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◀ Product: TRUCK ENGINE
Model: 3406E TRUCK ENGINE 2WS08494
Configuration: 3406E Truck Engine 2WS00001-UP

Troubleshooting

3406E, C-10, C-12, C-15, C-16 and C-18 On-highway Engines

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i01907625

Engine Speed/Timing Sensor Circuit - Test

SMCS - 1912-038

System Operation Description:

Use this procedure under the following situation:

- There is an active diagnostic code or an easily repeated diagnostic code that is associated with either the primary engine speed/timing sensor or the secondary engine speed/timing sensor.
- You have been directed to this test from Troubleshooting, "Troubleshooting without a Diagnostic Code".

The following background information is related to this procedure:

The engine uses two engine speed/timing sensors. One sensor picks up the camshaft gear and the other sensor picks up the crankshaft gear. Both of the engine speed/timing sensors detect the reference for engine speed and timing from a unique pattern on the gear. The ECM counts the time between pulses that is created by the sensor as the gear rotates in order to determine rpm.

Under normal operation, the secondary engine speed/timing sensor is used to determine timing for starting purposes. The secondary engine speed/timing sensor is used to determine when the piston in the No. 1 Cylinder is at the top of the compression stroke. When the timing has been established, the primary engine speed/timing sensor is then used to determine engine speed.

After locating the No. 1 cylinder, the ECM triggers each injector in the correct firing order and at the correct unit injector timing. The actual timing and duration of each injection is based on engine rpm and load. If the engine is running and the signal from the primary engine speed/timing sensor is lost, a slight change in engine performance will be noticed when the ECM performs the changeover to the secondary engine speed/timing sensor. Loss of the signal from the secondary engine speed/timing sensor during engine operation will not result in any noticeable change in engine performance.

However, if the signal from the secondary engine speed/timing sensor is not present during start-up the following conditions may exist:

- The engine may require a slightly longer period of time to start-up.
- The engine may run rough for a few seconds until the ECM determines the proper firing order by the use of the primary engine speed/timing sensor only.

The engine will start and the engine will run when only one sensor signal is present from either of the sensors. The loss of the signal from both of the sensors during engine operation will result in the termination of injection and the shutting down the engine by the ECM. The loss of the signal from both of the sensors during start-up will prevent the engine from starting.

Both sensors are magnetic sensors. The two sensors are not interchangeable. Do not switch the positions of the sensor. If the sensors are replaced, a timing calibration is NOT necessary for the engine. **Timing calibration is only necessary after replacing an ECM that will not communicate.**

