Engine Electrical

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Battery Ground Cable Fastener	9 N•m	80 lb in
Battery Ground Cable to Battery Negative Cable Fastener	9 N•m	80 lb in
Battery Hold Down Retainer Fastener	22 N•m	16 lb ft
Battery Negative Cable Ground Fastener (Engine Block)	22 N•m	16 lb ft
Battery Negative Cable Ground Fastener (Frame)	22 N•m	16 lb ft
Battery Negative Cable Fastener	4.5 N•m	40 lb in
Battery Positive Cable Fastener	4.5 N•m	40 lb in
Battery Positive Cable to Battey Junction Block Fastener	7 N•m	62 lb in
Battery Positive Cable to Underhood Fuse Block	7 N•m	62 lb in
Battery Tray Fastener	14 N•m	10 lb ft
Generator Mounting Fastener	35 N•m	26 lb ft
Generator Positive Cable Fastener	20 N•m	15 lb ft
Generator Pulley Fastener	90 N•m	66 lb ft
StarterMounting Fastener	25 N•m	18 lb ft
Starter Stud	25 N•m	18 lb ft
Starter Ground Cable Fastener	12.5 N•m	111 lb in
Starter Positive Cable Fastener	9 N•m	80 lb in

Battery Usage

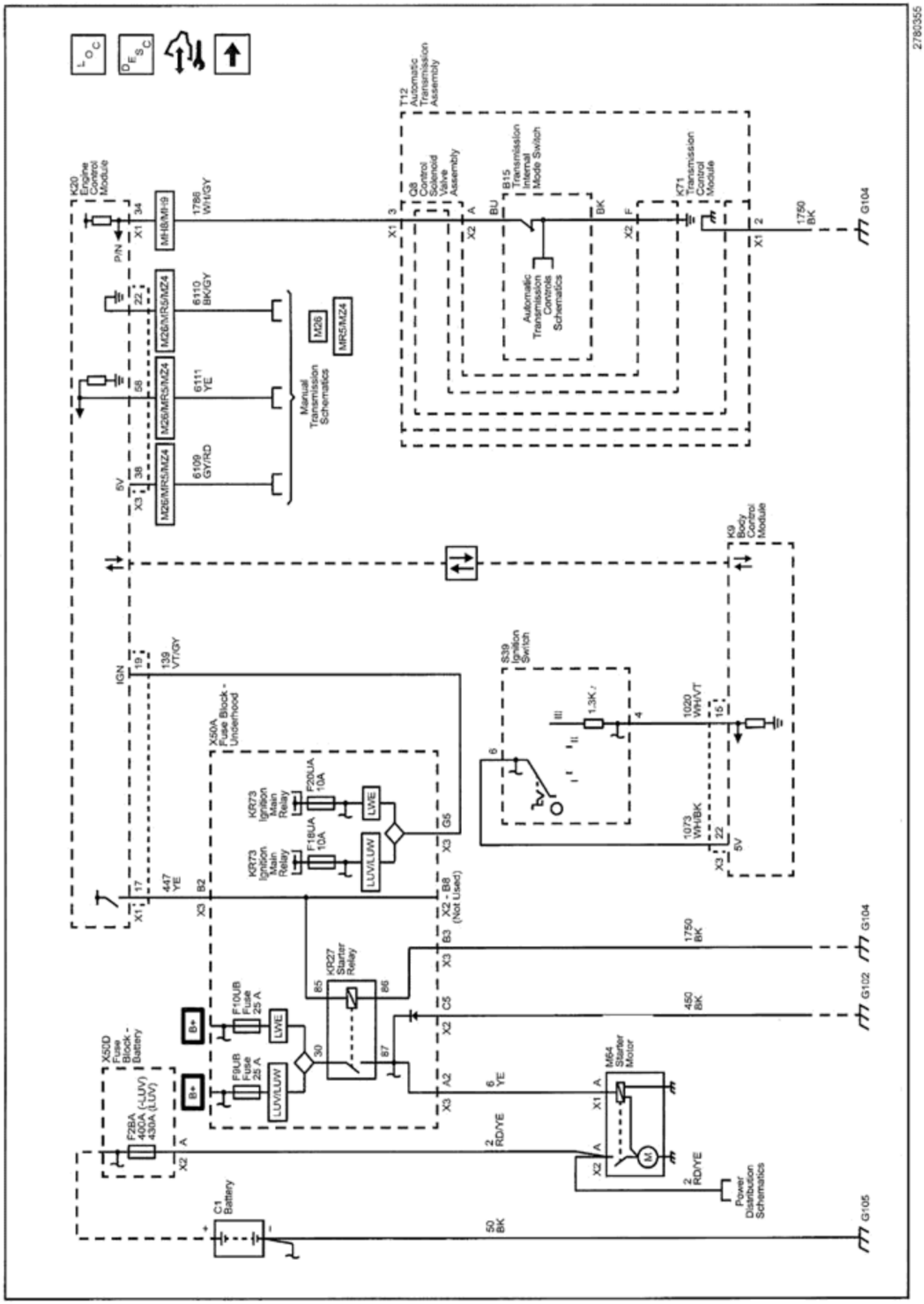
Application	Specification
Cold Cranking Amperage	438 amps
Reserve Capacity Rating	60 AH

Generator Usage

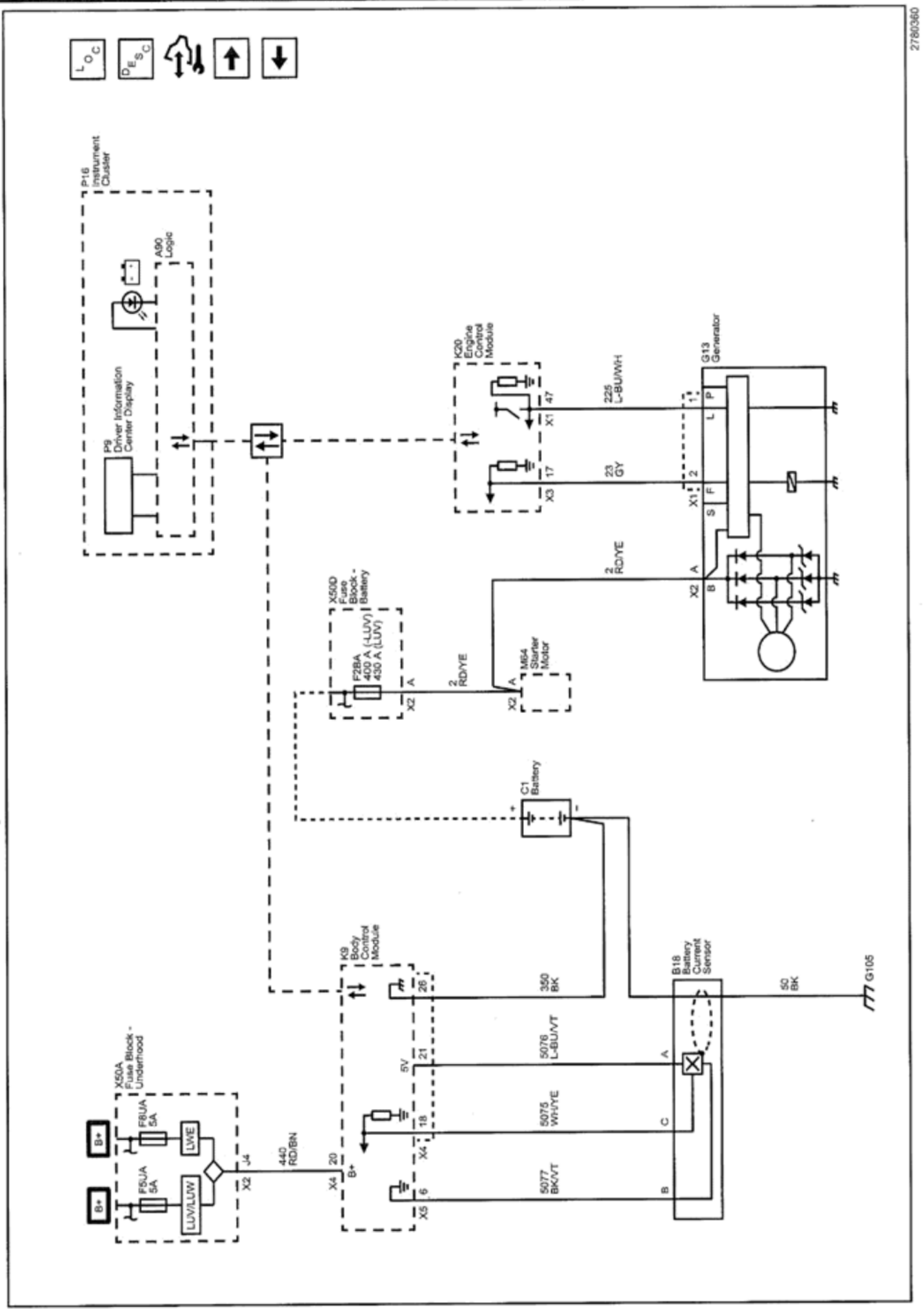
Application	Description
Rated Output	100 A
Load Test Output	70 A

Schematic and Routing Diagrams

Starting and Charging Schematics (Starting)



Starting and Charging Schematics (Charging)



Diagnostic Information and Procedures

DTC B1325, B1330, B1517, C0800, C0895, P0560, P0562, or P0563

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC B1325 03: Device Power Circuit Voltage Below Threshold
DTC B1325 07: Device Power Circuit Voltage Above Threshold
DTC B1330 03: Device Power 2 Circuit Voltage Below Threshold
DTC B1517 03: Battery Voltage Below Threshold
DTC B1517 07: Battery Voltage Above Threshold
DTC B1517 5A: Battery Voltage Plausibility Failure
DTC C0800 03: Device Power 1 Circuit Voltage Below Threshold
DTC C0800 07: Device Power 1 Circuit Voltage Above Threshold
DTC C0800 11: Device Power 1 Circuit High Input
DTC C0800 0D: Device Power 1 Circuit High Resistance
DTC C0895 00: Device Voltage
DTC P0560: System Voltage Low
DTC P0562: System Voltage Low
DTC P0563: System Voltage High

Circuit/System Description

The vehicle control modules or sensors monitor the system voltage to verify the system voltage is within the normal operating range.

Conditions for Running the DTC

The ignition is ON.

Conditions for Setting the DTC

The control module or sensor detects a system voltage of less than approximately 9 V for approximately 5 seconds.

Action Taken When the DTC Sets

- A driver information center message and/or warning indicator may be displayed.
- The control module may be temporarily disabled.

Conditions for Clearing the DTC

The system voltage returns to normal operating range.

Diagnostic Aids

- A high or low voltage DTC set or voltage value in multiple modules/sensors indicates a concern in the charging system.
- A possible cause of this DTC could be overcharging with a battery charger or jump starting.

Reference Information

Schematic Reference

Control Module References on page 6-3

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Charging System Description and Operation on page 9-729

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition OFF, measure and record the battery voltage at the battery terminals. The battery voltage should stabilize between 12.4 and 12.8 V within a few minutes of turning the ignition OFF.
   ⇒ If not within the specified range, refer to *Battery Inspection/Test on page 9-702*.
2. Engine running, accessories OFF, measure and record the battery voltage at the battery terminals. The voltage should be at least 1 V greater than the voltage measured in step 1 but less than 15 V.
   ⇒ If not within the specified range, refer to *Charging System Test on page 9-707*.
3. Observe the appropriate module scan tool B+ and ignition voltage parameters. The voltage readings should be within 1 V of the battery voltage.

Circuit/System Testing

Note: Use the schematic to identify the following:

- Control modules the vehicle is equipped with
- The control modules ground, B+, and Ignition circuit terminal IDs and connectors

1. Ignition OFF, disconnect the harness connectors at the appropriate control module.

Note: Some control module ground circuits may require up to 20 minutes to achieve a resistance reading of less than 10 Ω. In most cases the readings will drop below 20 Ω within 1 minute indicating the control modules are going to sleep.

2. Ignition OFF, scan tool disconnected, open and close the driver door and wait 1 minute. Test for less than 10 Ω between each ground circuit terminal and ground.
   ⇒ If greater than the specified range, test the ground circuit for an open/high resistance.
3. If equipped, verify that a test lamp illuminates between each B+ circuit terminal and ground.
   ⇒ If the test lamp does not illuminate, test the B+ circuit for a short to ground or an open/high resistance.
4. If equipped, ignition ON, verify that a test lamp illuminates between each ignition circuit terminal and ground.
   ⇒ If the test lamp does not illuminate, test the ignition circuit for a short to ground or an open/high resistance.
5. If all circuits test normal, replace the control module module.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

Control Module References on page 6-3 for control module replacement, setup, and programming

DTC B1516

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC B1516 08: Battery Current Sensor Signal Invalid

DTC B1516 66: Battery Current Sensor Wrong Mounting Position

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	B1516 08	B1516 08	—	—
Signal	B1516 08	B1516 08	B1516 08	B1516 08, B1516 66
Low Reference	—	B1516 08	—	—

Circuit/System Description

The battery current sensor is a 3-wire hall effect current sensor. The body control module (BCM) supplies 5 V and ground to the battery current sensor. The battery current sensor measures the amount of current flowing to or from the battery, and supplies a pulse width modulation (PWM) signal to the BCM.

Conditions for Running the DTC

B1516 08

The BCM is awake.

B1516 66

- The BCM is awake.
- The engine is OFF.

Conditions for Setting the DTC

B1516 08

The battery current signal is less than 4 percent or greater than 96 percent duty cycle for 2 minutes.

B1516 66

The battery current polarity is positive for 2 minutes.

Action Taken When the DTC Sets

The regulated voltage control (RVC) is disabled.

Conditions for Clearing the DTC

The DTC passes when the battery current returns to the normal range for 15 seconds.

Diagnostic Aids

DTC B1516 08 could be set by overcharging with a battery charger or jump starting.

Reference Information

Schematic Reference

Starting and Charging Schematics on page 9-683

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Charging System Description and Operation on page 9-729

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Testing

B1516 08

1. Ignition OFF, disconnect the harness connector at the B18 battery current sensor.
2. Ignition OFF and scan tool disconnected, open and close the driver door, and wait 1 minute. Test for less than 30 Ω between the low reference circuit terminal B and ground.
   ⇒ If greater than specified range , test the low reference circuit for an open/high resistance. If the circuit tests normal, replace the K9 BCM.

3. Ignition ON, test for 4.8–5.2 V between the 5 V reference circuit terminal A and ground.
   - ⇒ If less than the specified range , test the 5 V reference circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the K9 BCM.
   - ⇒ If greater than the specified range, test the 5 V reference circuit for a short to voltage. If the circuit tests normal, replace the K9 BCM.
4. Ignition ON, test for 4.8–5.2 V between the signal circuit terminal C and ground.
   - ⇒ If less than the specified range, test the signal circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the K9 BCM.
   - ⇒ If greater than the specified range, test the signal circuit for a short to voltage. If the circuit tests normal, replace the K9 BCM.
5. If all circuits test normal, test or replace the B18 battery current sensor.

B1516 66

1. Verify that the B18 battery current sensor is installed securely around the negative battery cable, with the tape tab pointing away from the negative terminal on the C1 battery.
   - ⇒ If the B18 battery current sensor is not installed correctly, remove and reinstall the sensor properly.
2. Replace the B18 battery current sensor.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

- *Battery Current Sensor Replacement on page 9-714*
- *Control Module References on page 6-3* for BCM replacement, setup, and programming

DTC B151A

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC B151A 58: Low Battery Capacity Detected

Circuit/System Description

The body control module (BCM) monitors the battery voltage level during an engine crank event to detect a low battery voltage condition.

Conditions for Running the DTC

The vehicle is ON

Conditions for Setting the DTC

A minimum crank battery voltage is less than the minimum crank battery voltage threshold for 16 consecutive crank events.

Action Taken When the DTC Sets

A driver information center (DIC) message is displayed.

Conditions for Clearing the DTC

The DTC will clear if the minimum crank voltage is greater than the minimum crank voltage threshold during a crank event.

Reference Information

Schematic Reference

Starting and Charging Schematics on page 9-683

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Charging System Description and Operation on page 9-729

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

Before replacing the C1 battery perform the *Battery Inspection/Test on page 9-702*.

DTC B1527

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC B1527 00: Parasitic Load

Circuit/System Description

The body control module (BCM) monitors the state of charge of the electrical system.

Conditions for Running the DTC

The ignition is in Accessory or Run mode.

Conditions for Setting the DTC

The state of charge at ignition ON is 30 percent lower than when the engine was running and battery drain is more than 2 A.

Action Taken When the DTC Sets

There is no battery telltale illuminated or DIC message displayed.

Conditions for Clearing the DTC

- The DTC will clear if the fault does not return after 50 consecutive ignition cycles.
- The DTC will clear when run state of charge is greater than or equal to 80%.

Reference Information

Schematic Reference

Starting and Charging Schematics on page 9-683

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Charging System Description and Operation on page 9-729

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

Refer to *Battery Electrical Drain/Parasitic Load Test on page 9-704*.

DTC P0615, P0616, or P0617

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0615: Starter Relay Control Circuit
DTC P0616: Starter Relay Control Circuit Low Voltage
DTC P0617: Starter Relay Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0616	P0615	P0617	—
Ground	—	P0615	—	—

Circuit/System Description

When the ignition switch is placed in the CRANK position, a discrete signal is supplied to the body control module (BCM) notifying it that the ignition is in the CRANK position. The BCM then sends a message to the engine control module (ECM) that crank has been requested. The ECM then verifies that the clutch pedal is depressed or the transmission is in Park/ Neutral. If it is, the ECM then supplies 12 V to the control circuit of the starter relay. When this occurs, battery voltage is supplied through the switch of the starter relay to the starter motor.

Conditions for Running the DTC

- The ignition is in the CRANK position.
- The system voltage is between 9.5–18 V.

Conditions for Setting the DTC

The ECM detects improper voltage on the control circuit of the starter relay.

Action Taken When the DTC Sets

DTC P0615, P0616, and P0617 are C type DTCs.

Conditions for Clearing the DTC

DTC P0615, P0616, and P0617 are C type DTCs.

Reference Information

Schematic Reference

Starting and Charging Schematics on page 9-683

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Starting System Description and Operation on page 9-732

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the KR27 Starter Relay. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 10 Ω between the ground circuit terminal 86 and ground.

⇒ **If 10 Ω or greater**

2.1. Ignition OFF.
2.2. Test for less than 2 Ω in the ground circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, repair the open/high resistance in the ground connection.

⇓ **If less than 10 Ω**

3. Ignition ON.

4. Verify a test lamp illuminates between the B+ circuit terminal 30 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

4.1. Ignition OFF.

4.2. Test for less than 2 Ω in the B+ circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, verify the fuse is good and there is voltage at the fuse.

⇒ **If the test lamp does not illuminate and the circuit fuse is open**

4.1. Ignition OFF.

4.2. Test for infinite resistance between the B+ circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

4.3. Test for infinite resistance between the control circuit terminal 87 and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇒ If infinite resistance, replace the KR27 Starter Relay.

⇓ **If the test lamp illuminates**

5. Connect a test lamp between the control circuit terminal 85 and the ground circuit terminal 86.
6. Verify the test lamp turns ON and OFF when activating the vehicle ignition switch.

⇒ **If the test lamp is always OFF**

6.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

6.2. Test for infinite resistance between the control circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

6.3. Test for less than 2 Ω in the control circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇒ **If the test lamp is always ON**

6.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

6.2. Test for less than 1 V between the control circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If the test lamp turns ON and OFF**

7. Ignition ON, connect a 30 A fused jumper wire between the B+ circuit terminal 30 and the control circuit terminal 87.
8. Verify the M64 starter motor is activated.

⇒ **If the M64 starter motor does not activate**

8.1. Ignition OFF, disconnect the X1 harness connector at the M64 starter motor.

8.2. Test for infinite resistance between the control circuit terminal X2 A (LFX) or X2 1 (LTG/LCV) and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

8.3. Test for less than 2 Ω in the control circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the M64 starter motor.

⇓ **If the M64 starter motor activates**

9. Test or replace the KR27 Starter Relay.

Component Testing

Relay Test

1. Ignition OFF, disconnect the KR27 Starter Relay.
2. Test for 60–180 Ω between terminals 85 and 86.

⇒ **If less than 60 or greater than 180 Ω**

Replace the relay.

⇓ **If between 60–180 Ω**

3. Test for infinite resistance between the terminals listed below:
   - 30 and 86
   - 30 and 87
   - 30 and 85
   - 85 and 87

⇒ **If less than infinite resistance**

Replace the relay.

⇓ **If infinite resistance**

4. Install a 20 A fused jumper wire between relay terminal 85 and 12 V. Install a jumper wire between relay terminal 86 and ground.
5. Test for less than 2 Ω between terminals 30 and 87.

