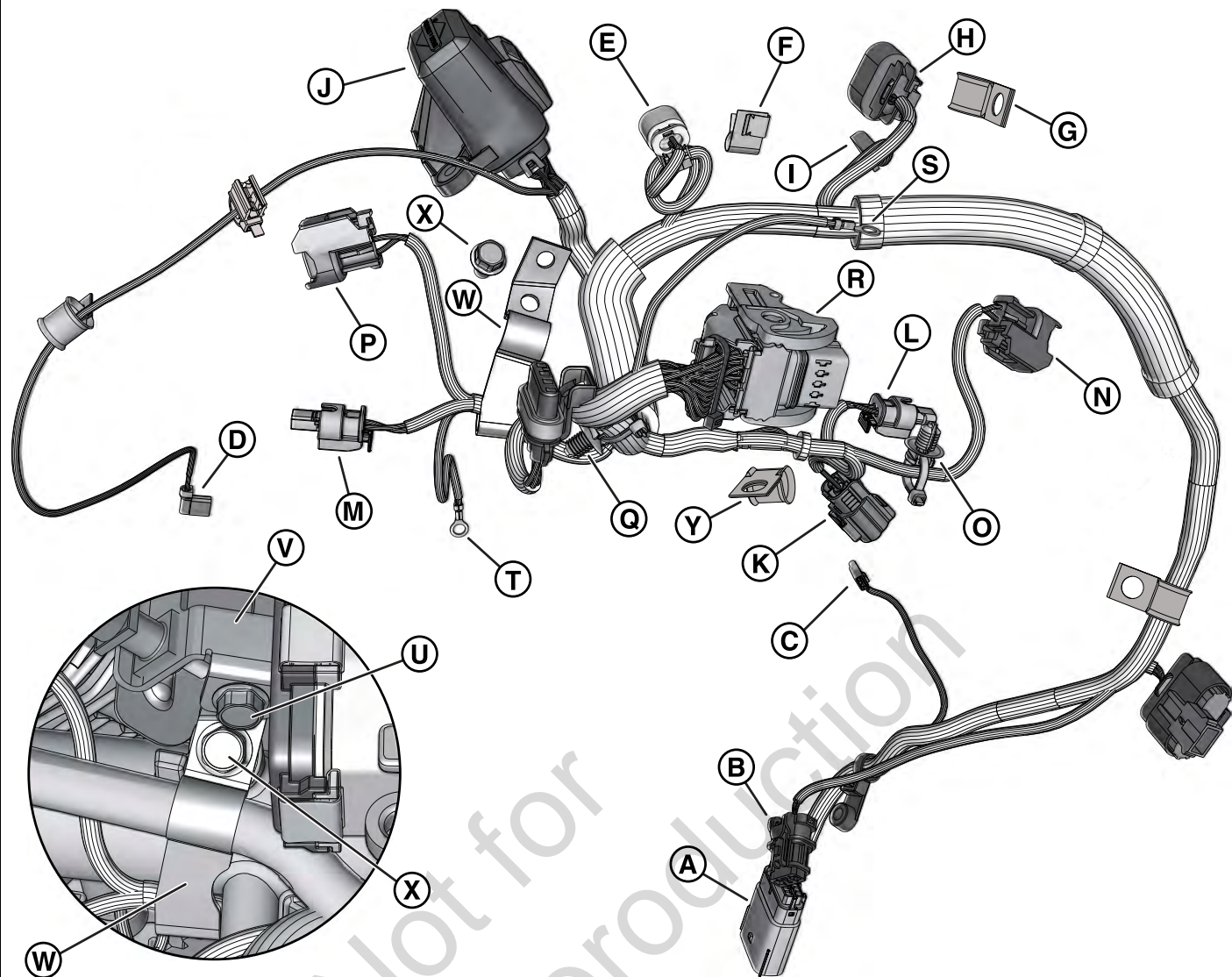
1. Disconnect HO<sub>2</sub> sensor connector.
2. Rotate sensor body hex counter-clockwise to release sensor from muffler.

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### Installation

1. Rotate sensor body hex clockwise to secure sensor to muffler. Tighten sensor to **146-173 lb-in** (16-19 N-m).
2. Connect HO<sub>2</sub> sensor connector.