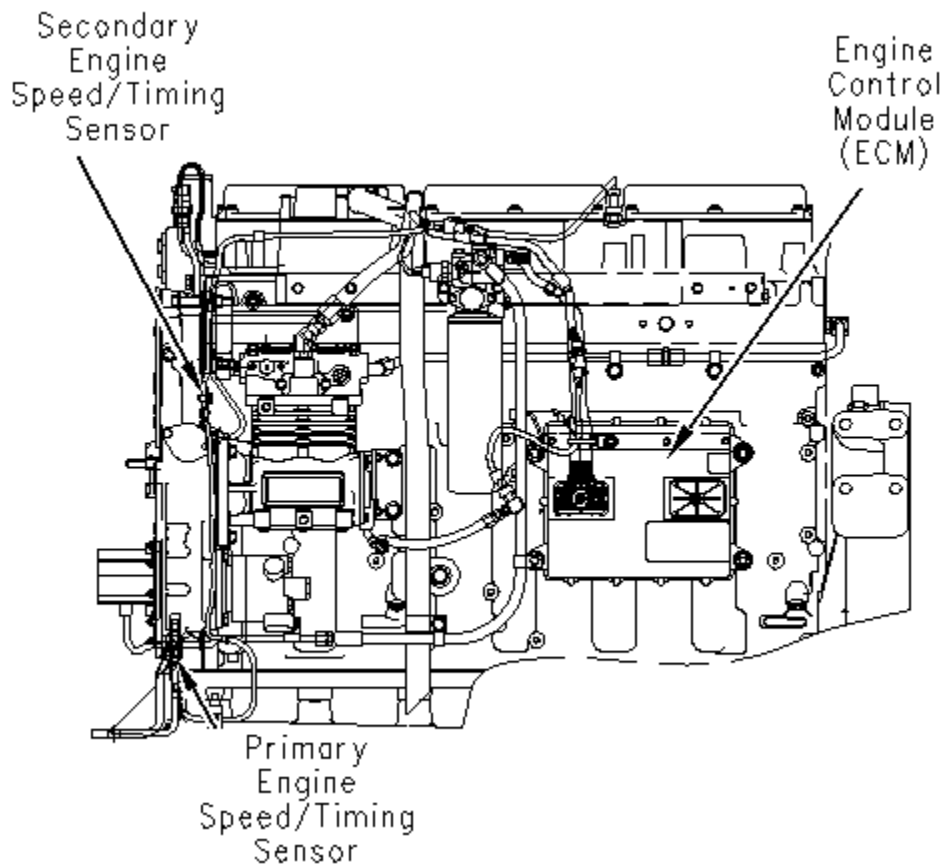


Illustration 1

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C-10 and C-12 Engine

Left side engine view

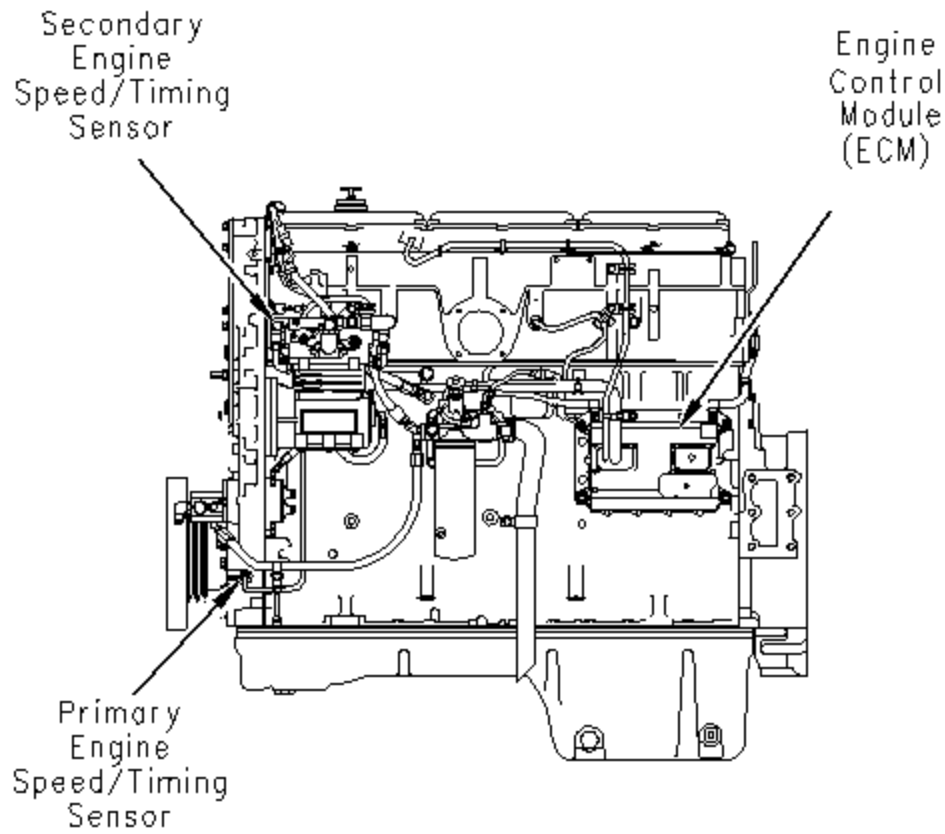


Illustration 2

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3406E Engine

Left side engine view

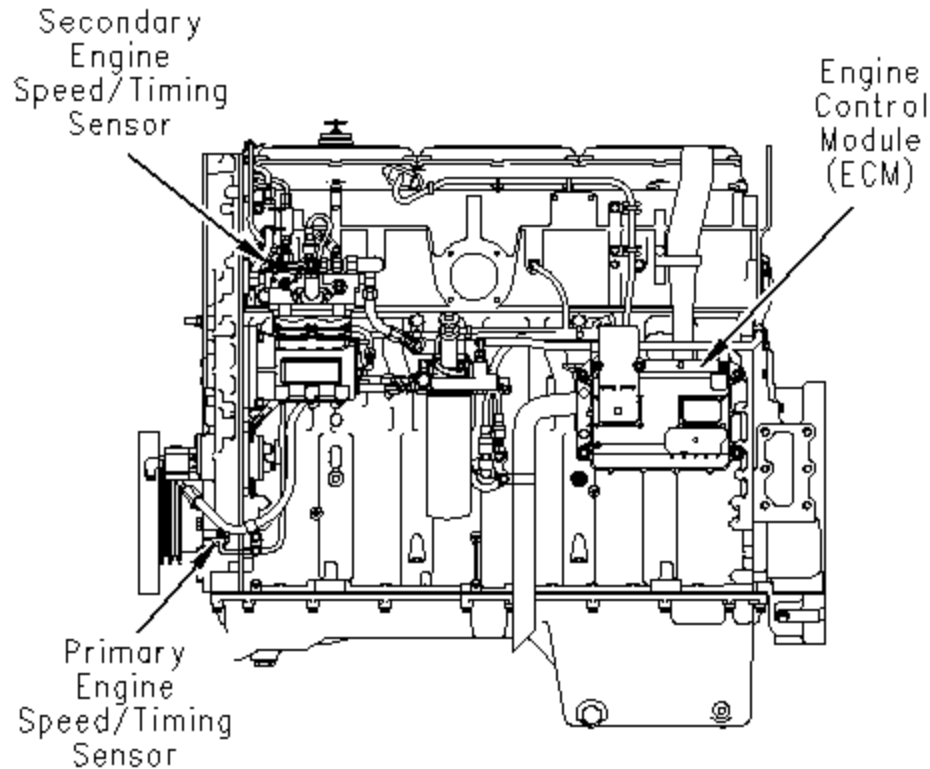


Illustration 3

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C-15, C-16 and C-18 Engine

Left side engine view

If a replacement of the ECM is required, the ECM parameters and the timing calibration can be transferred from the suspect ECM to the replacement ECM. Timing calibration will NOT be necessary. This feature requires the Caterpillar Electronic Technician (Cat ET) and this feature is only possible if the existing ECM can communicate with Cat ET. Use the "Copy Configuration - ECM Replacement" on Cat ET.

When the sensors are being installed, complete all of the following tasks:

- Lubricate the O-ring with oil.
- Ensure that the sensor has a connector face seal inside the connector body. If a seal is damaged or missing, replace the seal.
- Ensure that the sensor is fully seated into the engine before tightening the bracket bolt.
- Ensure that the connector is latched on both sides.

- Ensure that the harness is properly secured, and ensure that the tie-wraps are placed in the correct location.

Intermittent Faults That Are Due To The Wiring Harness Terminals

A problem with the engine wiring harness has been identified. This problem may cause the ECM to detect several intermittent speed signal conditions on the following engines:

- **C-10** (3CS00001-05369)
- **C-12** (2KS00001-15070)
- **3406E** (1MM00390-00838)
- **3406E** (2WS08900-20705)

If the intermittent condition occurs, the ECM will log the following diagnostic codes:

- 190-12 Primary Engine Speed loss of signal
- 64-12 Secondary Engine Speed loss of signal

The occurrence of these faults generally has no effect on engine performance, although the faults are occasionally accompanied by a speed burp of the engine.

