

ELECTRICAL

12 V Starting and Charging - CTS Sedan

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Battery Hold Down Bracket Bolt	9 N.m	80 lb in
Battery Negative Cable Extension Cable Bolt (Body Ground)	11 N.m	97 lb in
Battery Negative Cable Extension Cable Bolt (Engine Block)	22 N.m	16 lb ft
Battery Negative Cable Clamp Nut	7 N.m	62 lb in
Battery Negative Cable Ground Bolt (Battery)	22 N.m	16 lb ft
Battery Negative Cable Ground Bolt (Engine Block - LTG)	45 N.m	33 lb ft
Battery Positive Cable Clamp Nut	7 N.m	62 lb in
Battery Positive Cable Nut (at battery fuse block)	12 N.m	106 lb in
Battery Positive Cable Nut (at junction block)	12 N.m	106 lb in
Battery Positive Cable Nut (at the starter)	13 N.m	115 lb in
Body Harness Terminal to Battery Negative Clamp Bolt	7 N.m	62 lb in
Generator BAT Terminal Nut	22 N.m	16 lb ft
Generator Mounting Bolt (LFX)	58 N.m	43 lb ft
Generator Mounting Bolt (LTG)	22 N.m	16 lb ft
Starter Motor Mounting Bolt (LFX)	58 N.m	43 lb ft
Starter Motor Mounting Bolt (LTG)	22 N.m	16 lb ft
Starter Solenoid B + Nut	10 N.m	89 lb in

SCHEMATIC WIRING DIAGRAMS

STARTING AND CHARGING WIRING SCHEMATICS

Starting System

Charging System

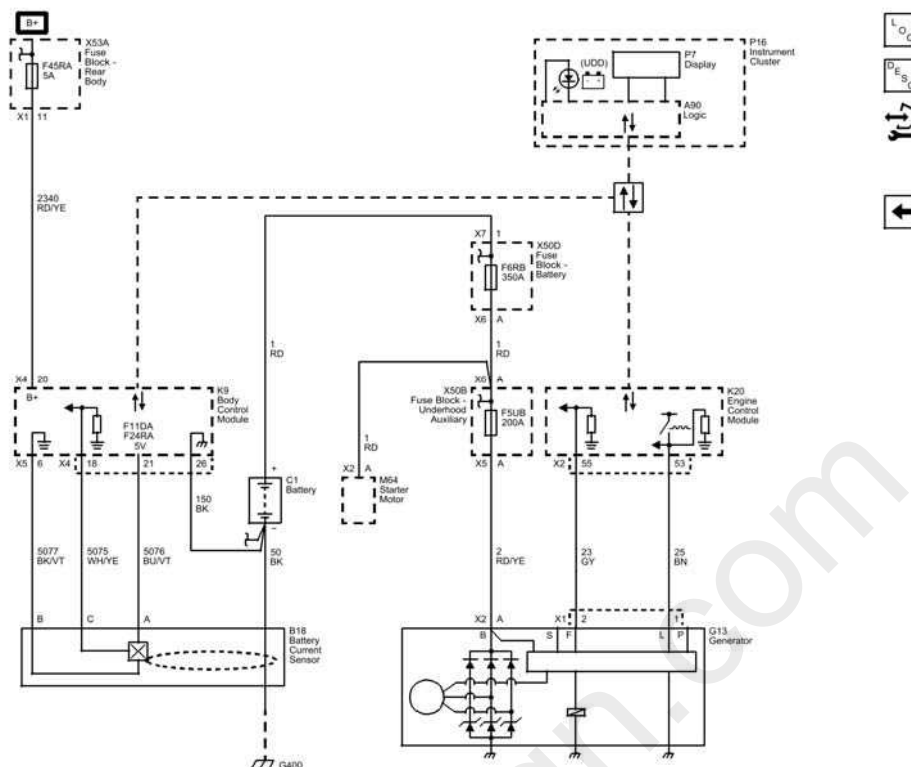


Fig. 2: NO CONTENT

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DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC CODE INDEX

DIAGNOSTIC CODE INDEX

DTC	Description
DTC B1325	Device Power Circuit Voltage
DTC B1327	Device Voltage Circuit
DTC B1328	Device Voltage Circuit
DTC B1330	Device Power 2 Circuit
DTC B1390	Control Module Supply Circuit 1
DTC B1395	Control Module Voltage Reference Output 1
DTC B1400	Control Module Supply Circuit 2
DTC B1410	Control Module Supply Circuit 3
DTC B1415	Control Module Voltage Reference Output 3
DTC B1424	Control Module Power Circuit
DTC B1425	Control Module Power Circuit
DTC B1439	Intermittent Device Voltage

<u>DTC B1325, B1327, B1328, B1330, B1390, B1400, B1410, B1517, C0800, C0805, C0895, C0899, C0900, P0560, P0562, P0563, P129B, or P129C</u>	DTC B1517 Battery Voltage DTC C0800 Device Power 1 Circuit Voltage DTC C0805 Control Module Power 2 Circuit DTC C0870 Control Module Voltage Reference DTC C0895 Device Voltage DTC C0899 Device Voltage DTC C0900 Device Voltage DTC P0560 System Voltage Low DTC P0561 System Voltage Performance DTC P0562 System Voltage Low DTC P0563 System Voltage High DTC P0611 Fuel Injector Control Module Performance DTC P129B System Voltage Low DTC P129C System Voltage High DTC P15AE Fuel Injector Control Module System Voltage Low Voltage DTC P15AF Fuel Injector Control Module System Voltage High Voltage
<u>DTC B1516</u>	DTC B1516 08 Battery Current Sensor Signal Invalid DTC B1516 66 Battery Current Sensor Incorrect Mounting
<u>DTC B151A</u>	DTC B151A 58 Battery Capacity Performance
<u>DTC B1527</u>	DTC B1527 00 Parasitic Load
<u>DTC P0615, P0616, or P0617</u>	DTC P0615 Starter Relay Control Circuit DTC P0616 Starter Relay Control Circuit Low Voltage DTC P0617 Starter Relay Control Circuit High Voltage
<u>DTC P0621</u>	DTC P0621 Generator L-Terminal Circuit
<u>DTC P0622</u>	DTC P0622 Generator F-Terminal Circuit
<u>DTC P0625 or P0626</u>	DTC P0625 Generator F-Terminal Circuit Low Voltage DTC P0626 Generator F-Terminal Circuit High Voltage

DTC B1325, B1327, B1328, B1330, B1390, B1400, B1410, B1517, C0800, C0805, C0895, C0899, C0900, P0560, P0562, P0563, P129B, OR P129C: DEVICE POWER CIRCUIT VOLTAGE/CONTROL MODULE SUPPLY/BATTERY VOLTAGE

Diagnostic Instructions

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

DTC Descriptors

DTC B1325

Device Power Circuit Voltage

DTC B1327

Device Voltage Circuit

DTC B1328

Device Voltage Circuit

DTC B1330

Device Power 2 Circuit

DTC B1390

Control Module Supply Circuit 1

DTC B1395

Control Module Voltage Reference Output 1

DTC B1400

Control Module Supply Circuit 2

DTC B1410

Control Module Supply Circuit 3

DTC B1415

Control Module Voltage Reference Output 3

DTC B1424

Control Module Power Circuit

DTC B1425

Control Module Power Circuit

DTC B1439

Intermittent Device Voltage

DTC B1517

Battery Voltage

DTC C0800

Device Power 1 Circuit Voltage

DTC C0805

Control Module Power 2 Circuit

DTC C0870

Control Module Voltage Reference

DTC C0895

Device Voltage

DTC C0899

Device Voltage

DTC C0900

Device Voltage

DTC P0560

System Voltage Low

DTC P0561

System Voltage Performance

DTC P0562

System Voltage Low

DTC P0563

System Voltage High

DTC P0611

Fuel Injector Control Module Performance

DTC P129B

System Voltage Low

DTC P129C

System Voltage High

DTC P15AE

Fuel Injector Control Module System Voltage Low Voltage

DTC P15AF

Fuel Injector Control Module System Voltage High Voltage

For symptom byte information refer to **Symptom Byte List**.

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 s.

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

Connector End View Reference

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Description and Operation

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- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition OFF, measure and record the battery voltage at the battery terminals.
2. Verify the battery voltage stabilizes between 12.4 and 12.8 V within a few minutes of turning the ignition OFF.
 - **If battery voltage is less than 12.4 V or more than 12.8 V**

Refer to Battery Inspection/Test.

- **If battery voltage is between 12.4 and 12.8 V**
3. Engine running, headlights ON, measure and record the battery voltage at the battery terminals.
4. Verify the voltage is at least 1 V greater than the voltage measured in step 1, but less than 15 V.
 - **If the voltage is not at least 1 V greater than the voltage measured in step 1 or is greater than 15 V.**

Refer to Charging System Test.

- **If the voltage is at least 1 V greater than the voltage measured in step 1, but less than 15 V.**
- 5. Verify the appropriate control module scan tool battery voltage and ignition voltage parameters are within 1 V of the battery voltage.

- **If not within 1 V of the battery voltage**

Refer to Circuit/System Testing.

- **If within 1 V of the battery voltage**

- 6. All OK.

Circuit/System Testing

NOTE: Use the schematic to identify the following:

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

NOTE: Some control module ground circuits may require up to 20 min after the ignition is turned off before achieving a resistance reading of less than 5 ohms. In most cases the readings will drop below 20 ohms within 1 min indicating the control module is going to sleep.

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connectors at the appropriate control module. It may take up to 2 min for all vehicle systems to power down.
2. Test for less than 10 ohms between each ground circuit terminal and ground.
 - **If 10 ohms or greater**
 1. Ignition OFF.
 2. Test for less than 2 ohms in the ground circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, repair the open/high resistance in the ground connection.
 - **If less than 10 ohms**
3. If equipped, verify a test lamp illuminates between each B+ circuit terminal and ground.
 - **If the test lamp does not illuminate and the circuit fuse is good**
 1. Ignition OFF.
 2. Test for less than 2 ohms in the B+ circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, 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. Ignition OFF.
 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, replace the appropriate control module.
 - **If the test lamp illuminates**
4. Ignition ON.
 5. If equipped, verify a test lamp illuminates between each ignition circuit terminal and ground.
 - **If the test lamp does not illuminate and the circuit fuse is good**
 1. Ignition OFF.
 2. Test for less than 2 ohms in the ignition circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, 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. Ignition OFF.
 2. Test for infinite resistance between the ignition circuit and ground.
 - If less than infinite resistance, repair the short to ground on the circuit.
 - If infinite resistance, replace the appropriate control module.
 - **If the test lamp illuminates**
 6. Replace the control module.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Control Module References for control module replacement, programming and setup.

DTC B1516: BATTERY CURRENT SENSOR

Diagnostic Instructions

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

DTC Descriptors

DTC B1516 08

Battery Current Sensor Signal Invalid

DTC B1516 66

Battery Current Sensor Incorrect Mounting

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 B18 Battery Current Sensor is a 3-wire hall effect current sensor. The body control module (BCM) supplies 5 V and ground to the B18 Battery Current Sensor. The B18 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 % or greater than 96 % duty cycle for 2 min.

B1516 66

The battery current polarity is positive for 2 min.

Action Taken When the DTC Sets

The regulated voltage control is disabled.

Conditions for Clearing the DTC

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

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

Connector End View Reference

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- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Testing

B1516 08

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B18 Battery Current Sensor. It may take up to 2 min for all vehicle systems to power down.
2. Test for less than 10 ohms between the low reference circuit terminal B and ground.
 - **If 10 ohms or greater**
 1. Ignition OFF, disconnect the X5 harness connector at the K9 Body Control Module.
 2. Test for less than 2 ohms in the low reference circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, replace the K9 Body Control Module.
 - **If less than 10 ohms**
3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal A and ground.
 - **If less than 4.8 V**
 1. Ignition OFF, disconnect the X4 harness connector at the K9 Body Control Module.
 2. Test for infinite resistance between the 5 V reference circuit and ground.
 - If less than infinite resistance, repair the short to ground on the circuit.
 - If infinite resistance

3. Test for less than 2 ohms in the 5V reference circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, replace the K9 Body Control Module.
 - **If greater than 5.2 V**
1. Ignition OFF, disconnect the X4 harness connector at the K9 Body Control Module, ignition ON.
2. Test for less than 1 V between the 5 V reference circuit and ground.
 - If 1 V or greater, repair the short to voltage on the circuit.
 - If less than 1 V, replace the K9 Body Control Module.
 - **If between 4.8-5.2 V**
5. Test for 4.8-5.2 V between the signal circuit terminal C and ground.
 - **If less than 4.8 V**
 - 1. Ignition OFF, disconnect the X4 harness connector at the K9 Body Control Module.
 - 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
 - 3. Test for less than 2 ohms in the signal circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, replace the K9 Body Control Module.
 - **If greater than 5.2 V**
 - 1. Ignition OFF, disconnect the X4 harness connector at the K9 Body Control Module, ignition ON.
 - 2. Test for less than 1 V between the signal circuit and ground.
 - If 1 V or greater, repair the short to voltage on the circuit.
 - If less than 1 V, replace the K9 Body Control Module.
 - **If between 4.8-5.2 V**
6. 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 B18 Battery Current Sensor properly.
 - **If the B18 Battery Current Sensor is installed correctly**
2. Replace the B18 Battery Current Sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- **Battery Negative Cable Replacement**
- **Control Module References** for K9 Body Control Module replacement, programming and setup.

DTC B151A: BATTERY CAPACITY PERFORMANCE

Diagnostic Instructions

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

DTC Descriptor

DTC B151A 58

Battery Capacity Performance

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 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

Connector End View Reference

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- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Verify DTC P0621 or P0622 is not set.
 - **If DTC P0621 or P0622 is set**

Refer to **DTC P0621**, or **DTC P0622**

- **If DTC P0621 or P0622 is not set**
2. Perform the **Battery Inspection/Test**.

DTC B1527: PARASITIC LOAD

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **Diagnostic Procedure Instructions** 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% 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

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- **Wiring Repairs**

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

Refer to **Battery Electrical Drain/Parasitic Load Test**.

DTC P0615, P0616, OR P0617: STARTER RELAY CONTROL CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **Diagnostic Procedure Instructions** 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
Relay Switch B+ Terminal 30	1	2	-	-
Relay Coil Ignition Terminal 85	P0616	P0615	P0617	-
Relay Switch Control Terminal 87	2	2	3	-
Relay Coil Ground Terminal 86	-	P0615	-	-
1. Opens fuse, Starter Solenoid does not click. 2. Starter Solenoid does not click. 3. Cranks all the time.				

Circuit/System Description

When the ignition is activated to start the vehicle, a discrete signal is supplied to the body control module (BCM). 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 pressed 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 solenoid.

Conditions for Running the DTC

- The ignition is activated to START.
- 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.

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References 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 min for all vehicle systems to power down.
2. Test for less than 10 ohms between the ground circuit terminal 86 and ground.

- **If 10 ohms or greater**
 1. Ignition OFF.
 2. Test for less than 2 ohms in the ground circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, repair the open/high resistance in the ground connection.
 - **If less than 10 ohms**
 - 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**
 1. Ignition OFF.
 2. Test for less than 2 ohms in the B+ circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, 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**
 1. Ignition OFF.
 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,
 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 M64 Starter Motor.
 - **If the test lamp illuminates**
5. Connect a test lamp between the control circuit terminal 85 and the ground circuit terminal 86.

NOTE: If the Starter Relay command is not available in the scan tool, verify the test lamps turns on and off when cycling the ignition between the OFF and CRANK position with the parking brake set and clutch pedal pressed (manual transmission) or the transmission in park (automatic transmission).

6. Verify the test lamp turns ON and OFF when commanding the Starter Relay ON and OFF with a scan tool.
 - **If the test lamp is always OFF**
 1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
 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. Test for less than 2 ohms in the control circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.

- If less than 2 ohms, replace the K20 Engine Control Module.
- **If the test lamp is always ON**
 1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
 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**
 1. Ignition OFF, disconnect the harness connector at the M64 Starter Motor.
 2. Test for infinite resistance between the control circuit terminal X1 A or X1 1 and ground..
 - If less than infinite resistance, repair the short to ground on the circuit.
 - If infinite resistance
 3. Test for less than 2 ohms in the control circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, 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 ohms between terminals 85 and 86.
 - **If less than 60 or greater than 180 ohms**

Replace the relay.

 - **If between 60-180 ohms**
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 ohms between terminals 30 and 87.

- **If 2 ohms or greater**

Replace the relay.

- **If less than 2 ohms**

6. All OK

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- **Relay Replacement (Within an Electrical Center)** , **Relay Replacement (Attached to Wire Harness)**
- **Control Module References** for ECM replacement, programming, and setup.

DTC P0621: GENERATOR L-TERMINAL CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **Diagnostic Procedure Instructions** 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+	-	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 on the generator turn on control circuit, a high voltage when the duty cycle voltage is commanded high, and a low voltage when the duty cycle voltage is commanded low.

Conditions for Running the DTC

- Ignition ON, engine OFF (Prior to Ignition ON, the ignition must have been OFF for at least 5 s).
- 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 s.
- Engine running - The ECM detects a low voltage for 15 s on the generator control circuit when the duty cycle voltage is commanded high.
- Engine running - The ECM detects a high voltage for 15 s 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

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Connector End View Reference

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References 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, B X2 or 1 X2, and ground.
 - **If the test lamp does not illuminate and the circuit fuse is good**
 1. Remove the test lamp and disconnect the B+ cable at the G13 Generator.
 2. Test for less than 2 ohms in the B+ circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, 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. Remove the test lamp, disconnect the battery negative cable, and disconnect the G13 Generator B+ cable.
 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 1 V or greater between the control circuit terminal 1 X1 and ground.
 - **If less than 1 V**
 1. Ignition OFF, disconnect the harness connectors at the K20 Engine Control Module.
 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. Test for less than 2 ohms in the control circuit end to end.
 - If greater than 2 ohms, repair the open/high resistance in the circuit.
 - If less than 2 ohms, replace the K20 Engine Control Module.
 - **If 1V or greater**
- 4. Ignition OFF, disconnect the harness connectors at the K20 Engine Control Module, Ignition ON.
- 5. Test for less than 1 V between the G13 Generator control circuit terminal 1 X1 and ground.
 - **If greater than 1 V**

Repair the short to voltage on the circuit.

- **If 1V or less**
- 6. Test or replace the G13 Generator.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- **Generator Replacement (LFX)**, **Generator Replacement (LTG)**, **Generator Replacement (LF3)**
- **Control Module References** for engine control module replacement, programming, and setup

DTC P0622: GENERATOR F-TERMINAL CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **Diagnostic Procedure Instructions** 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+	-	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 s)
- 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 s), the ECM detects a PWM signal that is greater than 65% for 5 s
- Engine running at less than 3,000 RPM-The ECM detects a PWM signal that is less than 5% for 30 s

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

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX - SEDAN

Description and Operation

Charging System Description and Operation

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References 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, B X2 or 1 X2, and

ground.

- **If the test lamp does not illuminate and the circuit fuse is good**
 1. Remove the test lamp and disconnect the B+ cable at the G13 Generator.
 2. Test for less than 2 ohms in the B+ circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, 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. Remove the test lamp, disconnect the battery negative cable, and disconnect the G13 Generator B+ cable.
 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, engine running.
 3. Verify the scan tool Engine Control Module Generator F-Terminal Signal parameter is less than 5%.
 - **If 5% or greater**
 1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
 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**
 1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
 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
 3. Test for less than 2 ohms in the signal circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit
 - If less than 2 ohms, replace the K20 Engine Control Module.
 - **If greater than 95%**
 6. Test or replace the G13 Generator.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- **Generator Replacement (LFX), Generator Replacement (LTG), Generator Replacement (LF3)**

- **Control Module References** for engine control module replacement, programming, and setup

DTC P0625 OR P0626: GENERATOR F-TERMINAL CIRCUIT VOLTAGE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **Diagnostic Procedure Instructions** 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	-	-
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 PWM signal less than 5% for 15 s.

P0626

The ECM detects a PWM signal greater than 65% for 15 s.

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

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX - SEDAN

Description and Operation

Charging System Description and Operation

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References 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, B X2 or 1 X2, and ground.
 - **If the test lamp does not illuminate and the circuit fuse is good**
 1. Disconnect the B+ cable at the G13 Generator.
 2. Test for less than 2 ohms in the B+ circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, 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. 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
 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**
 1. Ignition ON.
 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**
 1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
 2. Test for less than 2 ohms in the signal circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms
 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** after completing the repair.

- **Generator Replacement (LFX), Generator Replacement (LTG), Generator Replacement (LF3)**
- **Control Module References** 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** 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**
 - **Charging System Description and Operation**
 - **Electrical Power Management Description and Operation**
 - **Starting System Description and Operation**

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the starting and charging systems. Refer to **Checking Aftermarket Accessories**.
- 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** .

Symptom List

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

- **Battery Inspection/Test**
- **Battery Electrical Drain/Parasitic Load Test**
- **Charging System Test**
- **Generator Noise Diagnosis**
- **Starter Solenoid Does Not Click**
- **Starter Solenoid Clicks, Engine Does Not Crank**
- **Engine Cranks Slowly**
- **Starter Noise Diagnosis**

BATTERY INSPECTION/TEST

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **Diagnostic Procedure Instructions** 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

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX - SEDAN

Description and Operation

Starting System Description and Operation

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL 50313 Battery Tester

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 should be allowed to time out or be disabled (simply opening the driver door should disable retained accessory power) before disconnecting power. Disconnecting power to the OnStar® module in any way while the ignition is On or with retained accessory power activated may cause activation of the OnStar® Back-Up Battery 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 back-up battery is not rechargeable and once activated the back-up battery must be replaced.

1. Verify the C1 or C1B 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 or C1B Battery.
 - **If there is no damage**
2. Verify the cold cranking amperage and amperage hour rating of the C1 or C1B Battery. Refer to the manufacturer specifications on the battery label.
 - **If the C1 or C1B Battery does not meet specifications**

Replace the C1 or C1B Battery.
 - **If the C1 or C1B 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**.

- **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** after completing the repair.

Battery Replacement

BATTERY CHARGING

12 V Battery

The following procedure is for the 12 V battery only.

Special Tools

EL 50313 Midtronics GR8 Battery Tester Charger

For equivalent regional tools, refer to **Special Tools**.

Diagnostic Aids

NOTE: This vehicle is equipped with an Absorbent Glass Matt Battery. This type of battery requires different charging and testing parameters than the more common regular flooded lead acid type battery. ANY time you perform charging and or testing you MUST set up the charging/testing equipment or permanent damage to the battery may result.

- 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.
- The maximum permissible voltage is 14.8 V (at room temperature) for the absorbent glass mat battery equipped on this vehicle.

Battery State of Charge

NOTE: Using voltage to determine the battery's 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 .

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

Torque the battery side terminal adapters to 15 (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**.

BATTERY ELECTRICAL DRAIN/PARASITIC LOAD TEST

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

- Perform **Diagnostic System Check - Vehicle** 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**
 - **Charging System Description and Operation**
 - **Electrical Power Management Description and Operation**
 - **Starting System Description and Operation**

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the starting and charging systems. Refer to **Checking Aftermarket Accessories** .
- 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** .

Symptom List

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

- **Battery Inspection/Test**
- **Battery Electrical Drain/Parasitic Load Test**
- **Charging System Test**
- **Generator Noise Diagnosis**
- **Starter Solenoid Does Not Click**

- **Starter Solenoid Clicks, Engine Does Not Crank**
- **Engine Cranks Slowly**
- **Starter Noise Diagnosis**

CHARGING SYSTEM TEST

Diagnostic Instructions

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

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
B+	-	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

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX - SEDAN

Description and Operation

Charging System Description and Operation

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

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** .

- **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**.

- **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 s 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 ohms between the G13 Generator housing and C1 Battery negative terminal.
 - **If 6.5 ohms or greater**

Repair the open/high resistance in the circuit.
 - **If less than 6.4 ohms**
3. Verify a test lamp illuminates between the G13 Generator B+ circuit terminal A X2, B X2 or 1 X2 and ground.
 - **If the test lamp does not illuminate and the circuit fuse is good**
 1. Remove the test lamp and disconnect the B+ cable at the G13 Generator.
 2. Test for less than 2 ohms in the B+ circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, 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. Remove the test lamp, disconnect the C1 Battery negative cable, and disconnect the G13 Generator B+ cable.
 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**
4. Test or replace the G13 Generator.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Generator Replacement (LFX), Generator Replacement (LTG), Generator Replacement (LF3)

GENERATOR NOISE DIAGNOSIS

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **Diagnostic Procedure Instructions** 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 incorrectly routed or be the cause of noise being transmitted into the passenger compartment.
4. Ignition OFF, remove the engine drive belt.
5. 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.

- **If all belt driven components spin freely**

6. Start the engine. Operate the engine for no longer than 30-40 seconds.
7. Verify that the noise is no longer present.

- **If the noise is still present**

The generator is not the cause of the noise. Refer to **Symptoms - Engine Mechanical** , for 2.0L (LTG) or 2.5L (LCV) engines or **Symptoms - Engine Mechanical** for 3.6L (LFX) engine.

- **If noise is no longer present**

8. Inspect for worn accessory drive components or abnormalities such as severe cracking, bumps, or missing areas in the accessory drive belt and/or misalignment of system components

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

- **Drive Belt Replacement** for the 2.0L (LTG) or 2.5L (LCV) engines
- **Drive Belt Tensioner Replacement** for the 2.0L (LTG) or 2.5L (LCV) engines
- **Drive Belt Replacement (LFX)** , **Drive Belt Replacement (LF3)** for the 3.6L (LFX) engine
- **Drive Belt Tensioner Replacement (LFX)** , **Drive Belt Tensioner Replacement (LF3)** for the 3.6L (LFX) engine
- **Generator Replacement (LFX)**, **Generator Replacement (LTG)**, **Generator Replacement (LF3)**

STARTER SOLENOID DOES NOT CLICK

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **Diagnostic Procedure Instructions** 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	-	-
Signal	2	1	-	-
Relay Coil Control Terminal 85	-	1	3	-
Starter Control Terminal 87	1	1	3	-
Ground	-	1	-	-
1. Starter solenoid does not click 2. Cranks in any gear 3. Cranks all the time				

Circuit/System Description

When the ignition mode 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 serial data message to the engine control module (ECM) that crank has been requested. The ECM then verifies that the clutch is fully depressed or the automatic 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.

Reference Information

Schematic Reference

- **Starting and Charging Schematics**
- **Automatic Transmission Controls Schematics** for the Automatic Transmissions - 6L45/6L50/6L80/6L90

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX - SEDAN

Description and Operation

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Electrical Information Reference

- **Circuit Testing**

- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

Automatic Transmission

1. Ignition ON.
2. Verify that no ignition, KR27 Starter Relay, brake pedal position sensor, immobilizer, or transmission DTCs are set that would cause the ECM to disable engine starting.
 - **If DTCs are set**
 Refer to **Diagnostic Trouble Code (DTC) List - Vehicle**
 - **If no DTCs are set**
3. Verify the scan tool 5 V Ignition Switch parameter is Crank Request while attempting to start the vehicle.
 - **If parameter does not display Crank Request**
 Refer to **Vehicle Will Not Change Power Mode**
 - **If parameter displays Crank Request**
4. Verify the scan tool TCM Internal Mode Switch parameter displays Park when in park.
 - **If the TCM Internal Mode Switch parameter does not indicate Park .**
 Refer to **Transmission Internal Mode Switch Logic**
 - **If the TCM Internal Mode Switch parameter displays Park**
5. Verify the scan tool ECM Crankshaft Position Active Counter parameter is not incrementing.
 - **If the counter increments**
 Replace the B26 Crankshaft Position Sensor.
 - **If the counter does not increment**
6. Verify the engine cranks in park or neutral.
 - **If the KR27 Starter Relay does not click or the engine does not crank**
 Refer to Circuit/System Testing.
 - **If the engine cranks**

7. All OK

Circuit/System Testing

1. Ignition ON.
2. Verify the scan tool ECM Ignition 1 Signal parameter is greater than 10 V.
 - **If 10 V or less**
 1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
 2. Test for infinite resistance between the ignition voltage circuits and ground.
 - If less than infinite resistance, repair the short to ground on the circuit.
 - If infinite resistance
 3. Test for less than 2 ohms in the control circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, replace the K20 Engine Control Module.
 - **If greater than 10 V**
3. Ignition OFF, disconnect the KR27 Starter Relay, ignition ON.
4. Verify that 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**
 1. Ignition OFF.
 2. Test for less than 2 ohms in the B+ circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, 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. Ignition OFF.
 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,
 3. Disconnect X1 harness connector at the M64 Starter Motor.
 4. 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 M64 Starter Motor.
 - **If the test lamp illuminates**
5. Ensure the parking brake is applied and the automatic transmission is in PARK or the manual transmission is in neutral. Momentarily install a 30 A fused jumper wire between the B+ circuit terminal 30 and the control circuit terminal 87.
6. Verify the M64 Starter Motor is activated.
 - **If the M64 Starter Motor does not activate**
 1. Disconnect the X1 harness connector at the M64 Starter Motor.
 2. Test for less than 2 ohms in the control circuit end to end.

- If greater the 2 ohms, repair the open/high resistance in the circuit.
- If less than 2 ohms, replace the M64 Starter Motor.

- **If the M64 Starter Motor activates**

7. Test or replace the KR27 Starter Relay.

Component Testing

Relay Test

1. Ignition OFF.
2. Disconnect the KR27 Starter Relay.
3. Test for 60-180 ohms between terminals 85 and 86.

- **If not within 60-180 ohms**

Replace the relay.

- **If within 60-180 ohms**

4. Test for infinite resistance between the following terminals:

- 30 and 86
- 30 and 87
- 30 and 85
- 85 and 87

- **If not infinite resistance**

Replace the relay.

- **If infinite resistance**

5. Install a 20 A fused jumper wire between relay terminal 85 and B+.
6. Install a jumper wire between relay terminal 86 and ground.
7. Test for less than 2 ohms between terminals 30 and 87.

- **If 2 ohms or greater**

Replace the relay

- **If less than 2 ohms**

8. All OK

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- **Manual Shift Shaft Position Switch Replacement**
- **Relay Replacement (Within an Electrical Center)** , **Relay Replacement (Attached to Wire Harness)**

- **Starter Replacement (LFX), Starter Replacement (LTG), Starter Replacement (LF3)**
- **Crankshaft Position Sensor Replacement** for the 2.0L engine
- **Crankshaft Position Sensor Replacement (LFX) , Crankshaft Position Sensor Replacement (LF3)** for the 3.6L engine
- **Control Module References** for ECM replacement, programming, and setup

STARTER SOLENOID CLICKS, ENGINE DOES NOT CRANK

Diagnostic Instructions

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

Reference Information

Schematic Reference

Starting and Charging Schematics

Connector End View Reference

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- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Testing

1. Ignition OFF, measure and record the battery voltage at the C1 Battery terminals.
2. Verify the measured voltage is between 12-15 V.
 - **If voltage is less than 12 V or greater than 15 V**

Refer to **Battery Inspection/Test**.

- **If voltage is between 12-15 V**

3. Remove the drive belts. Refer to **Drive Belt Replacement** , for the 2.0 L LTG or 2.5 L LCV engines or **Drive Belt Replacement (LFX)** , **Drive Belt Replacement (LF3)** for the 3.6 L LFX engine.
4. Verify the crankshaft rotates. Rotate the crankshaft by hand using the appropriate tools.
 - **If the crankshaft does not rotate**

Refer to **Engine Will Not Crank - Crankshaft Will Not Rotate** .

- **If the crankshaft rotates**

5. Verify the engine does not crank when attempting to start the vehicle.
 - **If the engine cranks**

Inspect the engine and belt drive system for mechanical binding, seized engine, or seized generator.

- **If the engine does not crank**

6. Verify that a test lamp illuminates between the M64 Starter Motor B+ terminal A X2 and ground.
 - **If the test lamp does not illuminate and the circuit fuse is good**
 1. Ignition OFF.
 2. Test for less than 2 ohms in the B+ circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, 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. Ignition OFF.
 2. Test for greater than 100 ohms between the B+ circuit and ground.
 - If 100 ohms or less, repair the short to ground on the circuit.
 - If greater than 100 ohms, replace the M64 Starter Motor.
 - **If the test lamp illuminates**
7. Test for less than 0.5 V between the positive battery post and M64 Starter Motor B+ terminal A X2 with the ignition in the CRANK position.
 - **If 0.5 V or greater**

Replace the positive battery cable.

- **If less than 0.5 V**

8. Test for less than 0.5 V between the negative battery post and the M64 Starter Motor case with the ignition in the CRANK position.
 - **If 0.5 V or greater**

Replace the negative battery cable.

- less than 0.5 V

9. Replace the M64 Starter Motor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- **Battery Negative Cable Replacement**
- **Battery Positive Cable Replacement**
- **Starter Replacement (LFX), Starter Replacement (LTG), Starter Replacement (LF3)**

ENGINE CRANKS SLOWLY

Diagnostic Instructions

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

Reference Information

Schematic Reference

Starting and Charging Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX - SEDAN

Description and Operation

Starting System Description and Operation

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Testing

1. Ignition OFF, measure and record the battery voltage at the C1 Battery Terminals.
2. Verify the measured voltage is between 12-15 V.
 - **If voltage is less than 12 V or greater than 15 V**

Refer to **Battery Inspection/Test**.

- **If voltage is between 12-15 V**
3. Remove the drive belts. Refer to **Drive Belt Replacement** , for the 2.0L (LTG) or 2.5L (LCV) engines or **Drive Belt Replacement (LFX)** , **Drive Belt Replacement (LF3)** for the 3.6L LFX engine.
 4. Verify the engine cranks slowly when attempting to start the vehicle.
 - **If the engine cranks at normal speed**

Inspect the engine and belt drive system for mechanical binding, seized engine, or seized generator.

- **If the engine cranks slowly**
5. Verify that a test lamp illuminates between the M64 starter motor B+ terminal A X2 and ground.
 - **If the test lamp does not illuminate**
 1. Ignition OFF.
 2. Test for less than 2 ohms in the B+ circuit end to end.
 - If 2 ohms or greater, repair the open/high resistance in the circuit.
 - If less than 2 ohms, verify the fuse is not open and there is voltage at the fuse.
 - **If the test lamp illuminates**
 6. Test for less than 0.5 V between the positive battery cable and terminal A X2 at the M64 starter motor with the ignition in the START position.
 - **If 0.5 V or greater**

Replace the positive battery cable.

- **If less than 0.5 V**
7. Test for less than 0.5 V between the negative battery cable and the M64 starter motor case with the ignition in the START position.
 - **If 0.5 V or greater**

Replace the negative battery cable.

- **If less than 0.5 V**
8. Replace the M64 starter motor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- **Battery Positive Cable Replacement**

- **Battery Negative Cable Replacement**
- **Battery Negative Cable Extension Cable Replacement (LFX)**
- **Starter Replacement (LFX), Starter Replacement (LTG), Starter Replacement (LF3)**

STARTER NOISE DIAGNOSIS

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
 - If not within specifications, secure the flywheel bolts or replace the flywheel.
 - If all inspections were within specification, replace the starter motor.