## EFI Wire Harness

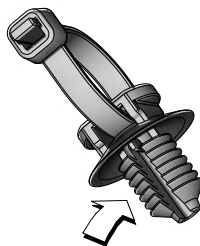
### Removal

**NOTE:** See Figure 54. The anchor on the fir tree style clip (A) resembles an upside down fir tree. Due to the rib configuration, the anchor is a very tight fit. To avoid damage to the clips and/or engine components, use the Briggs & Stratton Fuel Line Removal Tool (Part No. 19620) (B) to gently pry the clip from the anchor hole. If the clip is broken during removal, be sure to remove all plastic debris from the engine.

1. See *Air Cleaner Assembly/Top Cover, Removal*.
2. See *Blower Housing, Removal*.
3. See Figure 53. On starter motor side of engine, press tab and disconnect main vehicle connector (A).
4. Disconnect electric lift fuel pump connector (B).

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A



B



5. Remove elbow spade socket terminal (C) from starter solenoid spade contact.
6. Remove elbow spade socket terminal (D) from oil pressure switch spade contact. Remove wire harness retention clips, if still attached.
7. Disconnect fuel pump module connector (E). Pull out gray secondary lock, and then press and hold tab before pulling apart connector halves.

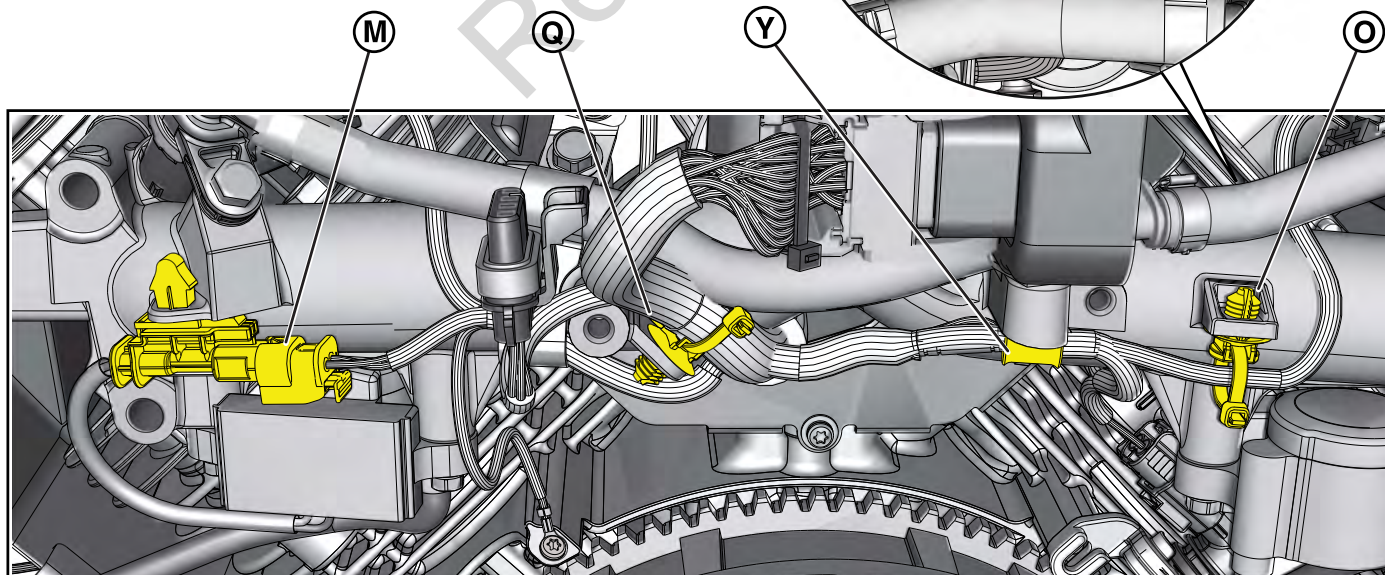
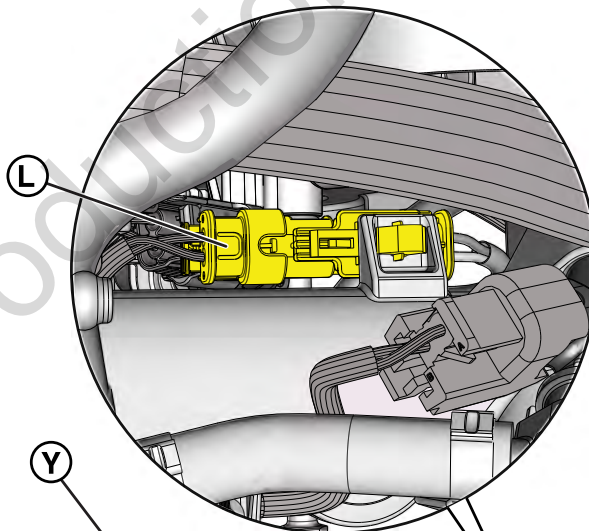
8. Remove O<sub>2</sub> sensor conduit from clip (**F**) at top of fuel pump module bracket support.
  9. Remove hex flange screw to release wire harness clip (**G**) capturing O<sub>2</sub> sensor and EHT sensor conduit from fuel pump module bracket support. Remove clip from wire harness.
  10. Disconnect O<sub>2</sub> sensor connector (**H**). Press tab to remove grey secondary lock, and then press black tab to separate connector halves.
  11. Remove T25 TORX screw to release EHT sensor (**I**) from cylinder head.
  12. Disconnect fuse/relay block (**J**) from cover.
  13. Disconnect CKP sensor connector (**K**).
  14. Disconnect cylinder 1 ignition coil connector (**L** in Figure 55) after removing anchor of rosebud style clip from boss at rear of intake manifold. Pull out red secondary lock, and then press and hold tab before pulling apart connector halves. Remove two screws to release ignition coil from intake manifold bosses, if necessary.
  15. Disconnect cylinder 2 ignition coil connector (**M** in Figure 55) at front of intake manifold. Pull out red secondary lock, and press and hold tab before pulling apart connector halves.
  16. Disconnect cylinder 1 fuel injector connector (**N**) after removing anchor of fir tree style clip (**O** in Figure 55) from boss at front of intake manifold. Pull out white secondary lock, and press and hold tab before pulling apart connector halves. Remove fuel injector cap screw if connector is caught beneath fuel rail.
  17. Disconnect cylinder 2 fuel injector connector (**P**). Pull out white secondary lock, and press and hold tab before pulling apart connector. Remove fuel injector cap screw if connector is caught beneath fuel rail.
  18. Remove anchor of fir tree style clip (**Q** in Figure 55) to release wire harness from intake manifold boss.
  19. Disconnect ECM connector (**R**).
  20. Remove Phillips screw to release ECM ground wire ring terminal (**S**) from throttle body.