Measure the sensor resistance through the engine harness, when both of the following conditions are met:

- The engine falls within the serial number ranges that are listed above.
- The engine has logged several 190-12 and/or 64-12 fault codes.

If the speed/timing sensors have the correct resistance, perform the following procedure in order:

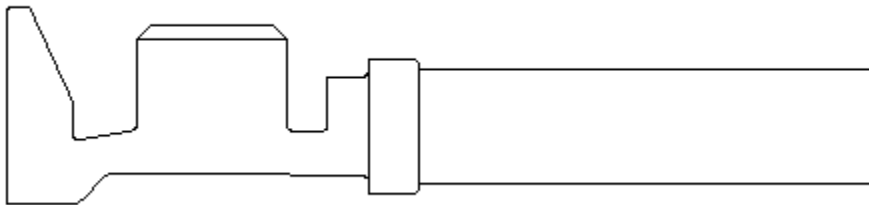


Illustration 4

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Socket that is stamped and formed

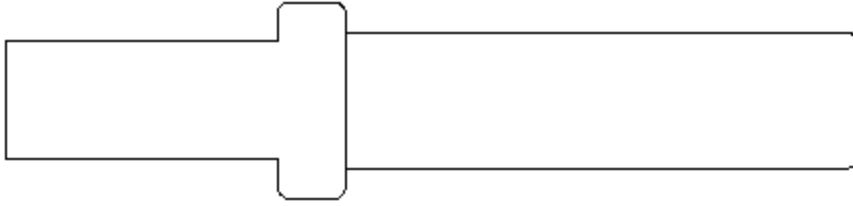


Illustration 5

g00660039

Socket that is machined

- Ensure that the software that is installed in the ECM is dated no earlier than March 1999. If the software is dated earlier than March 1999, flash the latest software into the ECM. Clear all of the fault codes that are related to the engine speed/timing sensors.
- Remove one of the terminals of the harness socket from the connector for the engine speed/timing sensor P401 or P402. The sockets that are present at the sensor end of the wiring harness will be one of two types. The socket will be either a socket that is stamped and formed or a socket that is machined. The socket that is stamped and formed will have fingers that are crimped onto the wire insulation. Refer to Illustration 4. The socket that is machined can only be crimped onto the electrical conductor or wire. Refer to Illustration 5.
- If the sockets that are stamped and formed are present in the sensor harness connectors, the sockets must be cut back at the sensor harness ends of the sensor harness for the engine speed/timing sensors, and each socket must be replaced by an **8T-8730** Connector Socket that is machined. The socket terminals in the connector assembly should be removed from the 2-pin connector. The 2-pin connector is a Deutsch DT-2 connector. The socket terminals should be changed, and reinserted. Perform this procedure on each wire one at a time in order to eliminate the chance of reversing the polarity of the connection. If machined terminals are already installed in the sensor harness connectors for the engine speed/timing sensors, resume troubleshooting at Test Step 3.
- There is generally sufficient wire length in the engine harness in order to perform this repair. Cut back the socket terminals close to the ends of the sensor wires. Leave the wire as long as possible.
- The wire tie-wraps for the speed-timing sensor harness can be loosened and the slack in the harness can be pushed toward the sensor, if necessary. Maintain at least 1 twist per inch in the speed-timing sensor harnesses from the ECM to the sensor.
- Ensure that the wiring is not pulled too tightly at the sensor connector. If the wiring is pulled too tightly at the sensor connector, intermittent connections may develop as vibrations occur.
- While this service is being performed on the C-10 and the C-12 engines, ensure that the wire tie-wrap for the primary engine speed/timing sensor on the engine front support is snug. This tie dampens excessive movement of the sensor wires during normal engine operation. If the wire

tie-wrap for the harness is damaged or missing, install a new tie approximately 102 mm (4 inch) from the sensor.