Repair Instructions

- **Fastener Tightening Specifications** for the LCV,LTG engine.
- **Fastener Tightening Specifications (LFX)** , **Fastener Tightening Specifications (LF3)** for the LFX engine.
- **Automatic Transmission Flex Plate Replacement** for the automatic transmission LCV,LTG engine.
- **Automatic Transmission Flex Plate Replacement** for the LFX engine.
- **Starter Replacement (LFX), Starter Replacement (LTG), Starter Replacement (LF3)**

REPAIR INSTRUCTIONS

BATTERY NEGATIVE CABLE DISCONNECTION AND CONNECTION

Removal Procedure

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 should be allowed to time out or be disabled (simply opening the driver door should disable retained accessory power) before disconnecting power. Disconnecting power to the OnStar® module in any way while the ignition is On or with retained accessory power activated may cause activation of the OnStar® Back-Up Battery 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 back-up battery is not rechargeable and once activated the back-up battery must be replaced.

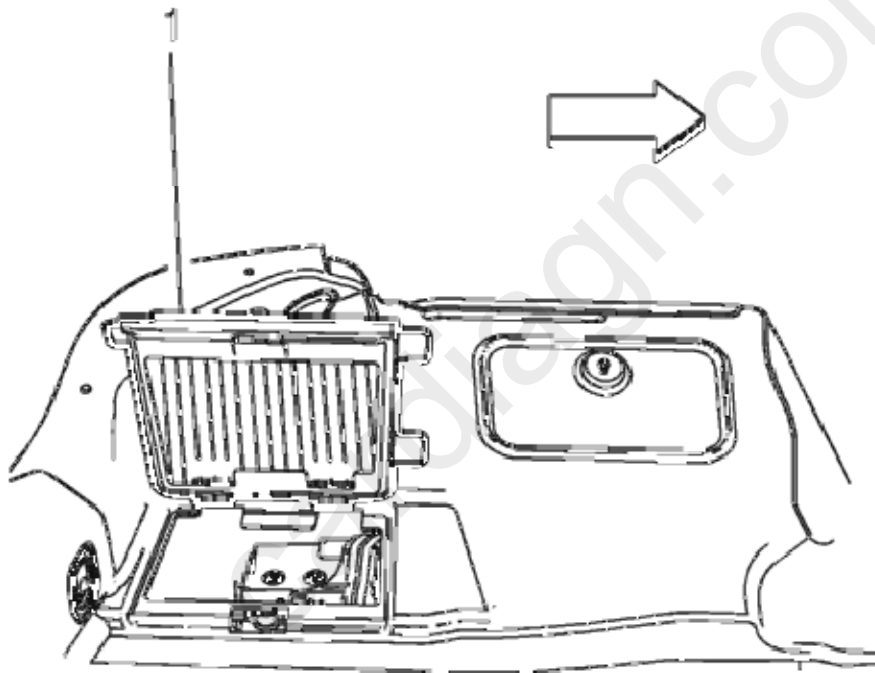


Fig. 3: Battery Access Cover Located At Left Rear Compartment Area
Courtesy of GENERAL MOTORS COMPANY

1. Open the battery access cover (1) located at the left rear compartment area.

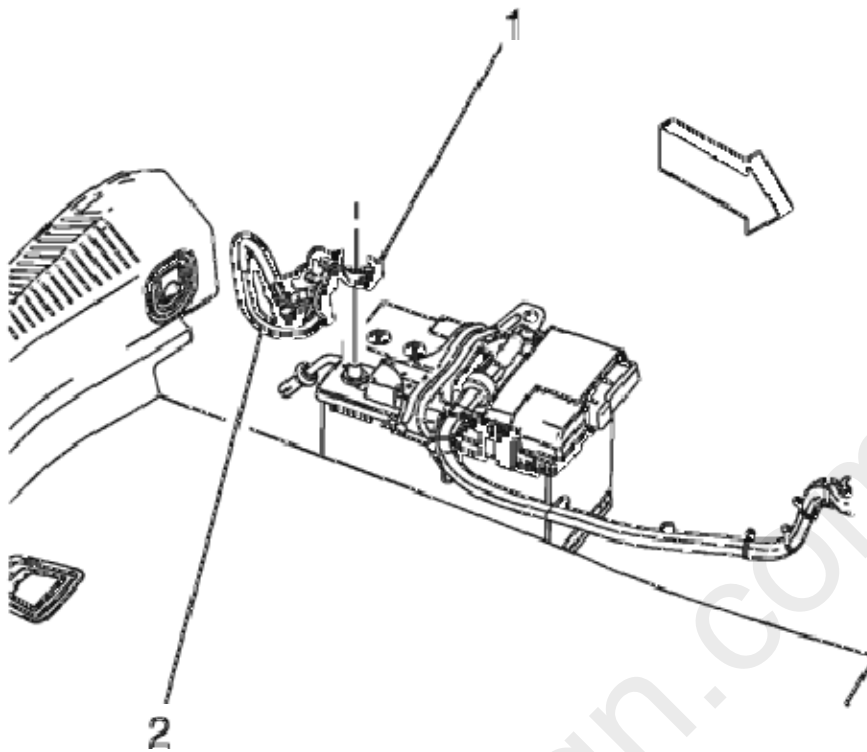


Fig. 4: Battery Negative Cable Clamp Fastener
Courtesy of GENERAL MOTORS COMPANY

2. Loosen the battery negative cable clamp fastener (1) and set aside the battery negative cable (2).

Installation Procedure

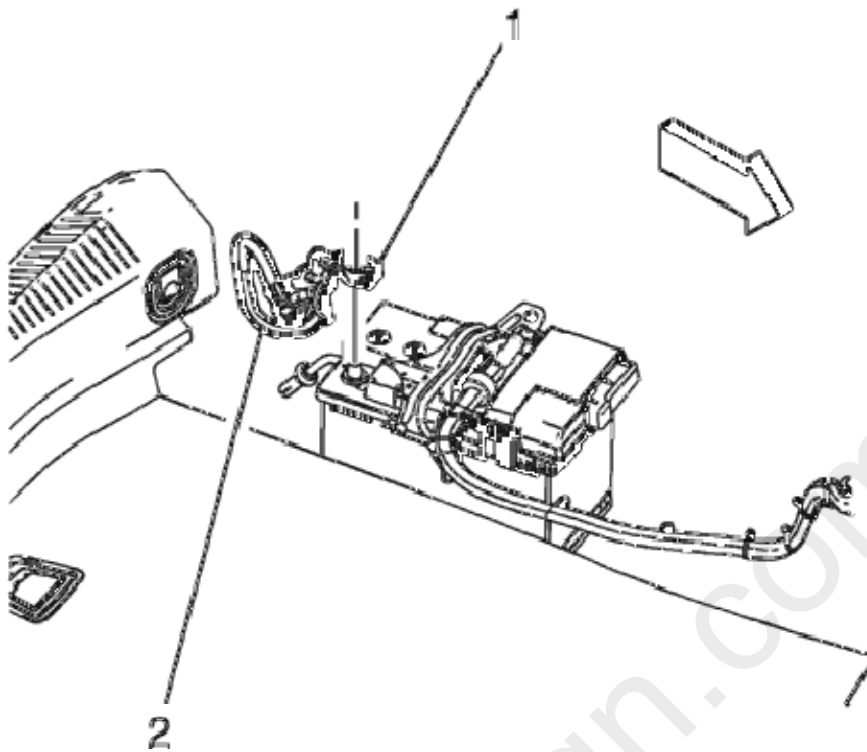


Fig. 5: Battery Negative Cable Clamp Fastener
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

1. Install the battery negative cable (2) to the negative battery post and tighten the fastener (1) to 7 (62 lb in).

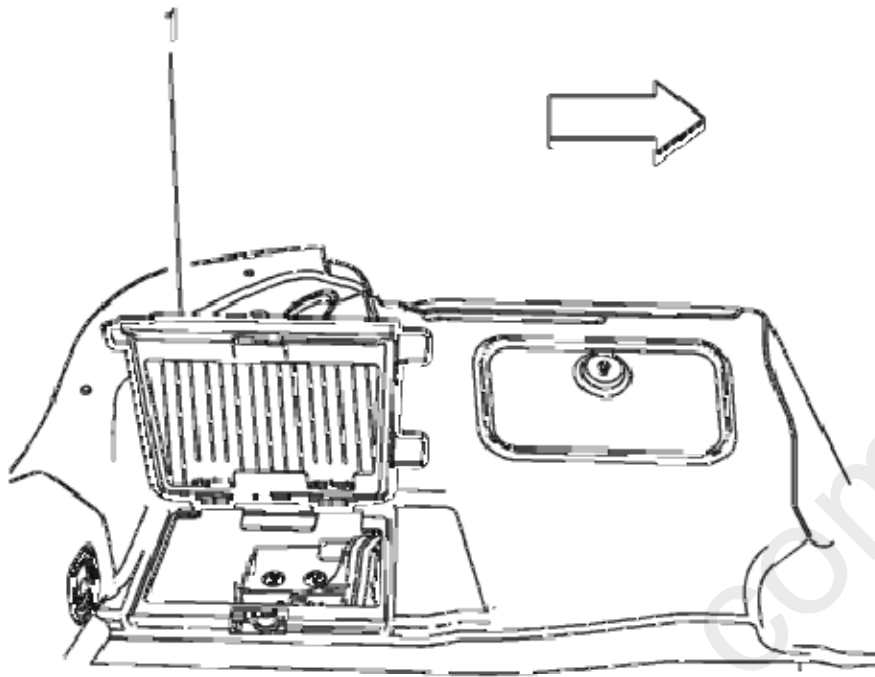


Fig. 6: Battery Access Cover Located At Left Rear Compartment Area
Courtesy of GENERAL MOTORS COMPANY

2. Close the battery access cover (1).

BATTERY SENSOR REPLACEMENT (KL9)

Removal Procedure

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 should be allowed to time out or be disabled (simply opening the driver door should disable retained accessory power) before disconnecting power. Disconnecting power to the OnStar® module in any way while the ignition is On or with retained accessory power activated may cause activation of the OnStar® Back-Up Battery 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 back-up battery is not rechargeable and once activated the back-up battery must be replaced.

1. Turn on the radio and record all of the customer radio station presets.
2. Ensure that all lamps and accessories are turned off.
3. Turn the ignition OFF and remove the ignition key.
4. Open the battery access panel in the left rear cargo area.

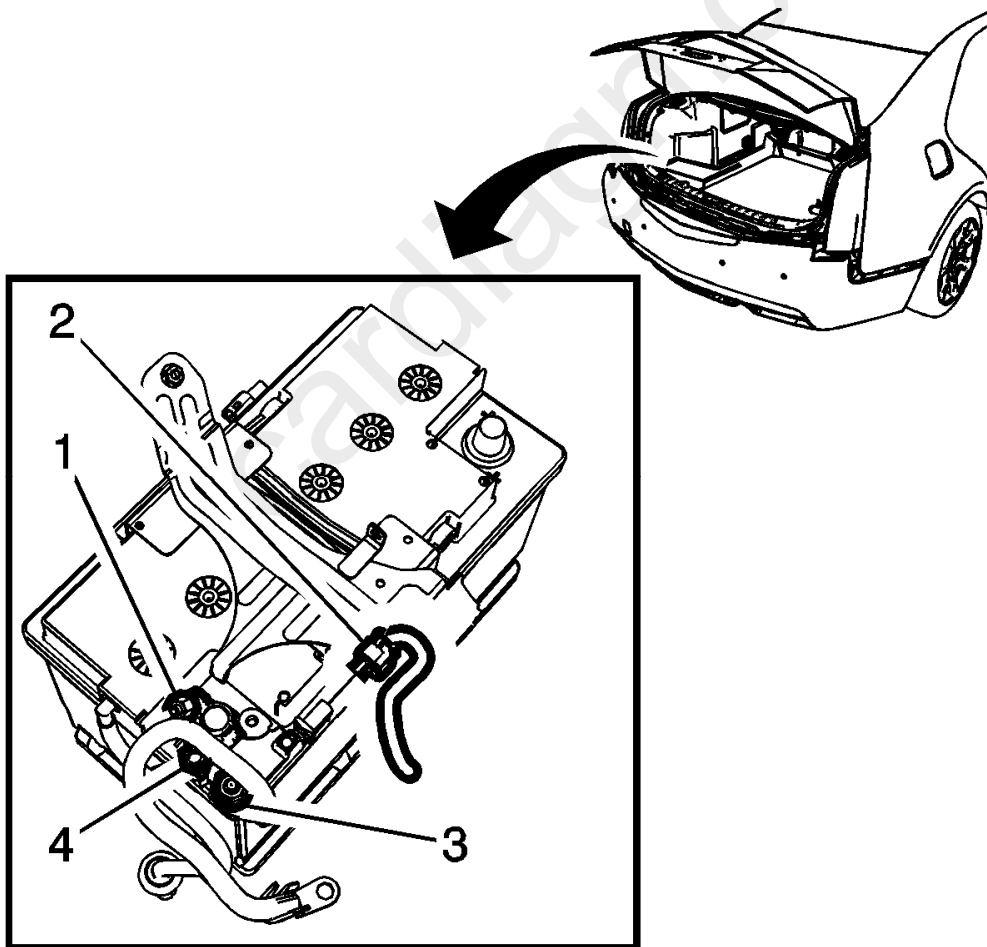


Fig. 7: Battery Sensor

Courtesy of GENERAL MOTORS COMPANY

5. Disconnect the battery sensor connector (2).
6. Remove the battery negative cable fastener (3) and the body harness fastener (4).
7. Loosen the battery negative cable clamp fastener (1).

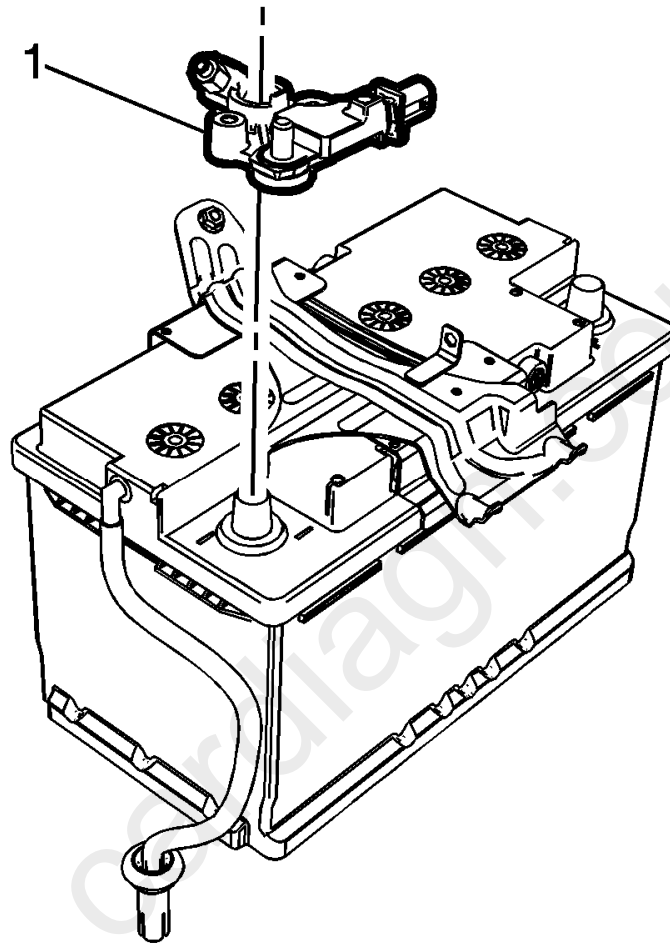


Fig. 8: Battery Sensor Removed

Courtesy of GENERAL MOTORS COMPANY

8. Remove the battery sensor (1).

Installation Procedure

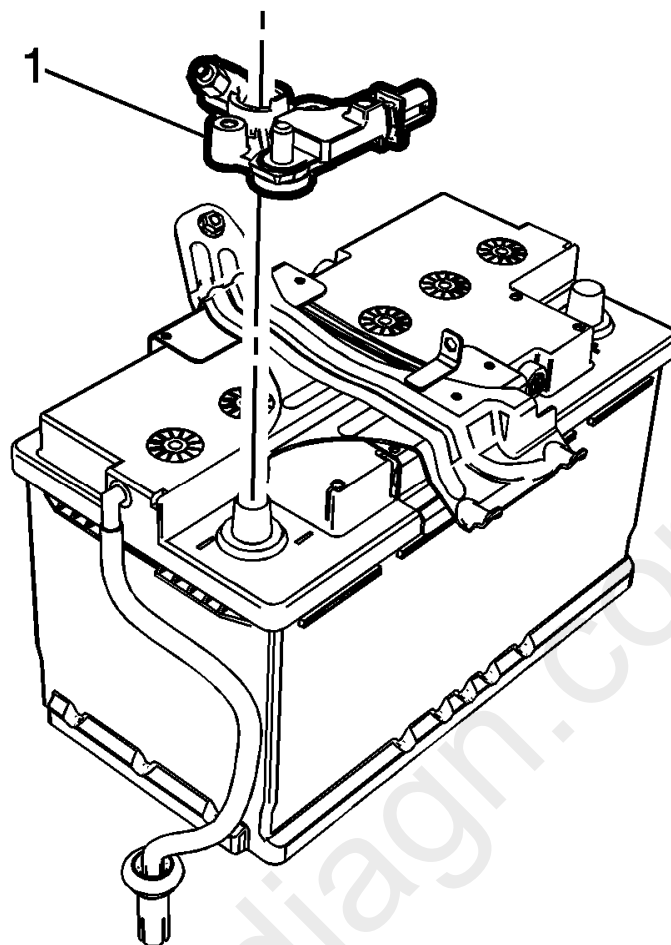


Fig. 9: Battery Sensor Removed
Courtesy of GENERAL MOTORS COMPANY

1. Install the battery sensor (1) to the battery.

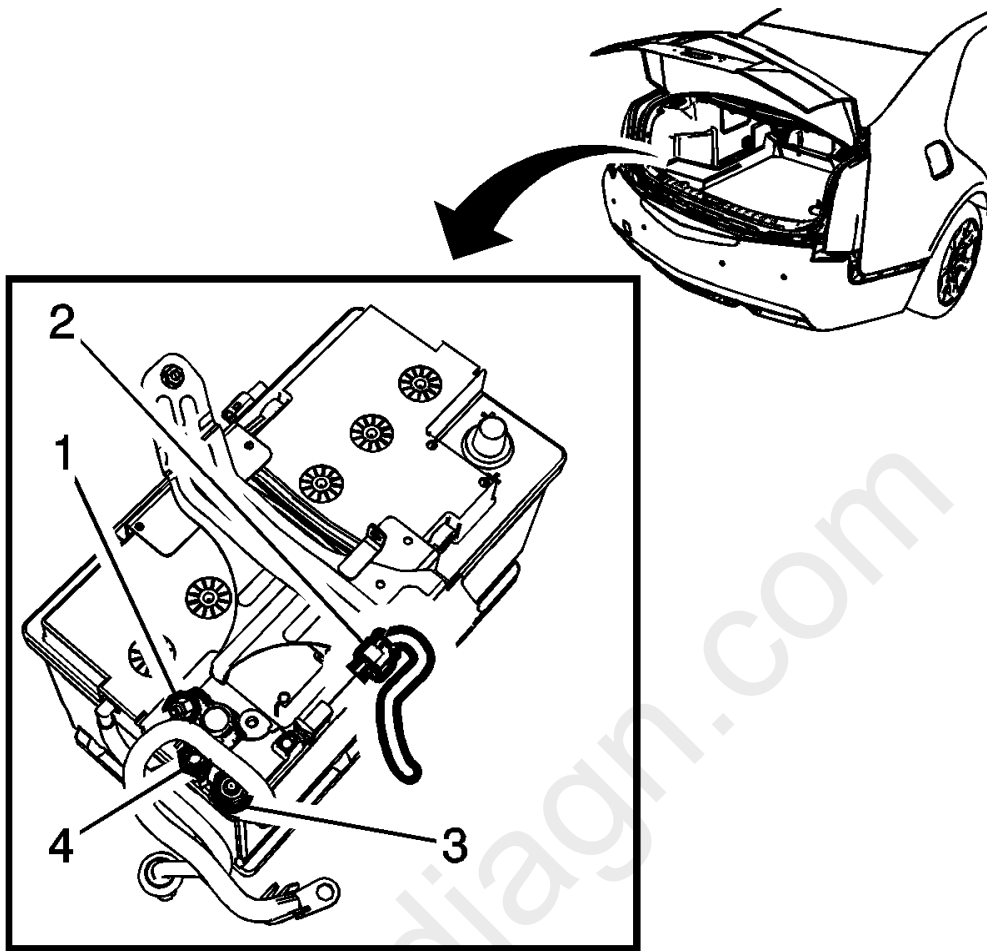


Fig. 10: Battery Sensor
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Tighten the battery negative clamp fastener (1) to 9 (80 lb in).
3. Install the battery negative cable fastener (3) and tighten to 12 (106 lb in).
4. Install the body harness negative terminal to the battery sensor and tighten the fastener (4) to 9 (80 lb in).
5. Connect the battery sensor connector (2).
6. Close the battery access panel in the left rear cargo area.
7. Program all of the customer's radio station presets and set the radio clock to the current time.

BATTERY NEGATIVE CABLE REPLACEMENT

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.
2. Remove the left rear compartment side trim panel. Refer to **Rear Compartment Side Trim Replacement - Left Side**.

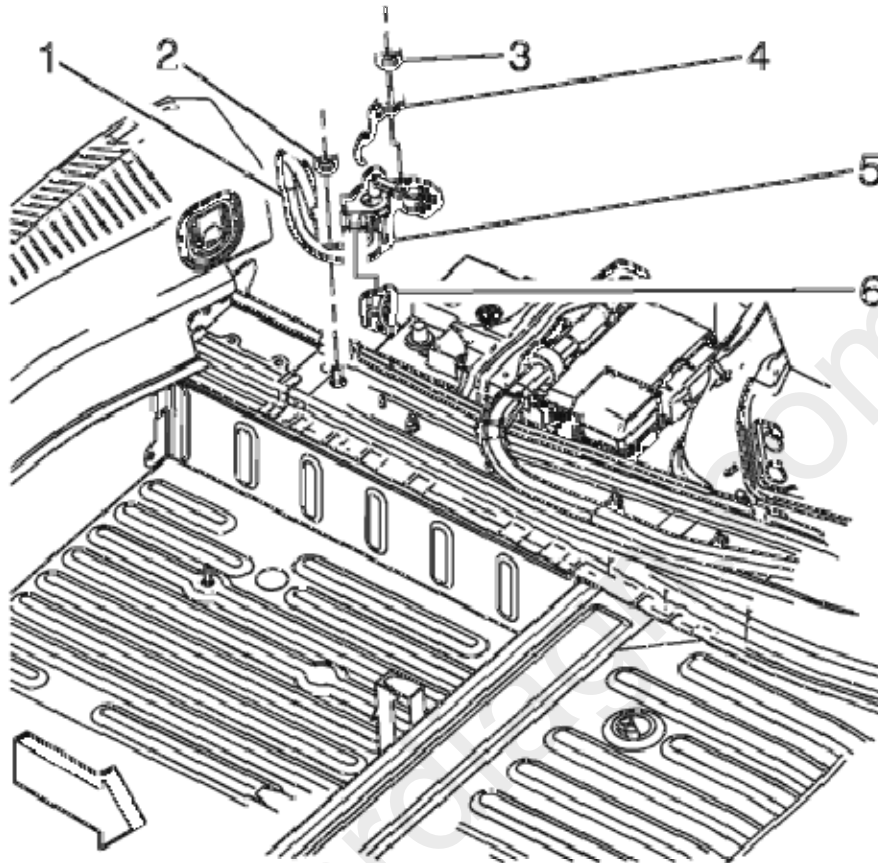


Fig. 11: Body Harness Connector At Battery Current Sensor
Courtesy of GENERAL MOTORS COMPANY

3. Disconnect the body harness connector (6) from the battery current sensor (5).
4. Remove the body harness ground terminal fastener (3) and remove the body harness terminal (4) from the battery negative cable.
5. Remove the battery negative cable ground fastener (2) and remove the battery negative cable (1) from the rear compartment.

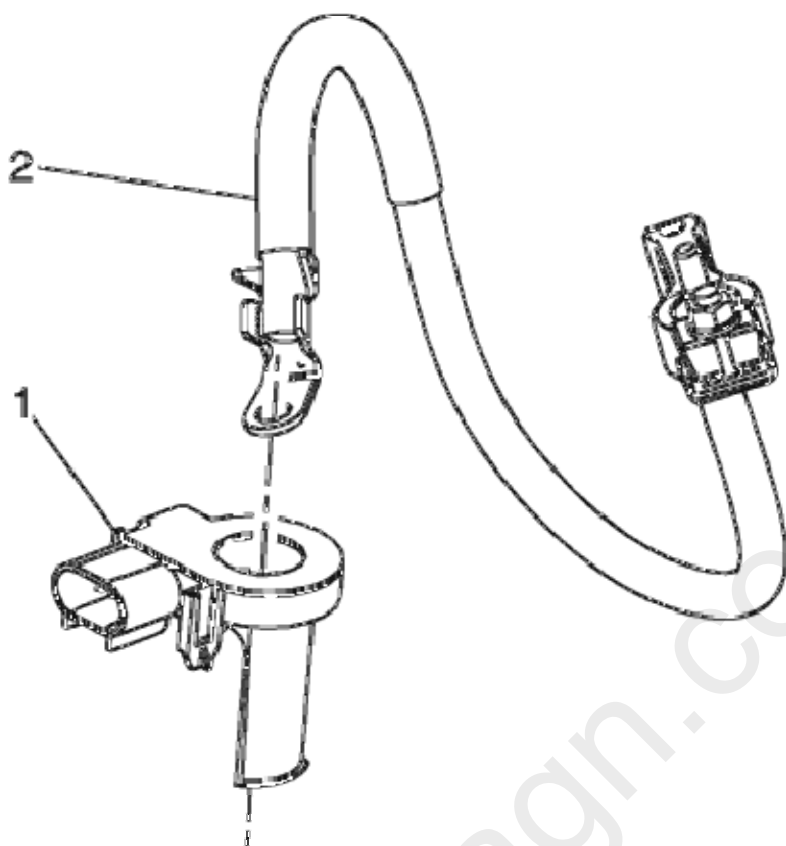


Fig. 12: Battery Negative Cable And Battery Current Sensor
Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the position of the battery current sensor when removing, with the tab facing downwards.

6. If replacing the battery negative cable (2), slide the battery current sensor (1) off the battery negative cable.

Installation Procedure

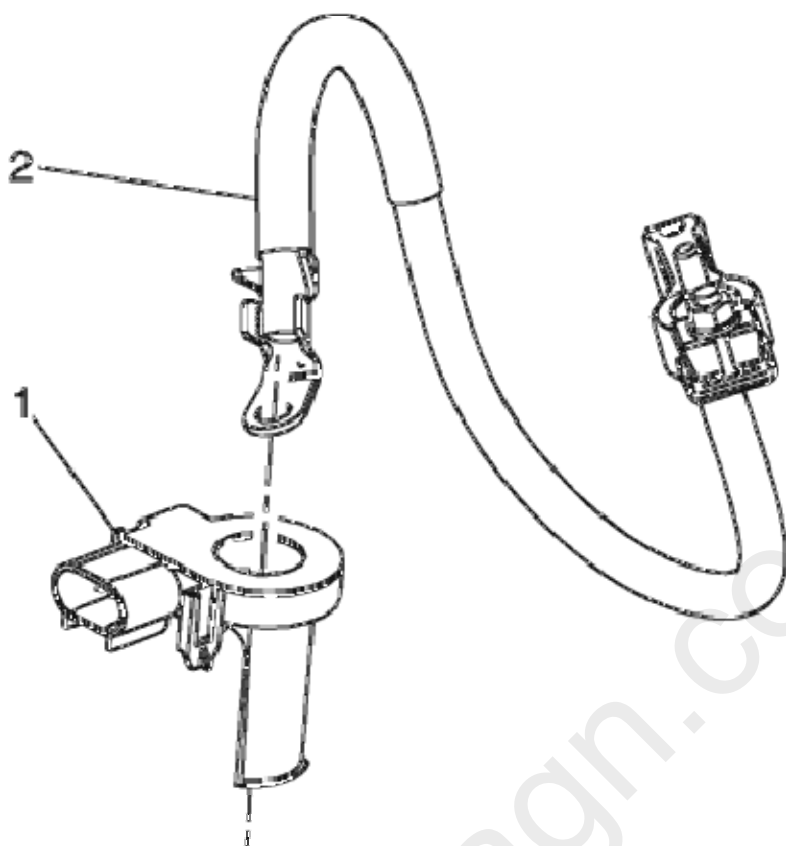


Fig. 13: Battery Negative Cable And Battery Current Sensor
Courtesy of GENERAL MOTORS COMPANY

1. Install the battery current sensor (1) into position on the battery negative cable (2).

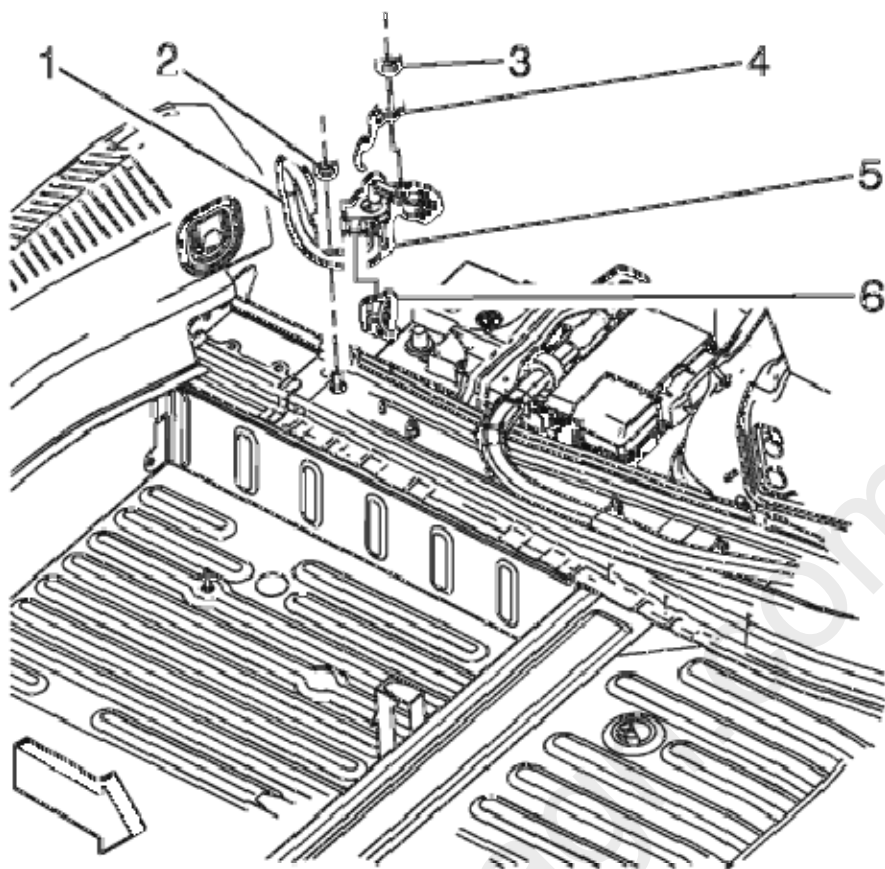


Fig. 14: Body Harness Connector At Battery Current Sensor
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Install the battery negative cable (1) to the ground stud and tighten the fastener (2) to 22 (16 lb ft).
3. Install the body harness ground terminal (4) to the battery negative cable and tighten the fastener (3) to 7 (62 lb in).
4. Connect the body harness connector (6) to the battery current sensor (5).
5. Connect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection.
6. Install the left rear compartment side trim panel. Refer to Rear Compartment Side Trim Replacement - Left Side .

BATTERY NEGATIVE CABLE EXTENSION CABLE REPLACEMENT (LFX)

Removal Procedure

1. Disconnect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection

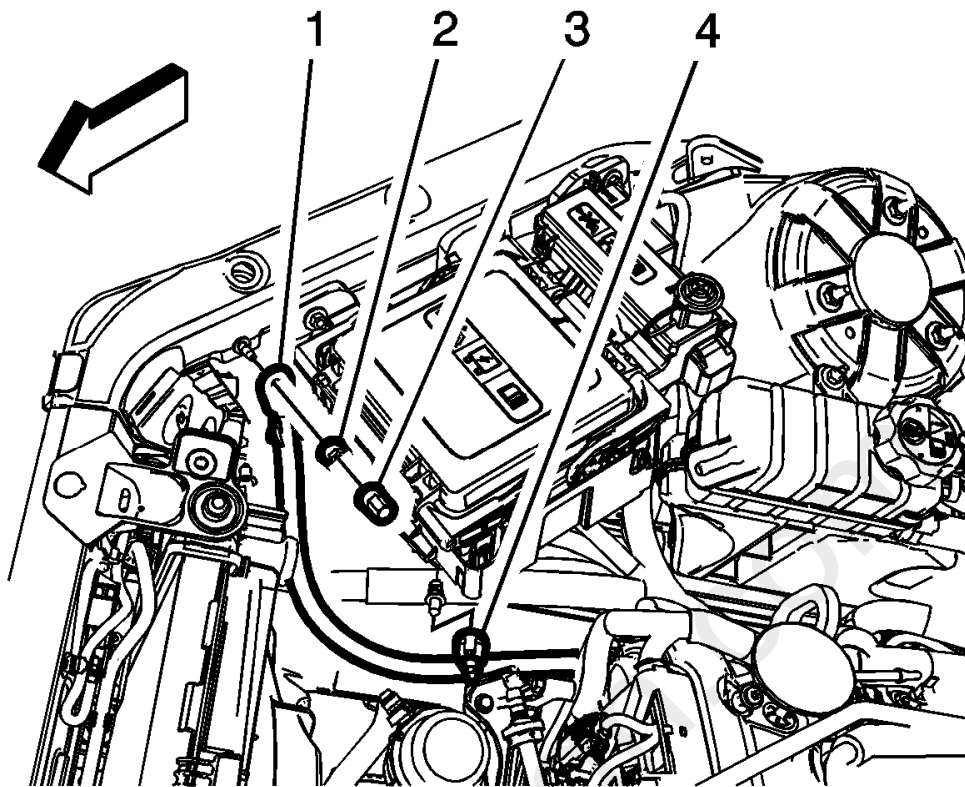


Fig. 15: Battery Negative Cable Extension Cable
Courtesy of GENERAL MOTORS COMPANY

2. Disconnect the battery negative cable extension cable retainer (4) from the engine harness.
3. Remove the protective cap (3) and the battery negative cable extension cable fastener (2).
4. Remove the battery negative cable extension cable (1) from the right front fender stud.