  21. Remove Phillips screw to release engine ground wire ring terminal (**T**) from crankcase boss.
  22. Proceed as follows:
    - A. Cylinder 2 (Oil Filter) Side:
      - Remove hex flange screw (**U**) to release fuse/relay block bracket (**V**) from double-sided clamp (**W**) at top of intake manifold.
      - Rotate fuse/relay block bracket outward.
      - Remove hex flange screw (**X**) to release clamp from intake manifold boss.
      - Remove wire harness from clamp.
    - B. Cylinder 1 (Starter Motor) Side:
      - Remove hex flange screw to release wire harness clip (**Y** in Figure 55) from intake manifold boss.
  23. Remove three hex flange screws to release fuel pump module bracket from fuel pump module bracket support. Move assembly up and out of the way.
  24. See inset of Figure 55. Remove Phillips screw to release air block plate from crankcase. Rotate plate in a counter-clockwise direction to enlarge opening for harness removal.
  25. Feed branches of wire harness down and then out through opening next to air block plate.
- ### Installation
1. See inset of Figure 55. Starting with the main vehicle connector and ending with the fuse/relay block, feed branches of **new** wire harness in through opening next to air block plate.
  2. Rotate air block plate in a clockwise direction and install Phillips screw to fasten plate to crankcase. Tighten screw to **15-20 lb-in** (1.7-2.3 N-m).
  3. See Figure 53. Install Phillips screw to fasten engine ground wire ring terminal (**T**) to crankcase boss. Tighten screw to **40-50 lb-in** (4.5-5.7 N-m).
  4. Install Phillips screw to fasten ECM ground wire ring terminal (**S**) to throttle body. Tighten screw to **15-20 lb-in** (1.7-2.3 N-m).
  5. Connect ECM connector (**R**).
  6. Install anchor of fir tree style clip (**Q** in Figure 55) into boss at front of intake manifold.
  7. Running conduit between intake manifold and fuel rail, connect cylinder 2 fuel injector connector (**P**). Push in white secondary lock. If removed, install fuel injector cap screw and tighten to **100-120 lb-in** (11.3-13.6 N-m).
  8. Running conduit between intake manifold and fuel rail, connect cylinder 1 fuel injector connector (**N**). Push in white secondary lock. Install anchor of fir tree style clip (**O** in Figure 55) into boss at front of intake manifold. If removed, install fuel injector cap screw and tighten to **100-120 lb-in** (11.3-13.6 N-m).
  9. Connect cylinder 2 ignition coil connector (**M** in Figure 55). Push in red secondary lock.
  10. Connect cylinder 1 ignition coil connector (**L** in Figure 55). Push in red secondary lock. Install anchor of rosebud style clip into boss at rear of intake manifold. Install two screws to fasten ignition coil to intake manifold bosses, if removed. Tighten screws to **22.5-37.5 lb-in** (2.5-4.2 N-m).
  11. Connect CKP sensor connector (**K**).
  12. Proceed as follows:
    - A. Cylinder 2 (Oil Filter) Side:
      - Capture wire harness in double-sided clamp (**W**). Opposite side of clamp captures fuel rail.
      - Install short hex flange screw (**X**) to fasten clamp to intake manifold boss and tighten to **80-100 lb-in** (9.0-11.3 N-m).