- Do Not replace the engine speed/timing sensors. To check the work that has been performed, start the engine and disconnect the primary engine speed/timing sensor. A slight speed burp may occur when the primary engine speed/timing sensor is disconnected. If the engine runs properly and the primary engine speed/timing sensor is disconnected, the engine repair has been accomplished without reversing the polarity of the wiring.

Note: If the above installation is not performed one wire at a time, the polarity of the wiring can accidentally be reversed. If the polarity of the wire for the secondary engine speed/timing sensor is reversed, the engine may start. The engine will run adequately until a failure of the primary engine speed/timing sensor occurs. At this point, the engine will run poorly. If the polarity of the wire for the primary engine speed/timing sensor is reversed, the engine may not start. If the polarities of both the engine speed/timing sensors are reversed, the engine will not start.

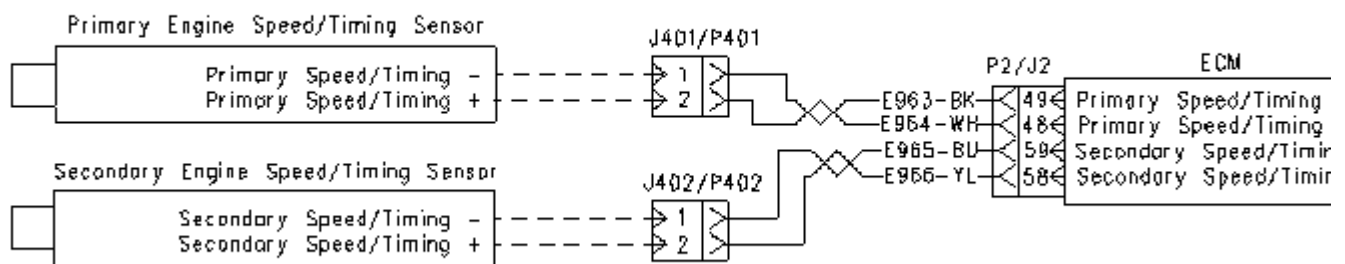


Illustration 6

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Schematic for engine speed/timing sensors