⇒ **If 2 Ω or greater**

Replace the relay.

⇓ **If less than 2 Ω**

6. All OK

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Relay Replacement (Within an Electrical Center) on page 11-607* or *Relay Replacement (Attached to Wire Harness) on page 11-607*
- *Starter Replacement (LUW) on page 9-722* or *Starter Replacement (LUV) on page 9-724*
- *Control Module References on page 6-3* for ECM replacement, programming, and setup.

DTC P0621

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P0621: Generator L-Terminal Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
B+	P0622	P0621	—	—
Control – L Terminal	P0621	P0621	P0621	—
Signal – F Terminal	P0622	P0622	P0622	P0622

Circuit/System Description

The engine control module (ECM) uses the generator turn on control circuit to control the load of the generator on the engine. A high side driver in the ECM applies a duty cycled voltage to the voltage regulator. The duty cycle controls the voltage regulator to turn the field circuit on and off. The ECM monitors the state of the generator turn on control circuit. The ECM should detect low voltage on the generator turn on control circuit when the ignition is ON and the engine is off, or when the charging system malfunctions. With the engine running, the ECM should detect high voltage when the duty cycle voltage is commanded high and a low voltage when the duty cycle voltage is commanded low. on the generator turn on control circuit.

Conditions for Running the DTC

- Ignition ON, engine OFF (Prior to Ignition ON, the ignition must have been OFF for at least 5 seconds)
- The engine is running for the run test

Conditions for Setting the DTC

- Ignition ON, engine OFF – The ECM detects greater than 3.5 V on the generator control circuit for 5 seconds.
- Engine running – The ECM detects a low voltage for 15 seconds on the generator control circuit when the duty cycle voltage is commanded high.
- Engine running – The ECM detects a high voltage for 15 seconds on the generator control circuit when the duty cycle voltage is commanded low.

Action Taken When the DTC Sets

DTC P0621 is a type C DTC.

Conditions for Clearing the DTC

- Ignition ON, engine OFF– Low voltage.
- Engine running – A control signal duty cycle is detected.

Reference Information

Schematic Reference

Starting and Charging Schematics on page 9-683

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Charging System Description and Operation on page 9-729

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
2. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

3. All OK.

Circuit/System Testing

1. Verify a test lamp illuminates between the G13 Generator B+ circuit terminal A X2 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

1.1. Remove the test lamp and disconnect the B+ cable at the G13 Generator.

1.2. Test for less than 2 Ω in the B+ circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

⇒ **If the test lamp does not illuminate and the circuit fuse is open**

1.1. Remove the test lamp, disconnect the battery negative cable, and disconnect the G13 Generator B+ cable.

1.2. Test for infinite resistance between the B+ circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ **If the test lamp illuminates**

2. Disconnect the X1 harness connector at the G13 Generator, ignition ON.
3. Test for 3.0– 5.5 V between the control circuit terminal 1 and ground.

⇒ **If less than 3.0 V**

3.1. Ignition OFF, disconnect the harness connectors at the K20 Engine Control Module.

3.2. Test for infinite resistance between the control circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

3.3. Test for less than 2 Ω in the control circuit end to end.

⇒ If greater the 2 Ω, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇒ **If greater than 5.5 V**

3.1. Ignition OFF, disconnect the harness connectors at the K20 Engine Control Module, Ignition ON.

3.2. Test for less than 1 V between the control circuit and ground.

⇒ If greater than 1 V, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If between 3.0–5.5 V**

4. Test or replace the G13 Generator.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Generator Replacement (LUV) on page 9-726* or *Generator Replacement (LUW) on page 9-727*
- *Control Module References on page 6-3* for engine control module replacement, programming, and setup

DTC P0622

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P0622: Generator F-Terminal Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
B+	P0622	P0621	—	—
Control – L Terminal	P0621	P0621	P0621	—
Signal – F Terminal	P0622	P0622	P0622	P0622

Circuit/System Description

The engine control module (ECM) uses the generator field duty cycle signal circuit, or F-terminal circuit, to monitor the duty cycle of the generator. The generator field duty cycle signal circuit connects to high side of the field windings in the generator. A pulse width modulated (PWM) high side driver in the voltage regulator turns the field windings on and off. The ECM uses the PWM signal input to determine the generator load on the engine. This allows the ECM to adjust the idle speed to compensate for high electrical loads. The ECM monitors the status of the generator field duty cycle signal circuit. When the ignition is ON and the engine is off, the ECM should detect a duty cycle near 0%. When the engine is running, the duty cycle should be between 5–99%.

Conditions for Running the DTC

- Ignition ON, engine OFF (Prior to Ignition ON, the ignition must have been OFF for at least 5 seconds)
- Engine running at less than 3,000 RPM

Conditions for Setting the DTC

- DTC P0621 is not set
- Ignition ON, engine OFF (Prior to Ignition ON, the ignition must have been OFF for at least 5 seconds), the ECM detects a PWM signal that is greater than 65% for 5 seconds
- Engine running at less than 3,000 RPM—The ECM detects a PWM signal that is less than 5% for 30 seconds

Action Taken When the DTC Sets

DTC P0622 is a type C DTC

Conditions for Clearing the DTC

- Ignition ON, Engine OFF– Low / no PWM signal detected
- Engine running – A 5–90% duty cycle is detected

Reference Information

Schematic Reference

Starting and Charging Schematics on page 9-683

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Charging System Description and Operation on page 9-729

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

Note: Do not have a battery charger connected during the generator testing.

1. Engine running.
2. Verify the scan tool Engine Control Module Generator F-Terminal Signal parameter is between 5–90%.

⇒ **If not between 5–90%**

Refer to Circuit/System Testing.

⇓ **If between 5–90%**

3. Verify the scan tool Generator F-Terminal Signal parameter changes when commanding the headlamps ON and OFF.

⇒ **If the parameter does not change**

Refer to Circuit/System Testing.

⇓ **If the parameter changes**

4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
5. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

6. All OK.

Circuit/System Testing

1. Verify a test lamp illuminates between the G13 Generator B+ circuit terminal A X2 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

1.1. Remove the test lamp and disconnect the B+ cable at the G13 Generator.

1.2. Test for less than 2 Ω in the B+ circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

⇒ **If the test lamp does not illuminate and the circuit fuse is open**

1.1. Remove the test lamp, disconnect the battery negative cable, and disconnect the G13 Generator B+ cable.

1.2. Test for infinite resistance between the B+ circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇒ If infinite resistance, test or replace the G13 Generator.

⇓ **If the test lamp illuminates**

2. Disconnect the X1 harness connector at the G13 Generator, engine running.
3. Verify the scan tool Engine Control Module Generator F-Terminal Signal parameter is less than 5%.

⇒ **If 5% or greater**

3.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

3.2. Test for less than 1 V between the signal circuit terminal 2 and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If less than 5%**

4. Install a 3 A fused jumper wire between the signal circuit terminal 2 and B+, engine running.
5. Verify the scan tool Engine Control Module Generator F-Terminal Signal parameter is greater than 95%.

⇒ **If 95% or less**

5.1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.

5.2. Test for infinite resistance between the signal circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

5.3. Test for less than 2 Ω in the signal circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit

⇓ If less than 2 Ω, replace the K20 Engine Control Module.

⇓ **If greater than 95%**

6. Test or replace the G13 Generator.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Generator Replacement (LUV) on page 9-726* or *Generator Replacement (LUW) on page 9-727*
- *Control Module References on page 6-3* for engine control module replacement, programming, and setup

DTC P0625 or P0626

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0625: Generator F-Terminal Circuit Low Voltage
DTC P0626: Generator F-Terminal Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
B+	P0625	P0625	—	—
Signal	P0625	P0625	P0626	—
Control	P0621	P0621	P0621	—

Circuit/System Description

The engine control module (ECM) uses the generator field duty cycle signal circuit, or F-terminal circuit, to monitor the duty cycle of the generator. The generator field duty cycle signal circuit connects to high side of the field windings in the generator. A pulse width modulated (PWM) high side driver in the voltage regulator turns the field windings ON and OFF. The ECM uses the PWM signal input to determine the generator load on the engine. This allows the ECM to adjust the idle speed to compensate for high electrical loads. The ECM monitors the status of the generator field duty cycle signal circuit. When the ignition is ON and the engine is OFF, the ECM should detect a duty cycle near 0%. When the engine is running, the duty cycle should be between 5–99%.

Conditions for Running the DTC

P0625

- The engine is running.
- The engine speed is less than 3000 RPM.

P0626

- The engine is not running.
- The ignition is in the ON position.

Conditions for Setting the DTC

P0625

The ECM detects a pulse width modulated (PWM) signal less than 5% for 15 seconds.

P0626

The ECM detects a pulse width modulated (PWM) signal greater than 65% for 15 seconds.

Action Taken When the DTC Sets

DTC P0625 and P0626 are C type DTCs.

Conditions for Clearing the DTC

DTC P0625 and P0626 are C type DTCs.

Reference Information

Schematic Reference

Starting and Charging Schematics on page 9-683

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Charging System Description and Operation on page 9-729

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Engine running.
2. Verify the scan tool Generator F-Terminal Signal Circuit parameter changes between 5 and 99%.

⇒ **If the parameter does not change**

Refer to Circuit/System Testing.

⇓ **If the parameter changes**

3. All OK.

Circuit/System Testing

1. Verify a test lamp illuminates between the G13 Generator B+ circuit terminal A X2 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

1.1. Disconnect the B+ cable at the G13 Generator.

1.2. Test for less than 2 Ω in the B+ circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

⇒ **If the test lamp does not illuminate and the circuit fuse is open**

1.1. Test for infinite resistance between the B+ circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

1.2. Test for infinite resistance between the signal circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇒ If infinite resistance, replace the G13 Generator.

⇓ **If the test lamp illuminates**

2. Ignition OFF, disconnect the X1 harness connector at the G13 Generator.
3. Verify the scan tool ECM Generator F-Terminal Signal parameter is less than 5%.

⇒ **If 5% or greater**

3.1. Ignition ON.

3.2. Test for less than 1 V between the signal circuit terminal 2 and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If less than 5%**

4. Install a 3 A fused jumper wire between the signal circuit terminal 2 and B+.
5. Verify the scan tool ECM Generator F-Terminal Terminal Signal parameter is greater than 95%.

⇒ **If 95% or less**

5.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

5.2. Test for less than 2 Ω in the signal circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇓ If less than 2 Ω

5.3. Test for infinite resistance between the signal circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇒ If infinite resistance, replace the K20 Engine Control Module.

⇓ **If greater than 95%.**

6. Replace the G13 Generator.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Generator Replacement (LUV) on page 9-726* or *Generator Replacement (LUW) on page 9-727*
- *Control Module References on page 6-3* for ECM replacement, programming, and setup

DTC P2500 or P2501

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P2500: Generator L-Terminal Circuit Low Voltage
DTC P2501: Generator L-Terminal Circuit High Voltage

For symptom byte information, refer to *Symptom Byte List on page 6-85*.

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
B+	P0625	P0625	—	—
Control	P2500	P2500	P2501	—
Signal	P0625	P0625	P0626	—

Circuit/System Description

The engine control module (ECM) uses the generator turn on control circuit, or L-terminal circuit, to control the load of the generator on the engine. A high side driver in the ECM applies a voltage to the voltage regulator. This controls the voltage regulator to turn the field circuit ON and OFF. The ECM monitors the state of the generator turn ON control circuit. The ECM should detect low voltage on generator turn on control circuit when the ignition is ON and the engine is OFF, or when the charging system malfunctions. With the engine running, the ECM should detect high voltage on the generator turn on control circuit. The ECM performs tests to determine the status of the generator turn on control circuit.

Conditions for Running the DTC

P2500

The engine is running.

P2501

- The ignition is ON.
- The engine is OFF.

Conditions for Setting the DTC

P2500

The ECM detects low voltage on the generator turn on control circuit for 2 s.

P2501

The ECM detects high voltage on the generator turn on control circuit for 2 s.

Action Taken When the DTC Sets

The charge indicator turns ON 15 s after the DTC sets.

Conditions for Clearing the DTC

- The DTC will pass when the conditions for setting the DTC are no longer met for 2 s.
- A history DTC will clear after 40 consecutive warm-up cycles have occurred without a malfunction.
- The charge indicator turns OFF 15 s after the DTC passes.

Reference Information

Schematic Reference

Starting and Charging Schematics on page 9-683

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Charging System Description and Operation on page 9-729

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Testing

1. Verify that a test lamp illuminates between the G13 Generator B+ terminal A X2 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

1.1. Ignition OFF.

1.2. Test for less than 2 Ω in the B+ circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

⇒ **If the test lamp does not illuminate and the circuit fuse is open**

1.1. Ignition OFF.

1.2. Test for greater than 100 Ω between the B+ circuit and ground.

⇒ If 100 Ω or less, repair the short to ground on the circuit.

⇒ If greater than 100 Ω, replace the G13 Generator.

⇓ **If the test lamp illuminates**

2. Ignition OFF, disconnect the X1 harness connector at the G13 Generator, ignition ON.
3. Test for 4.5–5.5 V between the control circuit terminal 1 X1 and ground.

⇒ **If less than 4.5 V**

3.1. Ignition OFF, disconnect the harness connectors at the K20 Engine Control Module.

3.2. Test for infinite resistance between the control circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

3.3. Test for less than 2 Ω in the control circuit end to end.

⇒ If greater the 2 Ω, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇒ **If greater than 5.5 V**

3.1. Ignition OFF, disconnect the harness connectors at the K20 Engine Control Module, ignition ON.

3.2. Test for less than 1 V between the control circuit and ground.

⇒ If greater than 1 V, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If between 4.5–5.5 V**

4. Test or replace the G13 Generator.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Generator Replacement (LUV) on page 9-726* or *Generator Replacement (LUW) on page 9-727*
- *Control Module References on page 6-3* for ECM replacement, programming and setup.

Symptoms - Engine Electrical

Note: The following steps must be completed before using the symptom tables.

- Perform *Diagnostic System Check - Vehicle on page 6-66* before using the Symptom Tables in order to verify that all of the following are true:
  - There are no DTCs set.
  - The control modules can communicate via the serial data link.
- Review the system descriptions and operations in order to familiarize yourself with the system functions. Refer to one of the following system operations:
  - *Battery Description and Operation on page 9-728*
  - *Charging System Description and Operation on page 9-729*
  - *Electrical Power Management Description and Operation on page 9-731*
  - *Starting System Description and Operation on page 9-732*

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the starting and charging systems. Refer to *Checking Aftermarket Accessories on page 11-525*.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.

Intermittent

Faulty electrical connections or wiring may be the cause of intermittent conditions. Refer to *Testing for Intermittent Conditions and Poor Connections on page 11-531*.

Symptom List

Refer to a symptom diagnostic procedure from the following list in order to diagnose the symptom:

- *Battery Inspection/Test on page 9-702*
- *Battery Electrical Drain/Parasitic Load Test on page 9-704*
- *Charging System Test on page 9-707*
- *Generator Noise Diagnosis on page 9-708*
- *Starter Solenoid Does Not Click on page 9-709*
- *Starter Solenoid Clicks, Engine Does Not Crank on page 9-711*
- *Engine Cranks Slowly on page 9-711*
- *Starter Noise Diagnosis on page 9-712*

Battery Inspection/Test

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Diagnostic Aids

Note: For Warranty repairs —

You must use regionally required battery test equipment for warranty repairs.

For accurate test results the battery must be disconnected from the vehicle and the equipment connected directly to the battery posts. When setting up the equipment, select "Out of Vehicle" and then the correct battery type (Flooded or AGM) and rated CCA (both from the battery label) must be entered.

- Failure to obtain the correct connections during the test may result in a failed test on a good battery.
- Use the Out of Vehicle test (both batteries disconnected with test equipment connected directly to the post) test for each battery when testing a vehicle with dual batteries.

Follow these instructions in order to avoid an incorrect diagnosis because of connections:

- If testing the vehicle with the battery cables still connected, wiggle the battery tester clips on the terminal. This may cut through any coating or through any oxidation that may be present on the terminal.
- If correct connections to the battery terminals in the vehicle are in doubt, perform the following steps:
  1. Disconnect the negative battery cable.
  2. Disconnect the positive battery cable.
  3. Follow the instructions for testing a removed battery.
- If the tester displays a REPLACE BATTERY or BAD CELL-REPLACE result for a battery tested in the vehicle with the battery cables connected, perform the following steps:
  1. Disconnect the negative battery cable.
  2. Disconnect the positive battery cable.

Note: Always write the test code displayed by the tester on the repair order for any warranty purposes. The number is a unique code that describes the test data for a particular battery at a particular time. The test code may occasionally repeat when you retest the same battery. More often, each test will result in a different code. Use the test code from the second, or Out of Vehicle test.

  3. Follow the instructions for testing a removed battery.
  4. Replace the battery only if the second test shows a REPLACE BATTERY or BAD CELL-REPLACE result.

     Use the test code from the second test for any warranty purposes.

Reference Information

Schematic Reference

Starting and Charging Schematics on page 9-683

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Starting System Description and Operation on page 9-732

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tools

Battery Tester, for regionally available devices, refer to *Special Tools on page 9-733*.

Circuit/System Testing

Warning: Unless directed otherwise, the ignition and start switch must be in the OFF or LOCK position, and all electrical loads must be OFF before servicing any electrical component. Disconnect the negative battery cable to prevent an electrical spark should a tool or equipment come in contact with an exposed electrical terminal. Failure to follow these precautions may result in personal injury and/or damage to the vehicle or its components.

For Vehicles equipped with OnStar® (UE1) with Back Up Battery:

The Back Up Battery is a redundant power supply to allow limited OnStar® functionality in the event of a main vehicle battery power disruption to the VCIM (OnStar® module). Do not disconnect the main vehicle battery or remove the OnStar® fuse with the ignition key in any position other than OFF. Retained accessory power (RAP) should be allowed to time out or be disabled (simply opening the driver door should disable RAP) before disconnecting power. Disconnecting power to the OnStar® module in any way while the ignition is On or with RAP activated may cause activation of the OnStar® Back-Up Battery (BUB) system and will discharge and permanently damage the back-up battery. Once the Back-Up Battery is activated it will stay on until it has completely discharged. The BUB is not rechargeable and once activated the BUB must be replaced.

1. Verify the C1 Battery case is not cracked, broken, or damaged, which may be indicated by battery acid leakage.

⇒ **If there is any apparent damage**

Replace the C1 Battery.

⇓ **If there is no damage**

2. Verify the cold cranking amperage and amperage hour rating of the C1 Battery. Refer to the manufacturer specifications on the battery label.

⇒ **If the C1 Battery does not meet specifications**

Replace the C1 Battery.

⇓ **If the C1 Battery meets specifications**

3. Verify that the battery cables are clean and tight. The battery terminal bolts should be torqued as specified in *Fastener Tightening Specifications on page 9-682*.

⇒ **If the battery cables need to be cleaned or tightened**

Clean as required and tighten as specified.

⇓ **If the battery cables are clean and tight**

4. Install the battery tester and follow directions supplied by the tester.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

Battery Replacement on page 9-719

Battery Charging

Special Tools

EL 50313 Battery Tester

For equivalent regional tools, refer to *Special Tools on page 9-733*.

Diagnostic Aids

- For best results, use an automatic taper-rate battery charger with a voltage capability of 16 V.
- The charging area should be well ventilated.
- Do not charge a battery that appears to be frozen. Allow the battery to warm to room temperature and test it using the EL 50313 before charging.

Battery State of Charge

Note: Using voltage to determine the batteries state of charge is only accurate after the battery has been at rest for 24 hours. This is enough time for the acid in each cell to equalize. If the battery has been charged or discharged in the past 24 hours, the battery state of charge will only be an estimate.

The maintenance-free batteries state of charge is estimated by reading the voltage of the battery across the battery terminals. Because the voltage is affected by current flow into or out of the battery, the engine must be stopped and all electrical loads turned OFF, including parasitic loads, when checking the voltage. The voltage can also be affected if the battery has just been charged or discharged, so it is important to consider what has happened to the battery in the time just before testing. Use the following procedure to determine the battery's state of charge:

1. Be sure all electrical loads are turned OFF.
2. Determine whether the battery has been used in a vehicle or charged within the past 12 hours.
   - If the answer is no, the terminal voltage will be stabilized and no action is necessary before reading the voltage. Skip to step 3.
   - If the answer is yes, terminal voltage will not be stabilized and you should wait 12 hours since the last time the battery was used.
3. Estimate the battery temperature by determining the average temperature to which the battery has been exposed for the past 12 hours.

Note: The table is accurate to 10 percent only after the battery has been at rest for 12 hours.