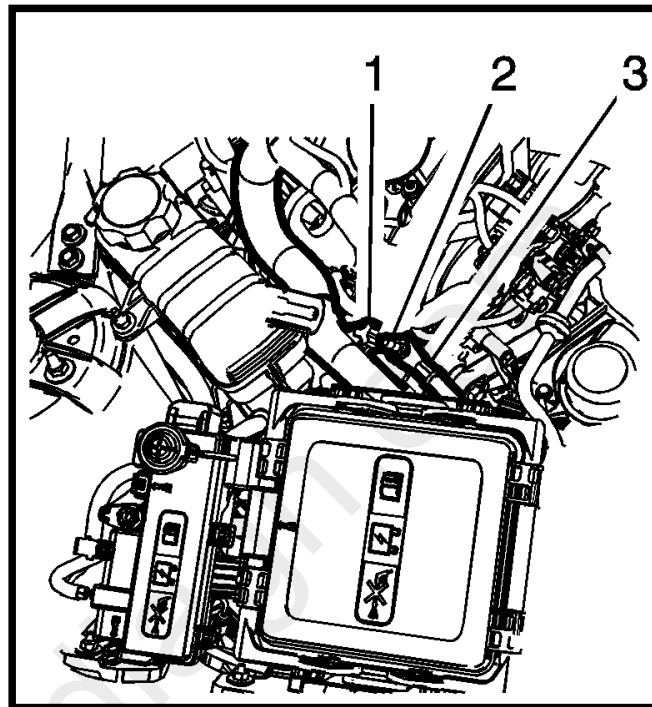
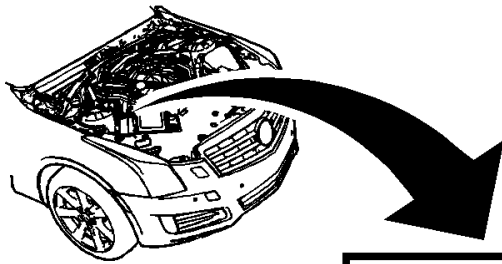


Fig. 16: Battery Negative Cable Extension Cable Connections
Courtesy of GENERAL MOTORS COMPANY

5. Remove the engine harness retainer (1) from the battery negative cable extension stud.
6. Remove the battery negative cable extension stud/fastener (2) and remove the battery negative cable extension cable (3).

Installation Procedure

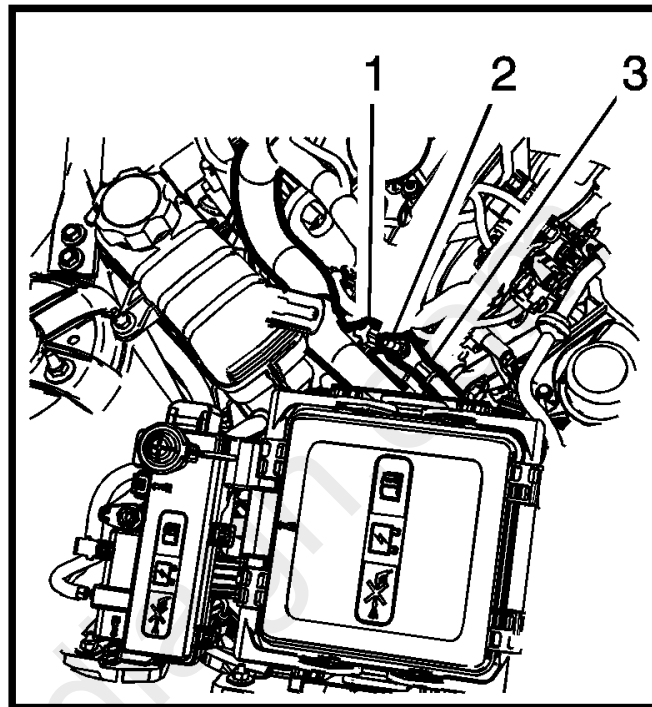
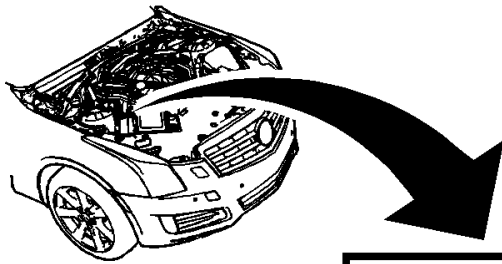


Fig. 17: Battery Negative Cable Extension Cable Connections
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

1. Install the battery negative cable extension cable (3) to the engine block and tighten the stud/fastener (2) to 22 (16 lb ft).
2. Install the engine harness retainer (1) to the top of the stud/fastener (2).

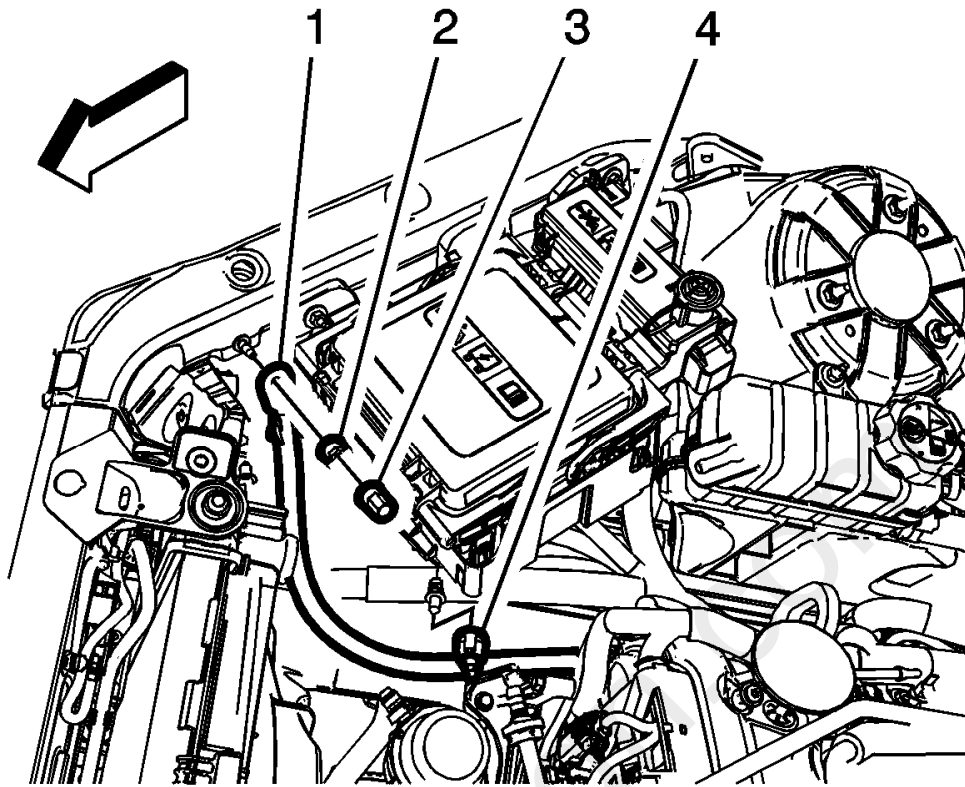


Fig. 18: Battery Negative Cable Extension Cable
Courtesy of GENERAL MOTORS COMPANY

3. Install the battery negative cable extension cable (1) to the upper tie bar extension panel and tighten the fastener (2) to 11 (97 lb in).
4. Install the protective cap (3) over the stud and connect the battery negative cable extension cable retainer (4), to the engine harness.
5. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**

BATTERY POSITIVE CABLE REPLACEMENT

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.
2. Remove the left side rear compartment trim panel. Refer to **Rear Compartment Side Trim Replacement - Left Side**.
3. Remove the rear side door sill garnish moldings left and right. Refer to **Rear Side Door Sill Garnish Molding Replacement**.

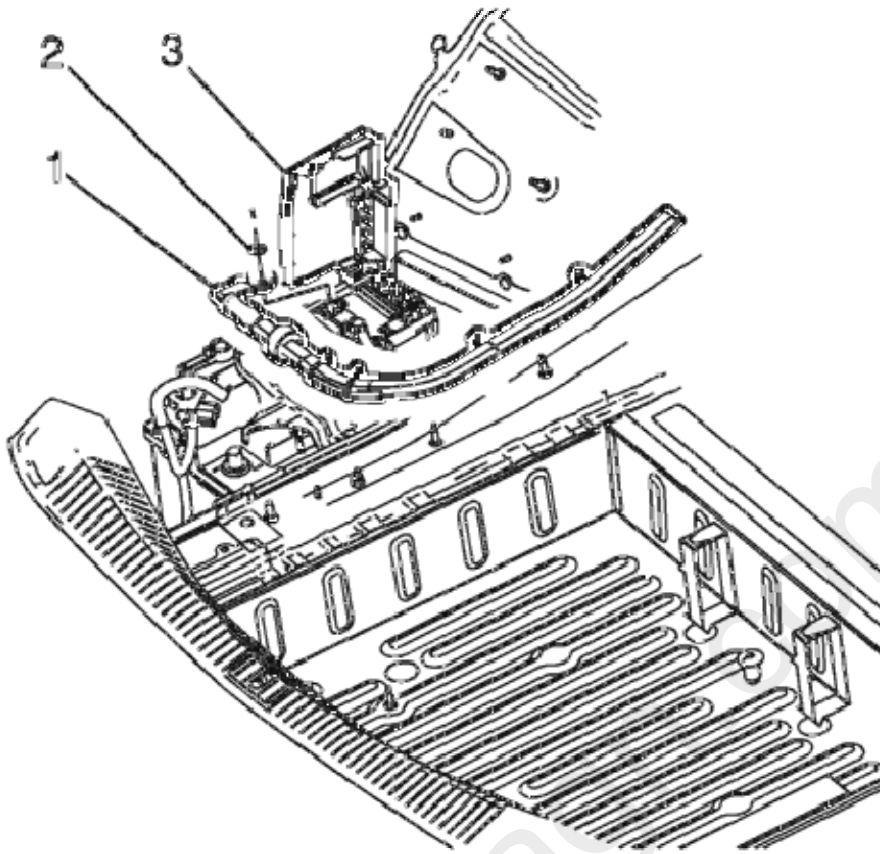


Fig. 19: Battery Fuse Block Cover
Courtesy of GENERAL MOTORS COMPANY

4. Open the battery fuse block cover (3).
5. Remove the battery positive cable fastener (2) from the battery fuse block and remove the battery positive cable terminal (1).

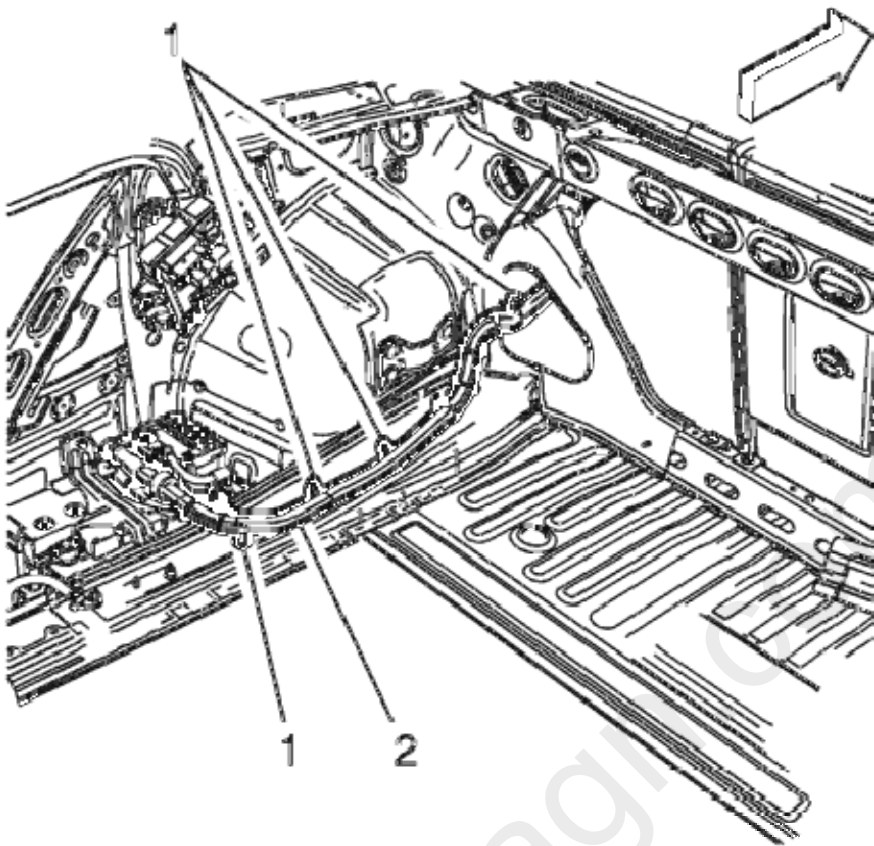


Fig. 20: Battery Positive Cable Retainers At Studs and body harness
Courtesy of GENERAL MOTORS COMPANY

6. Detach the battery positive cable retainers (1) from the studs and body harness.
7. Feed the battery positive cable (2) into the rear passenger compartment area.

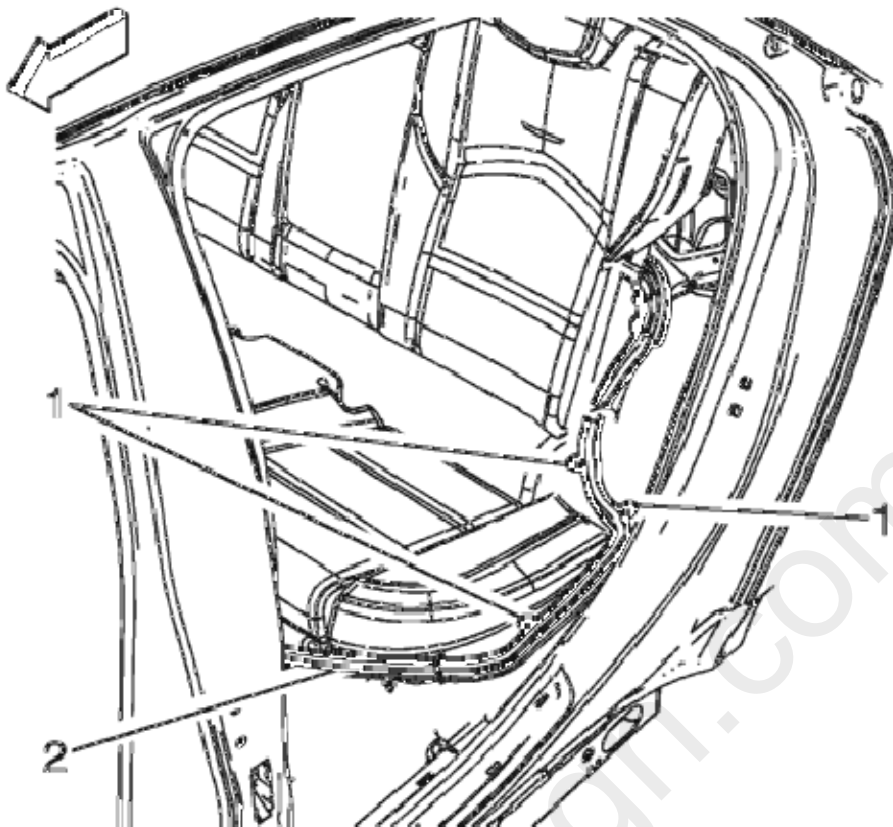


Fig. 21: Battery Positive Cable Retainers At Side Of Left Rear Seat.
Courtesy of GENERAL MOTORS COMPANY

8. Detach the battery positive cable retainers (1) from the side of the left rear seat.
9. Peel back the rear floor panel carpet from underneath the rear seat. Refer to **Rear Floor Panel Carpet Replacement** .

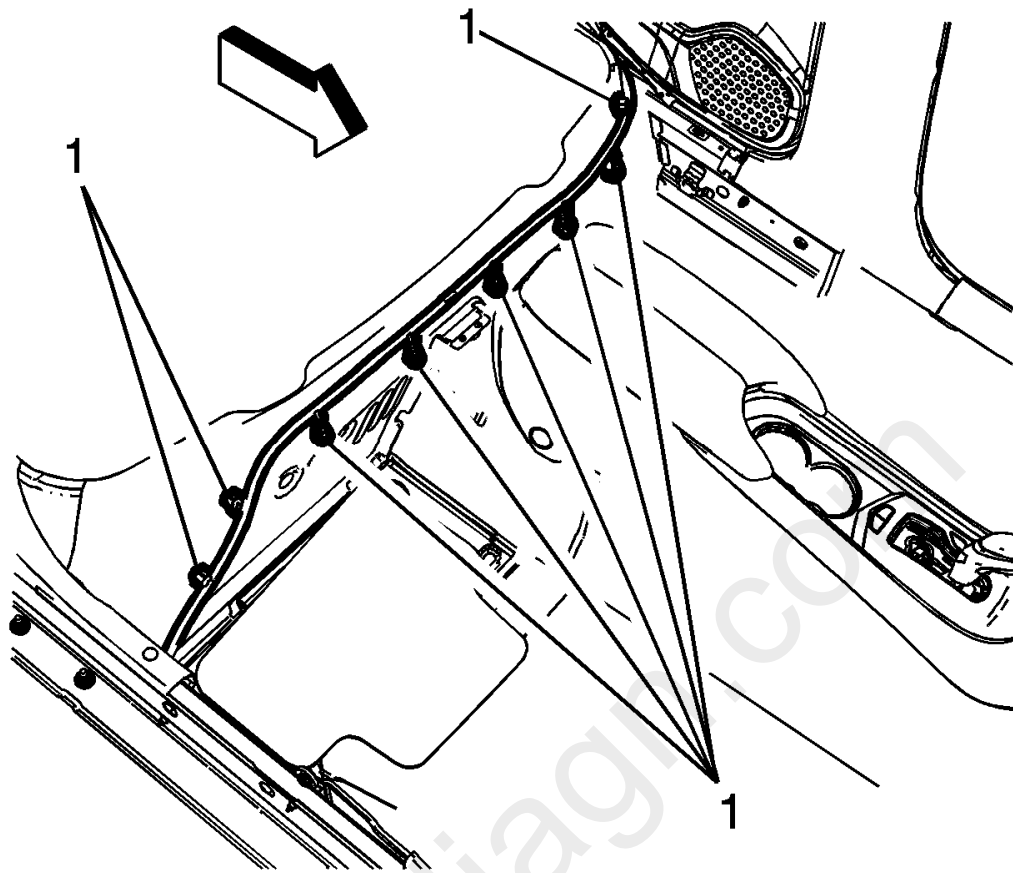


Fig. 22: Battery Positive Cable Retainers
Courtesy of GENERAL MOTORS COMPANY

10. Detach the battery positive cable retainers (1) .
11. Remove the right side passenger floor panel carpet. Refer to **Front Floor Panel Carpet Replacement - Right Side** .
12. Remove the right side instrument panel lower trim panel insulator. Refer to **Instrument Panel Lower Trim Panel Insulator Replacement - Right Side** .

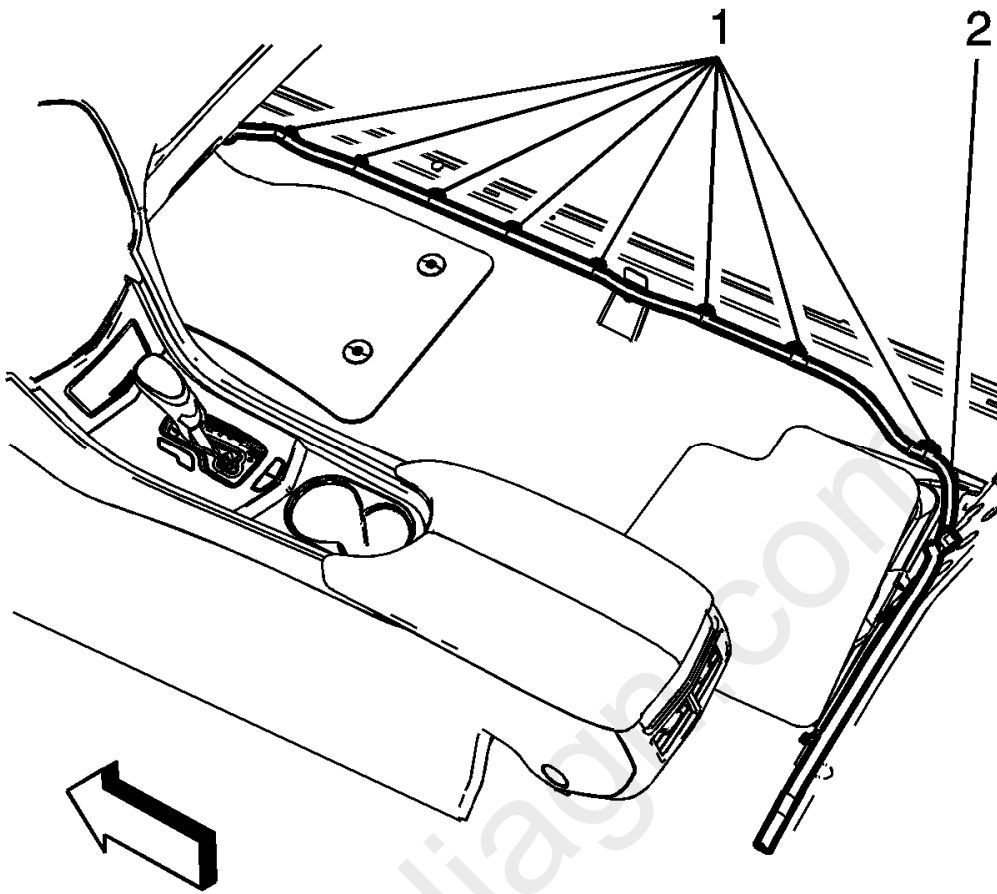


Fig. 23: Battery Positive Cable Retainers
Courtesy of GENERAL MOTORS COMPANY

13. Detach the battery positive cable retainers (1).

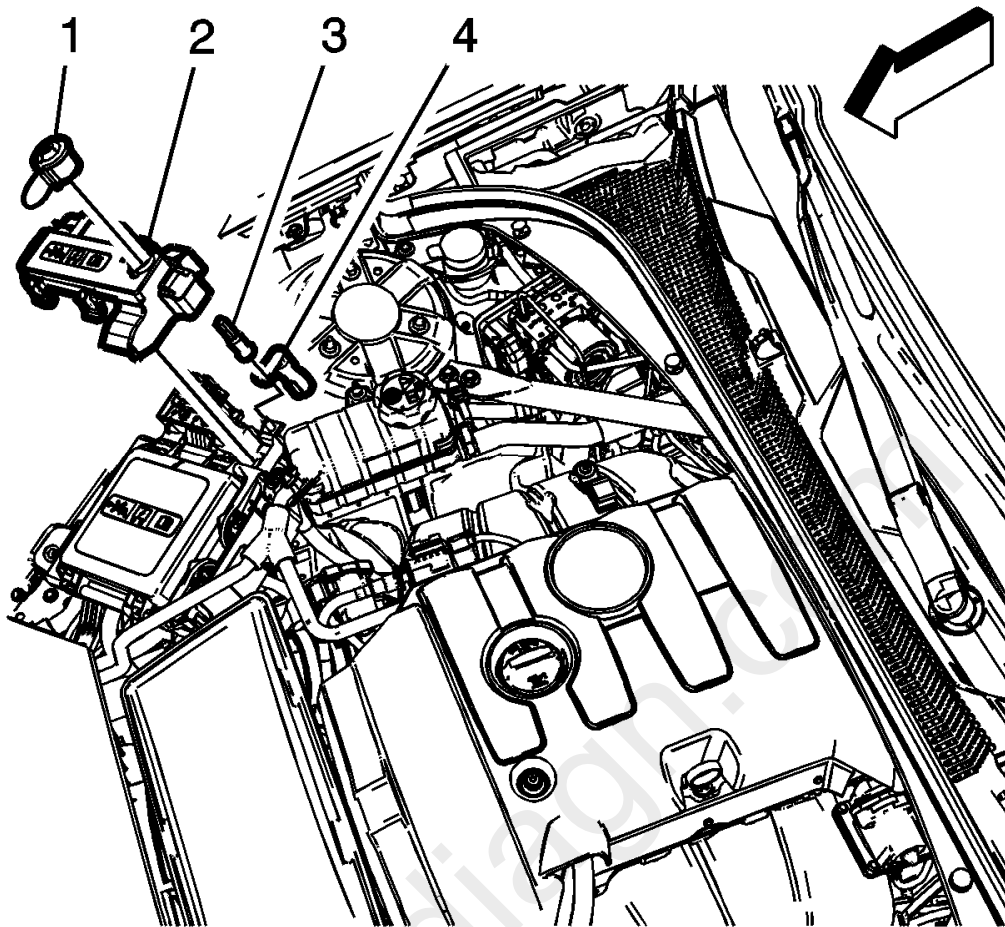


Fig. 24: Pre-Fuse Block
Courtesy of GENERAL MOTORS COMPANY

14. Remove the following from the pre-fuse block:

- Battery Jumper Post Cover (1).
- Pre-Fuse Block Cover (2).
- Battery Positive Barrel Retainer (3).
- Battery Positive Cable (4).

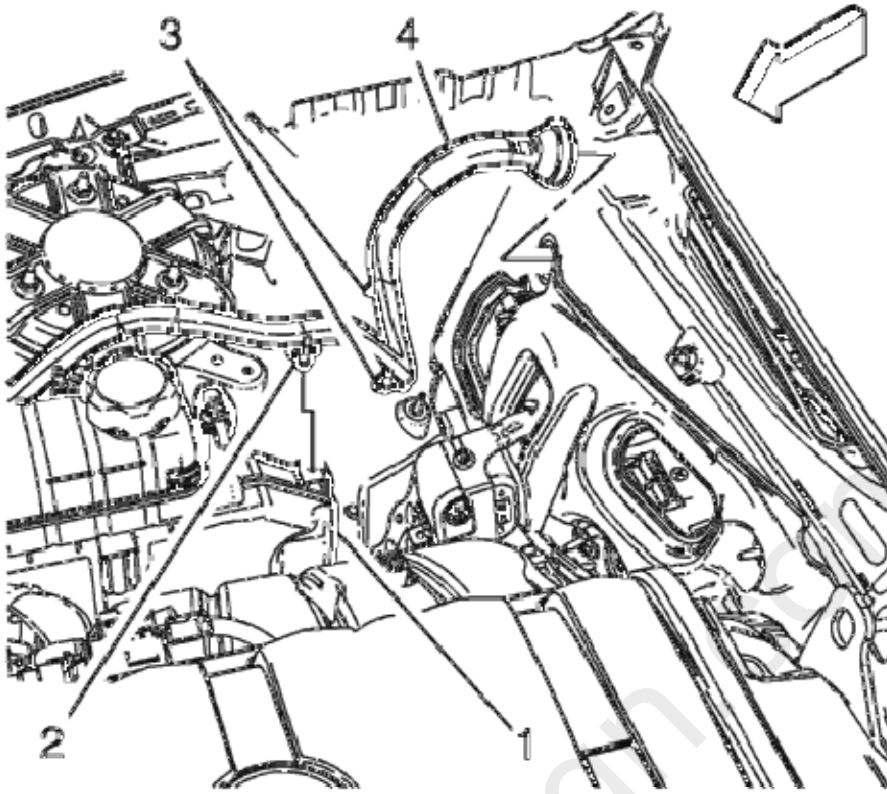


Fig. 25: Battery Positive Cable Retainer At Radiator Surge Tank
Courtesy of GENERAL MOTORS COMPANY

15. Detach the battery positive cable retainer (2) from the radiator surge tank (1) and reposition the radiator surge tank with the hoses attached. Refer to **Radiator Surge Tank Replacement (LTG)** , **Radiator Surge Tank Replacement (LFX, LF3)** .
16. Remove the front plenum panel. Refer to **Plenum Front Panel Replacement** .
17. Reposition the brake pressure modulator valve without disconnecting the brake pipes. Refer to **Brake Pressure Modulator Valve Replacement** .
18. Detach the battery positive cable retainers (3) from the body harness and wheel house.

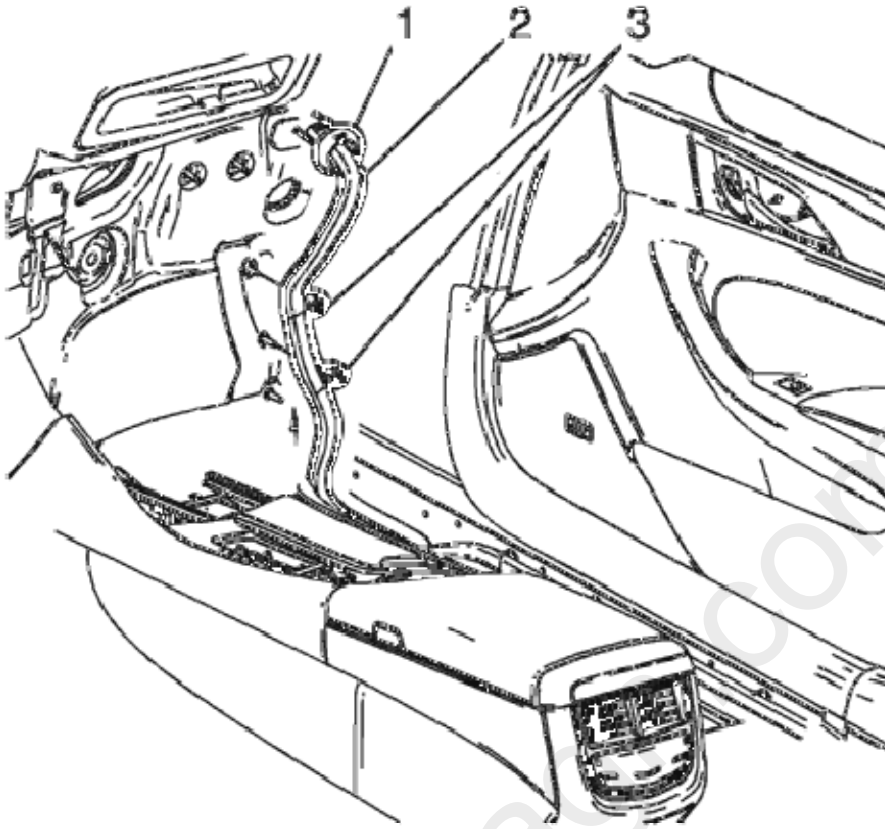


Fig. 26: Battery Positive Cable And Pass Through Grommet
Courtesy of GENERAL MOTORS COMPANY

19. Remove the pass through grommet (1) and detach the battery positive cable retainers (3) from the studs.
20. Pull the battery positive cable (2) through the pass through opening.
21. Remove the battery positive cable from inside the vehicle.

Installation Procedure

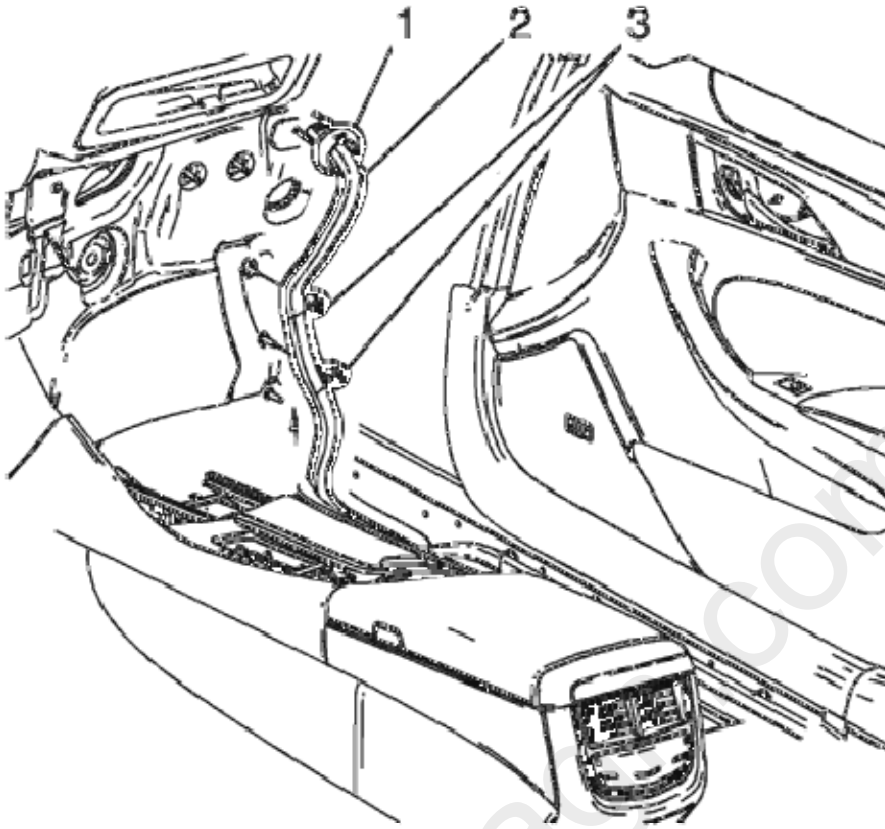


Fig. 27: Battery Positive Cable And Pass Through Grommet
Courtesy of GENERAL MOTORS COMPANY

1. Install the engine compartment battery positive cable (2) through the pass through opening and install the battery positive cable grommet (1).
2. Attach the battery positive cable retainers (3) to the plenum studs.

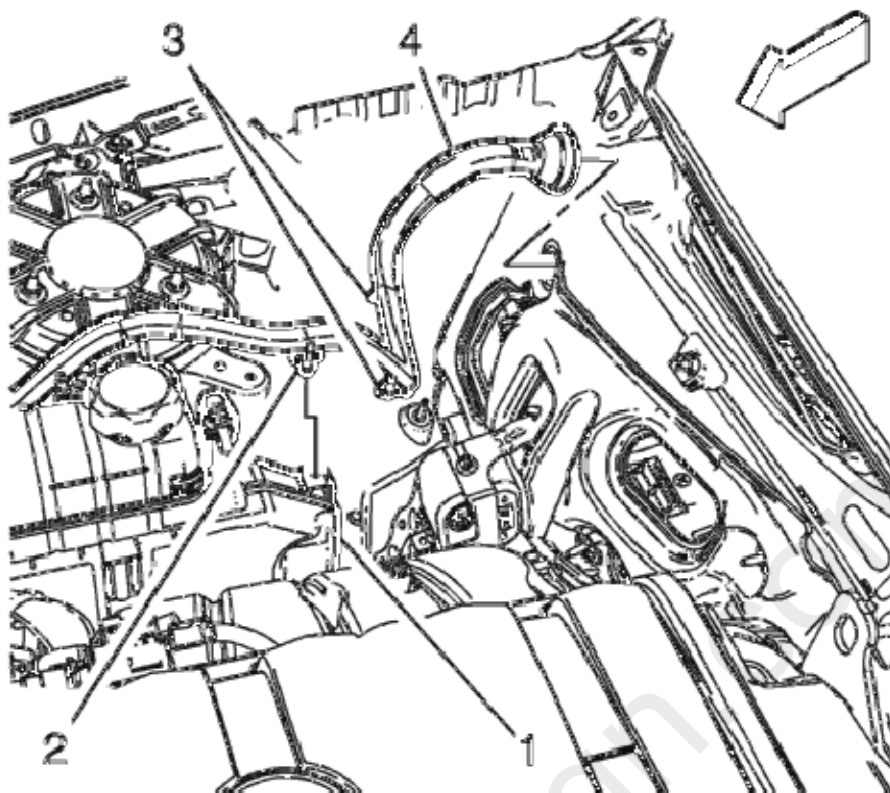


Fig. 28: Battery Positive Cable Retainer At Radiator Surge Tank
Courtesy of GENERAL MOTORS COMPANY

3. Install the battery positive cable (4) to the body harness and wheel house with the retainers (3).
4. Install the battery positive cable retainer (2), to the radiator surge tank (1).