- Install hex flange screw to fasten wire harness clip (**Y** in Figure 55) to intake manifold boss and tighten to **80-100 lb-in** (9.0-11.3 N-m).

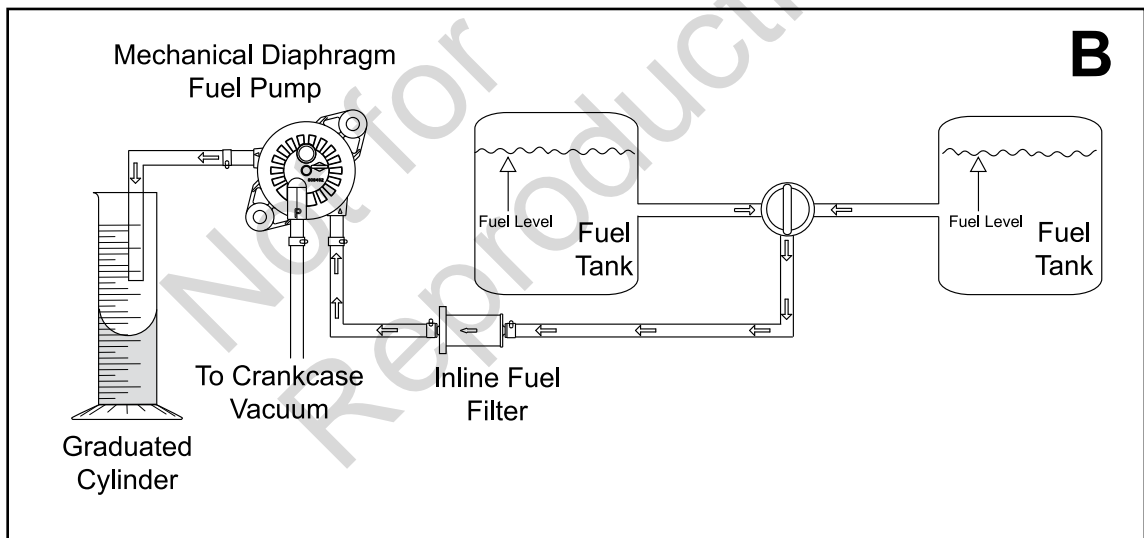
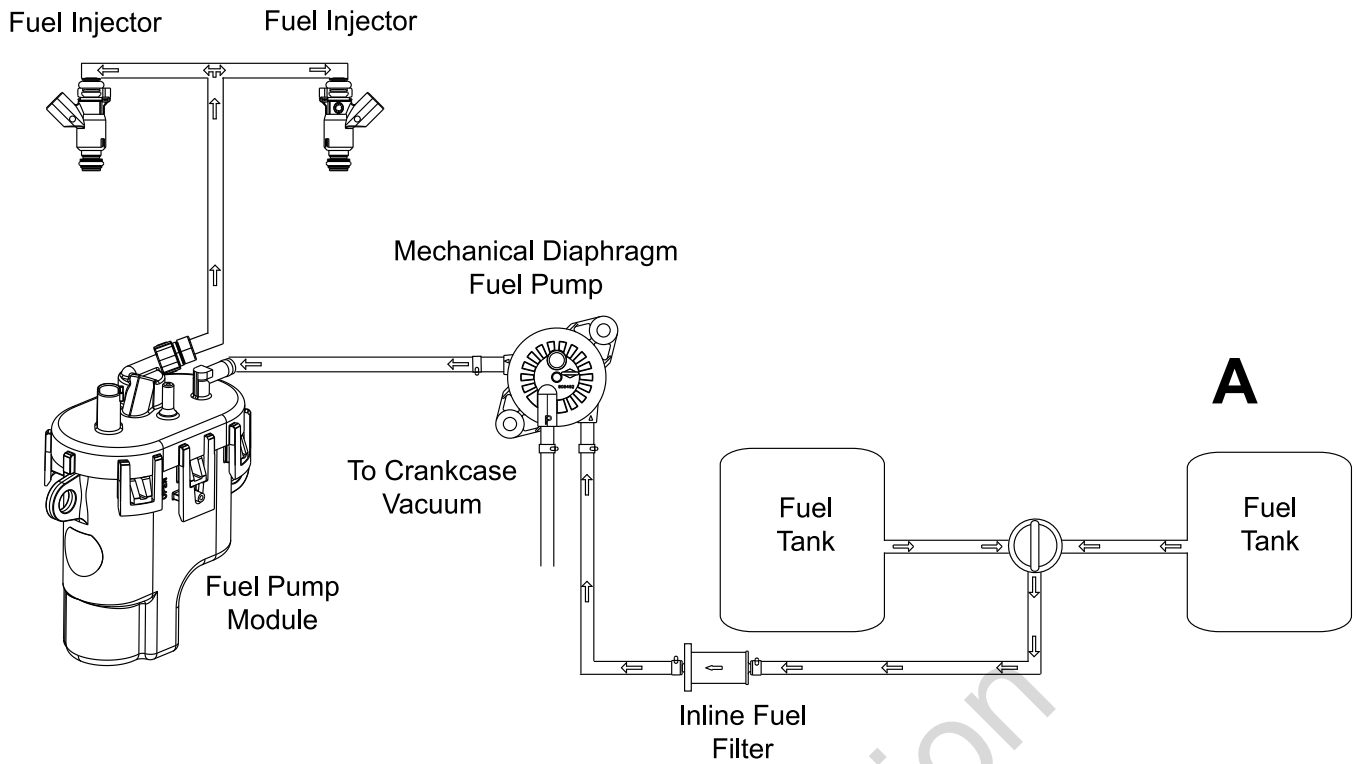
13. Connect fuse/relay block (**J**) to cover.
14. Install three hex flange screws to fasten fuel pump module bracket to fuel pump module bracket support. Tighten screws to **80-100 lb-in** (9.0-11.3 N-m).
15. Install T25 TORX screw to fasten EHT sensor (**I**) to cylinder head. Tighten screw to **35-55 lb-in** (4.0-6.2 N-m).
16. Connect O<sub>2</sub> sensor connector (**H**), and install gray secondary lock.