4. Measure the battery voltage at the battery terminals. Refer to the following table to determine the state of charge according to the estimated battery temperature:

Battery Voltage	% Charge at 0°C (32°F)	% Charge at 25° C (75°F)
12.75 V	100%	100%
12.7 V	100%	90%
12.6 V	90%	75%
12.45 V	75%	65%
12.2 V	65%	45%
12.0 V	40%	20%

Use the state of charge information as follows:

- A battery with a state of charge that is below 65 percent must always be recharged before returning it to service or continuing storage.
- A battery with a state of charge that is 65 percent or greater is generally considered to be charged enough in order to be returned to normal service or in order to continue storage. However, if the battery is being used in slow traffic or with short drive times, or if the temperature is very hot or very cold, the battery should be fully charged, to at least 90 percent, before returning it to service or continuing storage.

Charging Time Required

The time required to charge a battery will vary depending upon the following factors:

- The battery charger capacity—The higher the charger amperage, the less time it will take to charge the battery.
- The state of charge of the battery—A completely discharged battery requires more than twice as much charging time as a half charged battery. In a discharged battery with a voltage below 11 V, the battery has a very high internal resistance and may only accept a very low current at first. Later, as the charging current causes the acid content to increase in the electrolyte, the charging current will increase. Extremely discharged batteries may

not activate the reversed voltage protection in some chargers. Refer to the manufacturer's instructions for operating this circuitry.

- The temperature of the battery—The colder the battery is, the more time it takes to recharge the battery. The charging current accepted by a cold battery is very low at first. As the battery warms, the charging current will increase.

Charging Procedure

Caution: Turn OFF the ignition when connecting or disconnecting the battery cables, the battery charger or the jumper cables. Failure to do so may damage the ECM/PCM or other electronic components.

Caution: Refer to *Fastener Caution on page 0-8*.

When charging side-terminal batteries with the battery cables connected, connect the charger to the positive cable bolt and to a ground located away from the battery. When charging side-terminal batteries with the battery cables disconnected, install the battery side terminal adapters and connect the charger to the adapters.

Tighten

Tighten the battery side terminal adapters to 15 N•m (11 lb ft).

Use the following procedure to charge the battery:

1. Turn OFF the charger.
2. Ensure that all of the battery terminal connections are clean and tight.
3. Connect the charger positive lead to the battery positive terminal on the battery or the remote jumper stud underhood.

Caution: Do not connect the negative charger lead to the housings of other vehicle electrical accessories or equipment. The action of the battery charger may damage such equipment.

4. Connect the negative charger lead to a solid engine ground or to a ground stud in the engine compartment that is connected directly to the battery negative terminal, but away from the battery. If the negative battery cable is disconnected and a terminal adapter is being used, connect directly to the adapter.
5. Turn ON the charger and set to the highest setting for normal charging.
6. Inspect the battery every half hour after starting the battery charger.
   - Charge the battery until the taper-rate charger indicates that the battery is fully charged.
   - Estimate the battery temperature by feeling the side of the battery. If it feels hot to the touch or its temperature is over 45°C (125°F), discontinue charging and allow the battery to cool before resuming charging.
7. After charging, test the battery. Refer to *Battery Inspection/Test on page 9-702*.

Battery Electrical Drain/Parasitic Load Test

12 V Battery

The following procedure is for the 12 V battery only.

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Circuit/System Description

Components most likely to cause a parasitic draw on the vehicles battery are switches, relays, and control modules. After the ignition is turned OFF the control modules will begin to go to sleep (shut OFF). All control modules do not go to sleep at the same time, some may take up to 30 min or longer after turning the ignition off before going to sleep, like the HVAC and body control modules. Others such as the ON Star and keyless entry control modules may periodically wake up then go back to sleep. These are all normal conditions.

Diagnostic Aids

- Rule out any possible aftermarket equipment causing an unacceptable parasitic current drain. Aftermarket accessories installed into the courtesy lamp circuit can cause the inadvertent power timer in the body control module (BCM) to keep resetting. This may cause the BCM to remain awake and cause a current drain on the battery.
- Rule out customer driving habits such as regular short trips that do not allow enough time to properly charge the battery. Refer to *Battery Description and Operation on page 9-728*.
- Verify that the battery and charging system are in proper working order. Refer to *Battery Charging on page 9-703* and *Charging System Test on page 9-707*.
- A battery discharging for no apparent reason while the vehicle is parked can be caused by an intermittent draw, such as a module waking up, or a continuous draw, such as a dome light or stuck relay.
- Some systems and modules such as OnStar®, and regulated voltage control, if equipped, are designed to wake up, perform a task, and go back asleep at regular intervals. Refer to *Body Control System Description and Operation on page 11-68* for the system or modules description and operation.
- An engine off natural vacuum evaporative test can occur if the engine control module (ECM) determines the drive cycle has met the appropriate criteria immediately after key off. The ECM will stay awake and the vent solenoid will stay energized for as long as 45 min. The typical current draw for this is about 1 A.

- Digital OnStar generator 6 and later vehicle communication interface module do not "wake up" every 10 min for the first 48 h as the generator 5 and prior. Generator 6 and later vehicle communication interface module current draw is very low, less than 40 mA, so the OnStar system is left in that state for up to the first 48 h. Parasitic draw of up to 40 mA with an occasional spike as high as 80 mA through the vehicle communication interface module for the first 48 h is normal.
- Some automatic climate control systems can remain in a semi awake state for up to three hours, actual draw amounts vary by vehicle platform but are typically not greater than 50 mA.
- An extremely low mA current level is consumed by the remote keyless entry receiver for monitoring purposes, actual system wake up only occurs when the fobs for the vehicle are used. When other devices on the same remote keyless entry operating frequency are activated, such as the 4 tire pressure monitoring sensors and other vehicle FOBs in the vicinity, the remote keyless entry receiver will have a 100 mA spike. These spikes are normal and occur too briefly to have a significant effect on battery drain. Competing signals may cause remote keyless entry performance issues such as jamming but should not cause excessive battery draw.
- If an excessive current draw is not present during initial testing, continue periodic testing over a 1–2 hour period to see if the current draw increases and stays above an unacceptable level.

Note: The battery specification listed below is a generic specification. Refer to the label on the original battery when testing the battery.

- The battery run down time will vary depending on the batteries reserve capacity. If the reserve capacity is higher, then the battery run down time may be longer. If the reserve capacity is lower, then the battery run down time may be shorter. The graph below indicates roughly how many days a 690 cold cranking amperage battery with a 110 min. reserve capacity starting at 80 percent state of charge will last with a constant current draw until it reaches 50 percent state of charge. Differences in battery reserve capacity and temperature will affect the results.

Current Drain	Days
25 mA	33
50 mA	16.5
75 mA	11
100 mA	8.25
250 mA	3.3
500 mA	1.65
750 mA	1
1 A	0.8
2 A	0.4

Reference Information

Schematic Reference

Control Module References on page 6-3

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Connector Repairs on page 11-548*
- *Wiring Repairs on page 11-537*

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tools

EL 38758 Parasitic Draw Test Switch

For equivalent regional tools, refer to *Special Tools on page 9-733*.

Circuit/System Verification

Note:

- Most vehicle systems will go to sleep within 30 min but it can take up to 2 h before all systems power down allowing the parasitic draw test to pass. An occasional increase in the parasitic draw is normal as long as it returns within 1 s.
- Closing the door latches/ajar switch while leaving the doors open is recommended, this allows the vehicle systems to perform in a "doors closed" mode while allowing vehicle interior access that may be needed to complete the diagnostic steps.
- Locking doors will arm the vehicle content theft deterrent system if equipped. Failure to arm the system may cause a theft system fault to not be present during testing.
- There are many things that can prevent the vehicle from completely going to sleep and passing the parasitic draw test. Make sure all the conditions listed below are met before performing the parasitic current draw test.
  - Ignition OFF
  - Key out of the ignition switch – when not equipped with keyless access and start
  - Retained Accessory Power OFF – open and close the driver door after ignition OFF
  - Scan tool not communicating with a vehicle control module – in some cases it may need to be disconnected from the DLC
  - All access doors closed
  - Headlamps OFF – auto headlamps disabled
  - Any delay lighting OFF
  - If equipped with an under hood lamp disable it
  - HVAC after blow OFF

- Any accessory that can work with ignition OFF inactive or OFF
- Wait up to 2 min or longer, after all other listed conditions are met

Using an Inductive Pickup Probe

1. Connect an inductive pickup probe to the negative battery cable that can read down to 1 mA.
2. Ignition OFF, as the vehicle systems shut down test for less than 30 mA of parasitic current drain.
   ⇒ If greater than the specified range, refer to Circuit/System Testing.

Using the EL 38758 Parasitic Draw Test Switch

Warning: Refer to Battery Disconnect Warning on page 0-4.

Caution: When a fused jumper wire or digital multimeter is connected to the test switch terminals, always turn the test switch ON before opening any access door, turning the ignition on, or turning any accessory on. This is to prevent damaging the jumper wire or digital multimeter fuse.

Note: The switch knob on the *EL 38758* switch is marked ON and OFF. When the switch knob is in the ON position, the circuit is closed and electrical current will pass through the switch. When the switch knob is in the OFF position, the circuit is open and electrical current will not pass through the switch.

1. Ignition OFF, disconnect the battery negative cable from the battery. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.
2. Turn the *EL 38758* switch knob to the OFF position.
3. Install the male end of the *EL 38758* switch to the battery ground terminal.
4. Install the battery negative cable to the female end of the *EL 38758* switch.
5. Turn the *EL 38758* switch knob to the ON position.
6. Road test the vehicle and activate all of the accessories such as the radio and air conditioning.
7. Ignition OFF, connect a 10 A fused jumper wire to the test switch tool terminals.
8. Turn the *EL 38758* switch knob to the OFF position. The current now flows through the jumper wire.
9. Check the fuse in the jumper wire. The fuse should be OK.
   ⇒ Failed: If the jumper wire fuse is blown, refer to Circuit/System Testing.
   ⇓ Passed
10. Turn the *EL 38758* switch knob to the ON position. Remove the fused jumper wire.
11. Connect a DMM set to the 10 A DC scale between the test switch tool terminals.
12. Turn the *EL 38758* switch knob to the OFF position. The current now flows through the DMM.
13. As the vehicle systems shut down test for less than 30 mA of parasitic current drain.
    ⇒ If greater than the specified range, refer to Circuit/System Testing.

Circuit/System Testing

Note:

- Removing or installing a fuse, relay, or connector, to determine the area causing high parasitic draw may wake up control modules. You must wait for the control modules to go back to sleep before retesting. It is best to install any removed or disconnected components after the diagnosis is completed.
- Fuses for power mode master components such as the BCM should be removed last to avoid misdiagnosis.
- If a scan tool is connected to the DLC, either disconnect it or subtract the scan tool current draw from the DMM reading to get the actual vehicle parasitic current draw.

If the vehicle has an unacceptable amount of parasitic current draw, remove each fuse one at a time until the current draw falls to an acceptable level. A drop of more than 10–20 mA, when disabling a single system or circuit, is an indication of an overly high current draw that could be causing the battery drain. Refer to *Power Distribution Schematics on page 11-128* to diagnose exactly which circuit of the suspect system is causing the high parasitic drain. The following is a list of common components that could cause a high current draw:

- Stuck switch
- Stuck relay
- Control module

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

Control Module References on page 6-3 for control module replacement, programming and setup

Charging System Test

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
B+	P0622	P0621	—	—
Control – L Terminal	P0621	P0621	P0621	—
Signal – F Terminal	P0622	P0622	P0622	P0622

Circuit/System Description

The engine control module (ECM) uses the generator turn ON control circuit to control the load of the generator on the engine. A high side driver in the ECM applies a duty cycled voltage to the voltage regulator. The duty cycle controls the voltage regulator to turn the field circuit ON and OFF. The ECM monitors the state of the generator turn ON control circuit. The ECM should detect low voltage on the generator turn on control circuit when the ignition is ON and the engine is OFF, or when the charging system malfunctions. With the engine running, the ECM should detect high voltage when the duty cycle voltage is commanded high and a low voltage when the duty cycle voltage is commanded low on the generator turn on control circuit.

The engine control module (ECM) uses the generator field duty cycle signal circuit, or F-terminal circuit, to monitor the duty cycle of the generator. The generator field duty cycle signal circuit connects to high side of the field windings in the generator. A pulse width modulated (PWM) high side driver in the voltage regulator turns the field windings on and off. The ECM uses the PWM signal input to determine the generator load on the engine. This allows the ECM to adjust the idle speed to compensate for high electrical loads. The ECM monitors the status of the generator field duty cycle signal circuit. When the ignition is ON and the engine is off, the ECM should detect a duty cycle near 0%. When the engine is running, the duty cycle should be between 5–99%.

Reference Information

Schematic Reference

Starting and Charging Schematics on page 9-683

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Charging System Description and Operation on page 9-729

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

Circuit/System Verification

Note: Do not have a battery charger connected during the generator testing.

1. Ignition ON.
2. Verify that no G13 Generator or B18 Battery Current Sensor DTCs are set that would cause a charging system concern.

⇒ **If DTCs are set**

Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69.*

⇓ **If no DTCs are set**

3. Verify the scan tool Body Control Module Battery Voltage parameter is 12 V or greater.

⇒ **If less than 12 V**

Refer to *Battery Inspection/Test on page 9-702.*

⇓ **If 12 V or greater**

4. Engine running, all accessories OFF.
5. Verify the scan tool Body Control Module Battery Voltage parameter continually increases when controlling the Body Control Module Generator Regulator Setpoint from 10% to 80% with a scan tool. It may take up to 10 seconds for the battery voltage to stabilize between each setpoint change.

⇒ **If the battery voltage does not continually increase**

Refer to Circuit/System Testing.

⇓ **If the battery voltage continually increases**

6. All OK.

Circuit/System Testing

Note: You must perform the Circuit/System Verification before proceeding with Circuit/System Testing.

1. Ignition OFF.
2. Test for less than 2 Ω between the G13 Generator housing and battery negative terminal.

⇒ **If 2 Ω or greater**

Repair the open/high resistance in the circuit.

⇓ **If less than 2 Ω**

3. Verify a test lamp illuminates between the G13 Generator B+ circuit terminal A X2 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

3.1. Remove the test lamp and disconnect the B+ cable at the G13 Generator.

3.2. Test for less than 2 Ω in the B+ circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

⇒ **If the test lamp does not illuminate and the circuit fuse is open**

3.1. Remove the test lamp, disconnect the battery negative cable, and disconnect the G13 Generator B+ cable.

3.2. Test for infinite resistance between the B+ circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇒ If infinite resistance, test or replace the G13 Generator.

⇓ **If the test lamp illuminates**

4. Test or replace the G13 Generator.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

Generator Replacement (LUV) on page 9-726 or *Generator Replacement (LUW) on page 9-727*

Generator Noise Diagnosis

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Diagnostic Aids

Noise from a generator may be due to electrical or mechanical noise. Electrical noise or magnetic whine usually varies with the electrical load placed on the generator and is a normal operating characteristic of all generators. When diagnosing a noisy generator, it is important to remember that loose or misaligned components around the generator may transmit the noise into the passenger compartment and that replacing the generator may not solve the problem.

Circuit/System Testing

1. Start the engine. Verify the noise can be heard. Compare the concern to a similar vehicle.
2. Perform a charging system test. Verify that the generator is charging properly.
3. Inspect the generator, generator mounting, wiring harness, heater hoses, A/C lines, or other accessory equipment that may be misrouted or be the cause of noise being transmitted into the passenger compartment.
4. Ignition OFF, remove the engine drive belt. Verify the generator, A/C compressor, water pump pulley, power steering pump, idler pulley, and tensioner pulley spin freely.

⇒ If any of the pulleys do not spin freely, replace the affected component.

5. Start the engine, with the drive belt removed. Verify that the noise goes away. Operate the engine for no longer than 30-40 seconds.

⇒ If the noise is still present, the generator is not the cause of the noise.

6. Loosen all generator mounting bolts and ensure the generator is properly aligned. Tighten the mounting bolts to specification, refer to *Generator Replacement (LUV) on page 9-726* or *Generator Replacement (LUW) on page 9-727*.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

- *Drive Belt Replacement on page 9-974*
- *Drive Belt Tensioner Replacement on page 9-976*
- *Generator Replacement (LUV) on page 9-726* or *Generator Replacement (LUW) on page 9-727*

Starter Solenoid Does Not Click

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
B+	1	1	—	—
Control Terminal 85	—	1	2	—
Control Terminal 87	1	1	2	—
Ground	—	1	—	—
1. No Crank 2. Cranks All The Time				

Circuit/System Description

When the ignition switch is placed in the START position, a signal is supplied to the starter relay. Providing that the transmission is in Park/Neutral or the clutch is depressed. The engine will crank.

Reference Information

Schematic Reference

Starting and Charging Schematics on page 9-683

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Starting System Description and Operation on page 9-732

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Transmission range selector in park or neutral or clutch depressed on a manual transmission, attempt to start the vehicle. The starter solenoid should click and the engine should begin cranking.
   ⇒ If the starter solenoid does not click or the engine does not crank, refer to Circuit/System Testing.
2. Ignition ON, observe the scan tool ECM Crankshaft Position Sensor Active Counter is not incrementing.
   ⇒ If the Crankshaft Position Sensor Active Counter is incrementing, replace the Crankshaft Position Sensor.

Circuit/System Testing

Manual Transmission (without Clutch Pedal Position Switch)

1. Disconnect the harness connector at the ignition switch.
2. Verify that a test lamp illuminates between the ignition switch B+ circuit terminal 2 and ground.
   ⇒ If the test lamp does not illuminate, test the B+ circuit for a short to ground or an open/high resistance. If the circuit tests normal and the fuse is open, test the ignition switch output terminal 3 for a short to ground.
3. Ensure the parking brake is applied and the transmission is in Neutral.

4. Momentarily install a 30 A fused jumper wire between the ignition switch B+ circuit terminal 2 and the ignition switch output circuit terminal 3. The starter solenoid should engage and the engine should begin cranking.
   ⇒ If the solenoid does not engage, test the ignition switch output circuit for a short to ground or an open/high resistance. If the circuit tests normal, test or replace the starter motor.
5. If all circuits test normal, replace the ignition switch.

Manual Transmission (with Clutch Pedal Position Switch)

1. Disconnect the harness connector at the ignition switch.
2. Verify that a test lamp illuminates between the ignition switch B+ circuit terminal 2 and ground.
   ⇒ If the test lamp does not illuminate, test the B+ circuit for a short to ground or an open/high resistance. If the circuit tests normal and the fuse is open, test the ignition switch output terminal 3 for a short to ground.
3. Connect the harness connector at the ignition switch.
4. Connect a test lamp between the ignition switch output terminal 3 and ground.
5. Transmission in neutral and clutch pedal depressed, cycle the ignition between the OFF and Crank position. The test lamp should turn ON and OFF when changing between the Crank and OFF positions.
   ⇒ If the test lamp is always ON, test the ignition switch output circuit for a short to voltage. If the circuit tests normal, replace the ignition switch.
   ⇒ If the test lamp is always OFF, test the ignition switch output circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the ignition switch.
6. Connect a test lamp between the clutch start switch output terminal 3 and ground.
7. Transmission in neutral and clutch pedal depressed, cycle the ignition between the OFF and Crank position. The test lamp should turn ON and OFF when changing between the Crank and OFF positions.
   ⇒ If the test lamp is always ON, test the clutch start switch output circuit for a short to voltage. If the circuit tests normal, adjust or replace the clutch pedal position sensor, refer to *Clutch Pedal Position Sensor Replacement on page 17-415*.
   ⇒ If the test lamp is always OFF, test the clutch start switch output circuit for a short to ground or an open/high resistance. If the circuit tests normal, adjust or replace the clutch pedal position sensor, refer to *Clutch Pedal Position Sensor Replacement on page 17-415*.
8. If all circuits test normal, replace the starter motor.