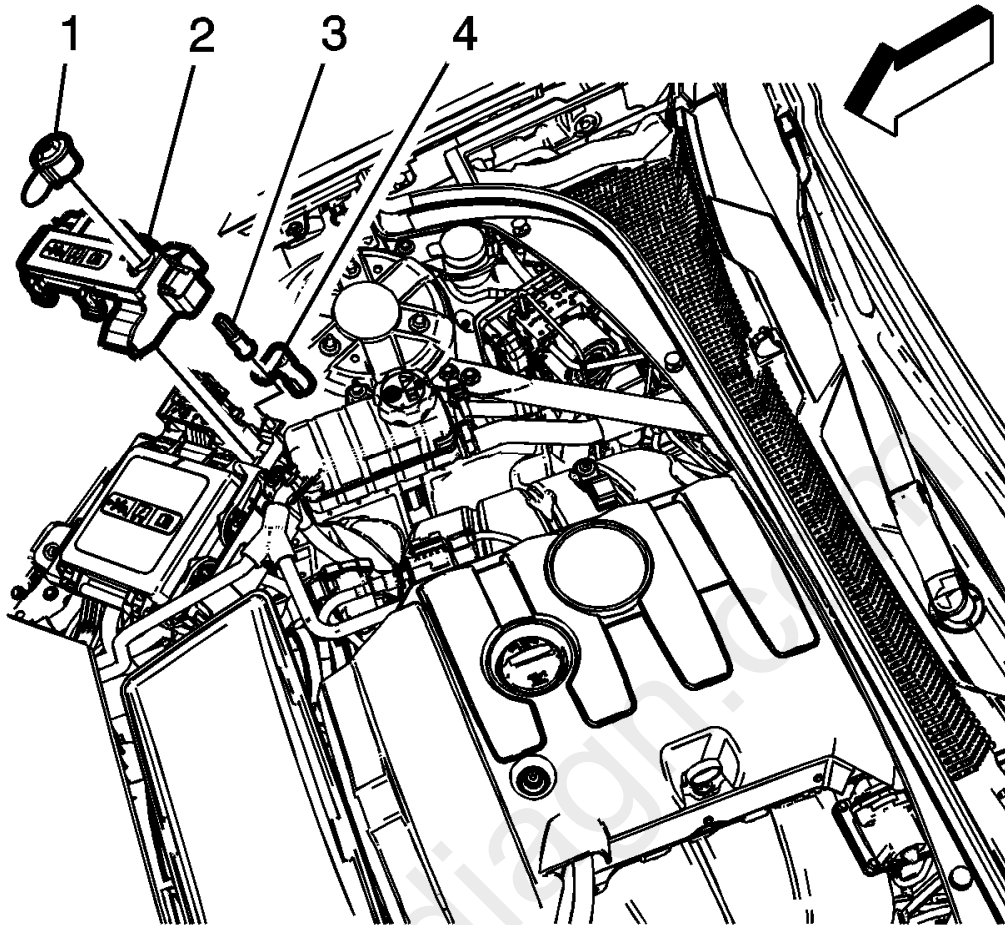


Fig. 29: Pre-Fuse Block
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

5. Attach the following to the pre-fuse block:
 - Starter Solenoid Cable (4).
 - Battery Positive Barrel Fastener (3). Tighten to 12 (106 lb in).
 - Pre-Fuse Block Cover (2).
 - Battery Jumper Post Cover (1).
6. Reposition the brake pressure modulator valve. Refer to Brake Pressure Modulator Valve Replacement .
7. Install the front plenum panel. Refer to Plenum Front Panel Replacement .

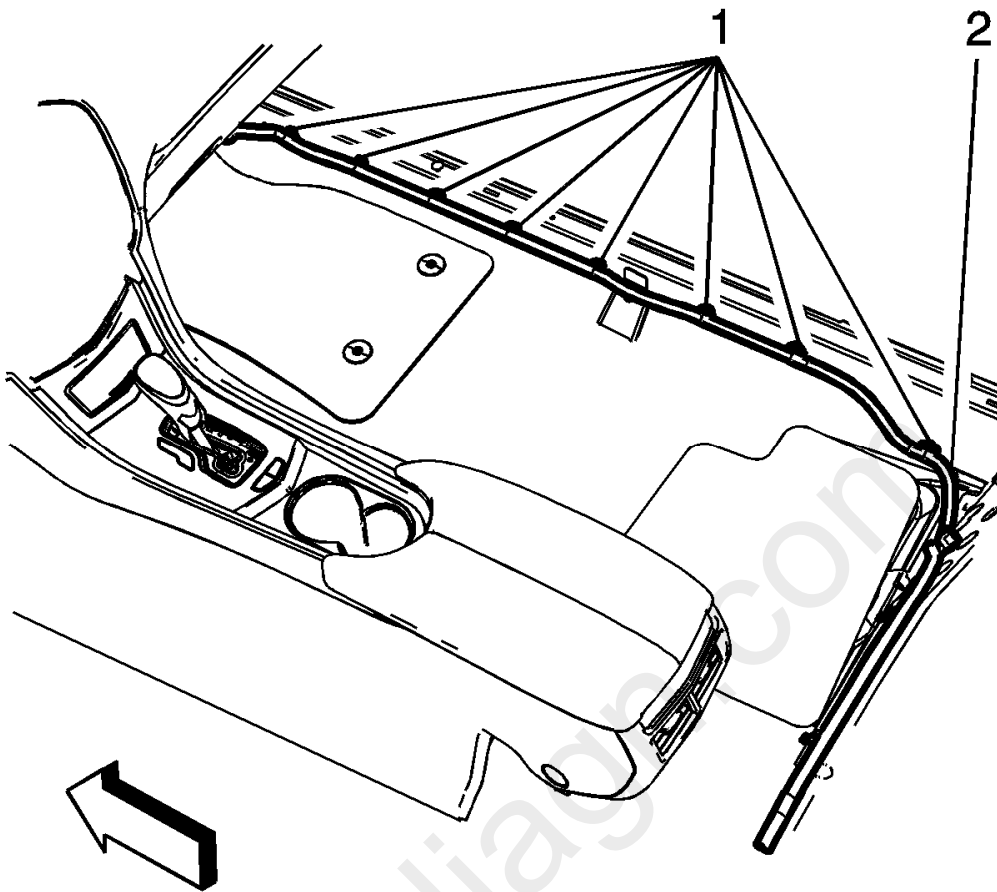


Fig. 30: Battery Positive Cable Retainers
Courtesy of GENERAL MOTORS COMPANY

8. Attach the battery positive cable (2) to the right side passenger compartment with the retainers (1).

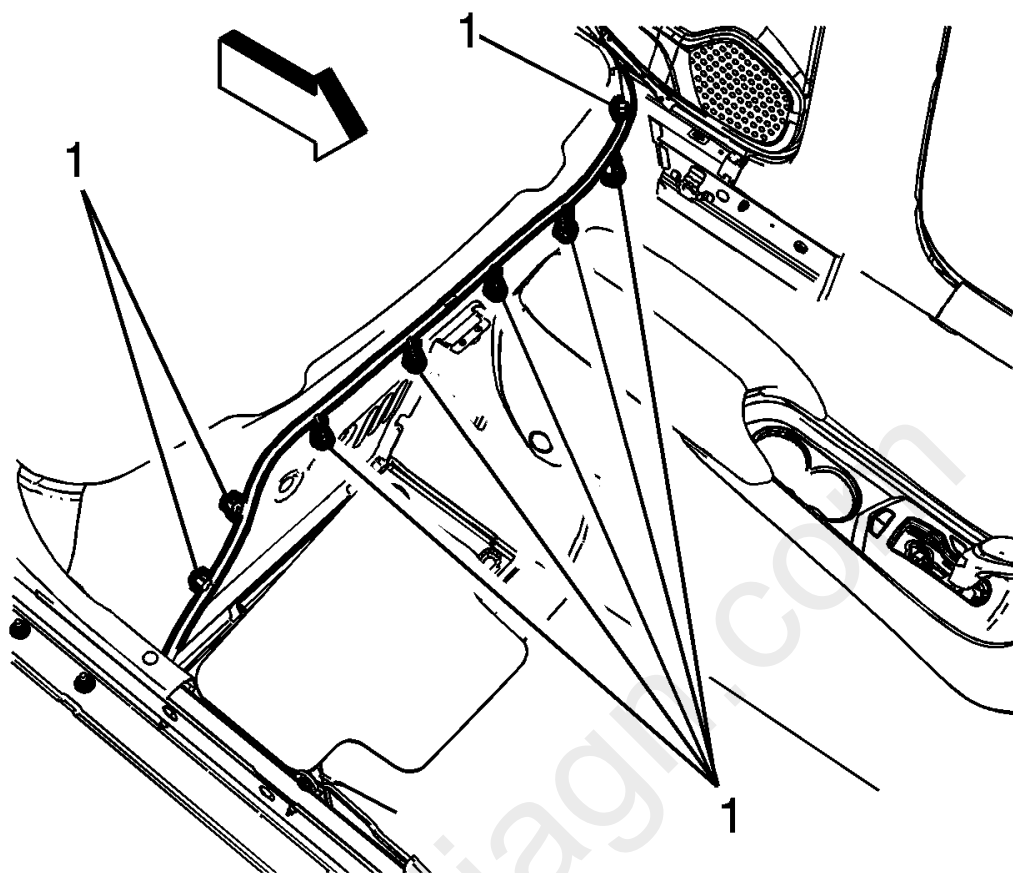


Fig. 31: Battery Positive Cable Retainers
Courtesy of GENERAL MOTORS COMPANY

9. Position the battery positive cable (2) along the rear seat area with the retainers (1).

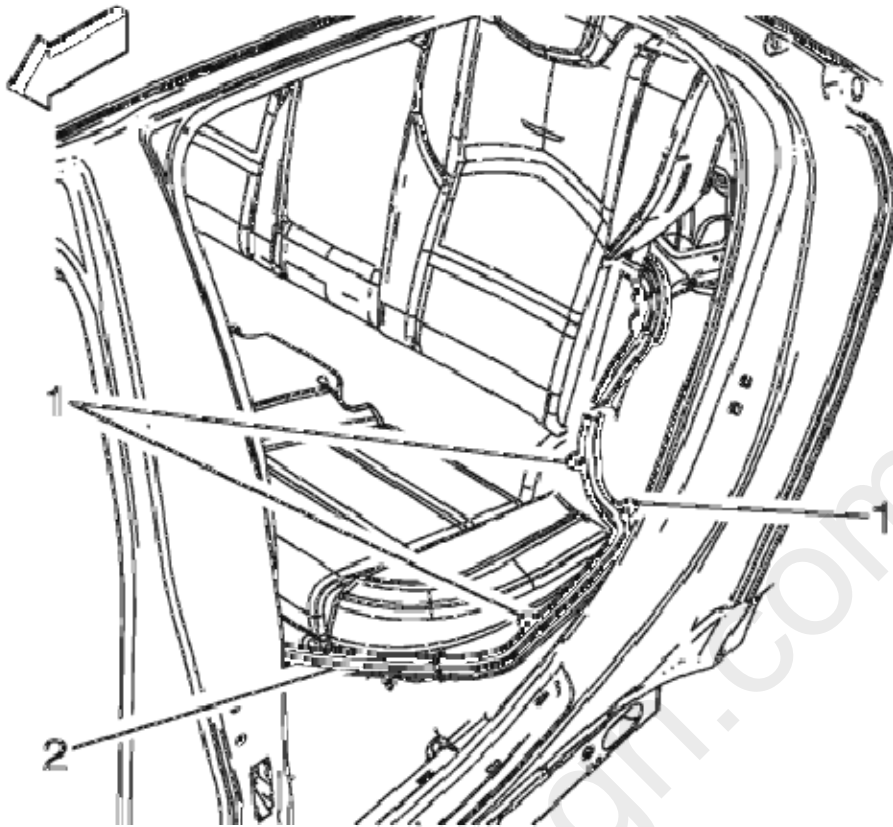


Fig. 32: Battery Positive Cable Retainers At Side Of Left Rear Seat.
Courtesy of GENERAL MOTORS COMPANY

10. Install the battery positive cable (2) along the left rear seat with the retainers (1).
11. Position the front and rear carpet back into position.
12. Install the front side door sill garnish molding. Refer to **Front Side Door Sill Garnish Molding Replacement** .
13. Install the rear side door sill garnish molding left and right. Refer to **Rear Side Door Sill Garnish Molding Replacement** .
14. Install the center pillar lower trim panel. Refer to **Center Pillar Lower Trim Panel Replacement** .
15. Install the rear seat cushion. Refer to **Rear Seat Cushion Removal and Installation** .
16. Install the rear seat back bolster. Refer to **Rear Seat Back Bolster Replacement** .
17. Install the passenger seat. Refer to **Driver or Passenger Seat Removal and Installation** .

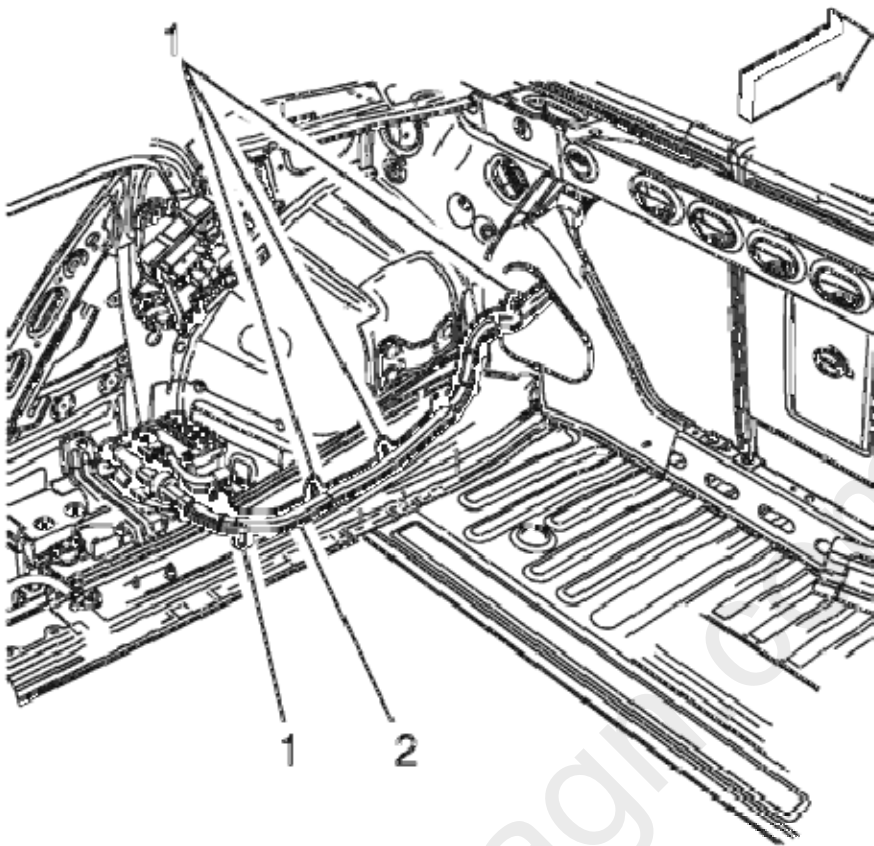


Fig. 33: Battery Positive Cable Retainers At Studs and body harness
Courtesy of GENERAL MOTORS COMPANY

18. Install the battery positive cable (2) along the left rear compartment area with the retainers (1).

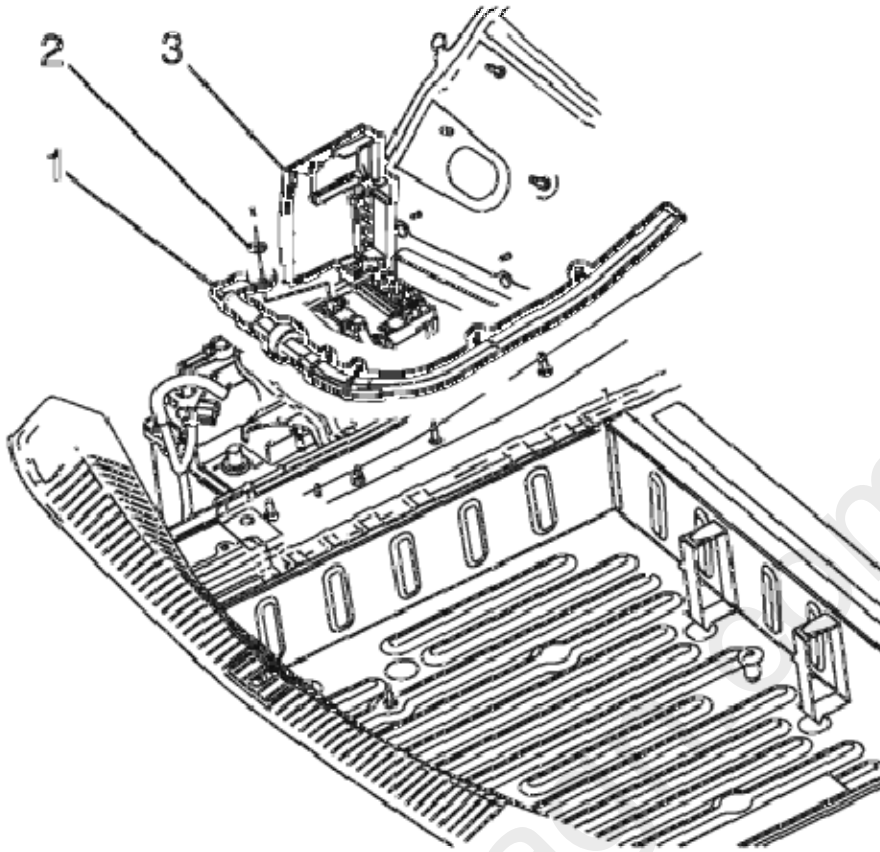


Fig. 34: Battery Fuse Block Cover
Courtesy of GENERAL MOTORS COMPANY

19. Install the battery positive cable terminal (1) to the battery fuse block stud and tighten the fastener (2) to 12 (106 lb in).
20. Install the battery fuse block cover (3).
21. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.
22. Install the left side rear compartment trim panel. Refer to **Rear Compartment Side Trim Replacement - Left Side**.

STARTER SOLENOID CABLE REPLACEMENT (LFX)

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.
2. Remove the left catalytic converter. Refer to **Catalytic Converter Replacement - Left Side (LFX)**.
3. Remove the plenum front panel. Refer to **Plenum Front Panel Replacement**.

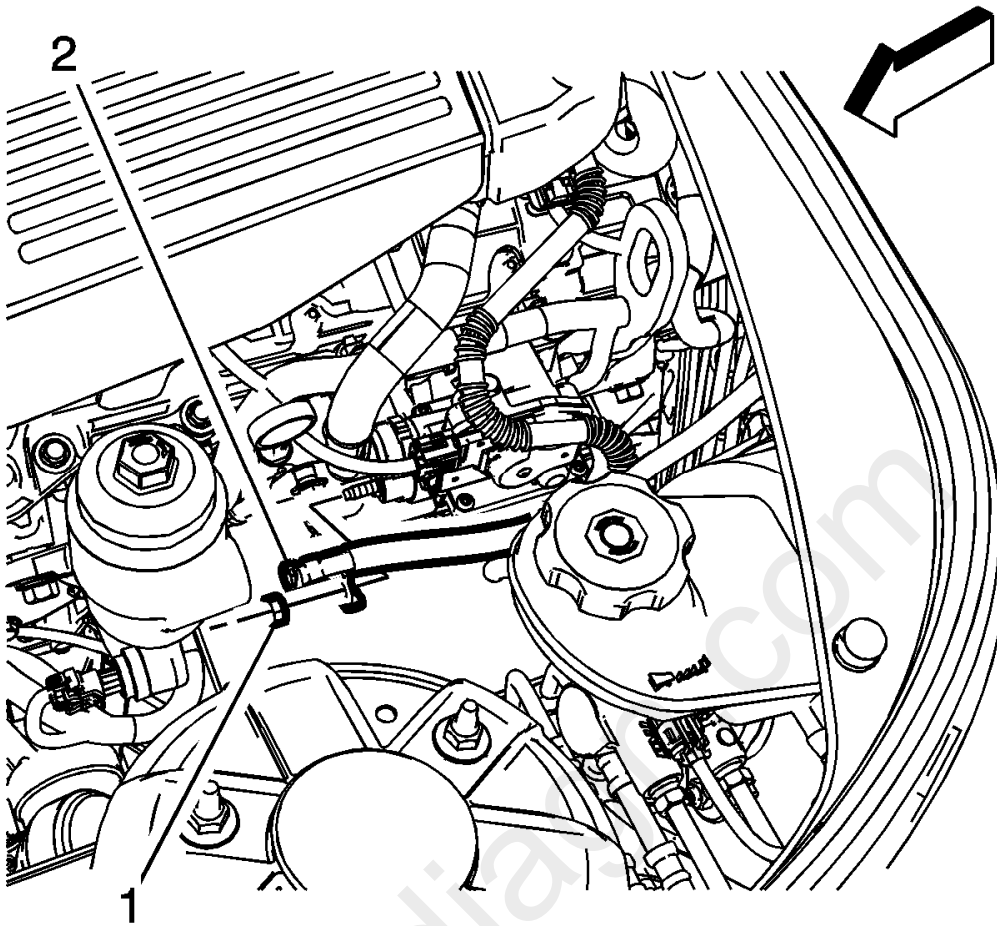


Fig. 35: Starter Solenoid Cable And Fastener
Courtesy of GENERAL MOTORS COMPANY

4. Remove the starter solenoid fastener (1) and remove the starter solenoid cable (2).

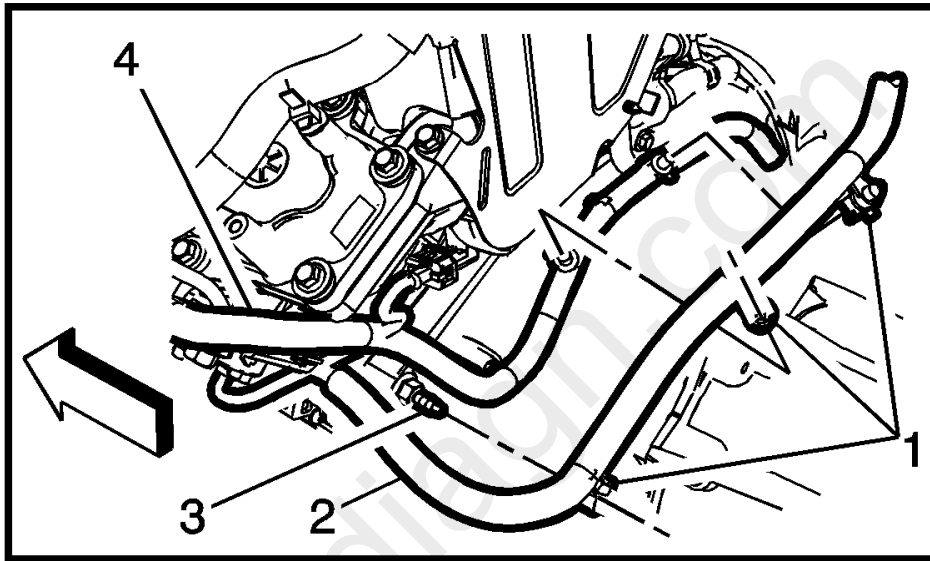
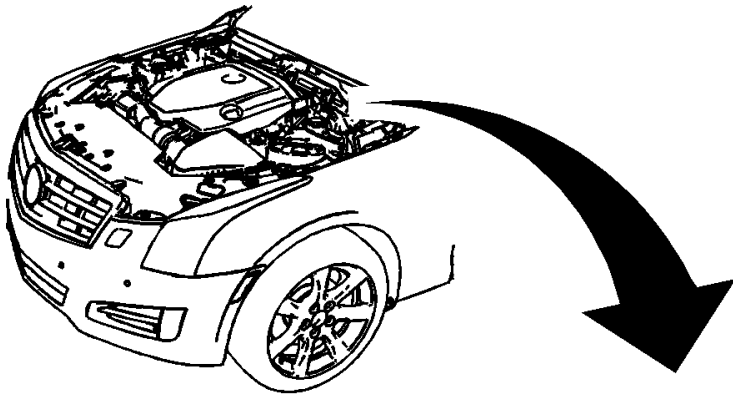


Fig. 36: Starter Solenoid Cable Retainers At Engine Harness And Transmission Stud
Courtesy of GENERAL MOTORS COMPANY

5. Remove the starter solenoid cable retainers (1) from the engine harness (4) and transmission stud (3).

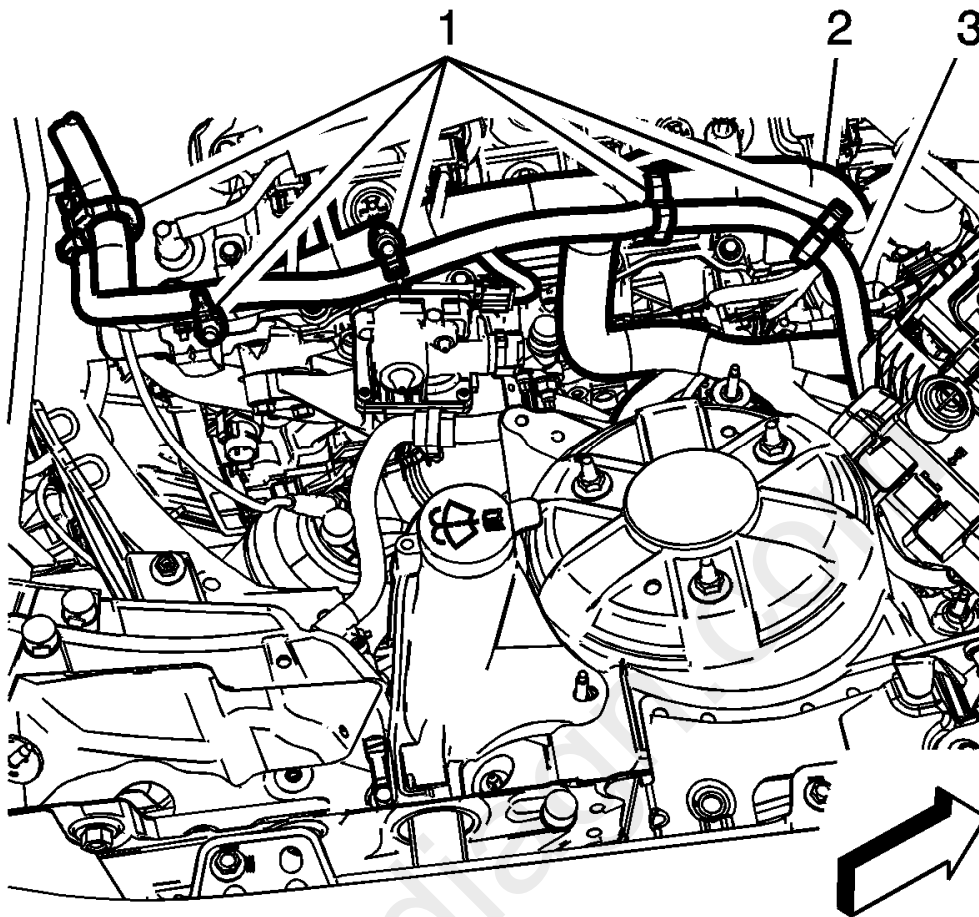


Fig. 37: Starter Solenoid Cable Retainers At Engine Harness
Courtesy of GENERAL MOTORS COMPANY

6. Remove the starter solenoid cable retainers (1) from the engine harness (2).

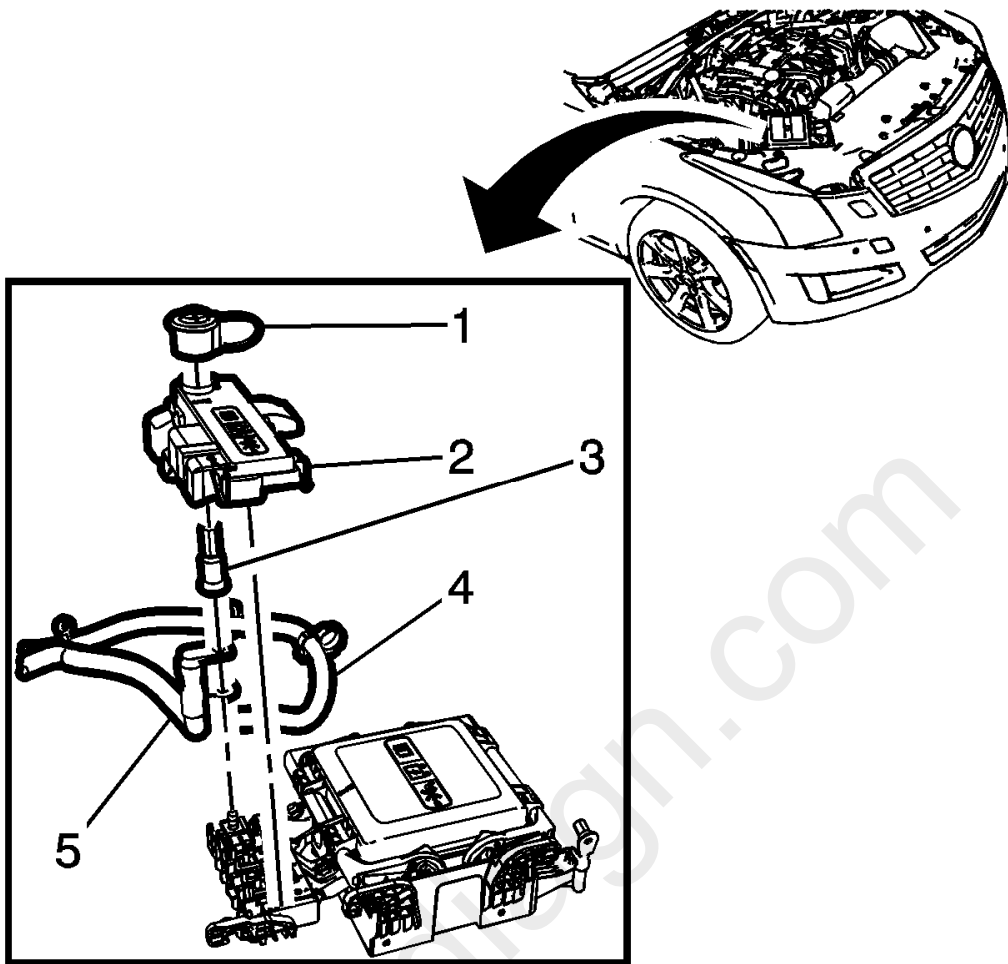


Fig. 38: Pre-Fuse Block

Courtesy of GENERAL MOTORS COMPANY

7. Remove the following from the pre-fuse block:
 - Battery Jumper Post Cover (1).
 - Pre-Fuse Block Cover (2).
 - Battery Positive Barrel Fastener (3).
 - Starter Solenoid Cable (4).
 - Battery Positive Cable (5).
8. Remove the starter solenoid cable (4) from the engine compartment.

Installation Procedure

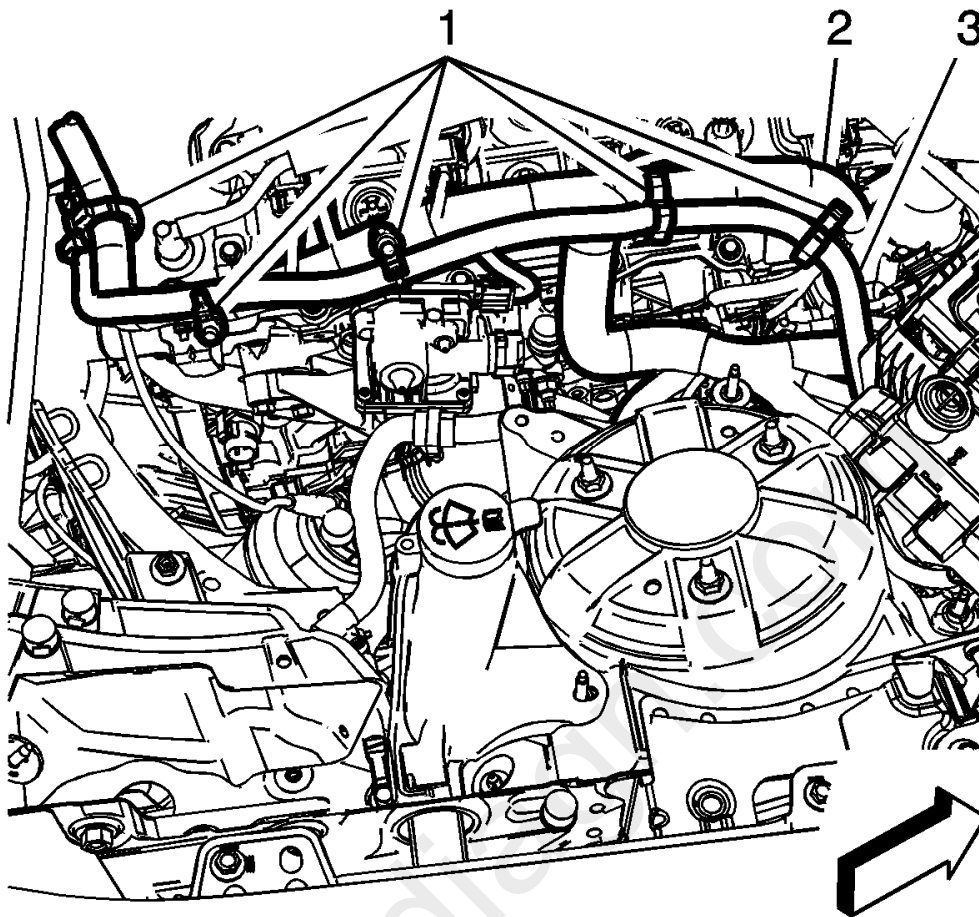


Fig. 39: Starter Solenoid Cable Retainers At Engine Harness
Courtesy of GENERAL MOTORS COMPANY

1. Position the starter solenoid cable (3) to the right top side of engine and attach to the engine harness (2) with the retainers (1).