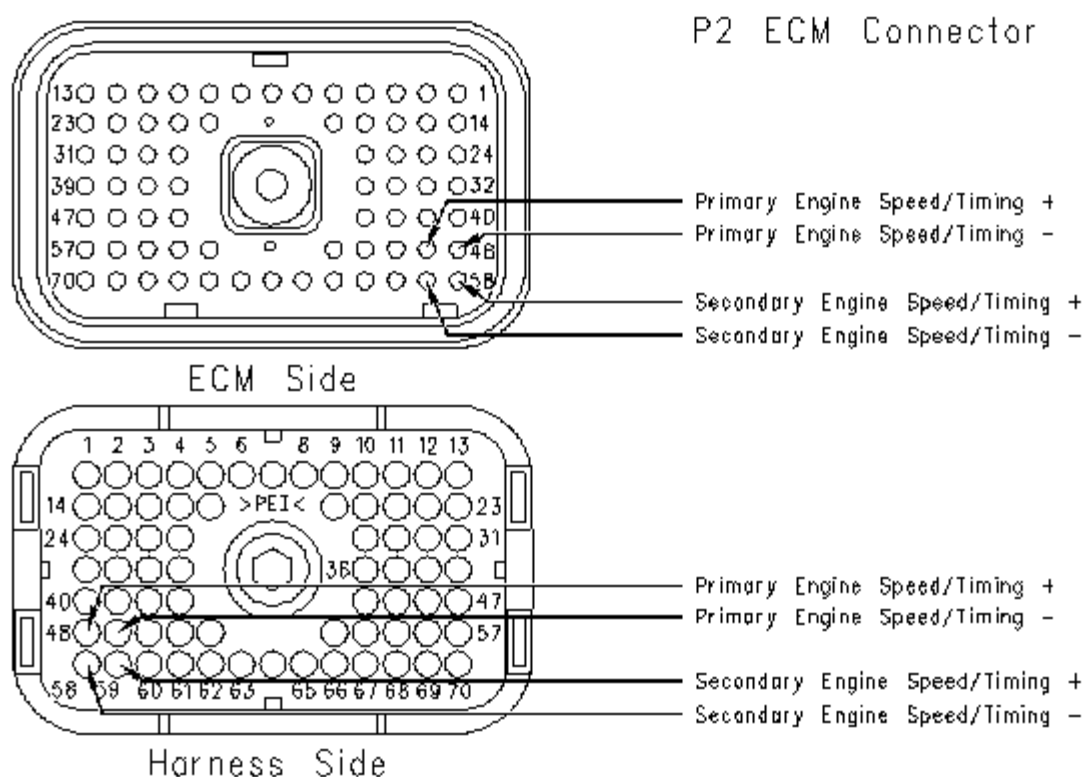


Illustration 7

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P2 ECM connector

Test Step 1. Check for Diagnostic Codes

- A. Connect the Caterpillar Electronic Technician (Cat ET) to the data link connector.
- B. Turn the key switch to the ON position.
- C. Check for one of the following logged diagnostic codes or active diagnostic codes:
 - 22-11 Primary to Secondary Engine Speed Signal Calibration
 - 64-12 Secondary Engine Speed loss of signal
 - 190-12 Primary Engine Speed loss of signal

Note: If the diagnostic code is logged but not active, run the engine until the engine is at normal operating temperature. The problem may only occur when the engine is at the normal operating temperature. If the engine will not start, monitor the engine rpm on Cat ET while the engine is being cranked. Cat ET may need to be powered from another battery while the engine is being cranked. This is done in order to ensure that Cat ET does not reset.

Note: If there are occurrences of the 64-12 and 190-12 faults, refer to the following information in the System Operation Section:

- Intermittent Faults That Are Due To The Wiring Harness Terminals

Expected Result:

One or more of the diagnostic codes that are listed above are logged or active.

Note: If you have been directed here from Troubleshooting, "Troubleshooting without a Diagnostic Code" for the following reason, select "No Engine rpm":

- The engine rpm was not indicated on Cat ET.

Results:

- **64-12, 190-12 or 22-11** - There is an active diagnostic code or a logged diagnostic code. Proceed to Test Step 3.
- **Not OK** - If none of the codes that are listed are active diagnostic codes or logged diagnostic codes and the engine is not running properly, refer to the appropriate symptoms in the service manual.**STOP**
- **No Engine rpm** - Engine rpm is not indicated on Cat ET. Proceed to Test Step 2.

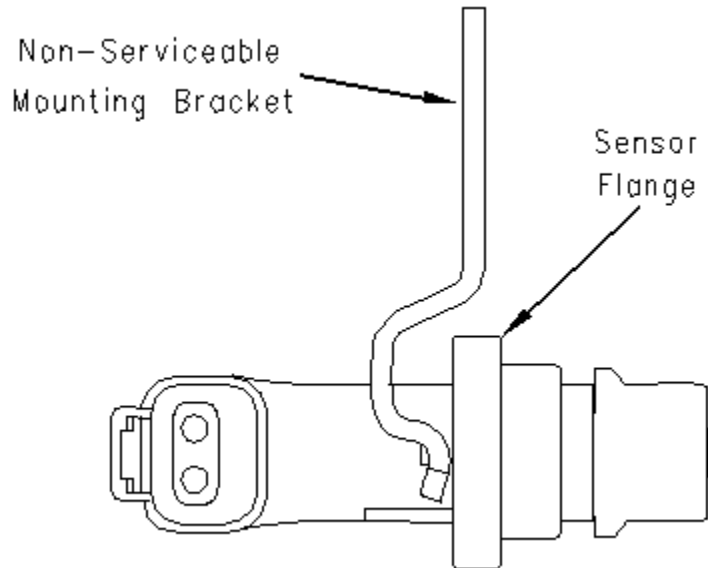
Test Step 2. Check the Installation of the Sensors and the Bracket

Illustration 8

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Flange of the sensor and mounting bracket

- A. The flange of the sensor should be flush against the engine in order to ensure proper operation.