Automatic Transmission

1. Verify DTC P0851, P0852, B1370, B1380, B1440, or B1441 are not set.
   ⇒ If either DTC is set, refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69*.
2. Ignition Off, disconnect the starter relay.
3. Test for less than 10 Ω between the relay ground coil terminal 85 and ground.
   ⇒ If greater than the specified range, test the ground circuit for an open/high resistance.
4. Ignition ON, verify that a test lamp illuminates between the B+ circuit terminal 30 and ground.
   ⇒ If the test lamp does not illuminate, test the B+ circuit for a short to ground or an open/high resistance. If the circuit tests normal and the fuse is open, test the relay switch control output terminal 87 for a short to ground.
5. Ensure the parking brake is applied and the transmission is in park/neutral.
6. Momentarily install a 30 A fused jumper wire between the B+ circuit terminal 30 and the relay switch output terminal 87.
7. The starter solenoid should engage and the engine should begin cranking
   ⇒ If the solenoid does not engage, test the relay switch output circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the starter motor.
8. Connect a test lamp between the starter relay coil control circuit terminal 86 and the coil ground terminal 85.
9. Transmission in park/neutral, cycle the ignition between the OFF and Crank position. The test lamp should turn ON and OFF when changing between the Crank and OFF positions.
   ⇒ If the test lamp is always ON, test the control circuit for a short to voltage. If the circuit tests normal, replace the ECM.
   ⇒ If the test lamp is always OFF, test the control circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the ECM.
10. If all circuits tests normal, replace the starter relay.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Crankshaft Position Sensor Replacement on page 9-575*
- *Clutch Pedal Position Sensor Replacement on page 17-415*
- *Relay Replacement (Within an Electrical Center) on page 11-607* or *Relay Replacement (Attached to Wire Harness) on page 11-607*
- *Starter Replacement (LUW) on page 9-722* or *Starter Replacement (LUV) on page 9-724*
- *Control Module References on page 6-3* for ECM replacement, setup and programming

Starter Solenoid Clicks, Engine Does Not Crank

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Reference Information

Schematic Reference

Starting and Charging Schematics on page 9-683

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Starting System Description and Operation on page 9-732

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition OFF, measure and record the battery voltage at the C1 battery terminals. The voltage should be between 12.0–15.0 V.
   ⇒ If not within the specified range, refer to *Battery Charging on page 9-703*.
2. Remove the drive belts. Refer to one of the following:
   - *Drive Belt Replacement on page 9-974*
   - *Drive Belt Tensioner Replacement on page 9-976*
3. Using the appropriate tools, rotate the crankshaft by hand and verify the crankshaft rotates.
   ⇒ If the crankshaft does not rotate, refer to *Engine Will Not Crank - Crankshaft Will Not Rotate on page 9-962*.
4. Place the ignition to the CRANK position.
   ⇒ If the engine cranks, inspect the engine and belt drive system for mechanical binding, power steering pump, or seized generator, etc.
5. Verify that a test lamp illuminates between the M64 starter motor B+ terminal B X2 and ground.
   ⇒ If the test lamp does not illuminate, test the B+ circuit for a short to ground or an open/high resistance.
6. Test for less than 0.5 V between the positive battery cable and terminal B X2 at the M64 starter motor as the ignition is placed to the START position.
   ⇒ If greater than the specified range, replace the positive battery cable.
7. Test for less than 0.5 V between the negative battery cable and the M64 starter motor case as the ignition is placed to the START position.
   ⇒ If greater than the specified range, replace the negative battery cable.
8. If all circuits test normal, replace the M64 starter motor.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

- *Battery Negative Cable Disconnection and Connection on page 9-713*
- *Starter Replacement (LUW) on page 9-722* or *Starter Replacement (LUV) on page 9-724*

Engine Cranks Slowly

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Reference Information

Schematic Reference

Starting and Charging Schematics on page 9-683

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Starting System Description and Operation on page 9-732

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition OFF, measure and record the battery voltage at the C1 battery terminals. The voltage should be between 12.0–15.0 V.
   ⇒ If not within the specified range, refer to *Battery Charging on page 9-703*.

2. Remove the drive belts. Refer to one of the following:
   - *Drive Belt Replacement on page 9-974*
   - *Drive Belt Tensioner Replacement on page 9-976*
3. Place the ignition to the CRANK position. verify the engine does not crank normal.
   ⇒ If the engine cranks normal, inspect the engine and belt drive system for mechanical binding, seized engine, or seized generator, etc.
4. Test for less than 0.5 V between the positive battery cable and terminal B X2 at the M64 starter motor as the ignition is placed to the CRANK position.
   ⇒ If greater than the specified value, replace the positive battery cable.
5. Test for less than 0.5 V between the negative battery cable and the M64 starter motor case as the ignition switch is placed to the CRANK position.
   ⇒ If greater than the specified value, replace the negative battery cable.
6. If all circuits test normal, replace the M64 starter motor.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

- *Battery Negative Cable Disconnection and Connection on page 9-713*
- *Starter Replacement (LUW) on page 9-722* or *Starter Replacement (LUV) on page 9-724*

Starter Noise Diagnosis

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Circuit/System Description

The PG starter motors are non-repairable. They have pole pieces that are arranged around the armature. Both solenoid windings are energized. The pull-in winding circuit is completed to the ground through the starter motor. The windings work together magnetically to pull and hold in the plunger. The plunger moves the shift lever. This action causes the starter drive assembly to rotate on the armature shaft spline as it engages with the flywheel ring gear on the engine. Moving at the same time, the plunger also closes the solenoid switch contacts in the starter solenoid. Full battery voltage is applied directly to the starter motor and it cranks the engine.

Reference Information

Description and Operation

Starting System Description and Operation on page 9-732

Circuit/System Verification

Start the engine. Listen to the starter noise, while the engine is cranking. Compare the concern to a similar vehicle.

Circuit/System Testing

1. Remove the flywheel inspection cover.
2. Inspect the flywheel for the following:
   - Loose flywheel bolts
   - Chipped gear teeth
   - Missing gear teeth
   - Bent flywheel
   - Debris in the bell housing
   ⇒ If not within specifications, remove the debris, tighten the flywheel bolts, or repair or replace the flywheel.
3. If all inspections were within specification, replace the starter motor.

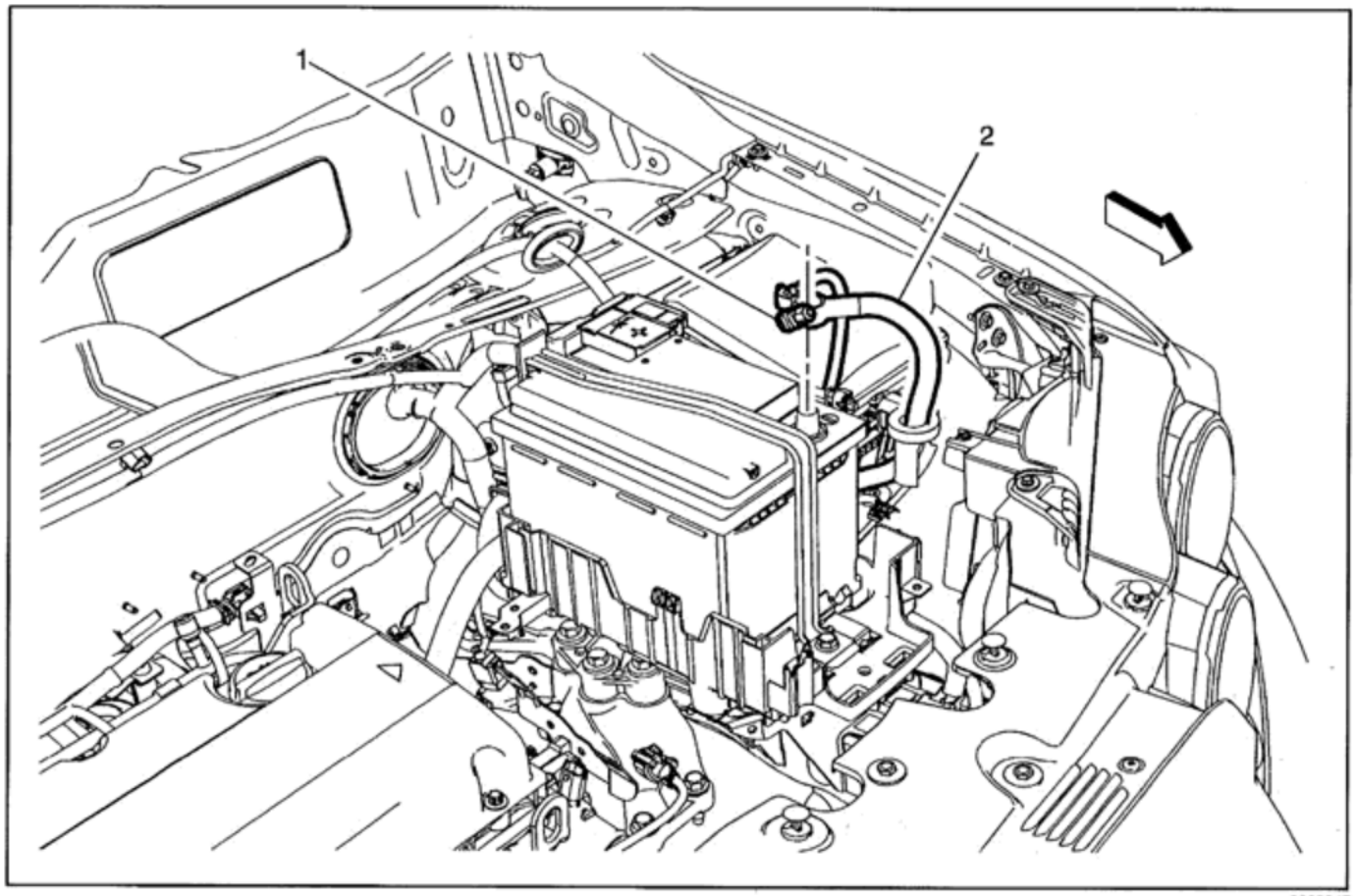
Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

- *Starter Replacement (LUW) on page 9-722* or *Starter Replacement (LUV) on page 9-724*
- *Engine Flywheel Replacement on page 9-814* for the 1.4 L (LUV) engine
- *Engine Flywheel Replacement on page 9-1013* for the 1.8 L (LUW) engine

Repair Instructions

Battery Negative Cable Disconnection and Connection



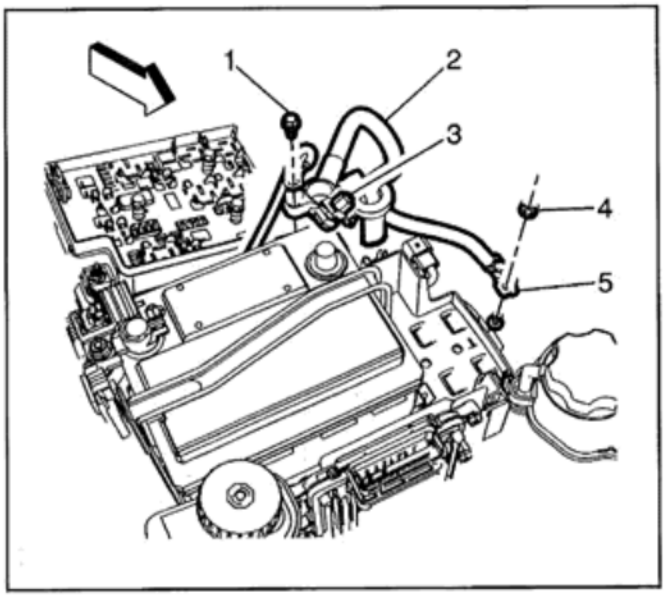
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Battery Negative Cable Disconnection and Connection

Callout	Component Name
Preliminary Procedures 1. Turn on the radio and record all of the radio pre-set stations. 2. Ensure that all lamps and accessories are turned off. 3. Turn the ignition OFF and remove the ignition key.	
1	Battery Negative Cable Fastener ***Warning: Refer to Battery Disconnect Warning on page 0-4.*** **Caution:** Refer to *Fastener Caution on page 0-8.* **Tighten** 4.5 N•m (40 lb in)
2	Battery Negative Cable **Procedure** 1. Disconnect the battery negative cable from the battery. 2. After connecting the battery negative cable, insert the ignition key and turn the ignition to the ON position. 3. Program the volatile memory. Refer to *Control Module References on page 6-3.*

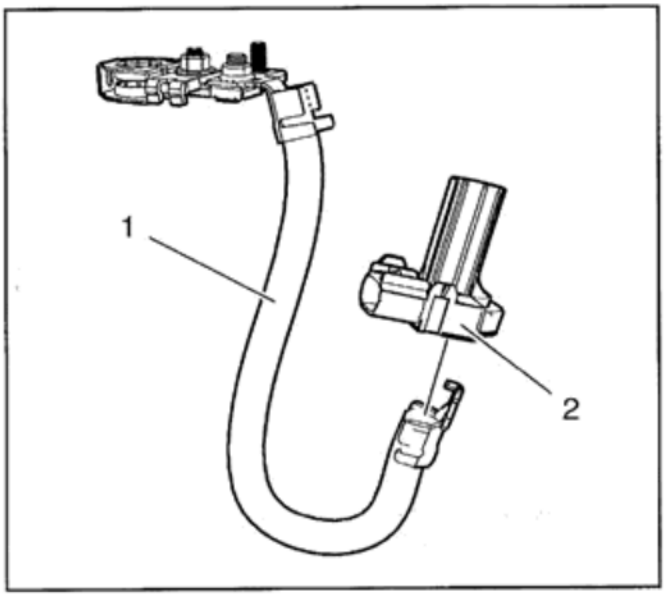
Battery Current Sensor Replacement

Removal Procedure



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1. Disconnect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.
2. Disconnect the battery current sensor from the body harness connector.
3. Unclip the battery current sensor from the battery tray.
4. Remove the battery tray. Refer to *Battery Tray Replacement on page 9-721*.
5. Remove the battery negative cable frame ground nut (4) and terminal (5).

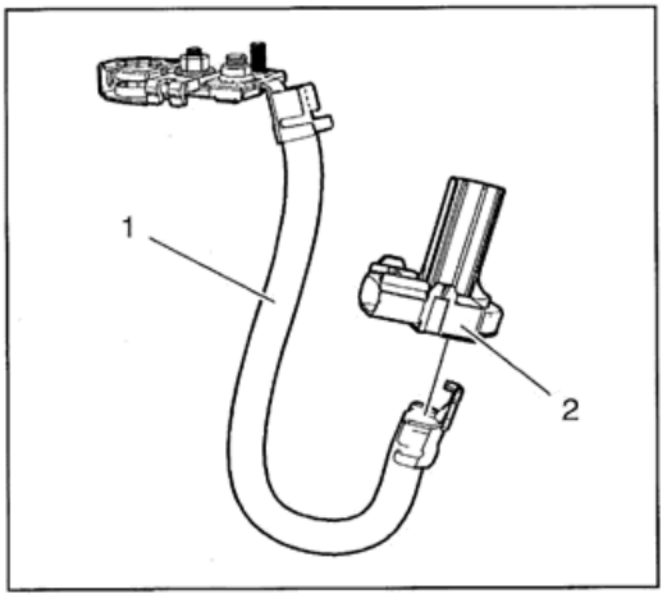


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Note: Observe the position of the battery current sensor when removing.

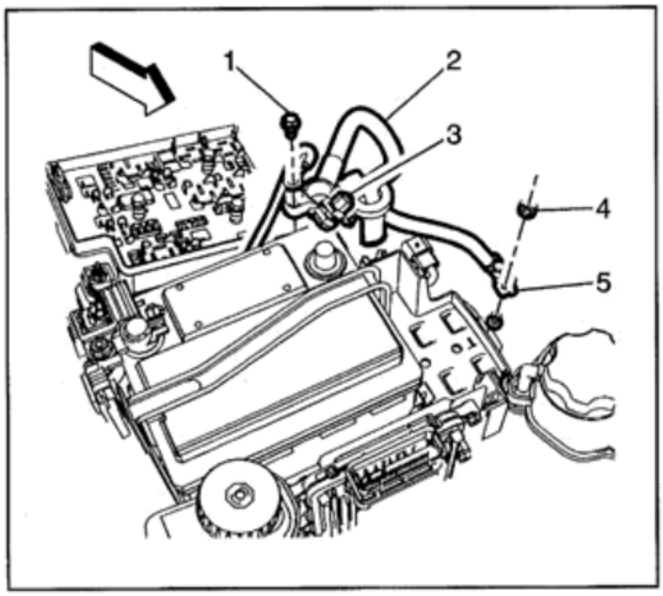
6. Slide the battery current sensor (2) off the battery negative cable (1).

Installation Procedure



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1. Install the battery current sensor (2) onto the battery negative cable (1).



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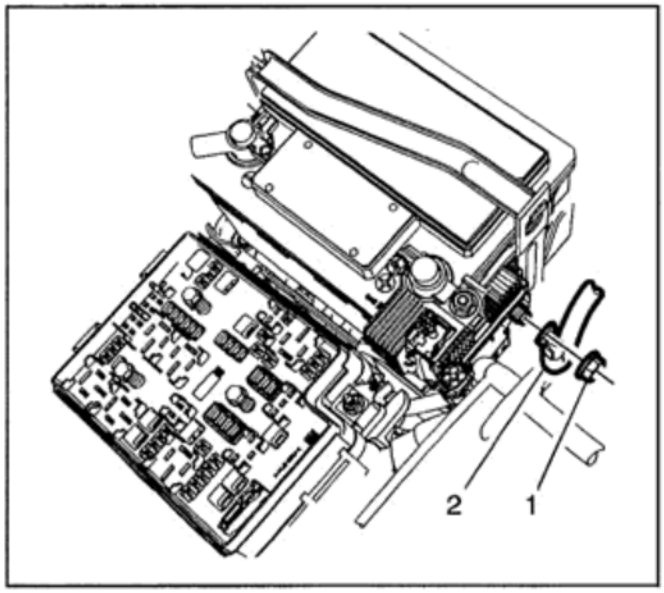
Caution: Refer to *Fastener Caution on page 0-8*.

2. Install the battery negative cable frame ground terminal (5) and bolt (4). Tighten to **22 N·m (16 lb ft)**.
3. Install the battery tray. Refer to *Battery Tray Replacement on page 9-721*.
4. Clip the battery current sensor onto the battery tray.
5. Connect the battery current sensor to the body harness connector.
6. Connect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.

Battery Positive and Negative Cable Replacement

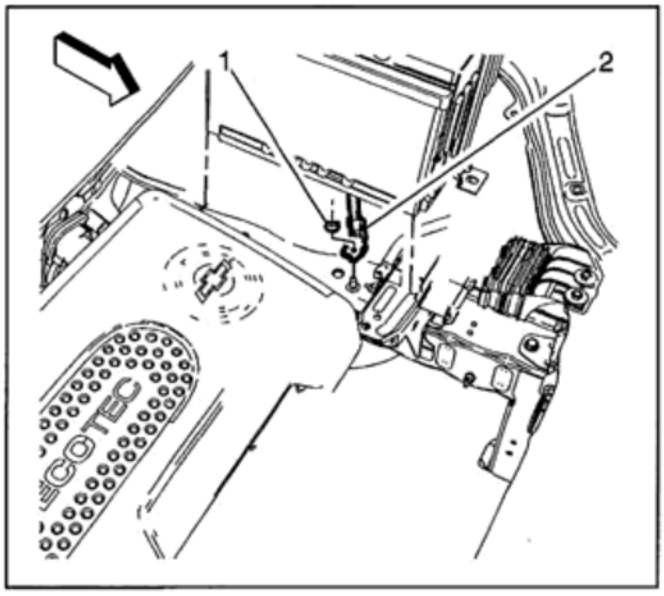
Removal Procedure

1. Disconnect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.
2. Remove the fuse block and battery positive cable cover.
3. Remove the battery tray. Refer to *Battery Tray Replacement on page 9-721*.



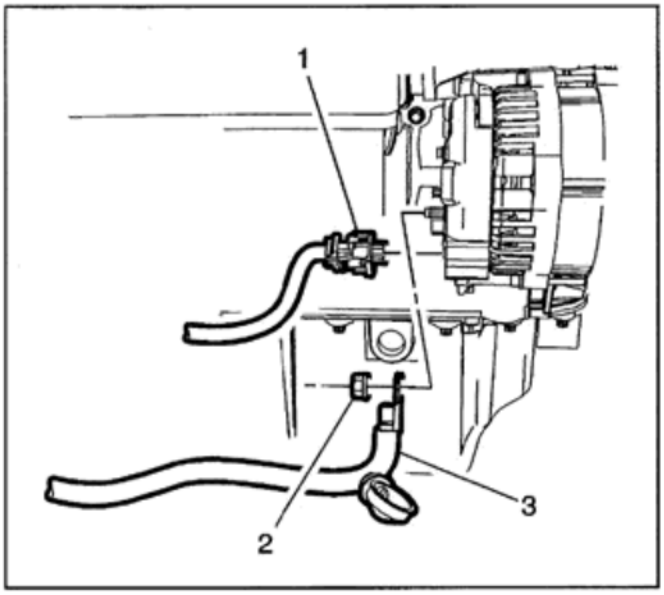
2496501

4. Remove the battery positive nut (1) and the battery positive cable (2), from the battery positive cable junction block.