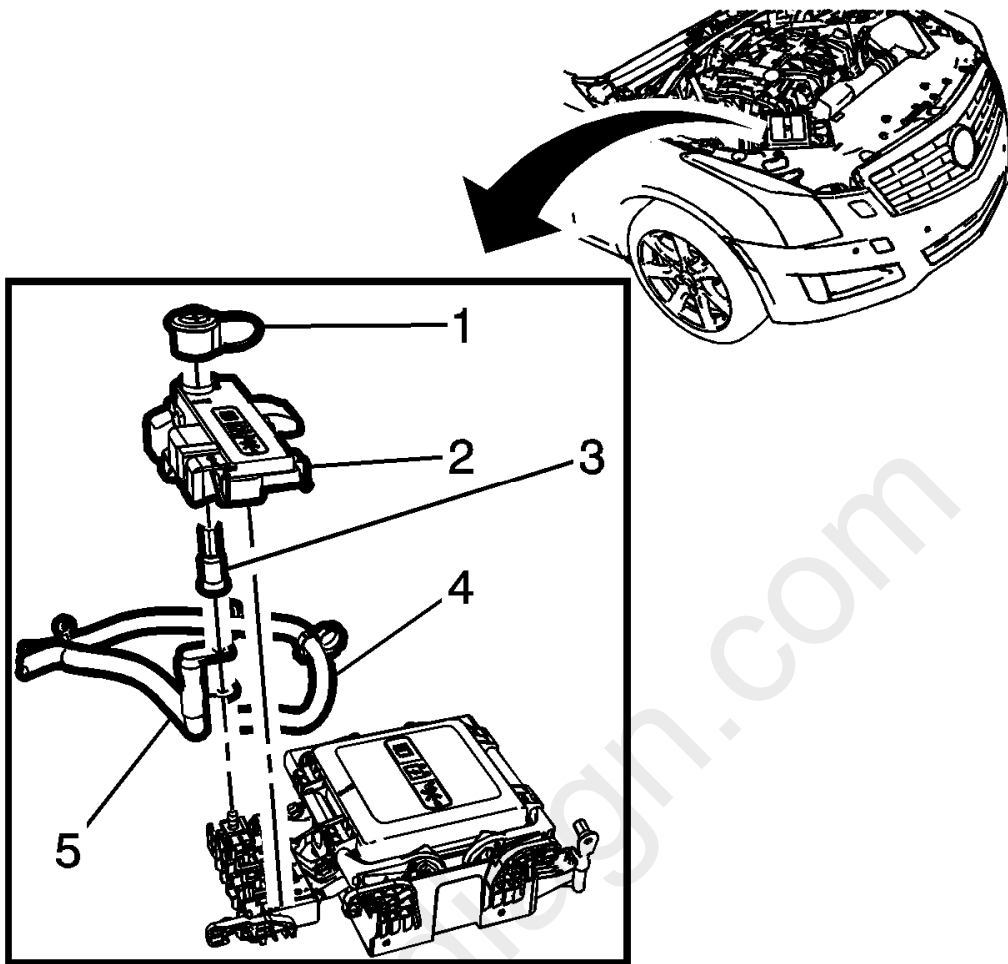


Fig. 40: Pre-Fuse Block
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Attach the following to the pre-fuse block:
 - Starter Solenoid Cable (4).
 - Battery Positive Cable (5).
 - Battery Positive Barrel Fastener (3). Tighten to 12 (106 lb in).
 - Pre-Fuse Block Cover (2).
 - Battery Jumper Post Cover (1).

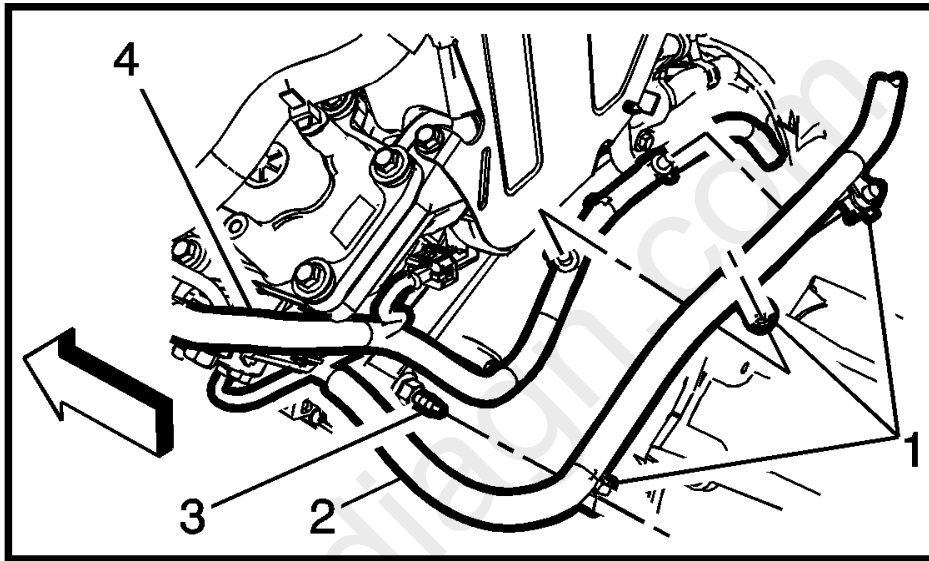
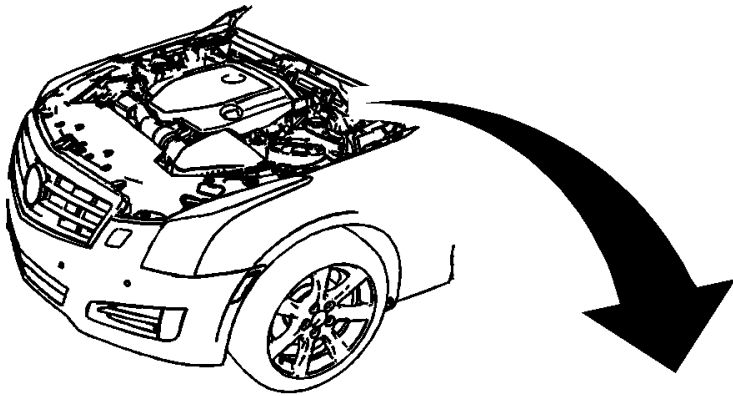


Fig. 41: Starter Solenoid Cable Retainers At Engine Harness And Transmission Stud
Courtesy of GENERAL MOTORS COMPANY

3. Install the starter solenoid cable (2) to the engine harness (4) and the transmission stud (3), with the retainers (1).

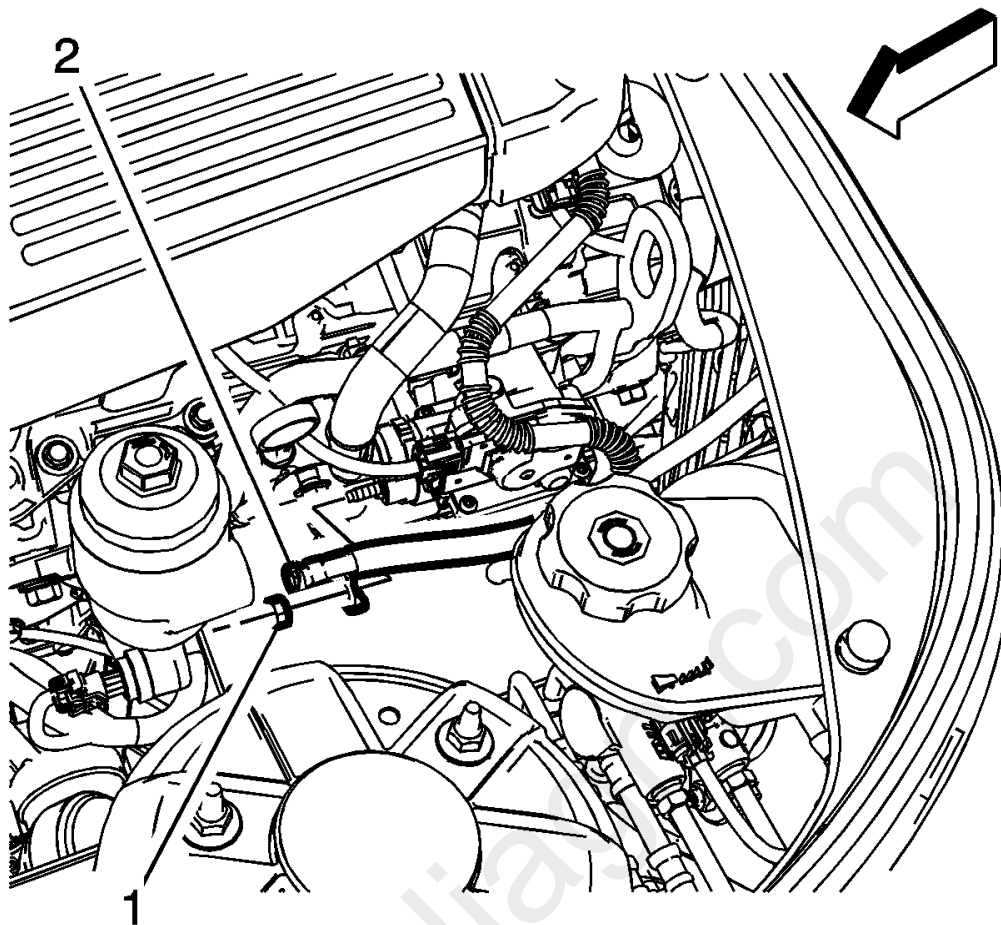


Fig. 42: Starter Solenoid Cable And Fastener
 Courtesy of GENERAL MOTORS COMPANY

4. Install the starter solenoid cable (2) to the starter solenoid and tighten the fastener (1) to 10 (89 lb in).
5. Install the left catalytic converter. Refer to **Catalytic Converter Replacement - Left Side (LFX)** .
6. Install the plenum front panel. Refer to **Plenum Front Panel Replacement** .
7. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.

STARTER SOLENOID CABLE REPLACEMENT (LTG)

Removal Procedure

1. If equipped with an engine block heater (K05), remove the engine block heater cord replacement. Refer to **Coolant Heater Cord Replacement (LTG)** .
2. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
4. If equipped with all-wheel drive, remove the front axle propeller shaft. Refer to **Front Axle Propeller Shaft Replacement** .

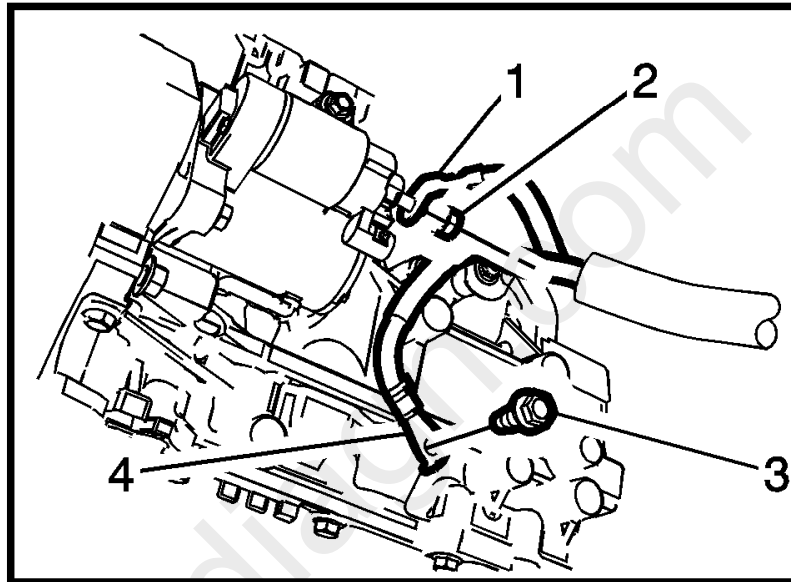
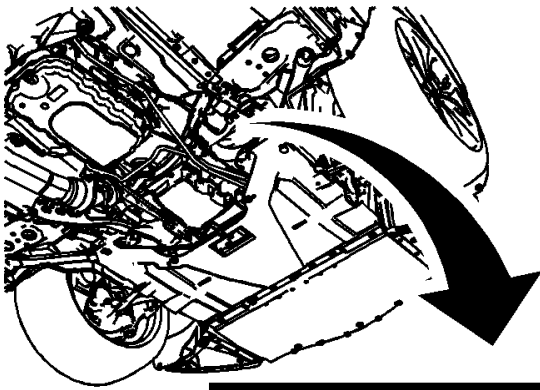


Fig. 43: Starter Solenoid And Cable
Courtesy of GENERAL MOTORS COMPANY

5. Remove the starter solenoid fastener (2) and remove the starter solenoid cable (1).
6. Remove the starter solenoid ground cable fastener (3) and remove the starter solenoid ground cable (4).

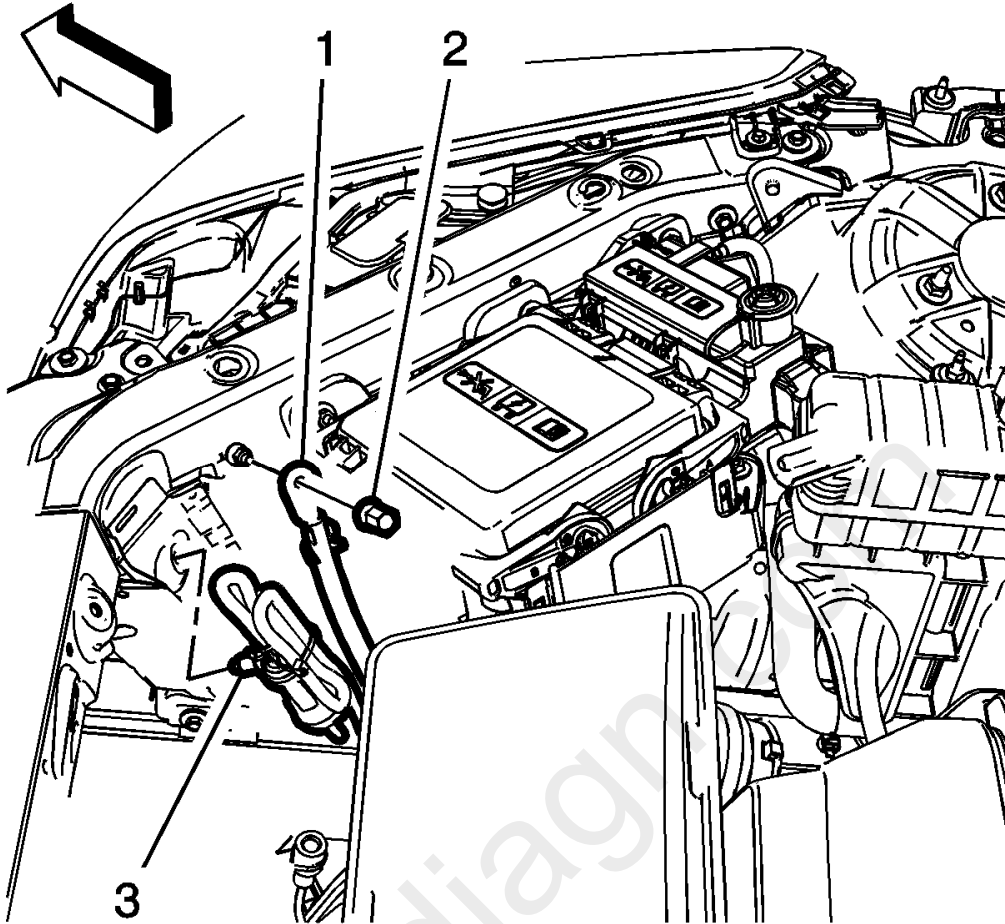


Fig. 44: Starter Solenoid Ground Cable
Courtesy of GENERAL MOTORS COMPANY

7. Remove the starter solenoid ground cable fastener (2) and remove the starter solenoid ground cable (1).
8. Detach the heater cord retainer (3), if equipped.

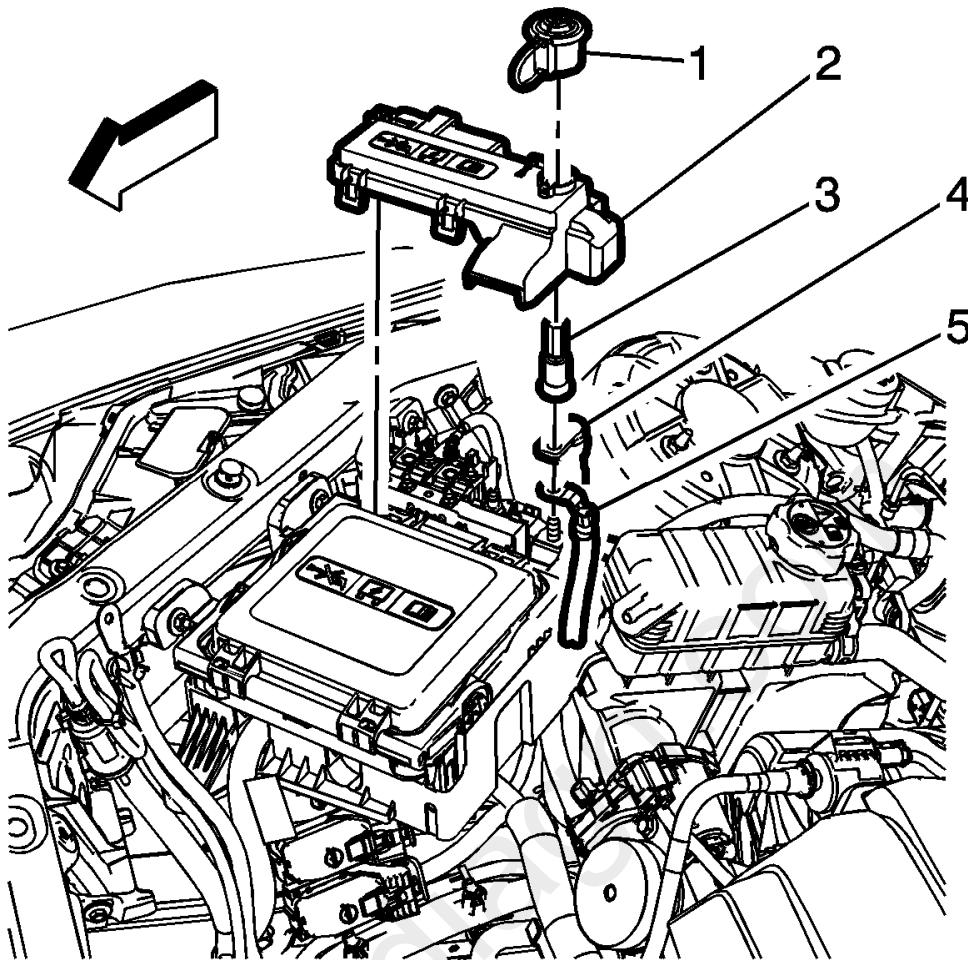


Fig. 45: Pre-Fuse Block
Courtesy of GENERAL MOTORS COMPANY

9. Remove the following from the pre-fuse block:

- Battery Jumper Post Cover (1).
- Pre-Fuse Block Cover (2).
- Battery Positive Barrel Fastener (3).
- Battery Positive Cable (4).
- Starter Solenoid Cable (5).

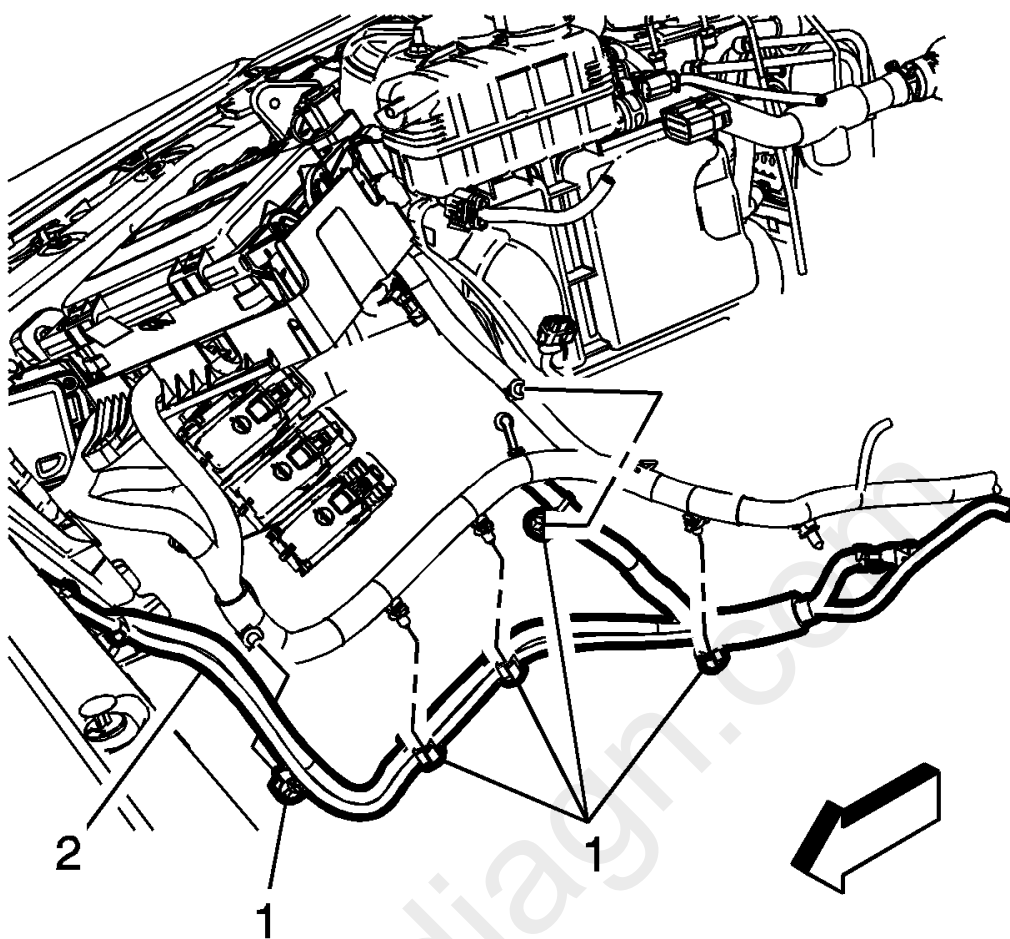


Fig. 46: Starter Solenoid Cable Retainers
Courtesy of GENERAL MOTORS COMPANY

10. Detach the starter solenoid cable retainers (1) from the engine harness and remove the starter solenoid cable (2) from the engine compartment.

Installation Procedure

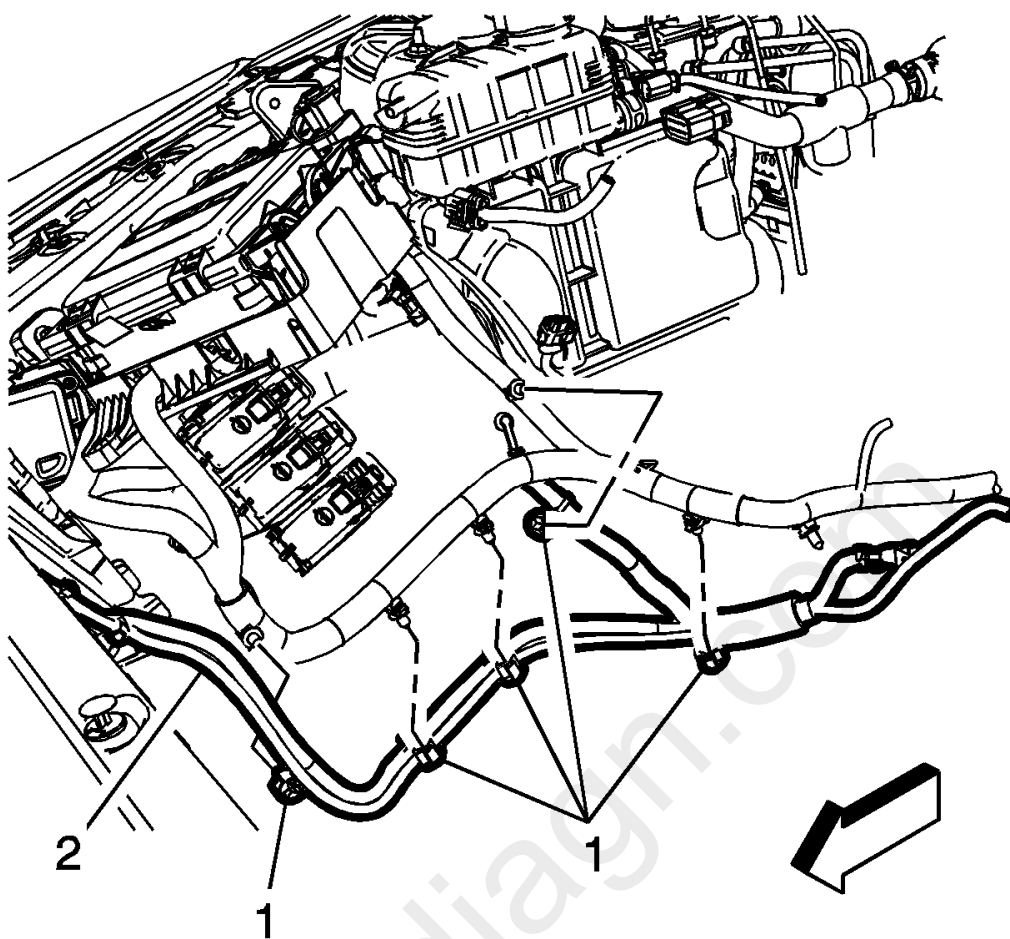


Fig. 47: Starter Solenoid Cable Retainers
Courtesy of GENERAL MOTORS COMPANY

1. Attach the starter solenoid cable retainers (1) to the engine harness.

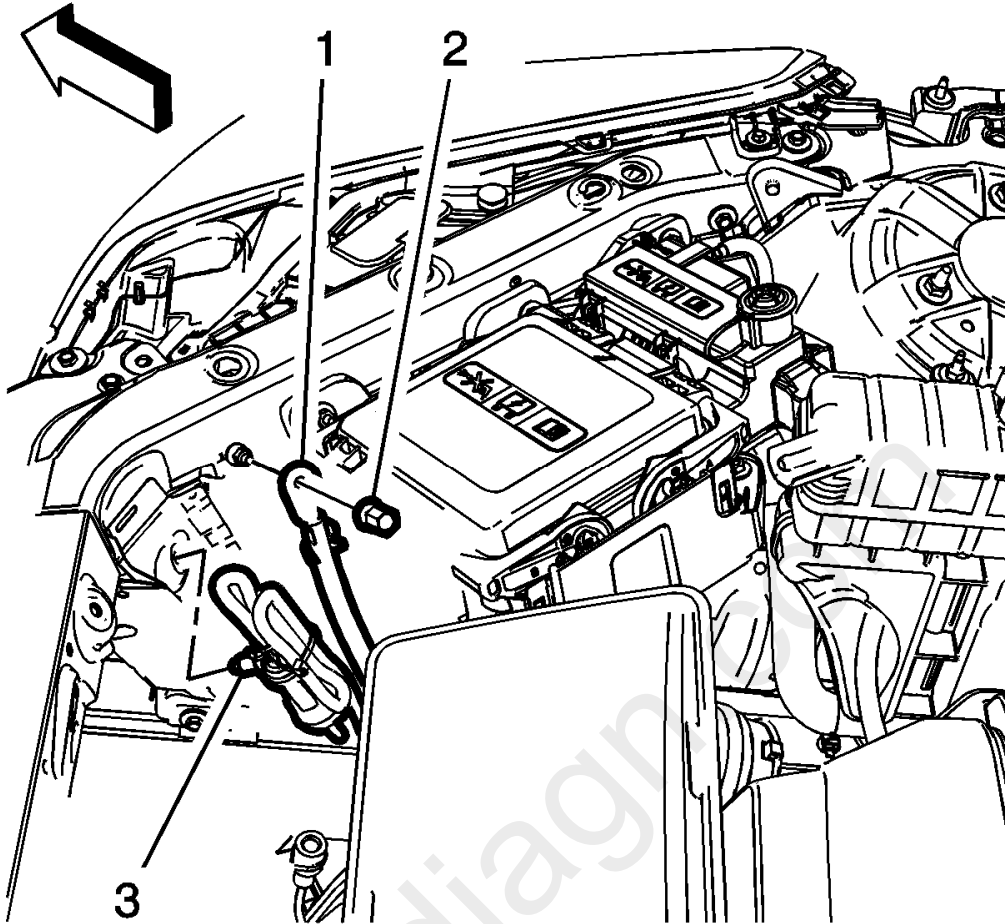


Fig. 48: Starter Solenoid Ground Cable
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Install the starter solenoid cable ground (1), to the right upper tie bar frame extension rail, and tighten the fastener (2) to 11 (97 lb in).
3. Attach the heater cord retainer (3), if equipped.

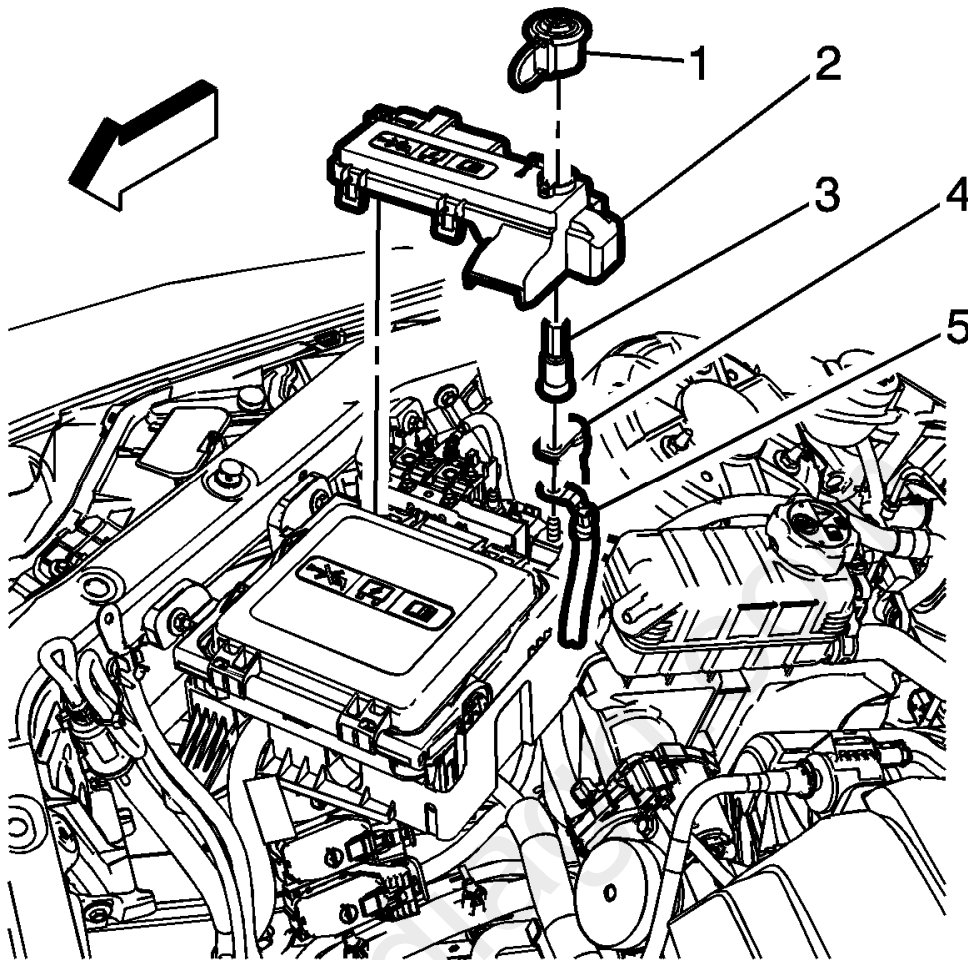


Fig. 49: Pre-Fuse Block
Courtesy of GENERAL MOTORS COMPANY

4. Attach the following to the pre-fuse block:
- Starter Solenoid Cable (5).
 - Battery Positive Cable (4).
 - Battery Positive Barrel Fastener (3). Tighten to 12 (106 lb in).
 - Pre-Fuse Block Cover (2).
 - Battery Jumper Post Cover (1).

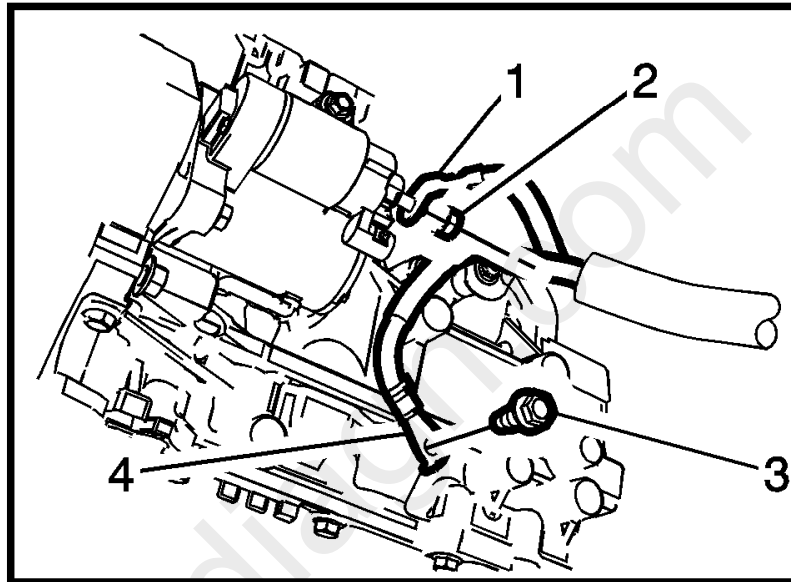
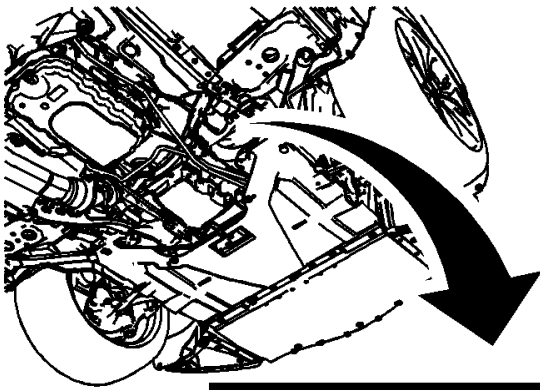


Fig. 50: Starter Solenoid And Cable
Courtesy of GENERAL MOTORS COMPANY

5. Install the starter solenoid cable (1) to the starter solenoid and tighten the fastener (2) to 10 (89 lb in).
6. Install the starter solenoid cable ground (4), to the engine block, and tighten the fastener (3) to 45 (33 lb ft).
7. If equipped with all-wheel drive, install the front axle propeller shaft. Refer to **Front Axle Propeller Shaft Replacement** .
8. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.
9. If equipped with an engine block heater (K05), install the engine block heater cord replacement. Refer to **Coolant Heater Cord Replacement (LTG)** .

STARTER SOLENOID CABLE REPLACEMENT (LF3)

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

3. Remove the starter heat shield. Refer to **Starter Shield Replacement (LF3)**.
4. Remove the left engine mount bracket. Refer to **Engine Mount Bracket Replacement - Left Side (LF3)**.