- B. Inspect the bracket in order to ensure that the installation allows the flange of the sensor to be flush against the engine.

Verify that the bracket is not bent.

Note: The bracket cannot be replaced separately.

- C. Ensure that one O-ring has been installed on the sensor, and ensure that the O-ring is free of damage.
- D. If the following diagnostic code is active, there may be a problem with the assembly of the engine:
- 22-11 Primary to Secondary Engine Speed Signal Calibration

Refer to Illustration 8.

Expected Result:

The sensors and the bracket are properly installed.

Results:

- **OK** - The sensors and the bracket are properly installed. Proceed to Test Step 3.
- **Not OK** -

Repair: Perform the following procedure in order to properly install the sensors and the bracket:

1. Loosen the bolt that holds the sensor mounting bracket to the engine.
2. Seat the sensor and tighten the bolt.

If the sensor will not seat, repair the sensor or replace the sensor, as required.

Note: The sensor must not be removed from the bracket.

3. Ensure that the sensor is properly oriented and that the harness is secured in the proper location.
4. Verify that the repair eliminates the problem.

STOP

Test Step 3. Measure the Sensor Resistance Through the Engine Harness

- A. Turn the key switch to the OFF position.
- B. Thoroughly inspect the J2/P2 ECM connector. Refer to Troubleshooting, "Electrical Connectors - Inspect" for details.

C. Perform a 45 N (10 lb) pull test on the following wires in the P2 ECM connector that are associated with the engine speed/timing sensors:

- Terminal 48
- Terminal 49
- Terminal 58
- Terminal 59

Refer to Illustration 7.

- D. Ensure that the latch tab on the connector is properly latched and ensure that the latch tab is fully latched.
- E. Check the ECM connector (allen head screw) for the proper torque of 6.0 N·m (55 lb in).
- F. Repair the harness or repair the connector if a problem is found.
- G. Ensure that the wiring harness is correctly routed and secured at the proper locations.
- H. Ensure that the harness wiring is not pulled too tightly. When the harness wiring is pulled too tightly, vibrations or movement can cause intermittent connections.
- I. Inspect the harness wiring for nicks and abrasions.
- J. If the harness and the connector are OK, disconnect ECM connector J2/P2.
- K. Primary engine speed/timing sensor

Refer to Illustration 7.

- a. Use a multimeter to measure the sensor resistance (Ohms) between P2:48 (Primary Speed/Timing Positive) and P2:49 (Primary Speed/Timing Negative).
- b. Check for an intermittent open circuit or short circuit by moving the harness while the measurement for resistance is being taken. Pull the wires that are directly behind the sensors or shake the wires that are directly behind the sensors.

Resistance ... 75.0 to 230.0 Ohms

L. Secondary engine speed/timing sensor

Refer to Illustration 7.

- a. Use a multimeter to measure the sensor resistance (Ohms) between P2:58 (Secondary Speed/Timing Positive) and P2:59 (Secondary Speed/Timing Negative).
- b. Check for an intermittent open circuit or short circuit by moving the harness while the measurement for resistance is being taken. Pull the wires that are directly behind the sensors or shake the wires that are directly behind the sensors.

Resistance ... 600 to 1800 Ohms

Expected Result:

The readings agree with the values that are listed above.

Results:

- **OK** - Neither a short circuit nor an open circuit is indicated. Proceed to Test Step 5.
- **Not OK** - The sensor resistance is not within the acceptable range when the sensor resistance is measured through the engine harness. Proceed to Test Step 4.