17. Capturing O<sub>2</sub> sensor and EHT sensor conduit in wire harness clip **(G)**, install hex flange screw to fasten clip, fuel pump module bracket support, and air guide to cylinder head.
18. Capture O<sub>2</sub> sensor conduit in clip **(F)** at top of fuel pump module bracket support.
19. Connect fuel pump module connector **(E)**. Push in grey secondary lock.
20. Running conduit inside of high tension lead, connect elbow spade socket terminal **(D)** to oil pressure switch spade contact.
21. Install elbow spade socket terminal **(C)** onto starter solenoid spade contact.
22. Connect electric lift fuel pump connector **(B)**.
23. Connect main vehicle connector **(A)**.
24. See *Blower Housing, Installation*.
25. See *Air Cleaner Assembly/Top Cover, Installation*.



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## MECHANICAL DIAPHRAGM FUEL PUMP FOR MODELS 440000/490000

### Volumetric Test

Do a volumetric test to verify that the proper amount of fuel is being delivered to the engine. See A of Figure 56 for a typical fuel flow diagram for these engine models. Proceed as follows:

1. Relieve fuel system pressure. See *CHECK/RELIEVE FUEL SYSTEM PRESSURE* in this section.
2. Remove battery negative cable (black) from battery negative (-) terminal.
3. Squeeze clip at fuel outlet port and remove hose to fuel pump module.