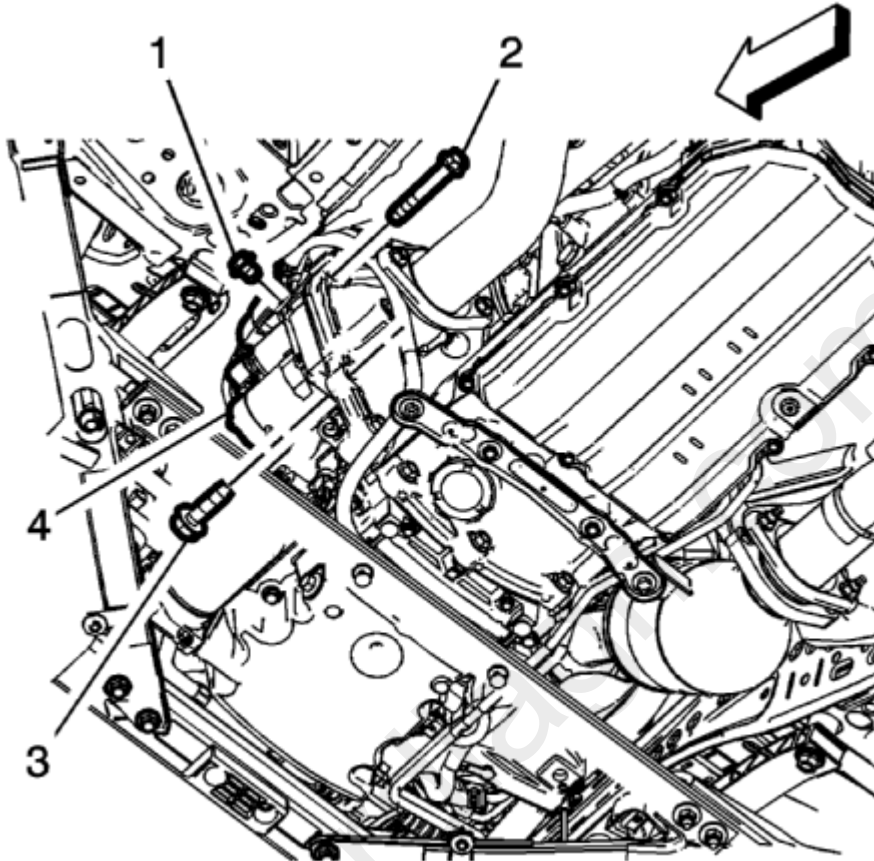


Fig. 51: Starter Mounting Fasteners And Starter
Courtesy of GENERAL MOTORS COMPANY

5. Remove the starter solenoid cable retainer fastener (1).
6. Remove the starter mounting fasteners (2, 3) and lower the starter (4) to access the electrical connections.

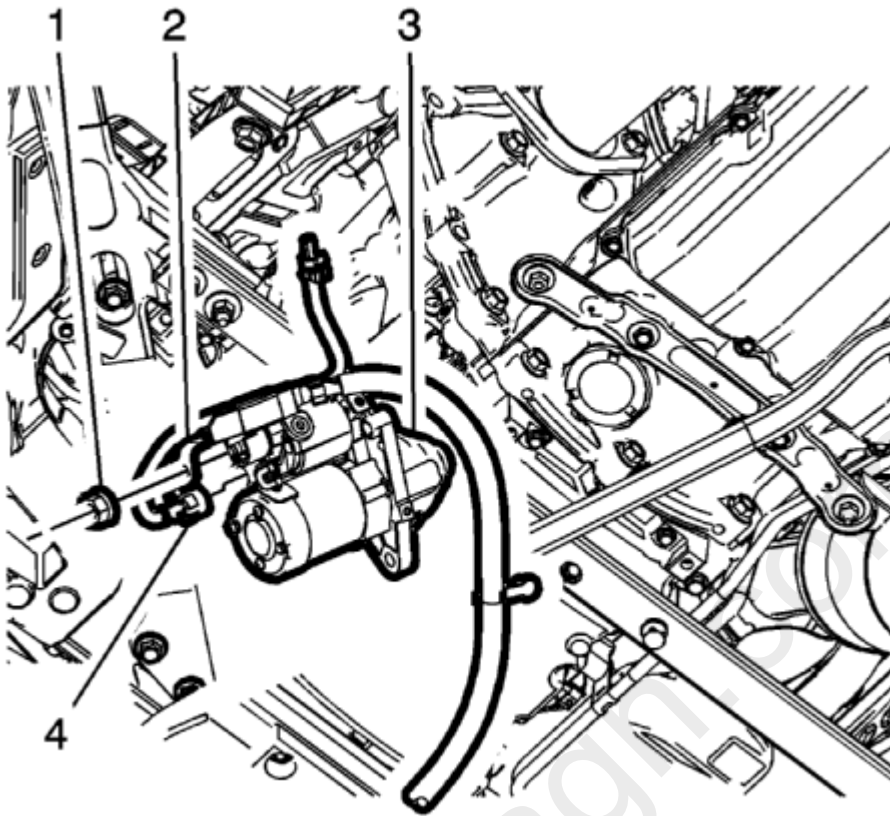


Fig. 52: Starter Solenoid Cable
Courtesy of GENERAL MOTORS COMPANY

7. Disconnect the starter solenoid cable connector (4).
8. Remove the starter solenoid fastener (1) and remove the starter solenoid cable terminal (2) from the starter.

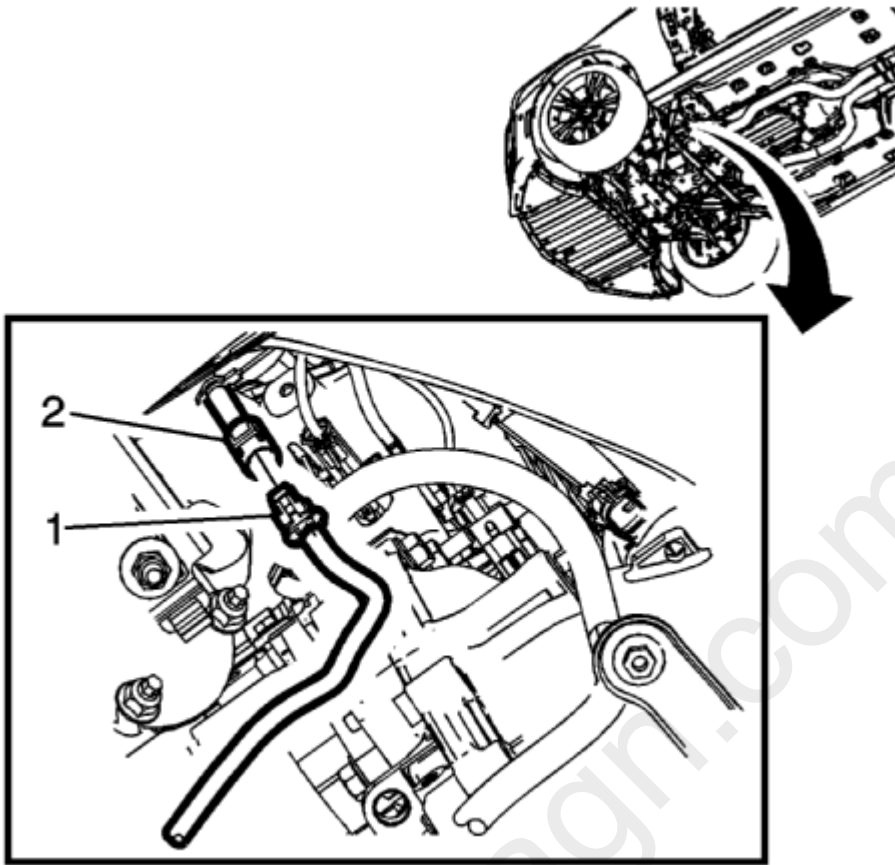


Fig. 53: Starter Solenoid Cable

Courtesy of GENERAL MOTORS COMPANY

9. Disconnect the starter solenoid cable connector (1) from the engine harness connector (2).

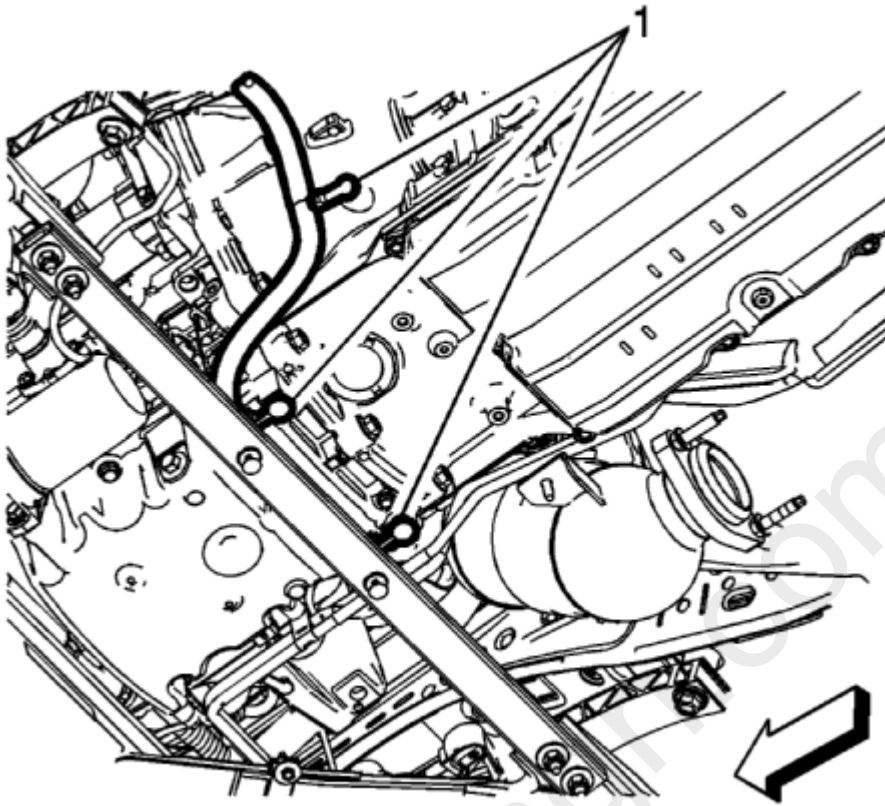


Fig. 54: Starter Solenoid Cable Retainers Around Transmission Housing
Courtesy of GENERAL MOTORS COMPANY

10. Remove the starter solenoid cable retainers (1) from around the transmission housing.

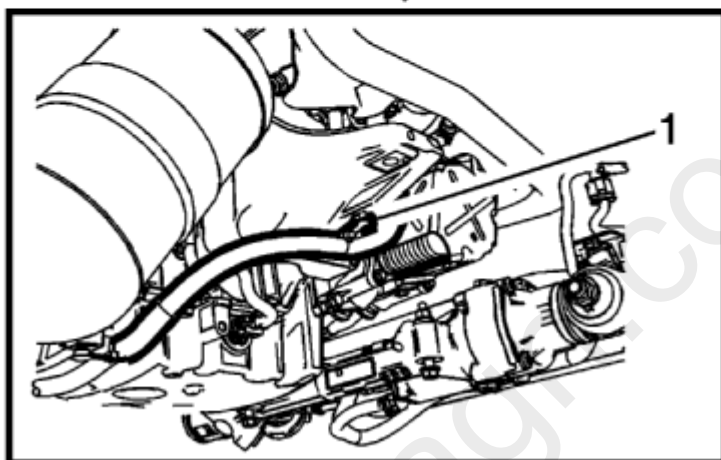
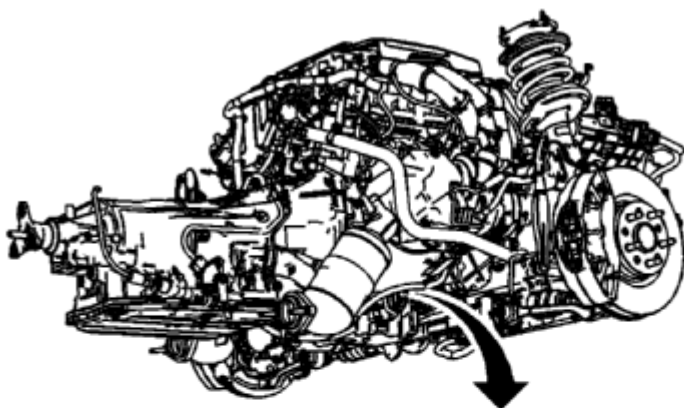


Fig. 55: Starter Solenoid Cable Retainer
Courtesy of GENERAL MOTORS COMPANY

11. Remove the starter solenoid cable retainer (1).

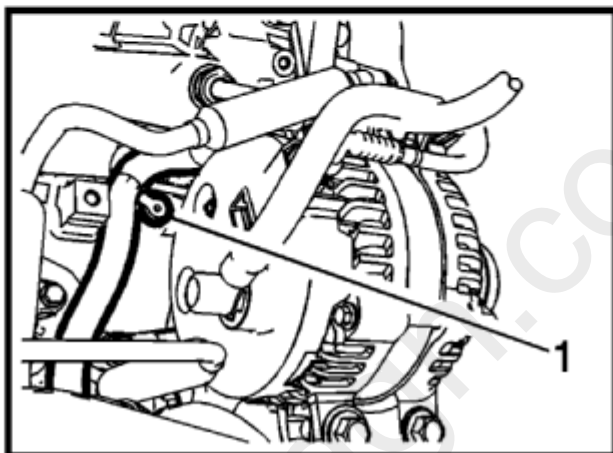
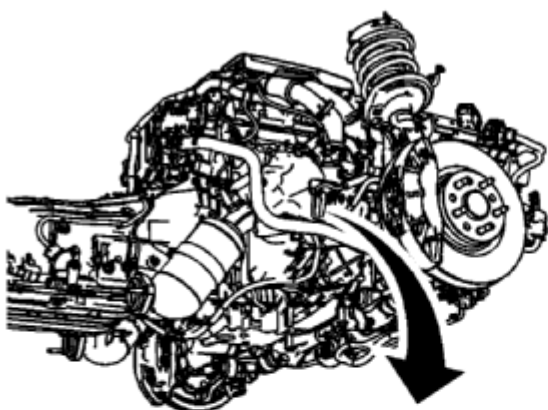


Fig. 56: Starter Solenoid Cable Retainer Behind Generator
Courtesy of GENERAL MOTORS COMPANY

12. Remove the starter solenoid cable retainer (1) behind the generator.

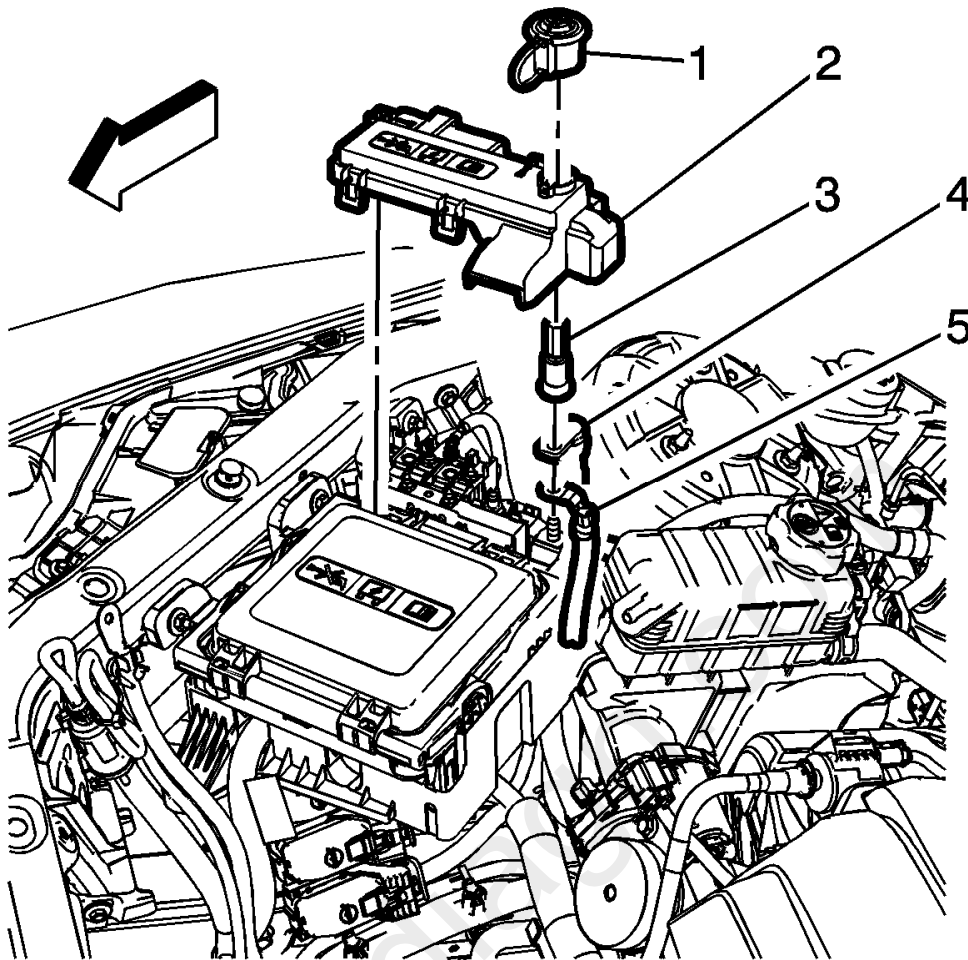


Fig. 57: Pre-Fuse Block
Courtesy of GENERAL MOTORS COMPANY

13. Remove the following from the pre-fuse junction block:
 - Battery Jumper Post Cover (1).
 - Pre-Fuse Block Cover (2).
 - Battery Positive Barrel Fastener (3).
 - Battery Positive Cable (4).
 - Starter Solenoid Cable (5).
14. Remove the starter solenoid cable (5) from the engine compartment.

Installation Procedure

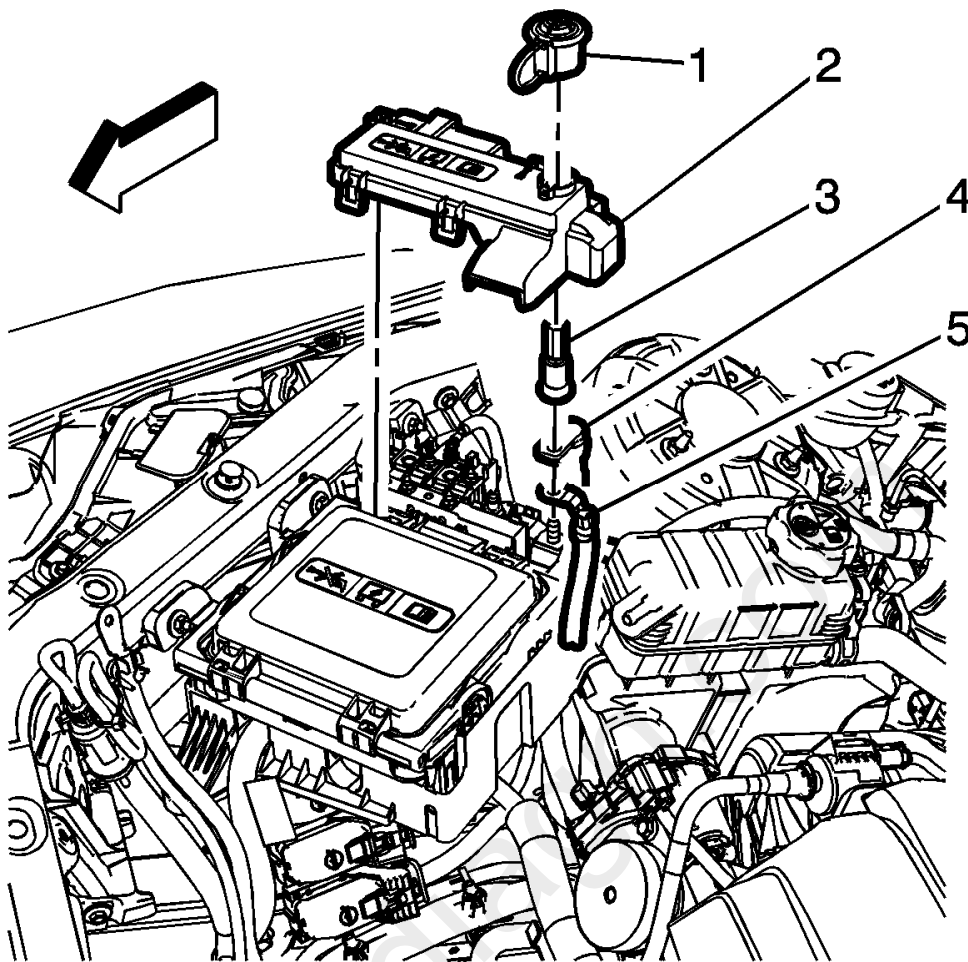


Fig. 58: Pre-Fuse Block

Courtesy of GENERAL MOTORS COMPANY

1. Attach the following to the pre-fuse junction block:

- Starter Solenoid Cable (5).
- Battery Positive Cable (4).

CAUTION: Refer to Fastener Caution .

- Battery Positive Barrel Fastener (3). Tighten to 15 (11 lb ft).
- Pre-Fuse Block Cover (2).
- Battery Jumper Post Cover (1).

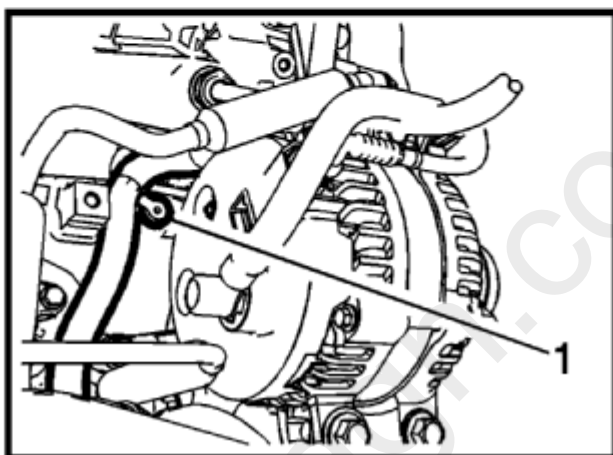
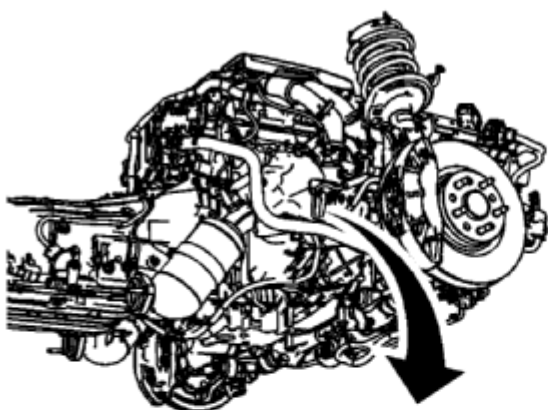


Fig. 59: Starter Solenoid Cable Retainer Behind Generator
Courtesy of GENERAL MOTORS COMPANY

2. Attach the starter solenoid cable retainer (1) , to the engine block, near the generator.

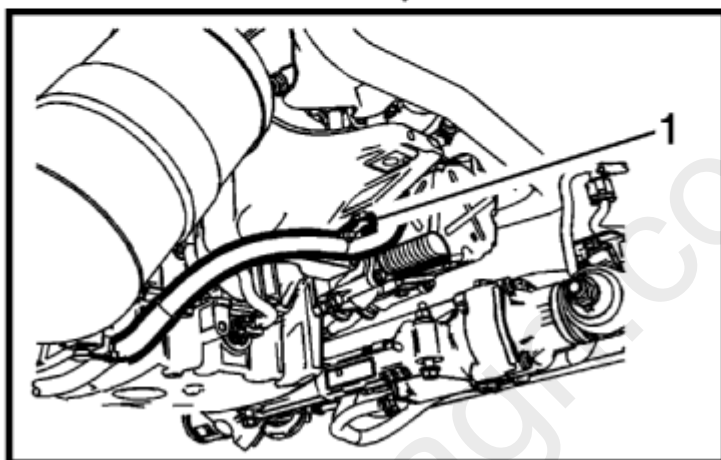
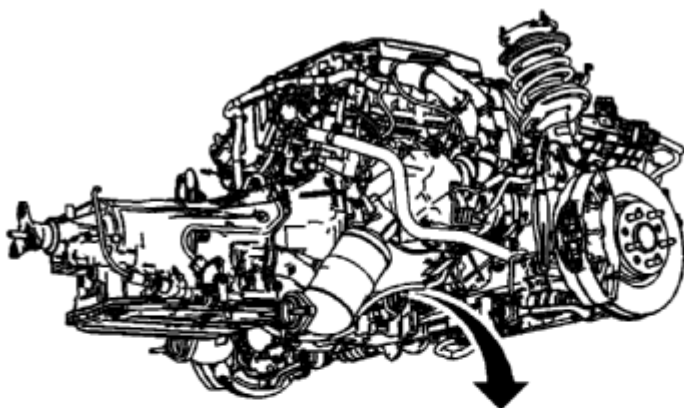


Fig. 60: Starter Solenoid Cable Retainer
Courtesy of GENERAL MOTORS COMPANY

3. Attach the starter solenoid cable retainer (1).

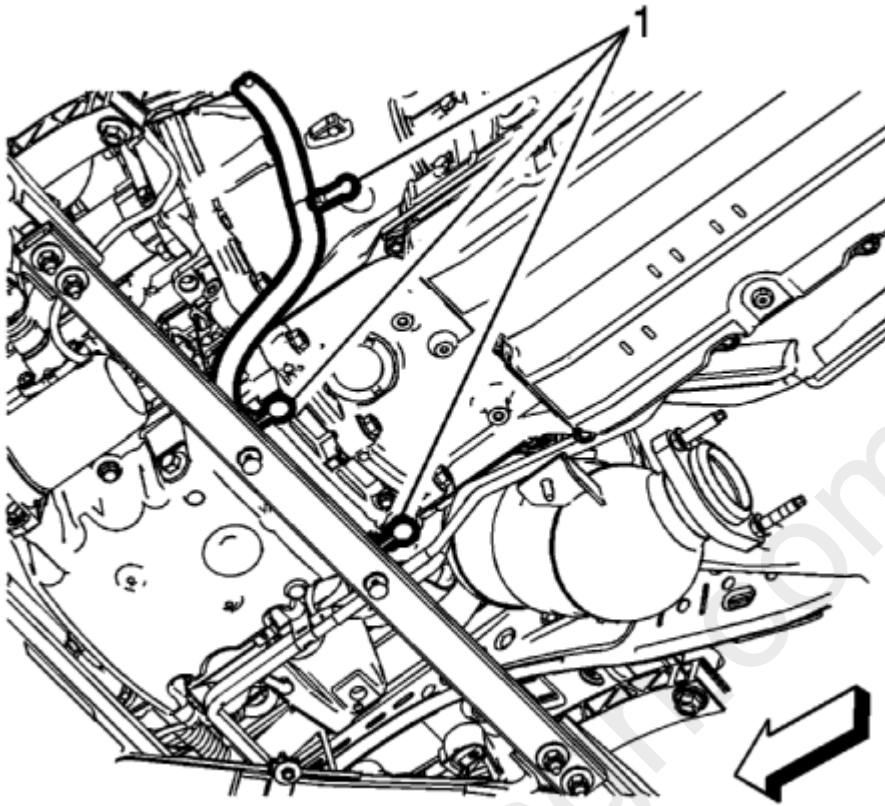


Fig. 61: Starter Solenoid Cable Retainers Around Transmission Housing
Courtesy of GENERAL MOTORS COMPANY

4. Attach the starter solenoid cable retainers (1) from around the transmission housing.

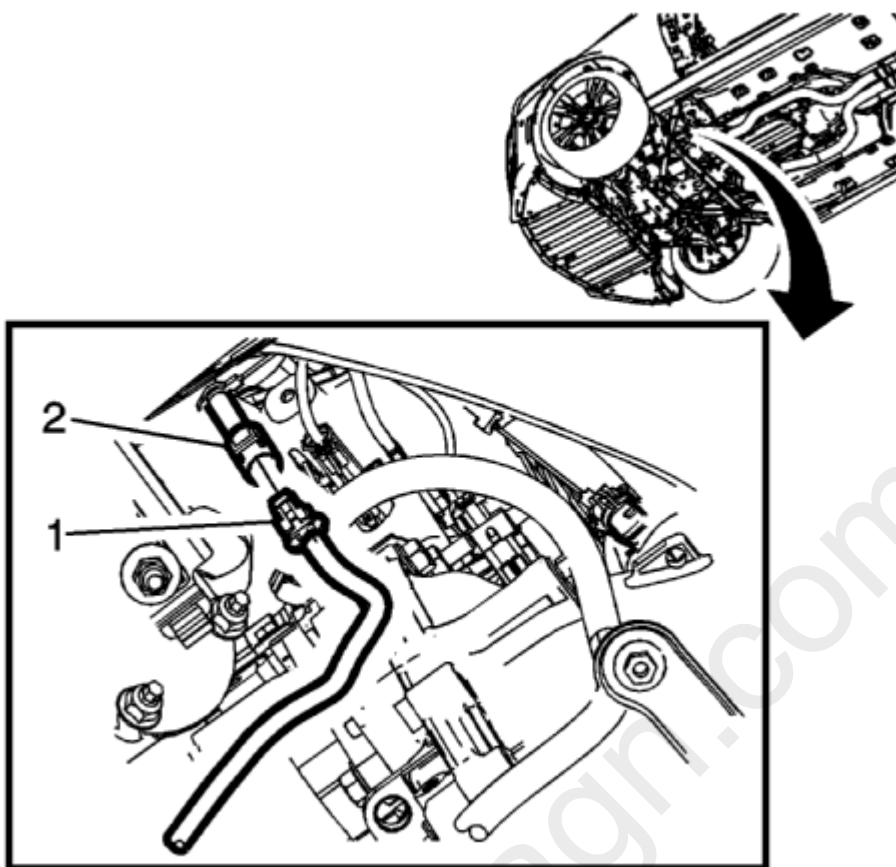


Fig. 62: Starter Solenoid Cable

Courtesy of GENERAL MOTORS COMPANY

5. Connect the starter solenoid cable connector (1) to the engine harness connector (2).

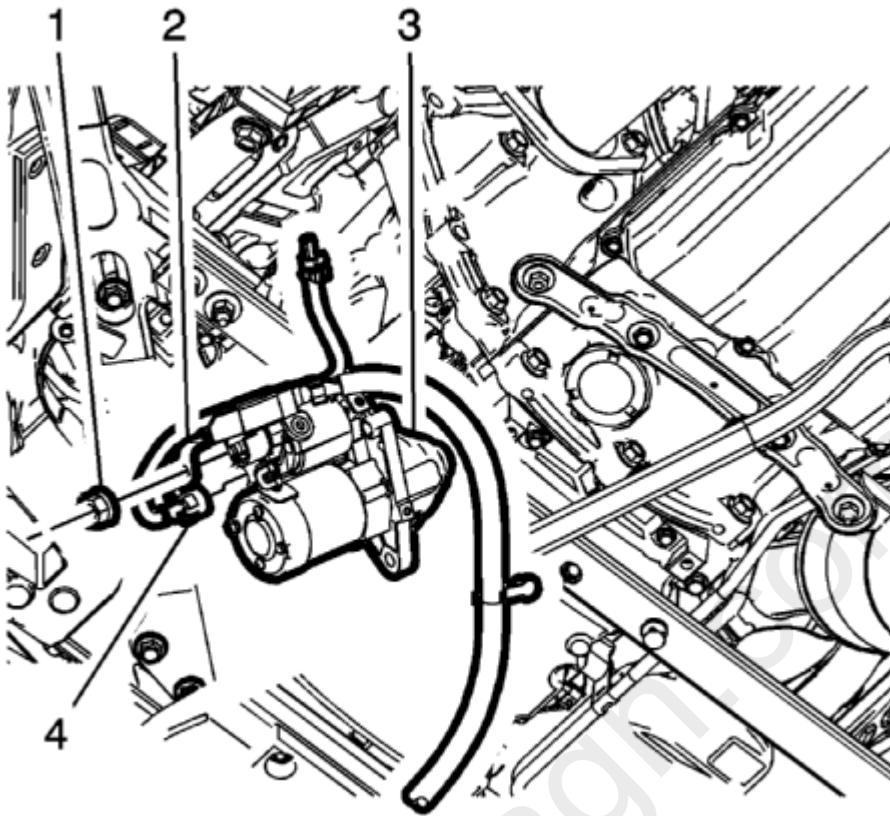


Fig. 63: Starter Solenoid Cable

Courtesy of GENERAL MOTORS COMPANY

6. Install the solenoid starter cable terminal (2) to the solenoid and tighten the fastener (1) to 12.5 (111 lb in).
7. Connect the starter solenoid cable connector (4) to the starter solenoid.
8. Install the starter (3) into position on the engine block.

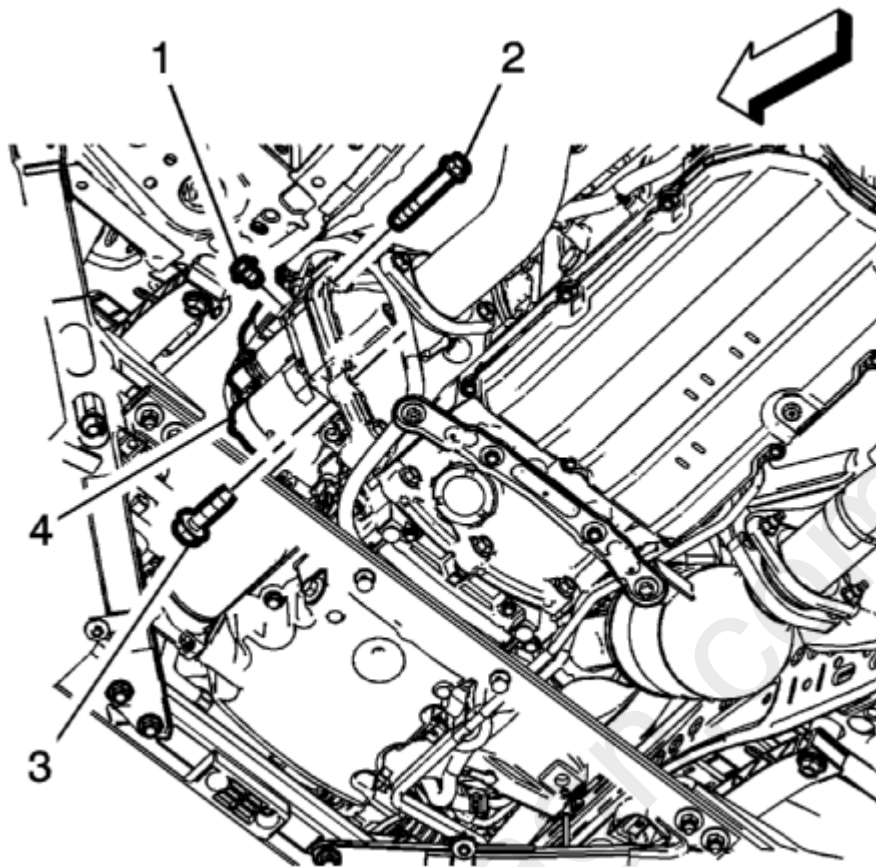


Fig. 64: Starter Mounting Fasteners And Starter
Courtesy of GENERAL MOTORS COMPANY

9. Install the starter mounting fasteners (2, 3) and tighten to 58 (43 lb ft).
10. Install the starter solenoid cable fastener (1) and tighten to 6 (53 lb in).
11. Install the starter heat shield. Refer to **Starter Shield Replacement (LF3)**.
12. Install the left engine mount bracket. Refer to **Engine Mount Bracket Replacement - Left Side (LF3)**.
13. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.