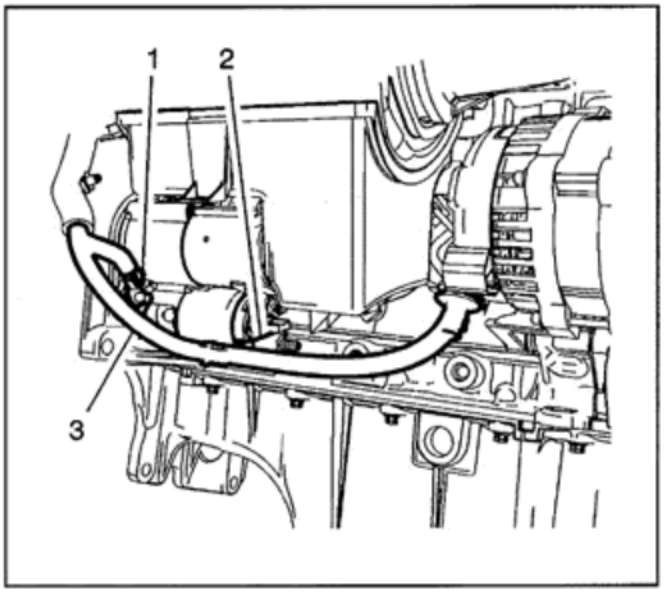
2552157

5. Remove the battery negative cable nut (1) and the battery negative cable (2), from the chassis frame stud.
6. Remove the drivetrain and front suspension frame skid plate. Refer to *Drivetrain and Front Suspension Frame Skid Plate Replacement on page 3-143*.



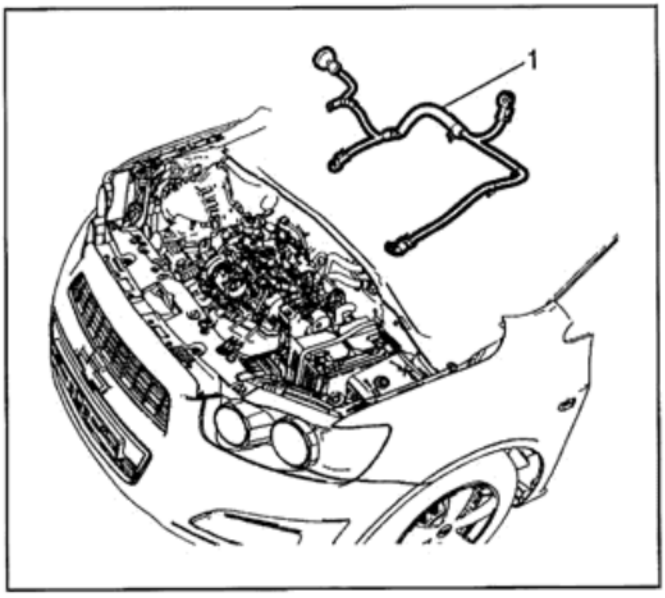
2498499

7. Remove the battery positive cable nut (2) and the battery positive cable (3), from the back of the generator.



2534851

8. Remove the battery negative cable stud/nut (1) and the starter solenoid nut (2).

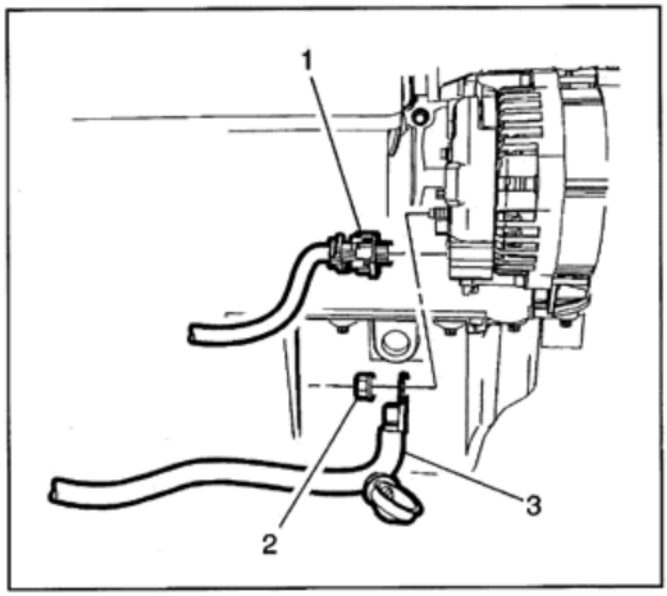


2552198

Note: Visualize the routing of the battery positive and negative cable within the engine compartment.

9. Remove the battery positive and negative cable (1) from the engine compartment.

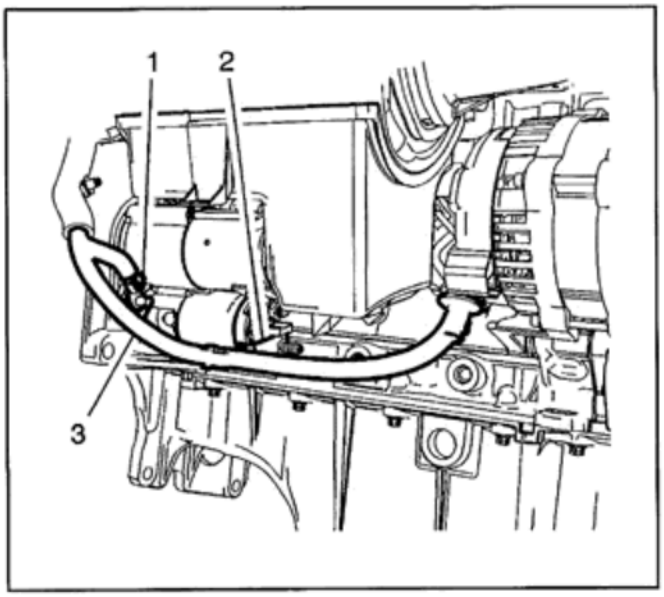
Installation Procedure



2498499

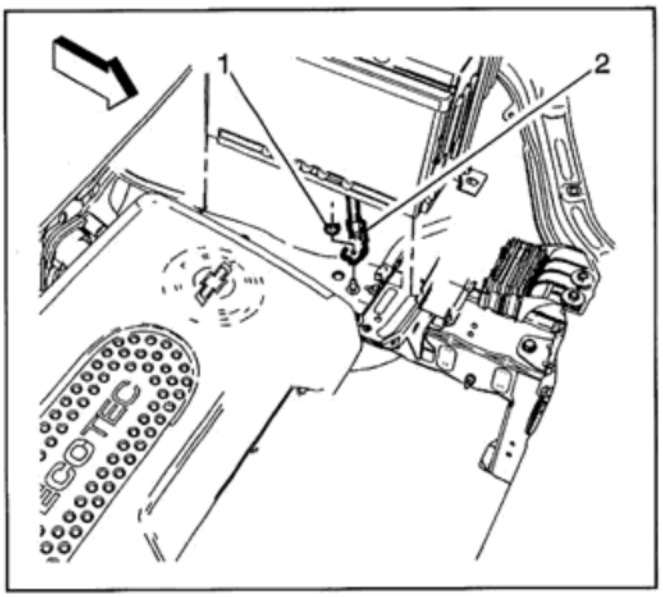
Caution: Refer to *Fastener Caution on page 0-8.*

1. Install the battery positive cable (3) to the back of the generator and tighten nut (2) to **20** N•m **(15 lb ft)**.



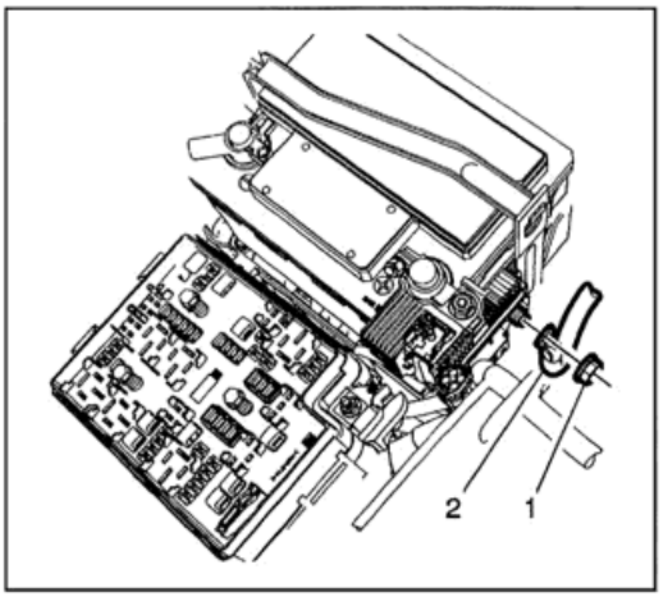
2534851

2. Install the battery positive cable (3) to the starter solenoid and tighten nut (2) to **12** N•m **(9 lb ft)**.
3. Install the battery negative cable to the starter and tighten the stud/nut (1) to **25** N•m **(18 lb ft)**.
4. Install the drivetrain and front suspension frame skid plate. Refer to *Drivetrain and Front Suspension Frame Skid Plate Replacement on page 3-143.*



2552157

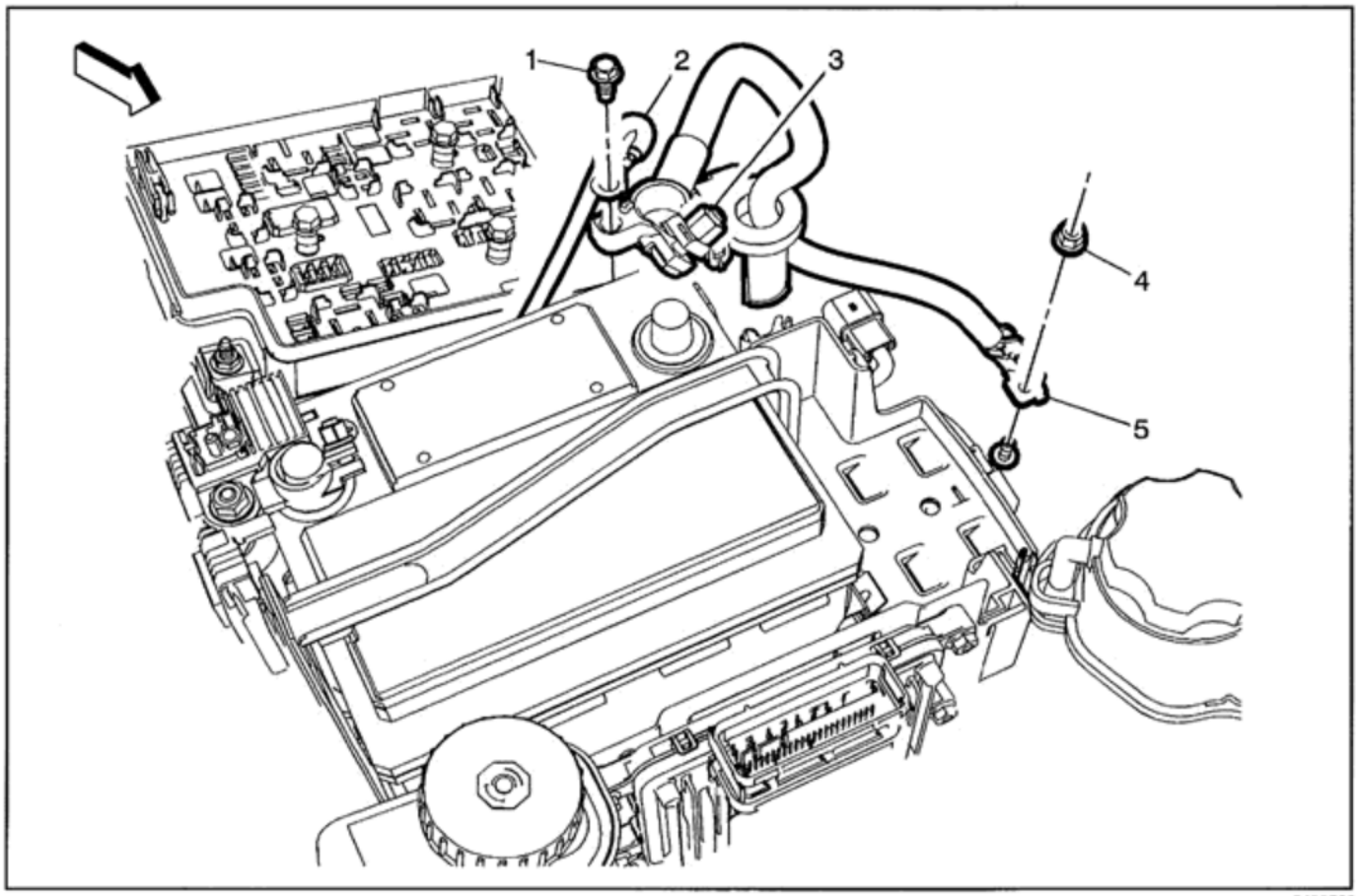
5. Install the battery negative cable nut (1) and the battery negative cable (2), to the chassis frame stud and tighten to **22** N•m **(16 lb ft)**.



2498501

6. Install the battery positive cable (2) to the battery positive cable extension cable junction block and tighten nut (1) to **12 N•m (9 lb ft)**.
7. Install the battery tray. Refer to *Battery Tray Replacement on page 9-721*.
8. Connect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.
9. Install the fuse block and battery positive cable cover.

Battery Negative Cable Replacement



2498502

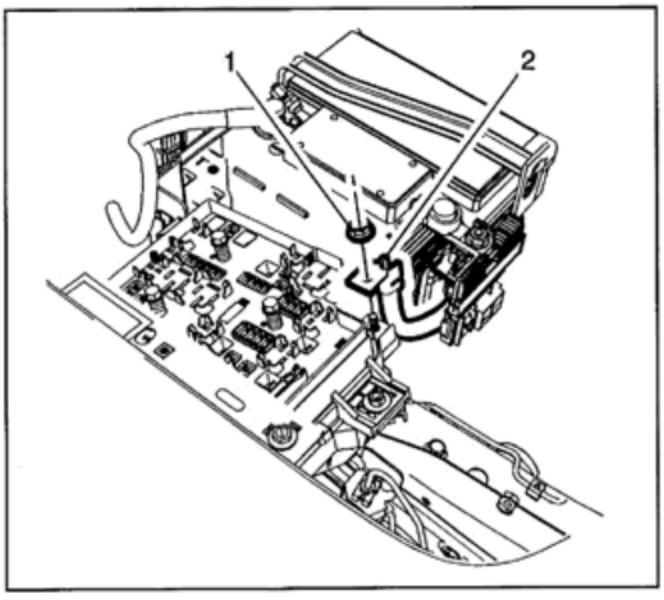
Battery Negative Cable Replacement

Callout	Component Name
Preliminary Procedures 1. Disconnect the battery current sensor connector. 2. Remove the battery tray. Refer to *Battery Tray Replacement on page 9-721*.	
1	Body Harness Terminal Bolt **Caution:** Refer to *Fastener Caution on page 0-8*. **Tighten** 9 N•m (80 lb in)
2	Body Harness Terminal
3	Battery Negative Post Clamp Nut **Tighten** 9 N•m (80 lb in)
4	Battery Negative Frame Ground Nut **Tighten** 22 N•m (16 lb ft)
5	Battery Negative Cable **Procedure** Transfer the current sensor, noting the location and direction on the cable.

Battery Positive Cable Replacement

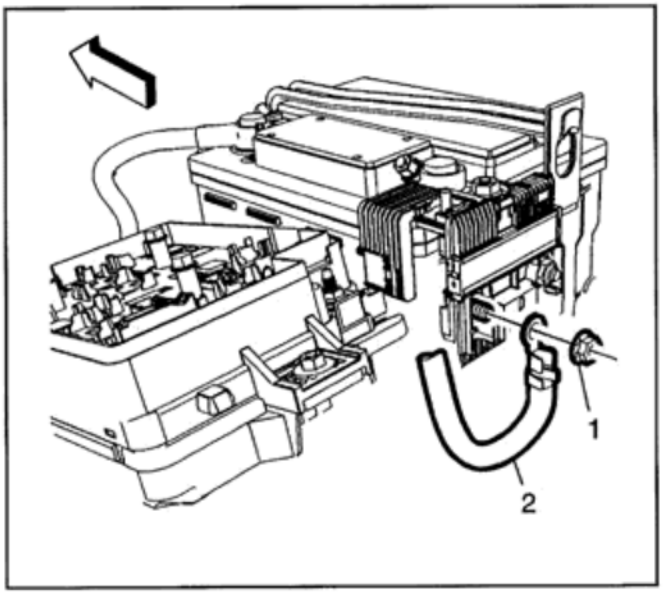
Removal Procedure

1. Disconnect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.
2. Remove the underhood fuse block cover.



2498504

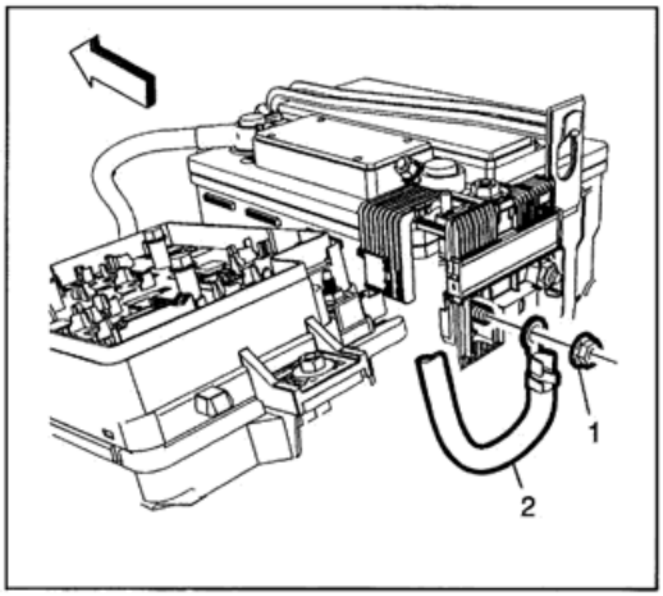
3. Remove the battery positive nut (1) and the battery positive cable (2), from the underhood fuse block.



2498506

4. Remove the battery positive cable nut (1) from the battery positive cable junction block.
5. Remove the battery positive cable (2) from the vehicle.

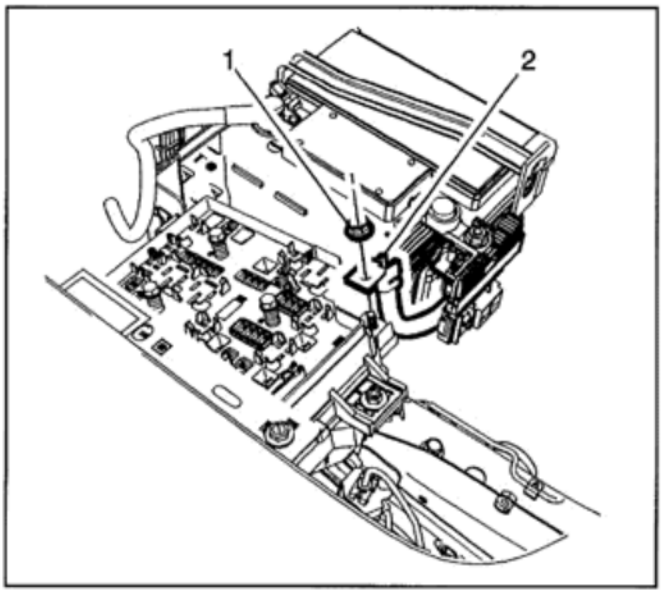
Installation Procedure



2498506

Caution: Refer to *Fastener Caution on page 0-8*.

1. Install the battery positive cable (2) to the battery positive cable junction block and tighten nut (1) to **7 N•m (62 lb in)**.



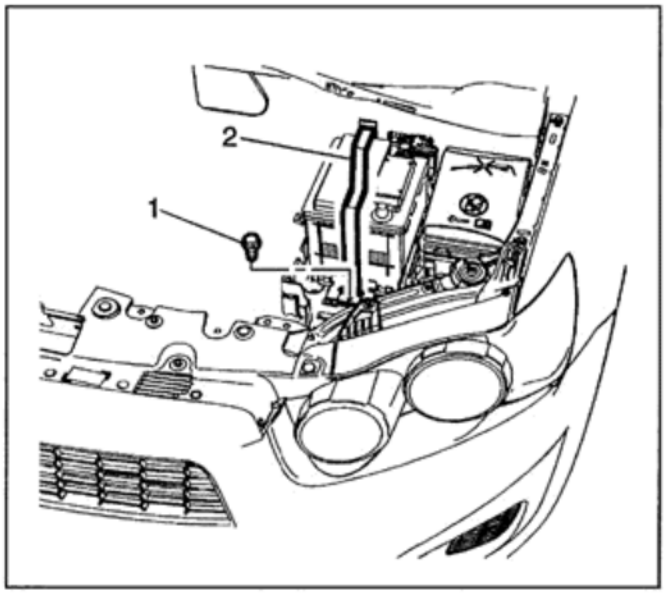
2498504

2. Install the battery positive cable (2) to the underhood fuse block and tighten nut (1) to **7 N•m (62 lb in)**.
3. Install the underhood fuse block cover.
4. Connect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.