**NOTE:** Wrap shop towel around fitting to catch any fuel leakage.

4. Obtain a stop watch and a graduated cylinder.
5. Attach suitable hose to fuel outlet port and direct free end into graduated cylinder. See B of Figure 56.
6. Install battery negative cable (black) to battery negative (-) terminal.
7. Start engine and watch for fuel discharge from outlet port hose. Start the stopwatch as soon as fuel flow is observed.
8. Run engine for 30 seconds at 2200 RPM.
9. After the time has elapsed, turn off the engine and stop the watch.
10. Measure the volume of fuel discharged into the graduated cylinder. See the table below for the approximate amount of fuel that should be discharged.

Pump Fuel for 30 Seconds	
Approximate Fuel Amount	237 ml
	0.5 pint
	0.25 quart
	1.0 cup

### NOTES:

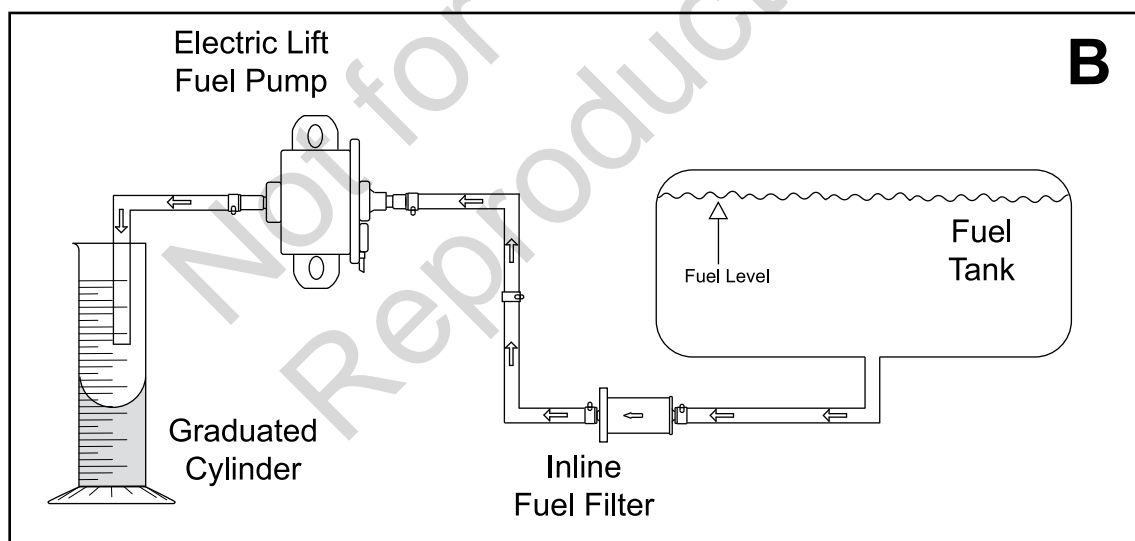
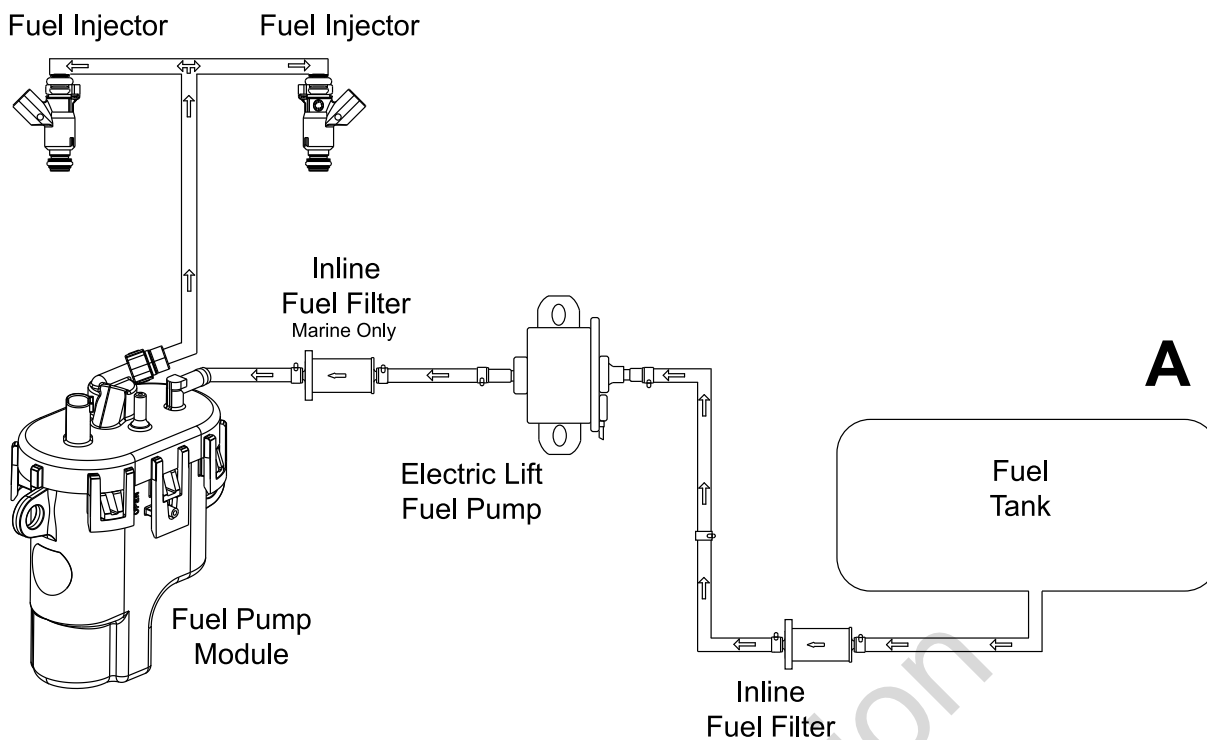
- Position the fuel tank so that it is near level with the fuel pump. Do not place the graduated cylinder **BELOW** the fuel pump or gravity feed will produce false results.
- The engine will run longer than the 30 second test interval using fuel trapped in the fuel pump module.
- View the graduated cylinder with your eyes directly level with the fuel. Note that the fuel curves up the sides of the graduated cylinder. This curve is called a meniscus. For the most accurate reading, read the measurement from the bottom of the meniscus.