Test Step 4. Measure the Resistance of the Sensor at the Sensor

- A. Turn the key switch to the OFF position.
- B. Check the harness and the wiring for abrasion and pinch points from the sensor back to the ECM.
- C. Disconnect the suspect sensor from the engine harness.
- D. Thoroughly inspect J401/P401 or J402/P402 connectors. Refer to Troubleshooting, "Electrical Connectors - Inspect" for details.
- E. Primary engine speed/timing sensor
 - a. Use a multimeter to measure the sensor resistance (Ohms) between J401:2 (Primary Speed/Timing Positive) and J401:1 (Primary Speed/Timing Negative).
Resistance ... 75.0 to 230.0 Ohms
- F. Secondary engine speed/timing sensor
 - a. Use a multimeter to measure the sensor resistance (Ohms) between J402:2 (Secondary Speed/Timing Positive) and J402:1 (Secondary Speed/Timing Negative).
Resistance ... 600 to 1800 Ohms

Note: Timing calibration is not necessary following replacement of the engine speed/timing sensors. Refer to the information in the System Operation Section regarding the installation of sensors.

Expected Result:

The readings agree with the values that are listed above.

Results:

- **OK** - The sensor resistance is correct. Proceed to Test Step 5.
- **Not OK** - The sensor resistance is out of the range.

Repair: Perform the following procedure in order to check and install the new sensor:

1. Before installing the new sensor, measure the resistance of the new sensor.

If the new sensor resistance is in the correct range, install the new sensor in the engine, as follows:

- a. Loosen the bolt that holds the sensor mounting bracket to the engine.
- b. Ensure that one O-ring is installed and free of damage.
- c. Seat the sensor and tighten the bolt.

If the sensor will not seat, repair the sensor or replace the sensor, as required.

Note: The sensor must not be removed from the bracket.

- d. Ensure that the sensor is properly oriented and that the harness is secured in the proper location.

2. Verify that the repair eliminates the problem.

STOP

Test Step 5. Install the Bypass Harness for the Engine Speed/Timing Sensors

- A. Turn the key switch to the OFF position.
- B. Disconnect the J2/P2 ECM connector.
- C. Use the following procedure for the primary engine speed/timing sensor:
 - a. Install a 16 AWG wire from J2/P2:48 to P401:2.
 - b. Install a 16 AWG wire from J2/P2:49 to P401:1.

Note: Twisted pair wiring is required. Ensure that the wires have at least one twist per inch.

- D. Use the following procedure for the secondary engine speed/timing sensor:
 - a. Install a 16 AWG wire from J2/P2:58 to P402:2.
 - b. Install a 16 AWG wire from J2/P2:59 to P401:1.

Note: Twisted pair wiring is required. Ensure that the wires have at least one twist per inch.

- E. Reconnect the J2/P2 ECM connector.
- F. Start the engine in order to determine if the bypass harness repairs the problem.

Expected Result:

The problem is corrected with the installation of the bypass harness.

Results:

- **OK -**

Repair: Permanently install a new section of harness.

STOP

- **Not OK -**

Repair: Verify that the correct terminals have been installed in the correct location of the P2 ECM connector. If the temporary harness was installed correctly, install the original wiring.

Proceed to Test Step 6.

Test Step 6. Check the ECM

- Turn the key switch to the OFF position.
- Temporarily connect a test ECM.
- Start the engine. Run the engine in order to repeat the conditions when the problem occurs.
- If the problem is resolved with the test ECM, reconnect the suspect ECM.
- If the problem returns with the suspect ECM, replace the ECM.

Verify that the repair eliminates the problem.

Expected Result:

The problem remains with the suspect ECM.

Results:

- **OK -**

Repair: If the problem is resolved with the test ECM and the problem returns with the suspect ECM, replace the ECM. Verify that the repair eliminates the problem.

STOP

- **Not OK -**

Repair: Replace the sensor. Verify that the repair eliminates the problem.

STOP