Battery Replacement

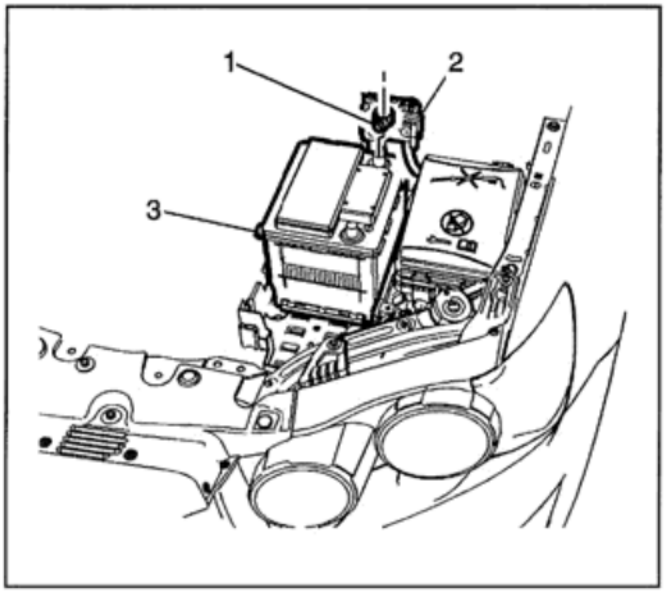
Removal Procedure

1. Open the hood.
2. Disconnect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.



2540434

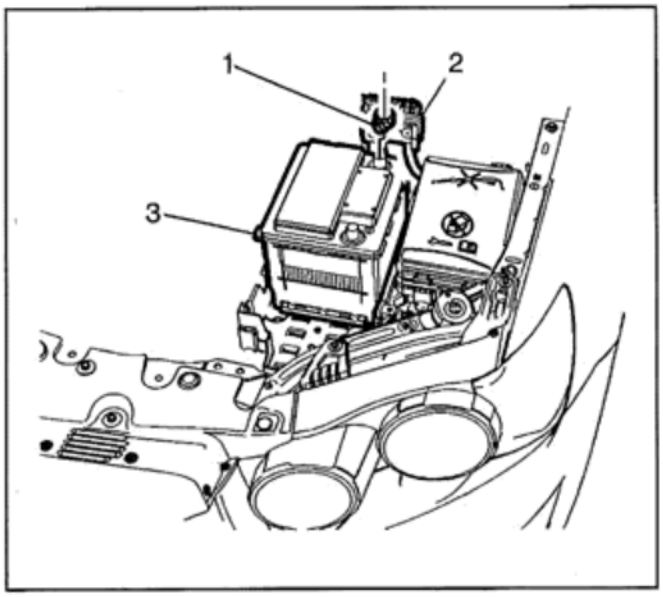
3. Remove the battery retainer bolt (1) and the battery retainer (2).



2540433

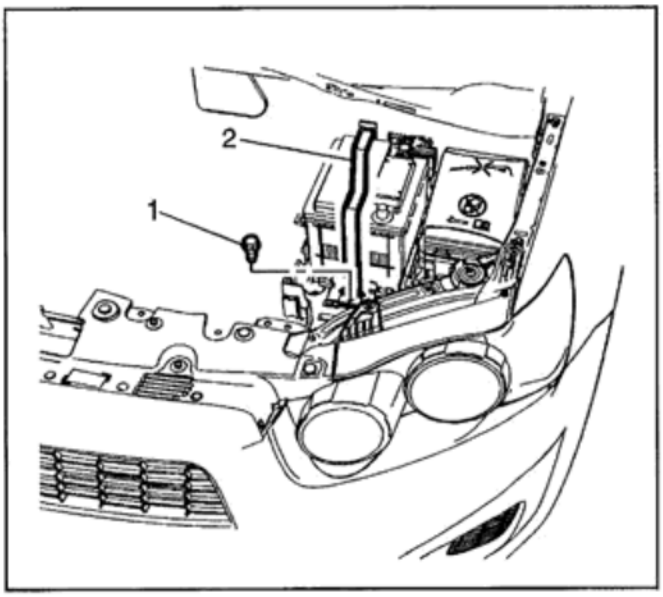
4. Loosen the battery positive cable junction bolt (1).
5. Remove the battery positive cable with the junction block (2) from the battery.
6. Remove the battery (3) from the battery tray floor.

Installation Procedure



2540433

1. Install the battery (3) to the battery tray floor..
2. Install the battery positive cable with junction block (2) to the battery (3).



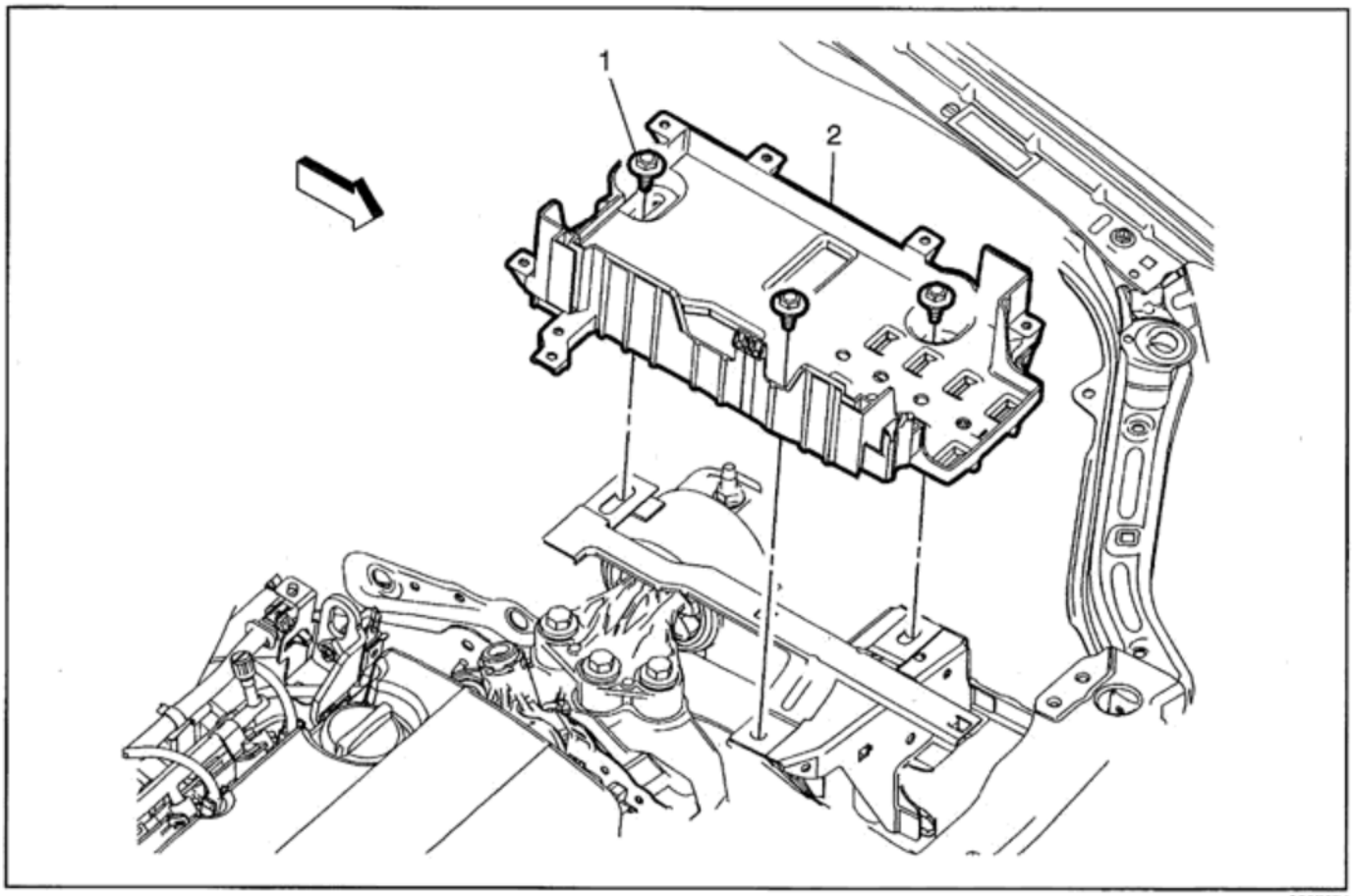
2540434

3. Install the battery retainer (2).

Caution: Refer to *Fastener Caution on page 0-8*.

4. Tighten the battery retainer bolt (1) to **22** N•m **(16 lb ft)**.
5. Connect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.

Battery Tray Replacement



2507871

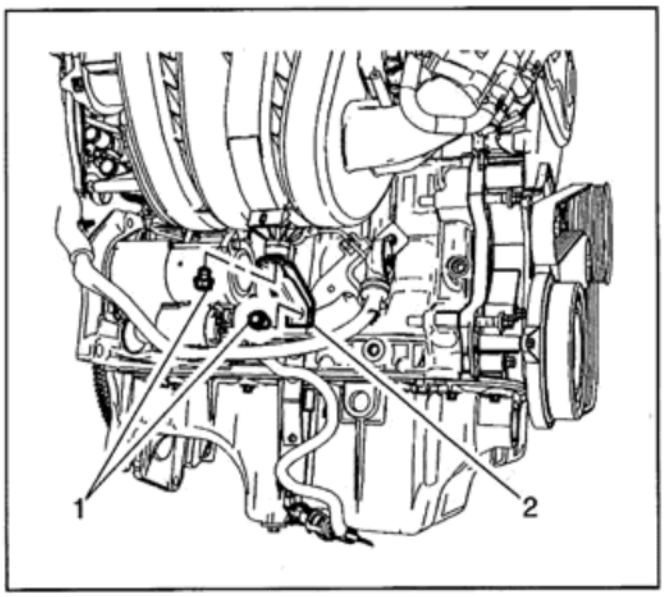
Battery Tray Replacement

Callout	Component Name
Preliminary Procedures 1. Remove the battery. Refer to *Battery Replacement on page 9-719*. 2. Unclip the engine control module (ECM) bracket from the battery tray and set aside. 3. Unclip the battery current sensor from the battery tray and set aside.	
1	Battery Tray Bolt (Qty: 3) **Caution:** Refer to *Fastener Caution on page 0-8*. **Tighten** 14 N•m (10 lb ft)
2	Battery Tray

Starter Replacement (LUW)

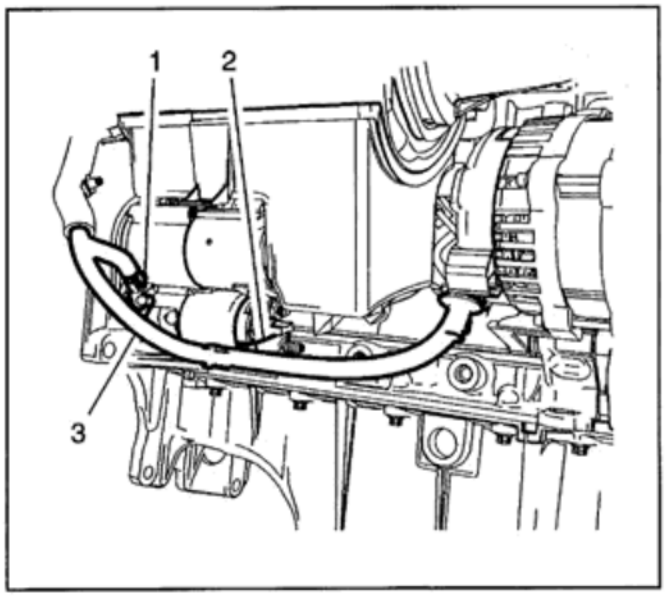
Removal Procedure

1. Disconnect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.
2. Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*.
3. Remove the drivetrain and front suspension frame skid plate. Refer to *Drivetrain and Front Suspension Frame Skid Plate Replacement on page 3-143*.



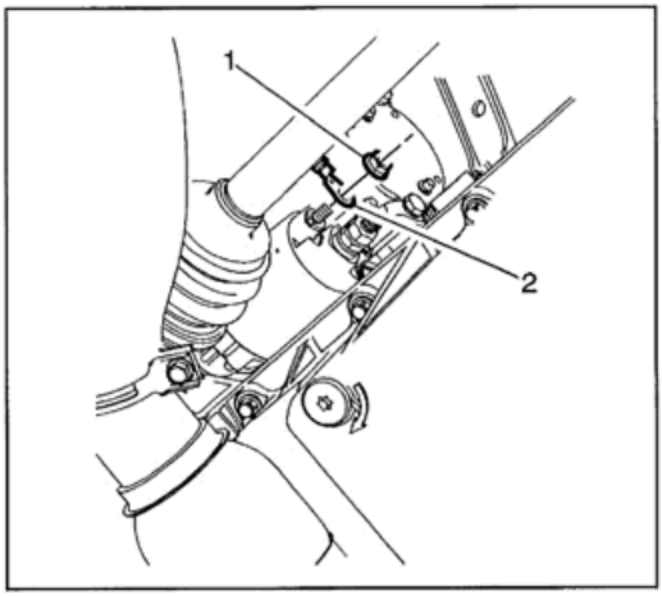
2680093

4. Remove the intake manifold brace fasteners (1) and remove the intake manifold brace (2).



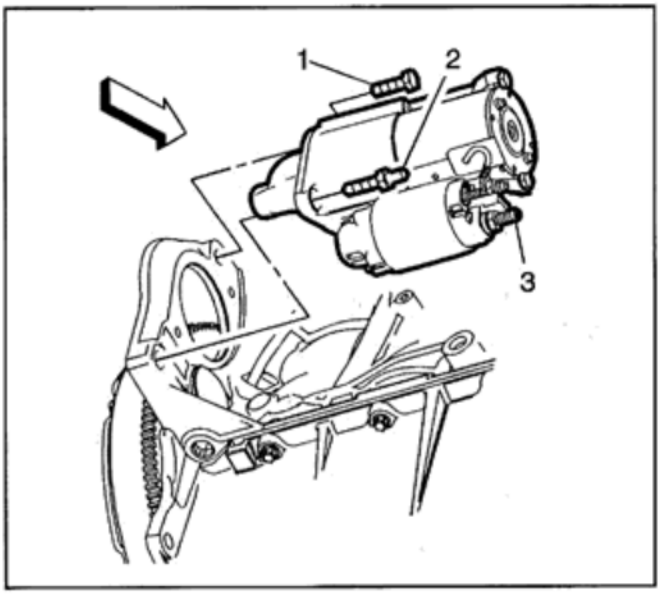
2534851

5. Remove the starter solenoid battery positive fastener (2) and the starter mounting stud/ fastener (1).
6. Remove the battery positive and negative cable (3) from the starter.



2508299

7. Remove the starter solenoid fastener (1) and the engine harness terminal (2) from the starter solenoid.

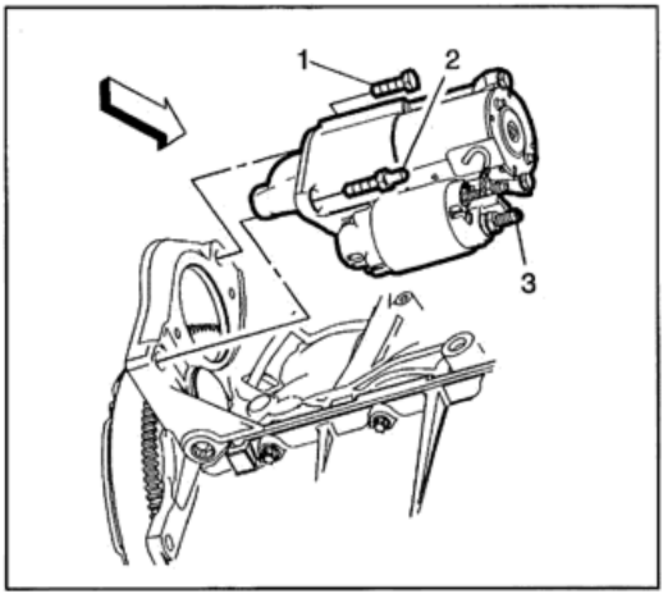


2508293

Note: The starter mounting fastener can be accessed from the top of the engine, with the battery tray removed.

8. Remove the starter mounting fastener (1) and the starter (3) from the vehicle.

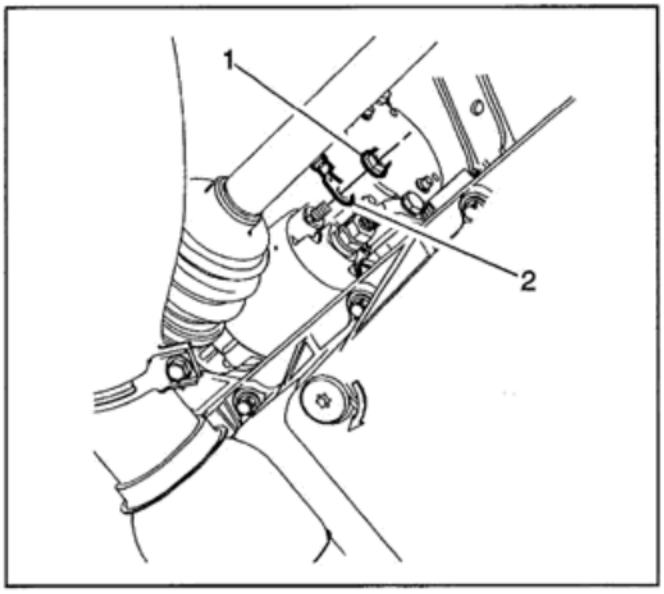
Installation Procedure



2508293

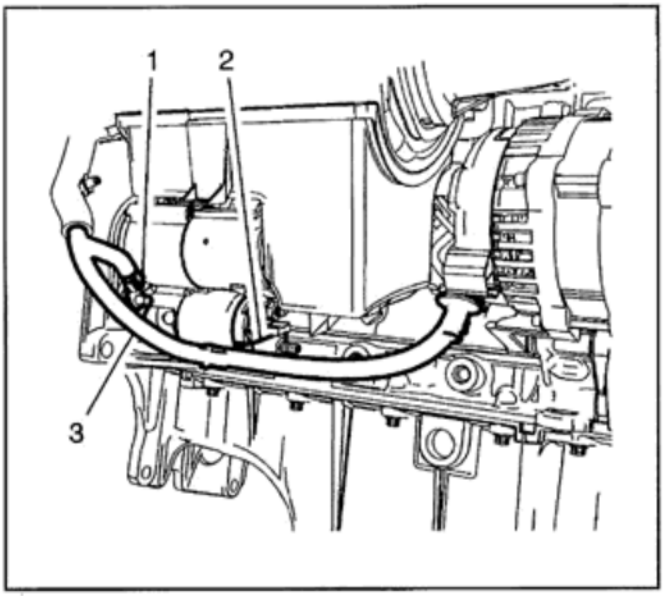
Caution: Refer to *Fastener Caution on page 0-8*.

1. Install the starter (3) into position and tighten the starter mounting fastener (1) to **25** N•m **(18 lb ft)**.



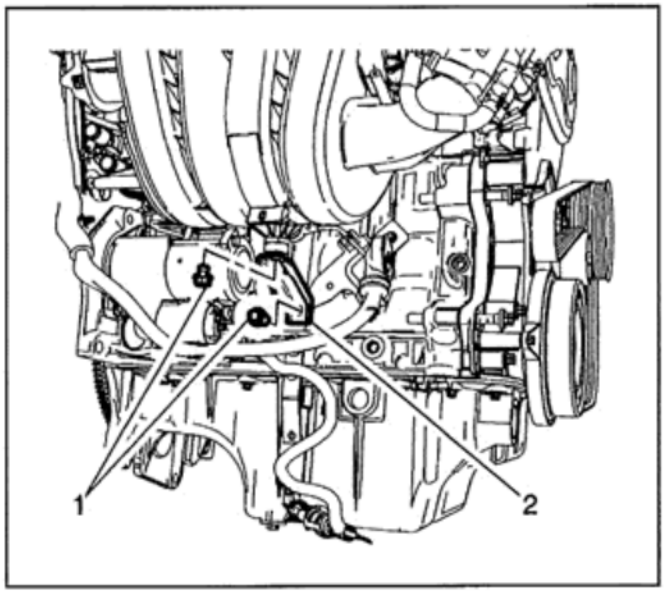
2508289

2. Install the engine harness terminal (2) to the starter solenoid and tighten the solenoid fastener (1) to **9** N•m **(80 lb in)**.



2534851

3. Install the battery negative cable terminal and the starter mounting stud/fastener (1) to the starter. Tighten to **25** N•m **(18 lb ft)**.
4. Install the positive battery cable terminal to the starter solenoid and tighten the fastener (2) to **9** N•m **(80 lb in)**.