- The volumetric measurement is only approximate. The fuel pump is likely functioning properly if the test results are within 10% of the approximate fuel amount.

### Engine Cranks But Will Not Start

Use the starter to turn the engine over for 10 seconds. See the table below for the approximate amount of fuel that should be discharged.

Crank Engine for 10 Seconds	
Approximate Fuel Amount	65 ml
	0.13 pint
	0.06 quart
	0.27 cup



## ELECTRIC LIFT FUEL PUMP FOR MODEL 610000

### Volumetric Test

Do a volumetric test to verify that the proper amount of fuel is being delivered to the engine. See A of Figure 57 for a typical fuel flow diagram for these engine models. Proceed as follows:

1. Relieve fuel system pressure. See *CHECK/RELIEVE FUEL SYSTEM PRESSURE* in this section.
2. Remove battery negative cable (black) from battery negative (-) terminal.
3. Squeeze clip at fuel outlet port and remove hose to fuel pump module.

**NOTE:** Wrap shop towel around fitting to catch any fuel leakage.

4. Obtain a stop watch and a graduated cylinder.
5. Attach suitable hose to fuel outlet port and direct free end into graduated cylinder. See B of Figure 57.
6. Install battery negative cable (black) to battery negative (-) terminal.
7. Start engine and watch for fuel discharge from outlet port hose. Start the stopwatch as soon as fuel flow is observed.

**NOTE:** The fuel pump primes for 2 seconds when the ignition is turned ON. Do not count this fuel in the volumetric measurement.

- If the engine will not run, connect a fused jumper wire from the fuel pump electrical connector to 12v B+. See *SECTION 3 - WIRE SCHEMATICS AND PIN-OUTS* section of this manual for reference.
8. After 30 seconds has elapsed, turn off the engine and stop the watch.
  9. Measure the volume of fuel discharged into the graduated cylinder. See the table below for the approximate amount of fuel that should be discharged.

Pump Fuel for 30 Seconds	
Approximate Fuel Amount	478 ml
	1.0 pint
	0.5 quart
	2.0 cup

### NOTES:

- Position the fuel tank, so that it is near level with the fuel pump. Do not place the graduated

cylinder **BELOW** the fuel pump or gravity feed will produce false results.

- The engine will run longer than the 30 second test interval using fuel trapped in the fuel pump module.
- View the graduated cylinder with your eyes directly level with the fuel. Note that the fuel curves up the sides of the graduated cylinder. This curve is called a meniscus. For the most accurate reading, read the measurement from the bottom of the meniscus.
- The volumetric measurement is only approximate. The fuel pump is likely functioning properly if the test results are within 10% of the approximate fuel amount.

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