BATTERY REPLACEMENT

Removal Procedure

1. Reposition the left side rear compartment trim panel. Refer to **Rear Compartment Side Trim Replacement - Left Side**.
2. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.

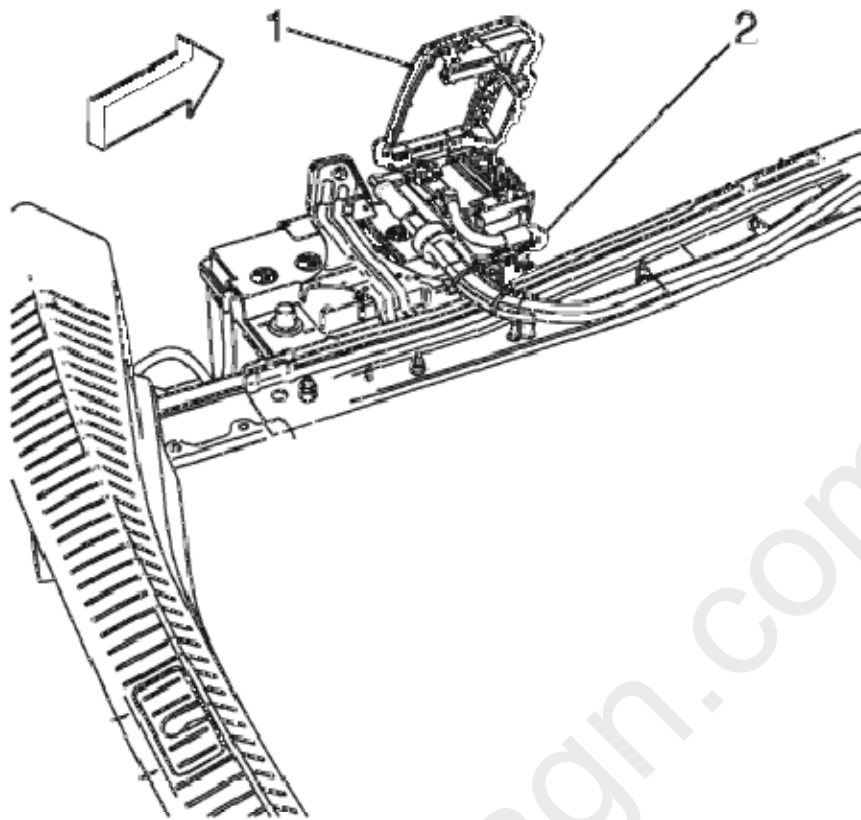


Fig. 65: Battery Fuse Block

Courtesy of GENERAL MOTORS COMPANY

3. Open the battery fuse block cover (1) and loosen the battery post cable clamp fastener (2) from the battery fuse block.

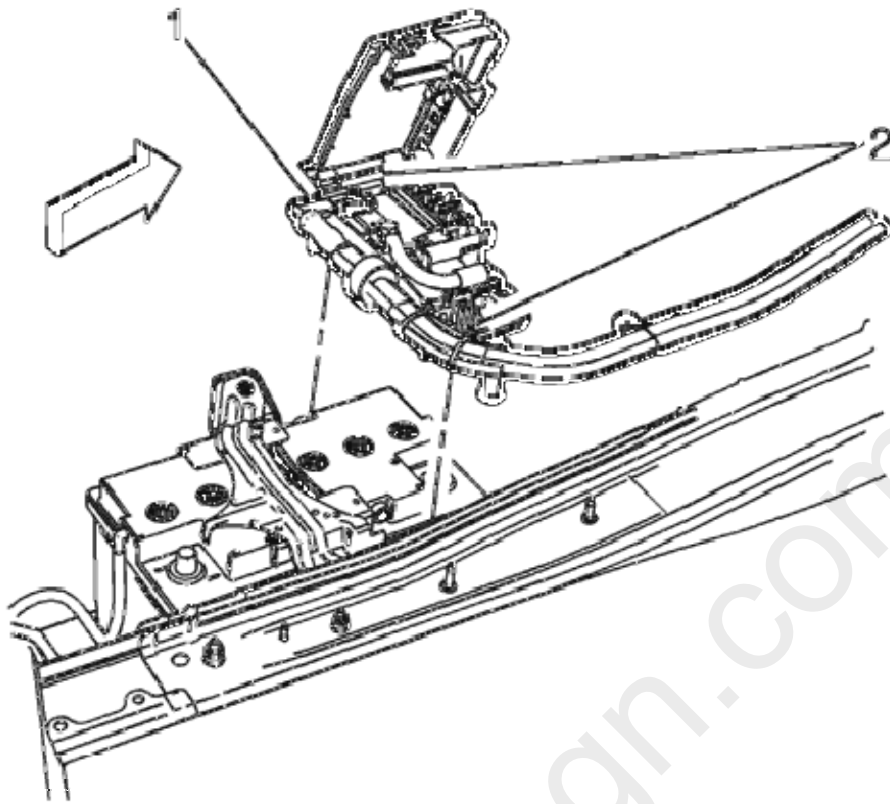


Fig. 66: Battery Fuse Block Retainer Clips
Courtesy of GENERAL MOTORS COMPANY

4. Unclip the battery fuse block retainer clips (2) and set aside the battery fuse block (1).

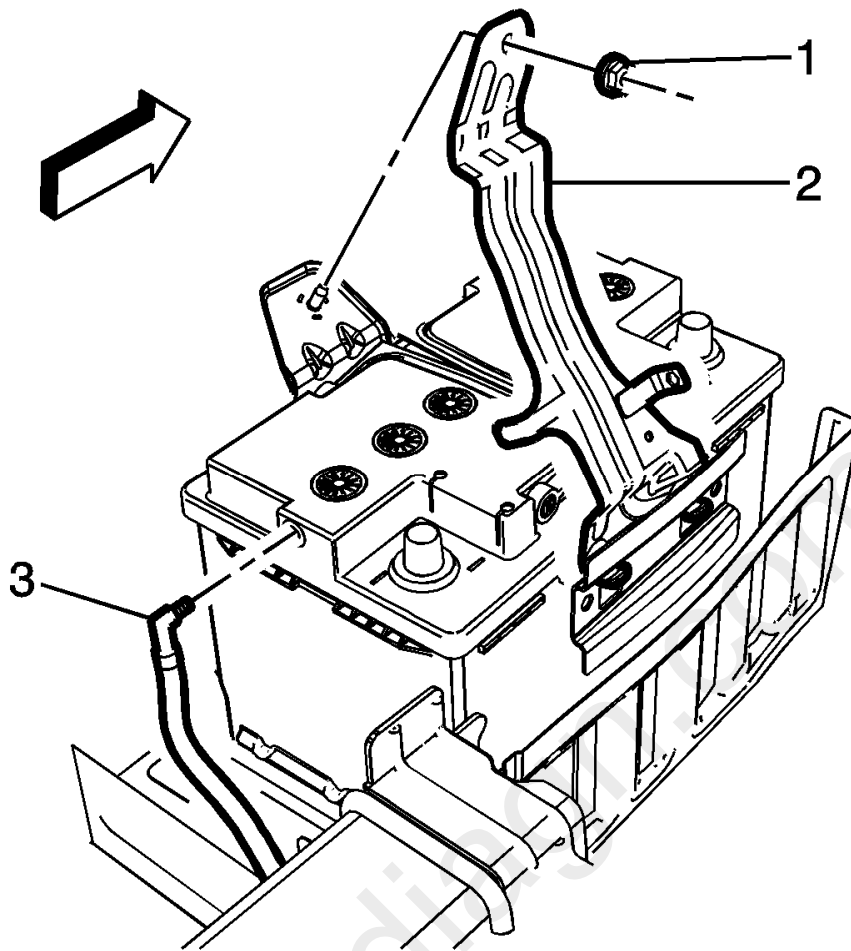


Fig. 67: Battery Hold Down Bracket Fastener And Vent Hose
Courtesy of GENERAL MOTORS COMPANY

5. Remove the battery hold down bracket fastener (1) and remove the battery hold down bracket (2).
6. Remove the battery vent hose (3) from the side of the battery.

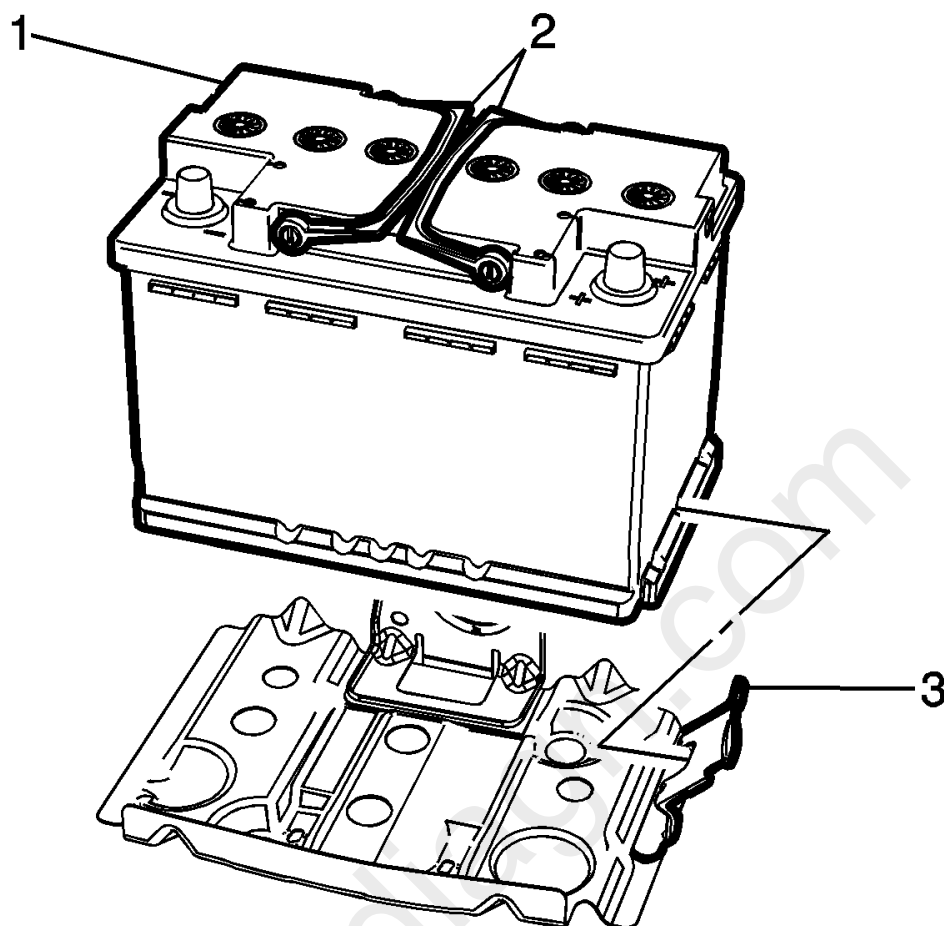


Fig. 68: Battery Tray Front Bracket
Courtesy of GENERAL MOTORS COMPANY

7. Push forward the battery tray front bracket (3) and remove the battery (1) using the battery assist handles (2).

Installation Procedure

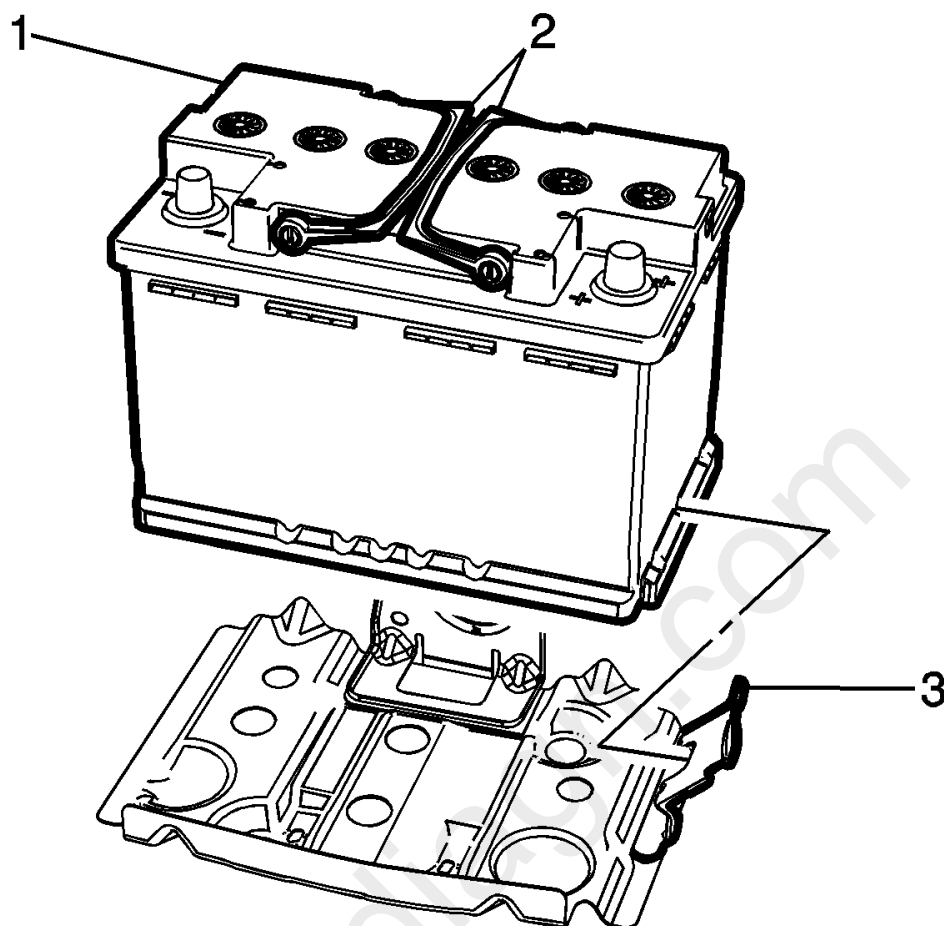


Fig. 69: Battery Tray Front Bracket
Courtesy of GENERAL MOTORS COMPANY

1. Push forward the front battery tray bracket (3) and install the battery (1) into position using the battery assist handles (2).

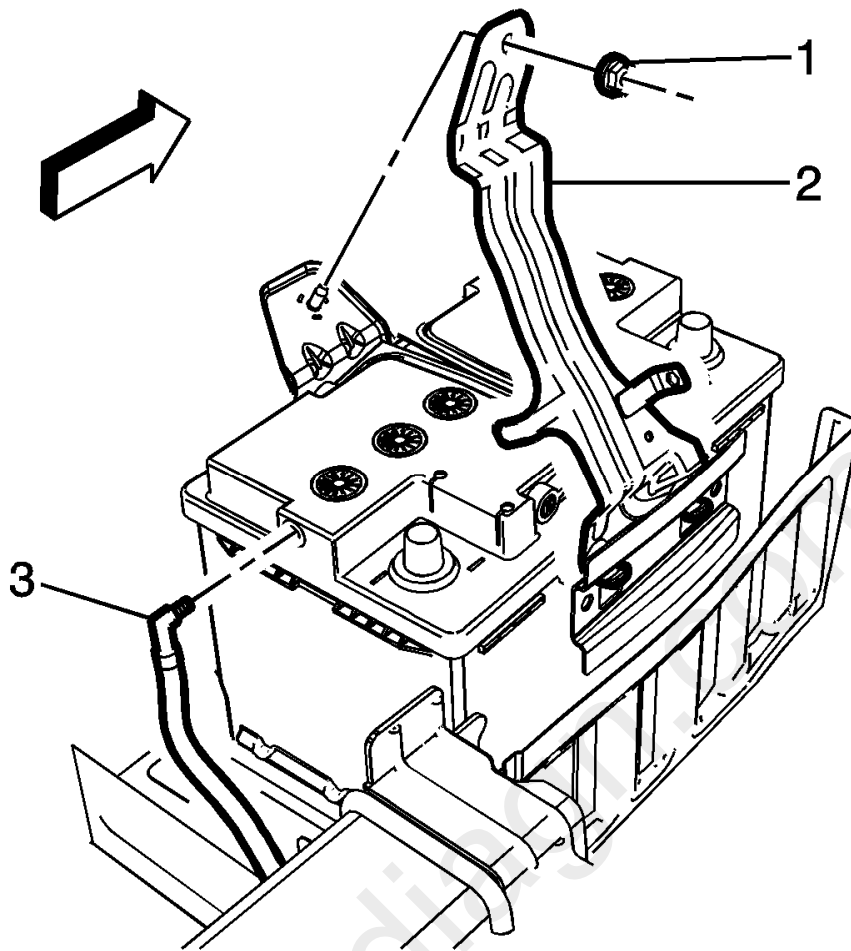


Fig. 70: Battery Hold Down Bracket Fastener And Vent Hose
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Install the battery hold down bracket (2) and tighten the fastener (1) to 9 (80 lb in).
3. Install the battery vent hose (3) to the side of the battery.

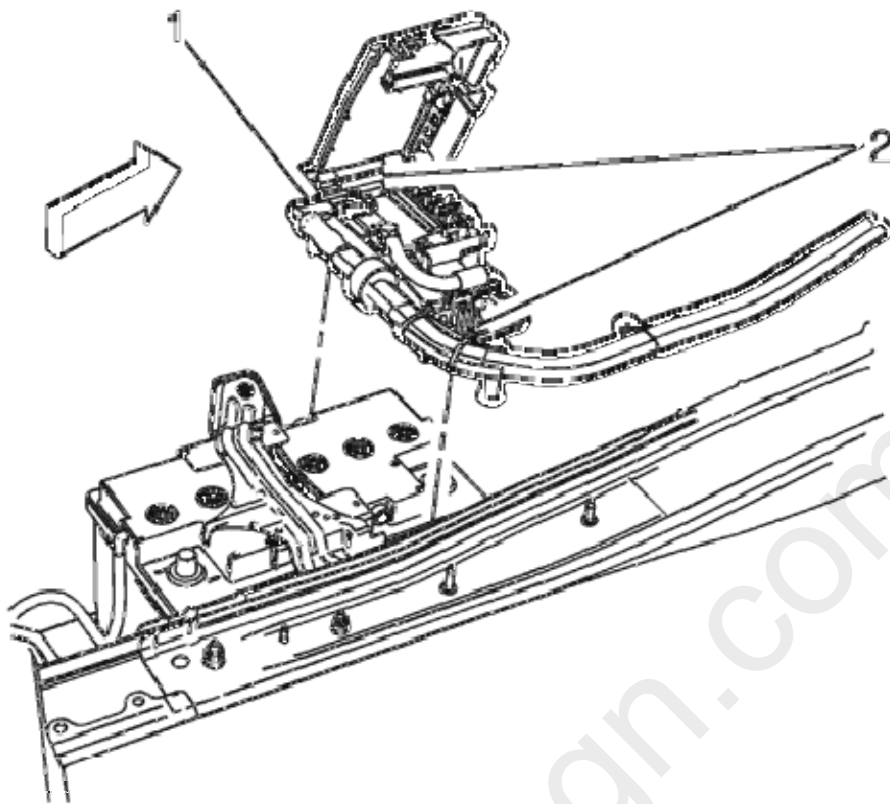


Fig. 71: Battery Fuse Block Retainer Clips
Courtesy of GENERAL MOTORS COMPANY

4. Install the battery fuse block (1) to the battery with the retaining clips (2).

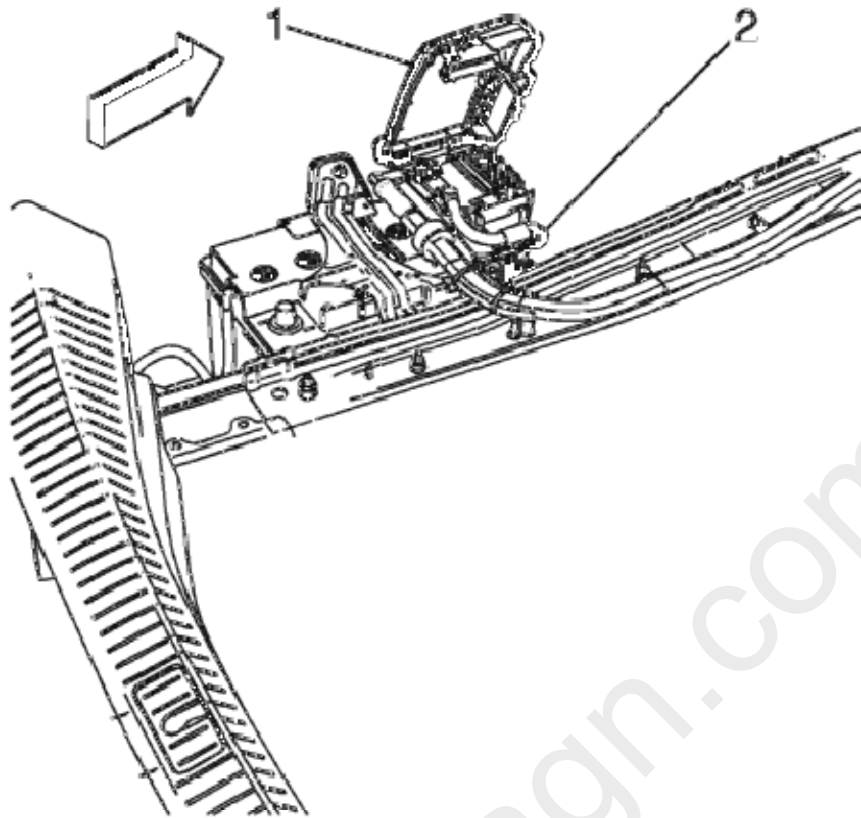


Fig. 72: Battery Fuse Block

Courtesy of GENERAL MOTORS COMPANY

5. Tighten the battery post clamp fastener (2) to 7 (62 lb in).
6. Close the fuse block cover (1).
7. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection.**
8. Position the left side rear compartment trim panel. Refer to **Rear Compartment Side Trim Replacement - Left Side .**

STARTER REPLACEMENT (LFX)

Removal Procedure

1. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection.**
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle .**
3. Remove the left catalytic converter. Refer to **Catalytic Converter Replacement - Left Side (LFX) .**

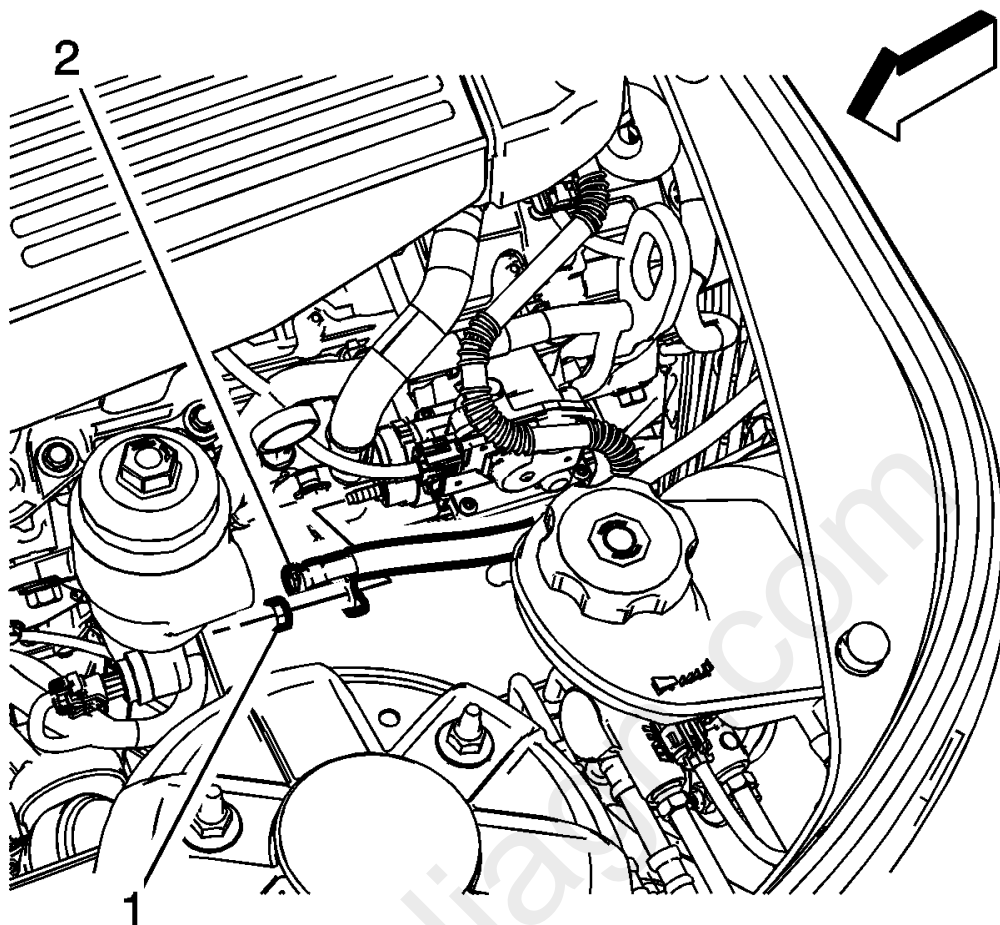


Fig. 73: Starter Solenoid Cable And Fastener
Courtesy of GENERAL MOTORS COMPANY

4. Remove the starter solenoid fastener (1) and remove the battery positive cable (2) from the starter solenoid.

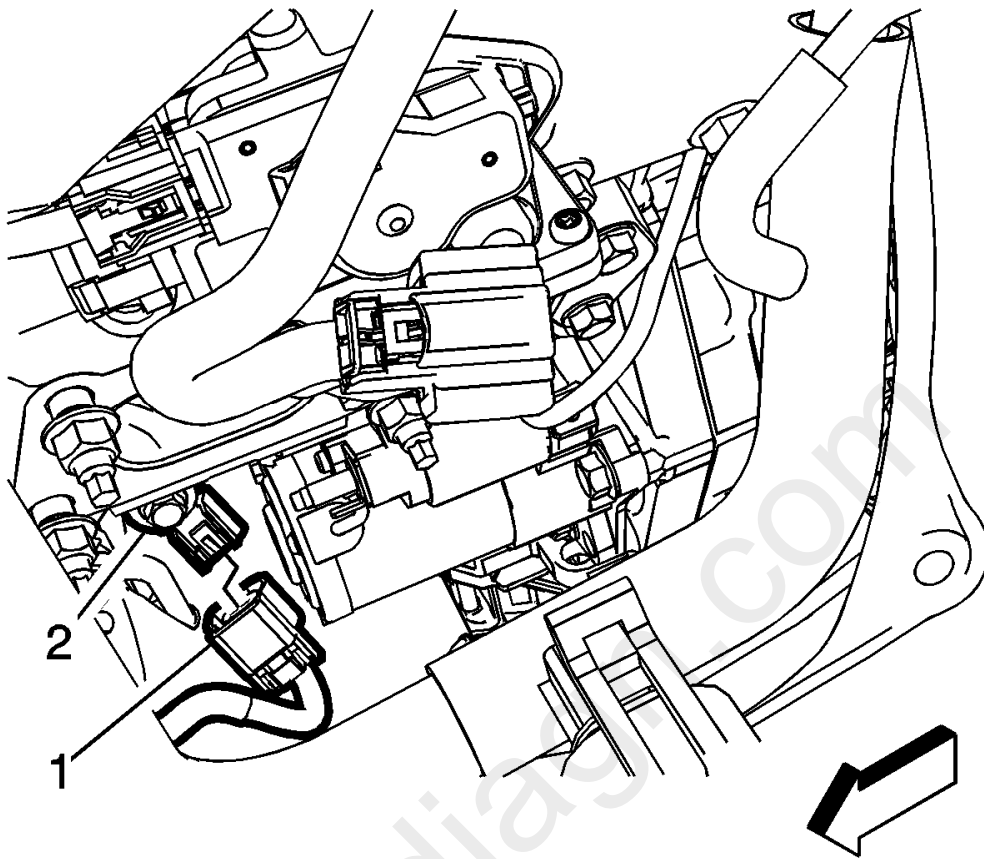


Fig. 74: Engine Knock Sensor (LFX)
Courtesy of GENERAL MOTORS COMPANY

5. From behind the starter, disconnect the engine harness connector (1), from the engine knock sensor (2).

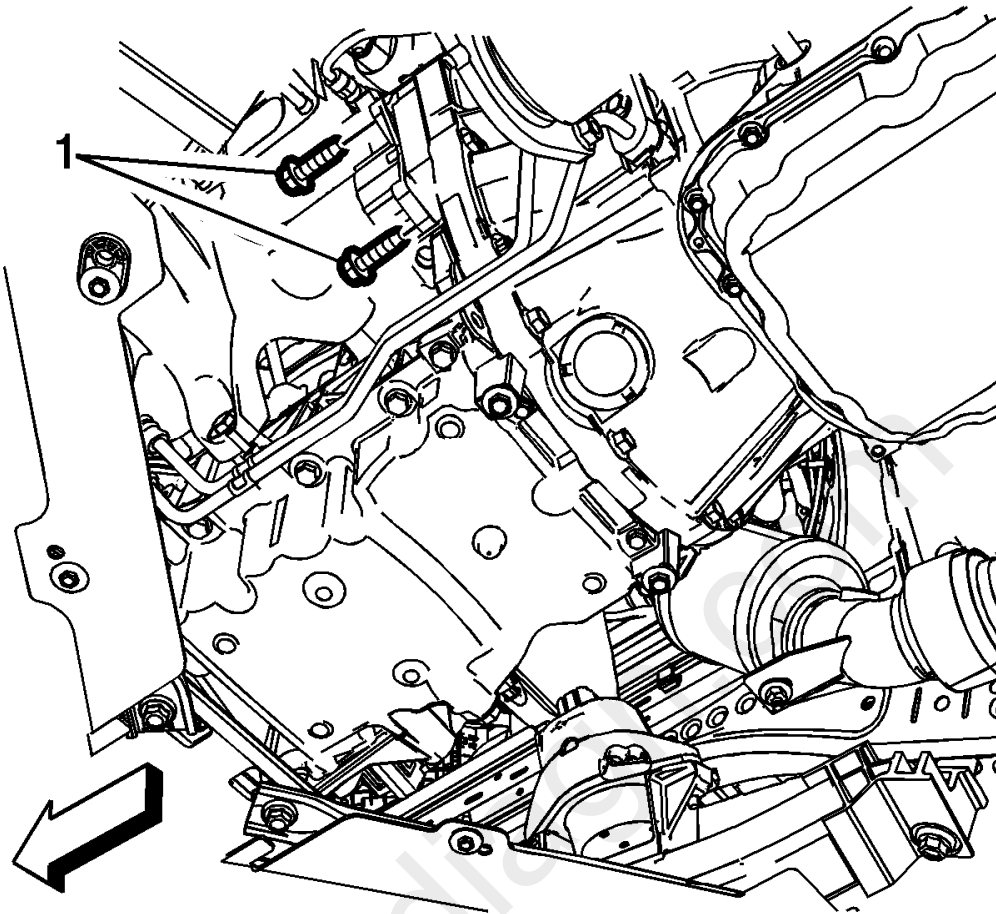


Fig. 75: Starter Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove the starter mounting fasteners (1).