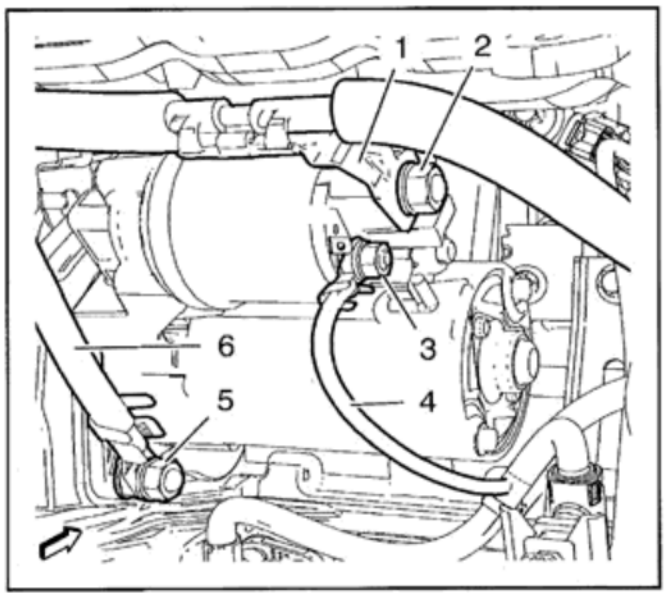
2680093

5. Install the intake manifold brace (2) and mounting fasteners (1). Tighten to **8** N•m **(71 lb in)**.
6. Install the drivetrain and front suspension frame skid plate. Refer to *Drivetrain and Front Suspension Frame Skid Plate Replacement on page 3-143*.
7. Connect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.

Starter Replacement (LUV)

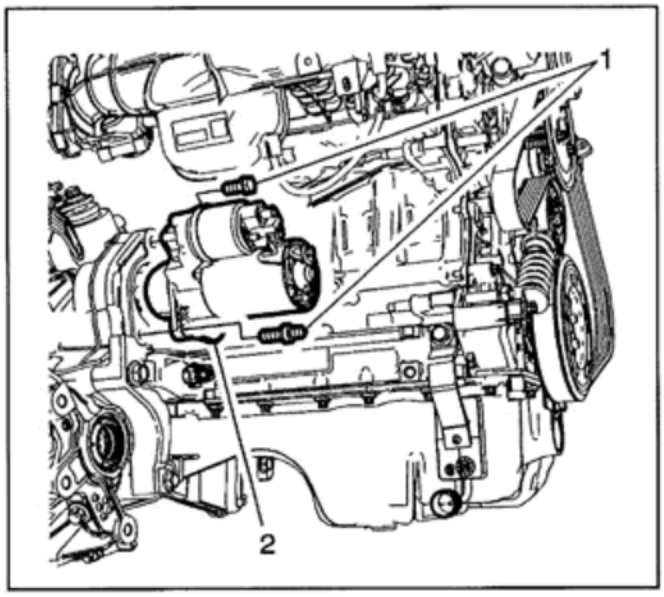
Removal Procedure

1. Disconnect the battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.
2. Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*.
3. If equipped with a front suspension skid plate, remove the drivetrain and suspension frame skid plate. Refer to *Drivetrain and Front Suspension Frame Skid Plate Replacement on page 3-143*.



2191724

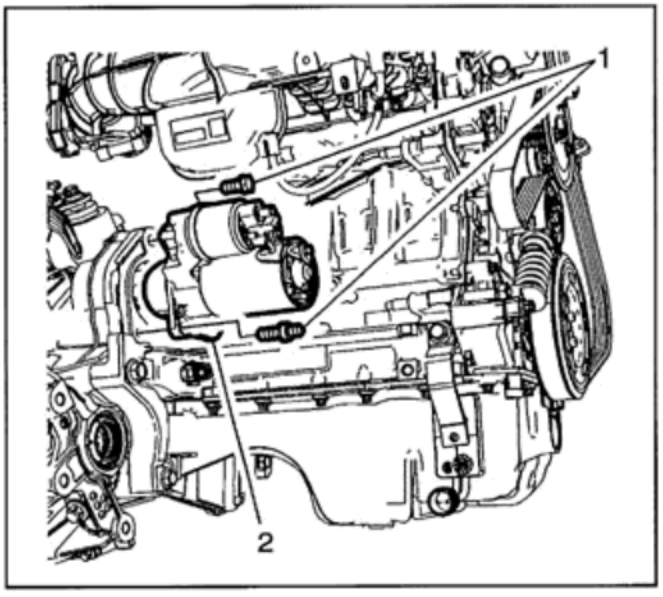
4. Remove the battery positive cable fastener (2) and the battery positive cable terminal (1), from the starter solenoid.
5. Remove the starter battery positive fastener (3) and the positive terminal (4), from the starter solenoid.
6. Remove the battery negative cable fastener (5) and the battery negative ground terminal (6), from the starter mounting stud.



2680106

7. Remove the starter mounting fasteners (1) and remove the starter from the vehicle.

Installation Procedure

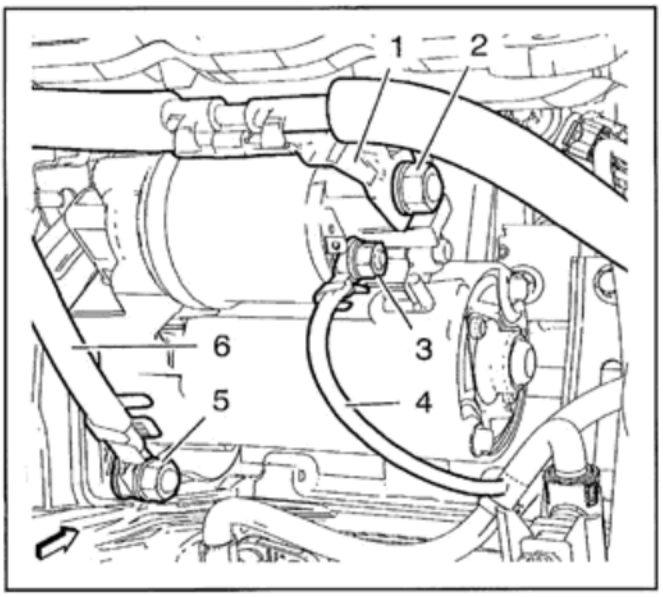


2680106

1. Install the starter (2).

Caution: Refer to *Fastener Caution on page 0-8*.

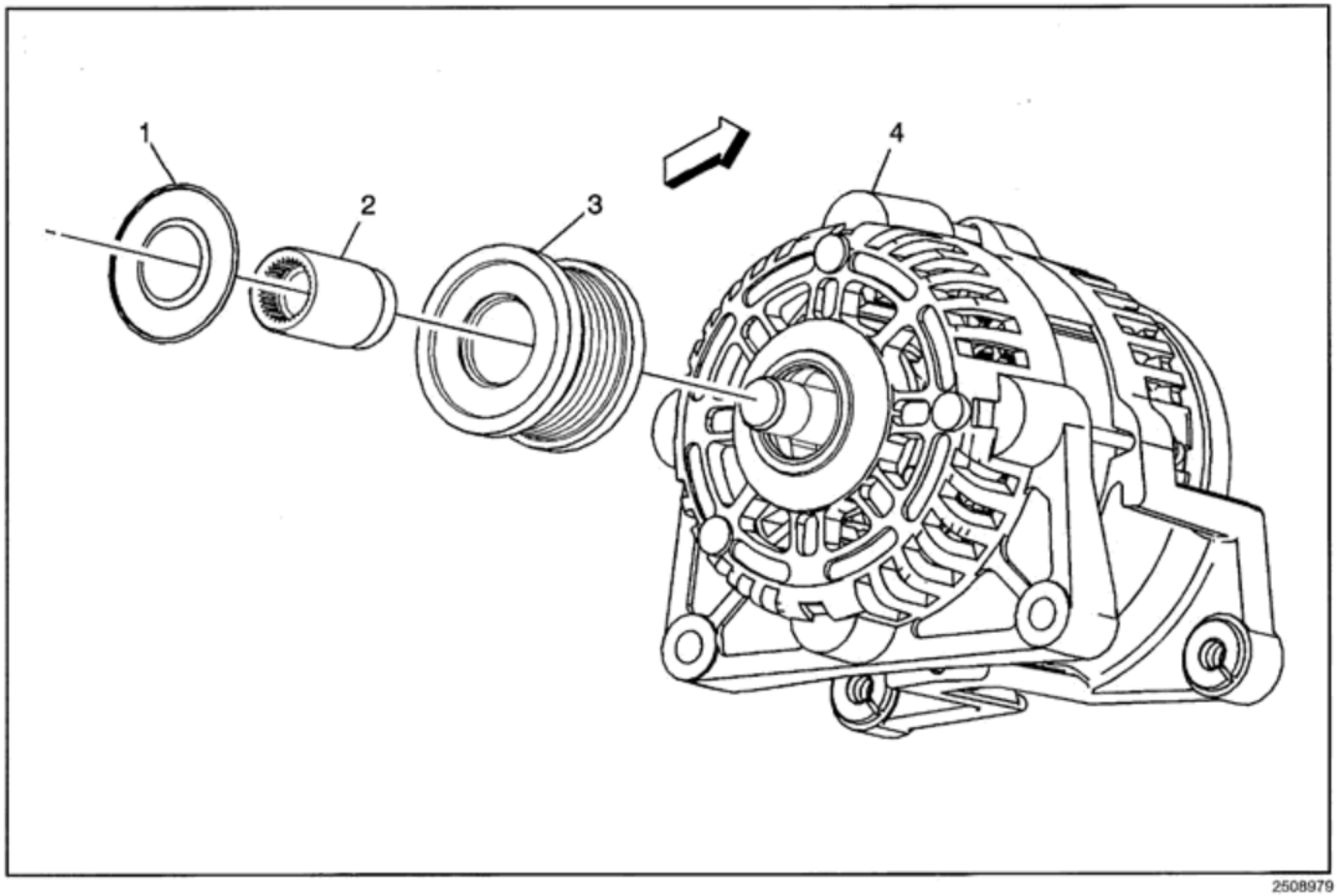
2. Install the starter fasteners (1) and tighten to **25 N·m (18 lb ft)**.



2191724

3. Install the ground cable (6).
4. Install the ground cable fastener (5) and tighten to **12.5 N·m (111 lb in)**.
5. Install the starter positive cable (4) to starter.
6. Install the starter positive cable fastener (3) and tighten to **12.5 N·m (111 lb in)**.
7. Install the battery positive cable terminal (1).
8. Install the battery positive cable fastener (2) and tighten to **12.5 N·m (111 lb in)**.
9. Install the drivetrain and suspension skid plate, if equipped. Refer to *Drivetrain and Front Suspension Frame Skid Plate Replacement on page 3-143*.
10. Lower the vehicle.
11. Connect the battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.

Generator Pulley Replacement (LUV)



2508979

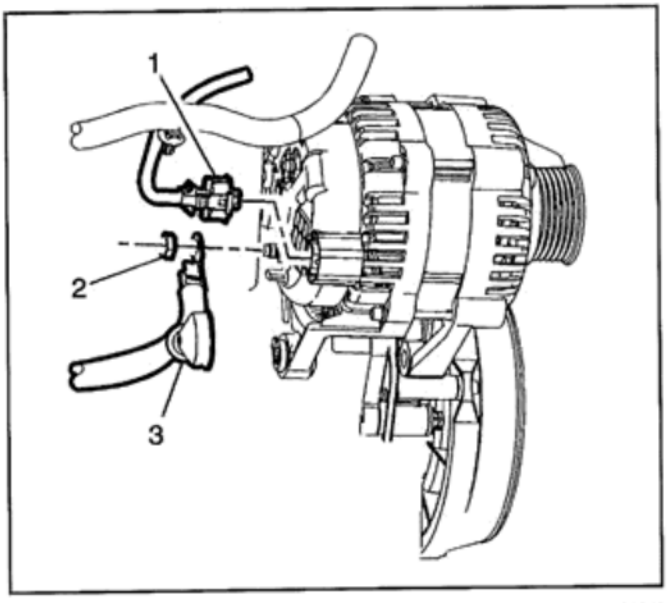
Generator Pulley Replacement (LUV)

Callout	Component Name
Preliminary Procedure Remove the generator. Refer to *Generator Replacement (LUV) on page 9-726* or *Generator Replacement (LUW) on page 9-727*.	
1	Generator Pulley Nut Cap
2	Generator Pulley Nut **Caution:** Refer to *Fastener Caution on page 0-8*. **Procedure** Remove the generator pulley nut by using *EN-6372* counterhold. **Tighten** 90 N•m (66 lb ft) **Special Tools** *EN-6372* Counterhold For equivalent regional tools, refer to *Special Tools on page 9-733*.
3	Generator Pulley
4	Generator

Generator Replacement (LUV)

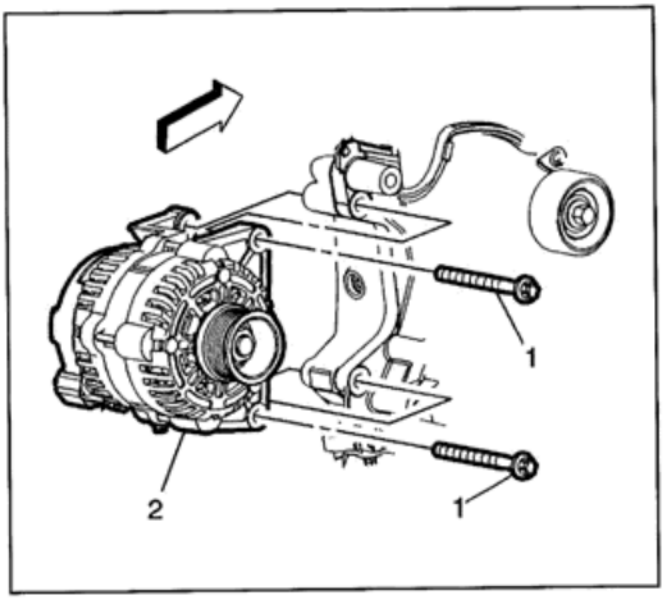
Removal Procedure

1. Disconnect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.
2. Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*.
3. Remove the drive belt. Refer to *Drive Belt Replacement on page 9-974*.
4. Remove the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement on page 9-786*.



2508846

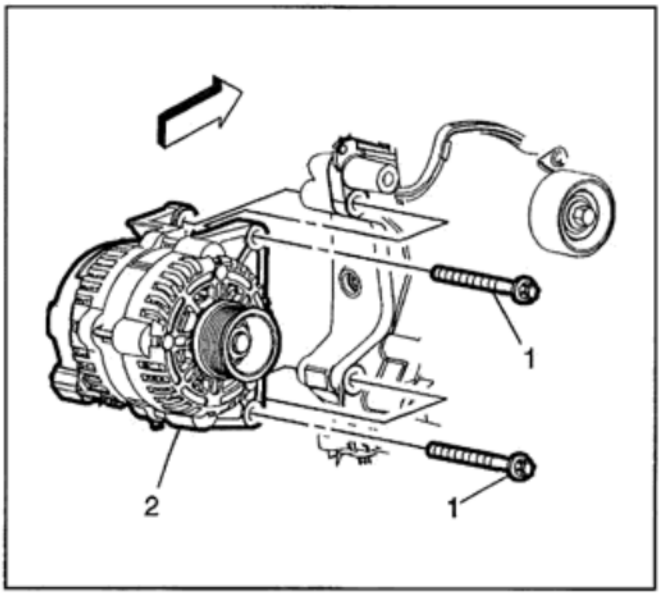
5. Remove the engine harness connector (1) and the battery positive cable generator fastener (2).
6. Remove the battery positive cable (3) from the back of the generator.



2508849

7. Remove the generator mounting fasteners (1) and remove the generator (2) from the engine.

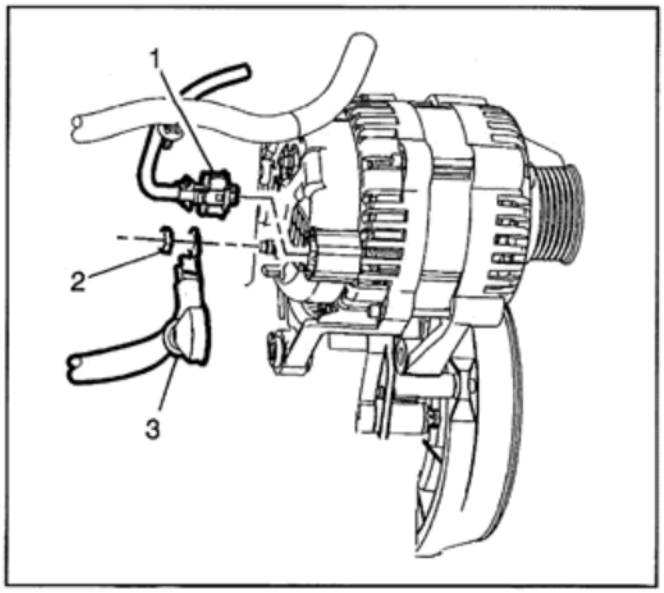
Installation Procedure



2508849

Caution: Refer to *Fastener Caution on page 0-8*.

1. Install the generator (2) with the mounting fasteners (1) and tighten to **35** N•m **(26 lb ft)**.



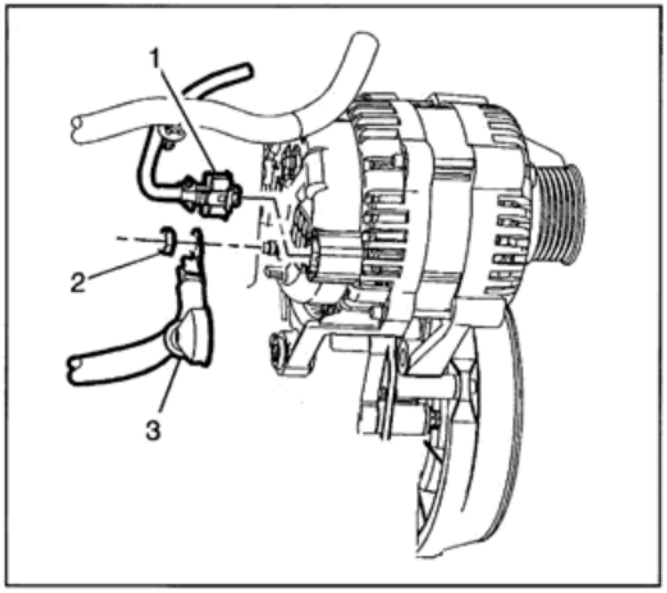
2508846

2. Install the battery positive cable (3) and the engine harness connector (1) to the back of the generator. Tighten fastener (2) to **9** N•m **(80 lb in)**.
3. Install the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement on page 9-786*.
4. Install the drive belt. Refer to *Drive Belt Replacement on page 9-974*.
5. Connect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.

Generator Replacement (LUW)

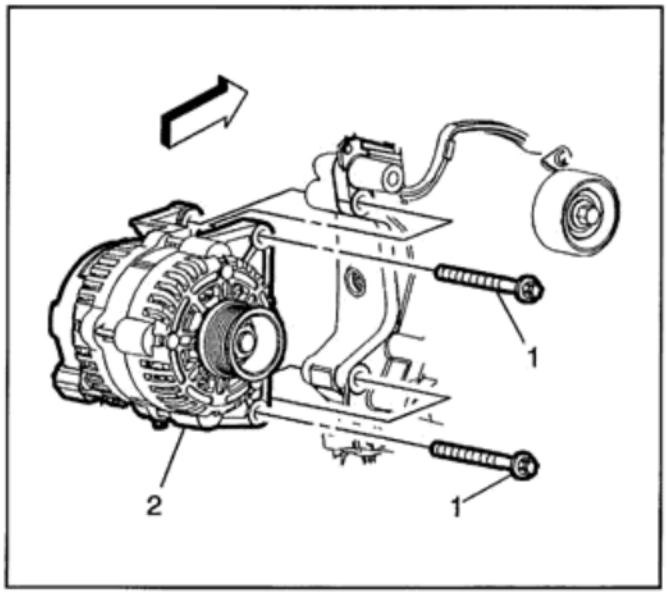
Removal Procedure

1. Disconnect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.
2. Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*.
3. Remove the drive belt. Refer to *Drive Belt Replacement on page 9-974*.



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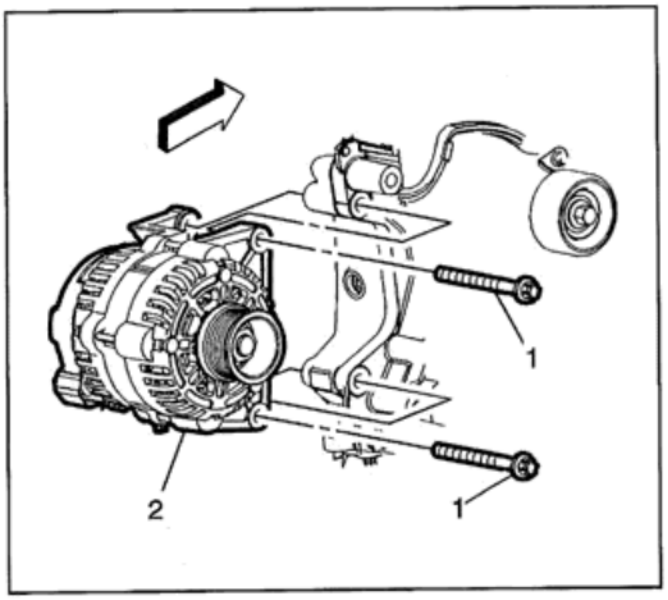
4. Remove the engine harness connector (1) and the battery positive cable generator fastener (2).
5. Remove the battery positive cable (3) from the back of the generator.



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6. Remove the generator mounting fasteners (1) and remove the generator (2) from the engine.

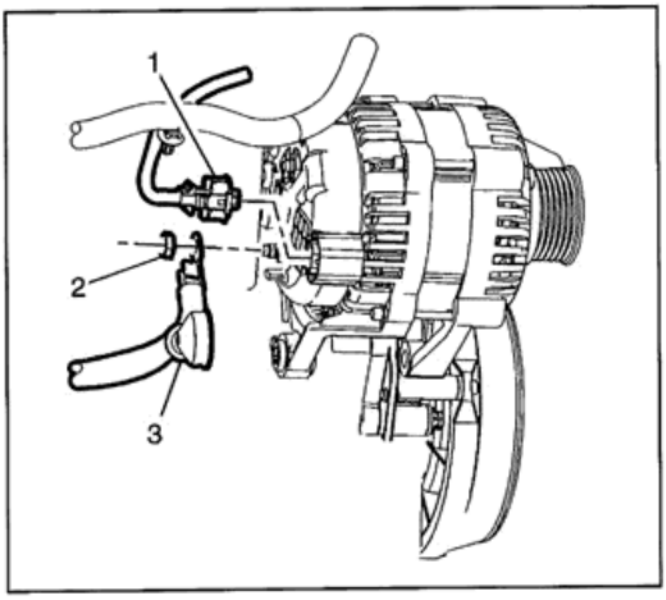
Installation Procedure



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Caution: Refer to *Fastener Caution on page 0-8*.

1. Install the generator (2) with the mounting fasteners (1) and tighten to **35 N•m (26 lb ft)**.



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2. Install the battery positive cable (3) and the engine harness connector (1) to the back of the generator. Tighten fastener (2) to **9 N•m (80 lb in)**.
3. Install the drive belt. Refer to *Drive Belt Replacement on page 9-974*.
4. Connect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.

Description and Operation

Battery Description and Operation

Warning: Batteries produce explosive gases, contain corrosive acid, and supply levels of electrical current high enough to cause burns. Therefore, to reduce the risk of personal injury when working near a battery:

- ***Always shield your eyes and avoid leaning over the battery whenever possible.***
- ***Do not expose the battery to open flames or sparks.***
- ***Do not allow the battery electrolyte to contact the eyes or the skin. Flush immediately and thoroughly any contacted areas with water and get medical help.***
- ***Follow each step of the jump starting procedure in order.***
- ***Treat both the booster and the discharged batteries carefully when using the jumper cables.***

Note: Because of the materials used in the manufacture of automotive lead acid batteries, dealers and service shops that handle them are subject to various regulations issued by OSHA, EPA, DOT, and various state or local agencies. Other regulations may also apply in other locations. Always know and follow these regulations when handling batteries.

Batteries that are no longer wanted must be disposed of by an approved battery recycler and must never be thrown in the trash or sent to a landfill.

Batteries that are not part of the vehicle itself, not the battery under the hood, must only be transported on public streets for business purposes via approved hazardous material transportation procedures.

Battery storage, charging and testing facilities in repair shops must meet various requirements for ventilation, safety equipment, material segregation, etc.

The maintenance free battery is standard. There are no vent plugs in the cover. The battery is completely sealed except for 2 small vent holes in the side. These vent holes allow the small amount of gas that is produced in the battery to escape.

The battery has 3 functions as a major source of energy:

- Engine cranking
- Voltage stabilizer
- Alternate source of energy with generator overload

Battery Low Start Vehicle Message

The body control module (BCM) monitors battery positive voltage to determine battery state of charge. If one or more of the BCM battery positive voltage terminals measure less than approximately 11.6V compared to the BCM ground circuits, this message will display and four chimes may sound. Start the vehicle immediately. If the vehicle is not started and the battery continues to discharge, the climate controls, heated seats, and audio systems will shut off and the vehicle may require a jump start. These systems will function again after the vehicle is started.

Battery Ratings

A battery has 2 ratings:

- Cold cranking amperage
- Amperage hours

When a battery is replaced use a battery with similar ratings. See battery specification label on the original battery.

Amperage Hours

The amperage hour rating tells you how much amperage is available when discharged evenly over a 20 hour period. The amperage hour rating is cumulative, so in order to know how many constant amperage the battery will output for 20 h, you have to divide the amperage hour rating by 20. Example: If a battery has an amperage hour rating of 74, dividing by 20 = 3.75. Such a battery can carry a 3.75 A load for 20 hours before dropping to 10.5 V. (10.5 V is the fully discharged level, at which point the battery needs to be recharged.) A battery with an amperage hour rating of 55 will carry a 2.75 A load for 20 hours before dropping to 10.5 V.

Cold Cranking Amperage

The cold cranking amperage is an indication of the ability of the battery to crank the engine at cold temperatures. The cold cranking amperage rating is the minimum amperage the battery must maintain for 30 seconds at −18°C (0°F) while maintaining at least 7.2 V. See battery label for the cold cranking amperage rating of this battery.

Charging System Description and Operation

Electrical Power Management Overview

The electrical power management system is designed to monitor and control the charging system and send diagnostic messages to alert the driver of possible problems with the battery and generator. This electrical power management system primarily utilizes existing on-board computer capability to maximize the effectiveness of the generator, to manage the load, improve battery state-of-charge and life, and minimize the system's impact on fuel economy. The electrical power management system performs 3 functions:

- It monitors the battery voltage and estimates the battery condition.
- It takes corrective actions by boosting idle speeds, and adjusting the regulated voltage.
- It performs diagnostics and driver notification.

The battery condition is estimated during ignition-off and during ignition-on. During ignition-off the state-of-charge of the battery is determined by measuring the open-circuit voltage. The state-of-charge is a function of the acid concentration and the internal resistance of the battery, and is estimated by reading the battery open circuit voltage when the battery has been at rest for several hours.

The state-of-charge can be used as a diagnostic tool to tell the customer or the dealer the condition of the battery. Throughout ignition-on, the algorithm continuously estimates state-of-charge based on adjusted net amp hours, battery capacity, initial state-of-charge, and temperature.

While running, the battery degree of discharge is primarily determined by a battery current sensor, which is integrated to obtain net amp hours.

In addition, the electrical power management function is designed to perform regulated voltage control to improve battery state-of-charge, battery life, and fuel economy. This is accomplished by using knowledge of the battery state-of-charge and temperature to set the charging voltage to an optimum battery voltage level for recharging without detriment to battery life.

The Charging System Description and Operation is divided into 3 sections. The first section describes the charging system components and their integration into the electrical power management. The second section describes charging system operation. The third section describes the instrument panel cluster operation of the charge indicator, driver information center messages, and voltmeter operation.

Charging System Components

Generator

The generator is a serviceable component. If there is a diagnosed failure of the generator it must be replaced as an assembly. The engine drive belt drives the generator. When the rotor is spun it induces an alternating current (AC) into the stator windings. The AC voltage is then sent through a series of diodes for rectification. The rectified voltage has been converted into a direct current (DC) for use by the vehicles electrical system to maintain electrical loads and the battery charge. The voltage regulator integral to the generator controls the output of the generator. It is not serviceable. The voltage regulator controls the amount of current provided to the rotor. If the generator has field control circuit failure, the generator defaults to an output voltage of 13.8 V.

Body Control Module (BCM)

The body control module (BCM) is a GMLAN device. It communicates with the engine control module (ECM) and the instrument panel cluster for electrical power management (electrical power management) operation.

The BCM determines the output of the generator and sends the information to the ECM for control of the generator turn on signal circuit. It monitors the generator field duty cycle signal circuit information sent from the ECM for control of the generator. It monitors a battery current sensor, the battery positive voltage circuit, and estimated battery temperature to determine battery state of charge. The BCM performs idle boost.

Battery Current Sensor

The battery current sensor is a serviceable component that is connected to the negative battery cable at the battery. The battery current sensor is a 3-wire hall effect current sensor. The battery current sensor monitors the battery current. It directly inputs to the BCM. It creates a 5-volt pulse width modulation (PWM) signal of 128 Hz with a duty cycle of 0–100 percent. Normal duty cycle is between 5–95 percent. Between 0–5 percent and 95–100 percent are for diagnostic purposes.

Engine Control Module (ECM)

When the engine is running, the generator turn-on signal is sent to the generator from the ECM, turning on the regulator. The generator's voltage regulator controls current to the rotor, thereby controlling the output voltage. The rotor current is proportional to the electrical pulse width supplied by the regulator. When the engine is started, the regulator senses generator rotation by detecting AC voltage at the stator through an internal wire. Once the engine is running, the regulator varies the field current by controlling the pulse width. This regulates the generator output voltage for proper battery charging and electrical system operation. The generator field duty terminal is connected internally to the voltage regulator and externally to the ECM. When the voltage regulator detects a charging system problem, it grounds this circuit to signal the ECM that a problem exists. The ECM monitors the generator field duty cycle signal circuit, and receives control decisions based on information from the BCM.

Instrument Panel Cluster

The instrument panel cluster provides the customer notification in case a concern with the charging system. There are 2 means of notification, a charge indicator and a driver information center message of SERVICE BATTERY CHARGING SYSTEM if equipped.

Charging System Operation

The purpose of the charging system is to maintain the battery charge and vehicle loads. There are 6 modes of operation and they include:

- Battery Sulfation Mode
- Charge Mode
- Fuel Economy Mode
- Headlamp Mode
- Start Up Mode
- Voltage Reduction Mode

The engine control module (ECM) controls the generator through the generator turn ON signal circuit. The ECM monitors the generator performance though the generator field duty cycle signal circuit. The signal is a pulse width modulation (PWM) signal of 128 Hz with a duty cycle of 0–100 percent. Normal duty cycle is between 5–95 percent. Between 0–5 percent and 95–100 percent are for diagnostic purposes. The following table shows the commanded duty cycle and output voltage of the generator:

Commanded Duty Cycle	Generator Output Voltage
10%	11 V
20%	11.56 V
30%	12.12 V
40%	12.68 V
50%	13.25 V
60%	13.81 V
70%	14.37 V
80%	14.94 V
90%	15.5 V

The generator provides a feedback signal of the generator voltage output through the generator field duty cycle signal circuit to the ECM. This information is sent to the body control module (BCM). The signal is PWM signal of 128 Hz with a duty cycle of 0–100 percent. Normal duty cycle is between 5–99 percent. Between 0–5 percent and 100 percent are for diagnostic purposes.

Battery Sulfation Mode

The BCM will enter this mode when the interpreted generator output voltage is less than 13.2 V for 45 minutes. When this condition exists the BCM will enter Charge Mode for 2–3 minutes. The BCM will then determine which mode to enter depending on voltage requirements.

Charge Mode

The BCM will enter Charge Mode when ever one of the following conditions are met.

- The wipers are ON for more than 3 seconds.
- GMLAN (Climate Control Voltage Boost Mode Request) is true, as sensed by the HVAC control head. High speed cooling fan, rear defogger and HVAC high speed blower operation can cause the BCM to enter the Charge Mode.
- The estimated battery temperature is less than 0° C (32°F).
- Battery State of Charge is less than 80 percent.
- Vehicle speed is greater than 145 km/h (90 mph)
- Current sensor fault exists.
- System voltage was determined to be below 12.56 V

When any one of these conditions is met, the system will set targeted generator output voltage to a charging voltage between 13.9–15.5 V, depending on the battery state of charge and estimated battery temperature.

Fuel Economy Mode

The BCM will enter Fuel Economy Mode when the estimated battery temperature is at least 0°C (32°F) but less than or equal to 80°C (176°F), the calculated battery current is less than 15 amperes and greater than −8 amperes, and the battery state-of-charge is greater than or equal to 80 percent. Its targeted generator output voltage is the open circuit voltage of the battery and can be between 12.5–13.1 V. The BCM will exit this mode and enter Charge Mode when any of the conditions described above are present.

Headlamp Mode

The BCM will enter Headlamp Mode when ever the headlamps are ON (high or low beams). Voltage will be regulated between 13.9–14.5 V.

Start Up Mode

When the engine is started the BCM sets a targeted generator output voltage of 14.5 V for 30 seconds.

Voltage Reduction Mode

The BCM will enter Voltage Reduction Mode when the calculated ambient air temperature is above 0°C (32° F). The calculated battery current is less than 1 ampere and greater than −7 amperes, and the generator field duty cycle is less than 99 percent. Its targeted generator output voltage is 12.9 V. The BCM will exit this mode once the criteria are met for Charge Mode.

Instrument Panel Cluster Operation

Charge Indicator Operation

The instrument panel cluster illuminates the charge indicator and displays a warning message in the driver information center if equipped, when the one or more of the following occurs:

- The engine control module (ECM) detects that the generator output is less than 11 V or greater than 16 V. The instrument panel cluster receives a GMLAN message from the ECM requesting illumination.
- The instrument panel cluster determines that the system voltage is less than 11 V or greater than 16 V for more than 30 seconds. The instrument panel cluster receives a GMLAN message from the body control module (BCM) indicating there is a system voltage range concern.
- The instrument panel cluster performs the displays test at the start of each ignition cycle. The indicator illuminates for approximately 3 seconds.

Display Message: BATTERY NOT CHARGING SERVICE CHARGING SYSTEM or SERVICE BATTERY CHARGING SYSTEM

The BCM and the ECM will send a serial data message to the driver information center for the BATTERY NOT CHARGING SERVICE CHARGING SYSTEM or SERVICE BATTERY CHARGING SYSTEM message to be displayed. It is commanded ON when a charging system DTC is a current DTC. The message is turned OFF when the conditions for clearing the DTC have been met.

Electrical Power Management Description and Operation

Electrical Power Management

The electrical power management is used to monitor and control the charging system and alert the driver of possible problems within the charging system. The electrical power management system makes the most efficient use of the generator output, improves the battery state-of-charge, extends battery life, and manages system electrical loads.

The load shed operation is a means of reducing electrical loads during a low voltage or low battery state-of-charge condition.

The idle boost operation is a means of improving generator performance during a low voltage or low battery state-of-charge condition.

Each electrical power management function, either idle boost or load shed, is discrete. No two functions are active at the same time. Idle boost is activated in incremental steps, idle boost 1 must be active before idle boost 2 can be active. The criteria used by the body control module (BCM) to regulate electrical power management are outlined below:

Function	Battery Temperature Calculation	Battery Voltage Calculation	Amp-Hour Calculation	Action Taken
Idle Boost 1 Start	Less Than −15°C (5°F)	Less Than 13 V	—	First level Idle boost requested
Idle Boost 1 Start	—	—	Battery has a net loss greater than 0.6 AH	First level Idle boost requested
Idle Boost 1 Start	—	Less Than 10.9 V	—	First level Idle boost requested
Idle Boost 1 End	Greater Than −15°C (5°F)	Greater Than −12 V	Battery has a net loss less than 0.2 AH	First level Idle boost request cancelled
Load Shed 1 Start	—	—	Battery has a net loss of 4 AH	Rear Defrost, Heated Mirrors, Heated Seats cycled OFF for 20% of their cycle
Load Shed 1 Start	—	Less Than 10.9 V	—	Rear Defrost, Heated Mirrors, Heated Seats cycled OFF for 20% of their cycle

Function	Battery Temperature Calculation	Battery Voltage Calculation	Amp-Hour Calculation	Action Taken
Load Shed 1 End	—	Greater Than 12 V	Battery has a net loss of less than 2 AH	Clear Load Shed 1
Idle Boost 2 Start	—	—	Battery has a net loss greater than 1.6 AH	Second level Idle boost requested
Idle Boost 2 Start	—	Less Than 10.9 V	—	Second level Idle boost requested
Idle Boost 2 End	—	Greater Than 12 V	Battery has a net loss less than 0.8 AH	Second level Idle boost request cancelled
Idle Boost 3 Start	—	—	Battery has a net loss of 10 AH	Third level Idle boost requested
Idle Boost 3 Start	—	Less Than 10.9 V	—	Third level Idle boost requested
Idle Boost 3 End	—	Greater Than 12 V	Battery has a net loss of less than 6.0 AH	Third level Idle boost request cancelled
Load Shed 2 Start	—	Less Than 10 V	Battery has a net loss greater than 12 AH	Rear Defrost, Heated Mirrors, Heated Seats cycled OFF for 50% of their cycle. The BATTERY SAVER ACTIVE message will be displayed on the DIC
Load Shed 2 Start	—	Less Than 10.9 V	—	Rear Defrost, Heated Mirrors, Heated Seats cycled OFF for 50% of their cycle. The BATTERY SAVER ACTIVE message will be displayed on the DIC
Load Shed 2 End	—	Greater Than 12.6 V	Battery has a net loss of less than 10.5 AH	Clear Load Shed 2
Load Shed 3 Start	—	Less Than 11.9 V	Battery has a net loss greater than 20 AH	Rear Defrost, Heated Mirrors, Heated Seats cycled OFF for 100% of their cycle. The BATTERY SAVER ACTIVE message will be displayed on the DIC
Load Shed 3 End	—	Greater Than 12.6 V	Battery has a net loss of less than 15 AH	Clear Load Shed 3

Starting System Description and Operation

The starter motors are non-repairable starter motors. They have pole pieces that are arranged around the armature. Both solenoid windings are energized. The pull-in winding circuit is completed to the ground through the starter motor. The windings work together magnetically to pull and hold in the plunger. The plunger moves the shift lever. This action causes the starter drive assembly to rotate on the armature shaft spline as it engages with the flywheel ring gear on the engine. Moving at the same time, the plunger also closes the solenoid switch contacts in the starter solenoid. Full battery voltage is applied directly to the starter motor and it cranks the engine.

As soon as the solenoid switch contacts close, current stops flowing thorough the pull-in winding because battery voltage is applied to both ends of the windings. The hold-in winding remains energized. Its magnetic field is strong enough to hold the plunger, shift lever, starter drive assembly, and solenoid switch contacts in place to continue cranking the engine. When the engine starts, pinion overrun protects the armature from excessive speed until the switch is opened.

When the ignition switch is released from the START position, the START relay opens and battery voltage is removed from the starter solenoid S terminal. Current flows from the motor contacts through both windings to the ground at the end of the hold-in winding. However, the direction of the current flow through the pull-in winding is now opposite the direction of the current flow when the winding was first energized.

The magnetic fields of the pull-in and hold-in windings now oppose one another. This action of the windings, along with the help of the return spring, causes the starter drive assembly to disengage and the solenoid switch contacts to open simultaneously. As soon as the contacts open, the starter circuit is turned off.

Circuit Description (Key Start)

When the ignition switch is placed in the Start position, a discrete signal is supplied to the body control module (BCM) notifying it that the ignition is in the Start position. The BCM then sends a message to the engine control module (ECM) notifying it that CRANK has been requested. The ECM verifies that the transmission is in Park or Neutral. If it is, the ECM then supplies 12 V to the control circuit of the crank relay. When this occurs, battery positive voltage is supplied through the switch side of the crank relay to the S terminal of the starter solenoid.

Special Tools and Equipment

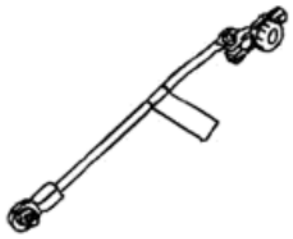
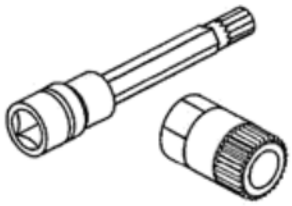
Illustration	Tool Number/Description
 3432	EL 38758 EL 50074 J 38758 Parasitic Draw Test Switch

Illustration	Tool Number/Description
 404758  2239959	EL 50313 EL 42000 EL 50076 J 42000 Battery Tester
 2359517	EN-6372 KM-6372 Counterhold