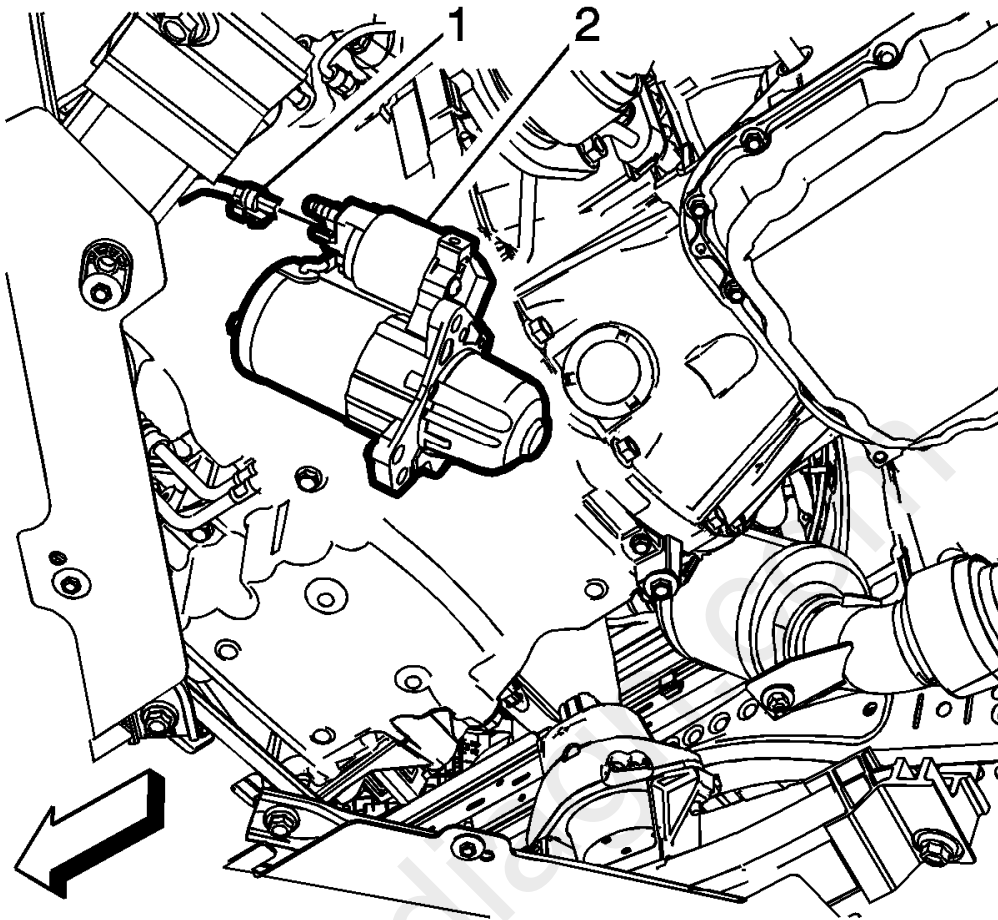


Fig. 76: Starter
Courtesy of GENERAL MOTORS COMPANY

7. Rotate the starter (2) and detach the engine harness connector (1).
8. Remove the starter (2).

Installation Procedure

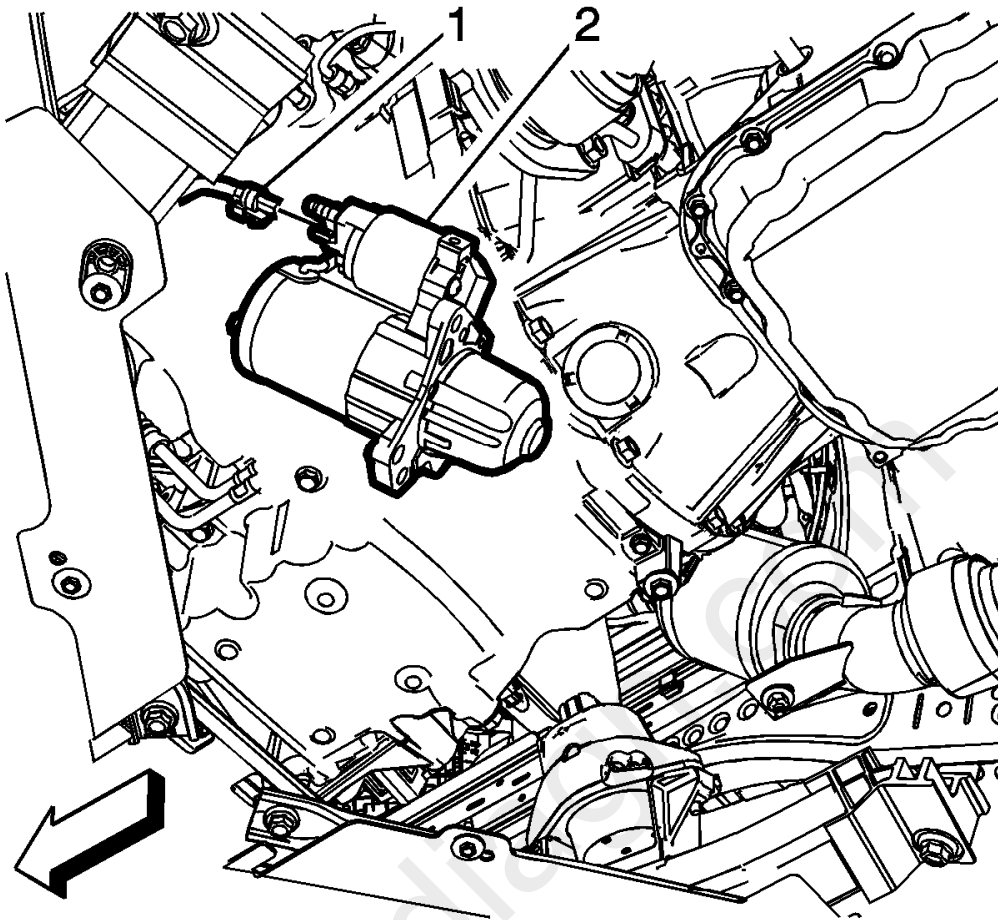


Fig. 77: Starter
Courtesy of GENERAL MOTORS COMPANY

1. Install the engine harness connector (1) to the starter (2) and slide the starter into position.

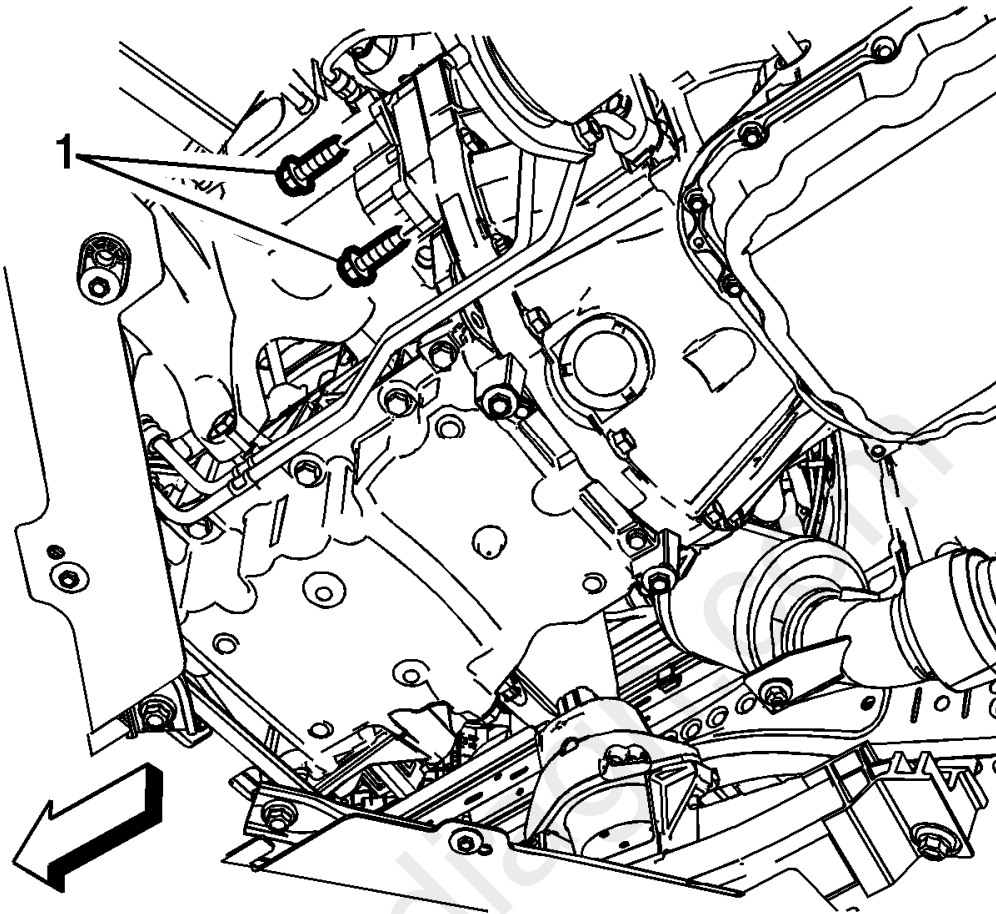


Fig. 78: Starter Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Install the starter mounting fasteners (1) and tighten to 58 (43 lb ft).

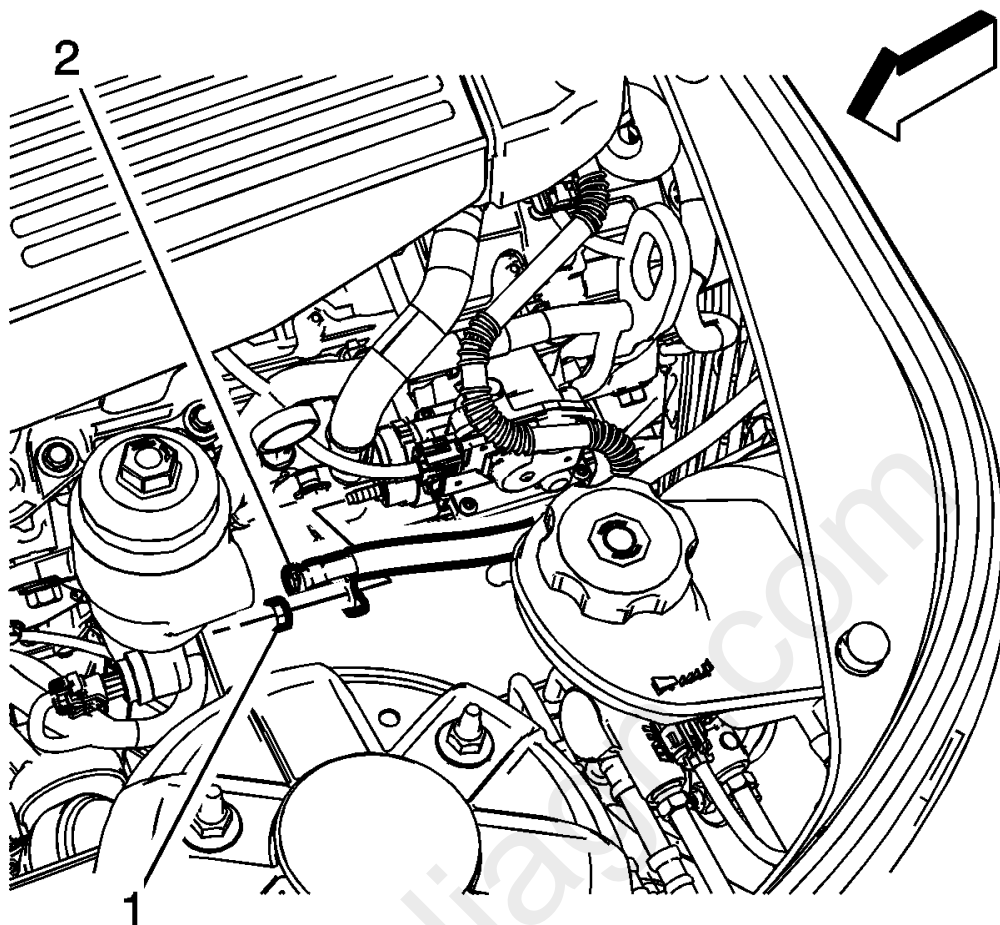


Fig. 79: Starter Solenoid Cable And Fastener
Courtesy of GENERAL MOTORS COMPANY

3. Install the battery positive cable (2) to the starter solenoid and tighten the fastener (1) to 13 (115 lb in).

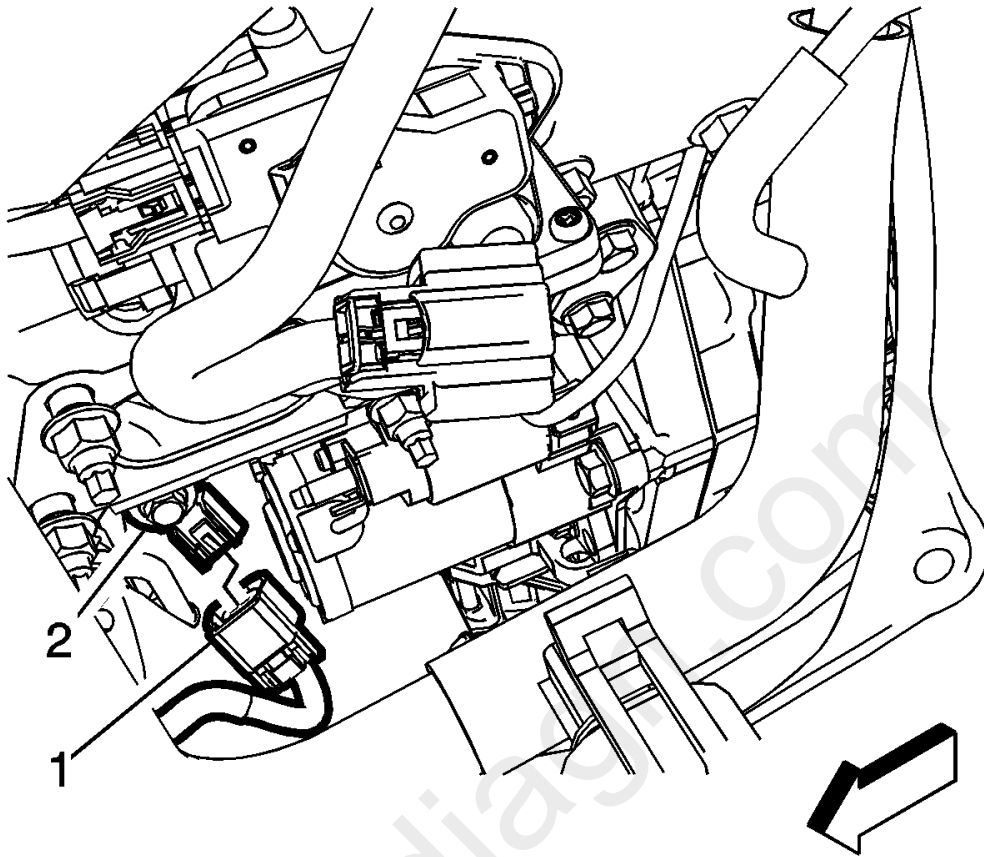


Fig. 80: Engine Knock Sensor (LFX)
Courtesy of GENERAL MOTORS COMPANY

4. Connect the engine harness connector (1) to the engine knock sensor (2).
5. Install the left catalytic converter. Refer to **Catalytic Converter Replacement - Left Side (LFX)** .
6. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection.**

STARTER REPLACEMENT (LTG)

Removal Procedure

1. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection.**
2. Remove the intake manifold. Refer to **Intake Manifold Replacement** .

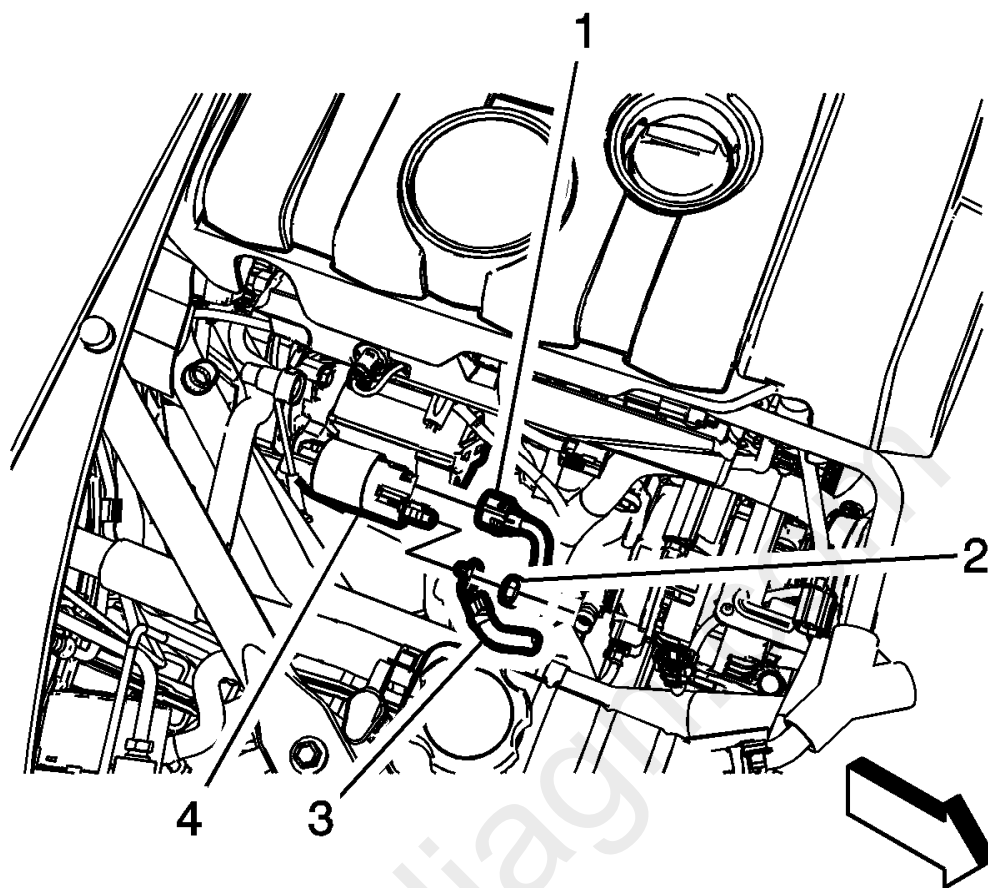


Fig. 81: Starter Solenoid Fasteners
Courtesy of GENERAL MOTORS COMPANY

3. Remove the starter solenoid fastener (2) and remove the battery positive cable (3), from the starter solenoid (4).
4. Disconnect the engine harness connector (1), from the starter solenoid (4).

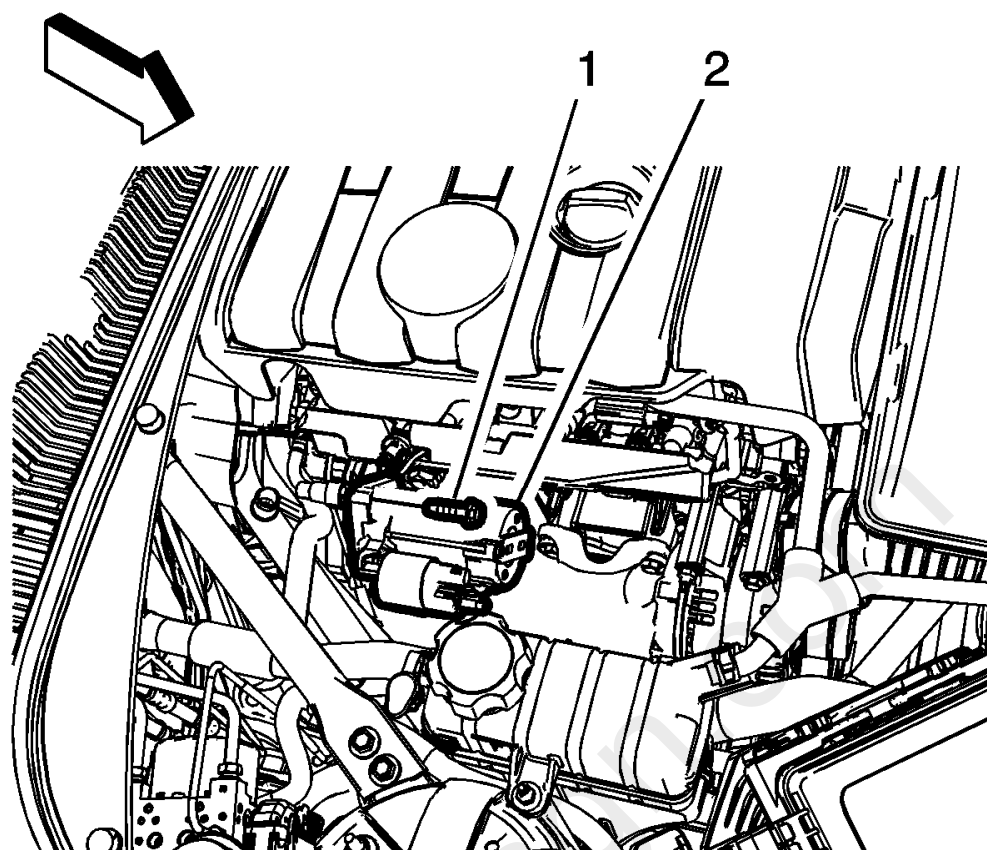


Fig. 82: Starter Top Mounting Fastener
Courtesy of GENERAL MOTORS COMPANY

5. Remove the top mounting fastener (1) from the starter (2).
6. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

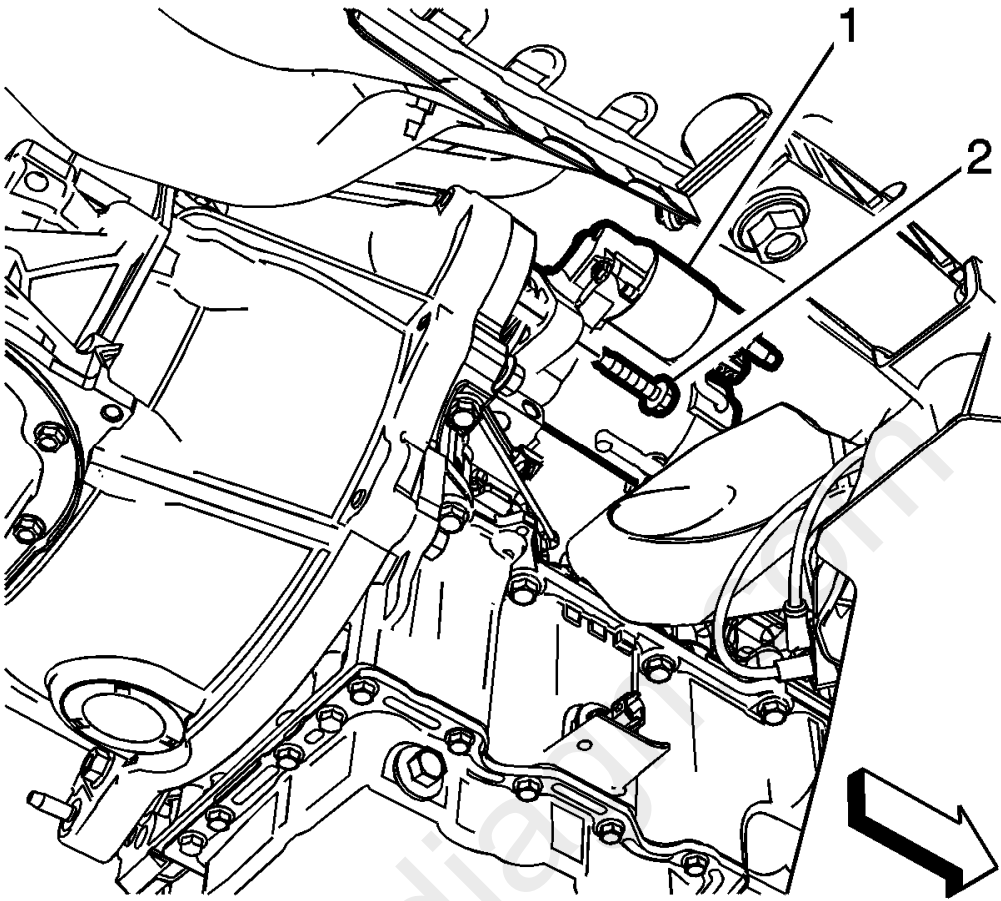


Fig. 83: Starter Lower Mounting Fastener
Courtesy of GENERAL MOTORS COMPANY

7. Remove the lower mounting fastener (2) from the starter (1).
8. Remove the starter.

Installation Procedure

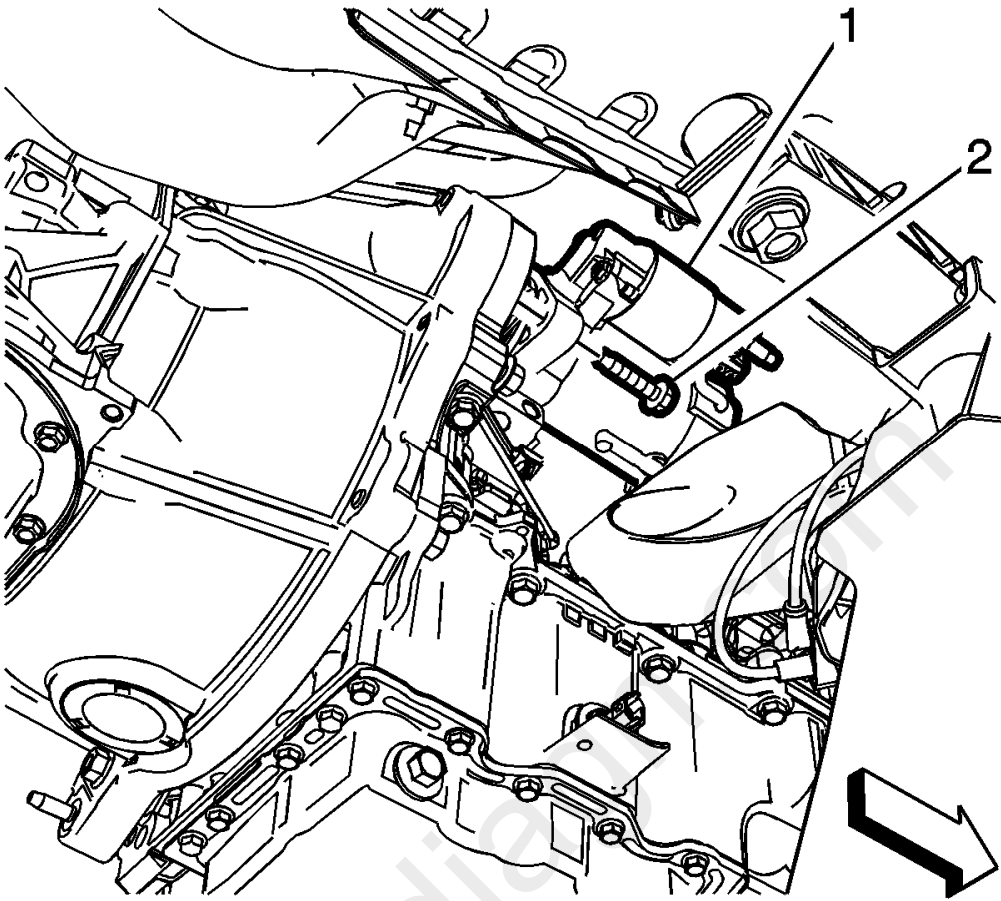


Fig. 84: Starter Lower Mounting Fastener
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

1. Install the starter (2) into position and tighten the starter lower mounting fastener (2) to 22 (16 lb ft).

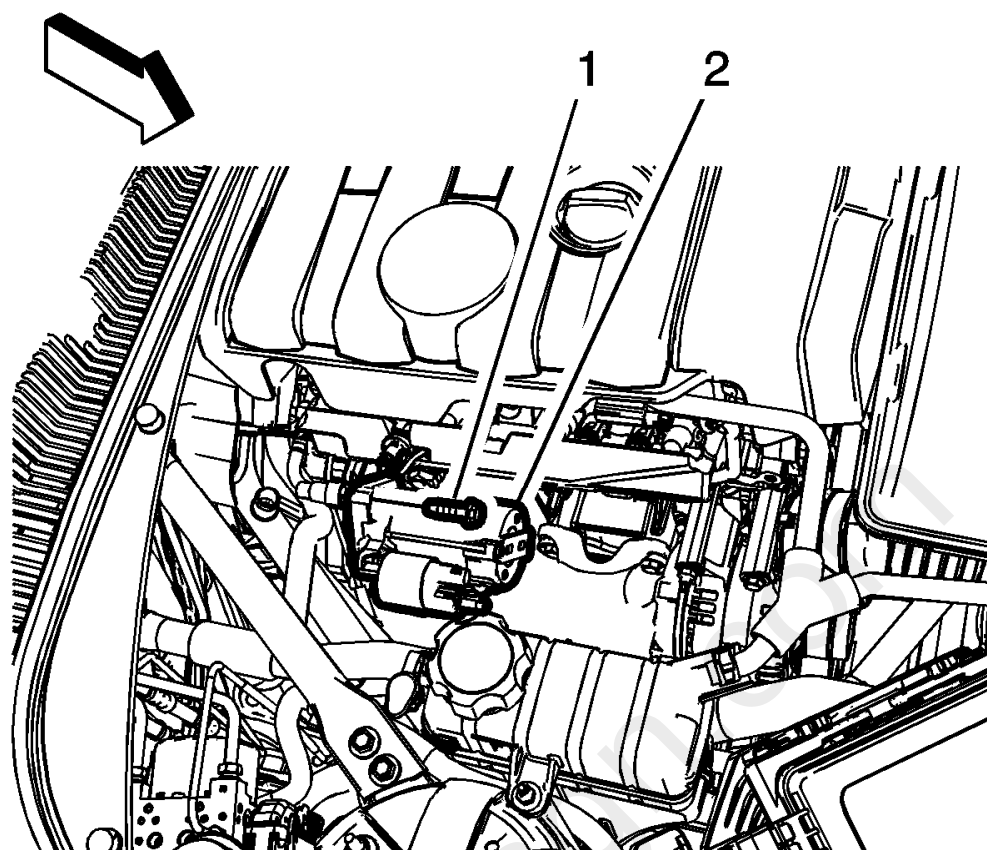


Fig. 85: Starter Top Mounting Fastener
Courtesy of GENERAL MOTORS COMPANY

2. Install the starter upper mounting fastener (1), to the starter (2), and tighten to 22 (16 lb ft) .

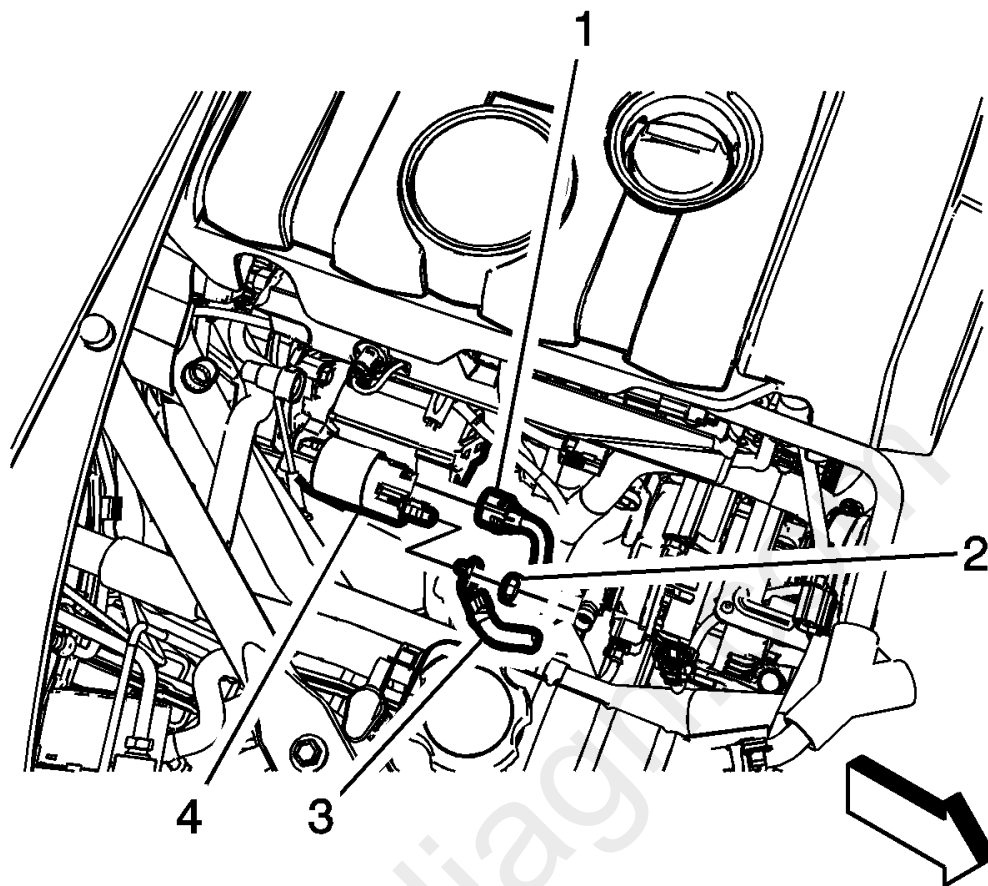


Fig. 86: Starter Solenoid Fasteners
Courtesy of GENERAL MOTORS COMPANY

3. Install the battery positive cable (3), to the starter solenoid (4), and tighten the fastener (1) to 10 (89 lb in).
4. Connect the engine harness connector (1) to the starter solenoid (4).
5. Install the intake manifold. Refer to **Intake Manifold Replacement** .
6. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection**.

STARTER REPLACEMENT (LF3)

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. Remove the left engine mount bracket. Refer to **Engine Mount Bracket Replacement - Left Side (LF3)** .
4. Remove the starter heat shield. Refer to **Starter Shield Replacement (LF3)**.

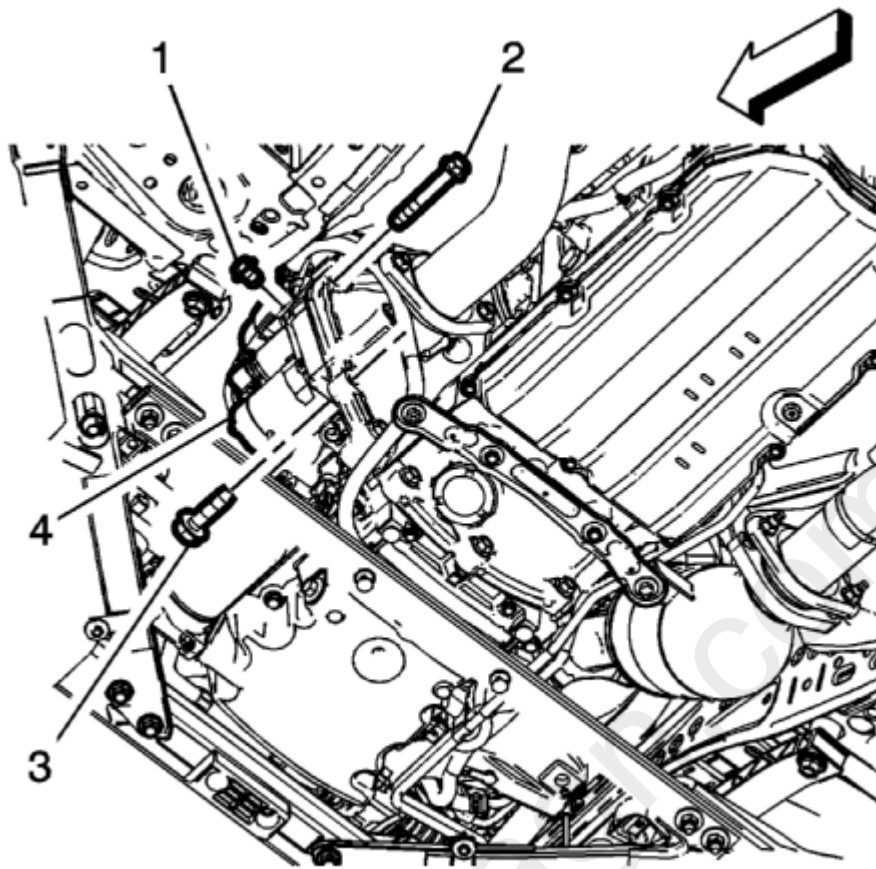


Fig. 87: Starter Mounting Fasteners And Starter
Courtesy of GENERAL MOTORS COMPANY

5. Remove the starter solenoid cable retainer fastener (1).
6. Remove the starter mounting fasteners (2, 3) and lower the starter (4) to access the electrical connections.

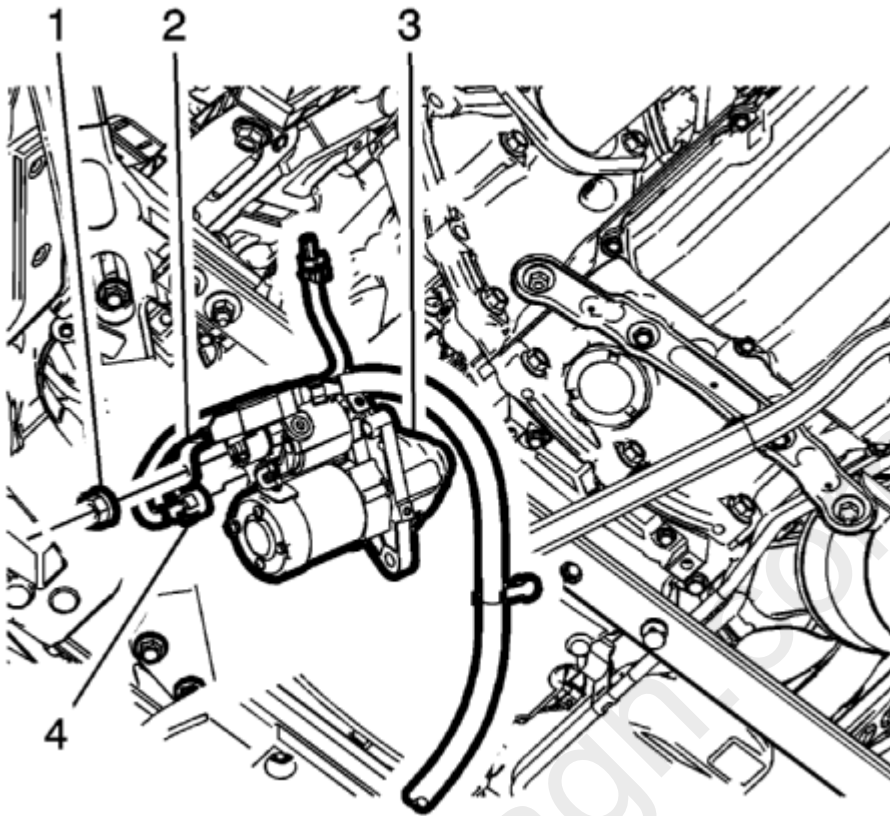


Fig. 88: Starter Solenoid Cable
Courtesy of GENERAL MOTORS COMPANY

7. Disconnect the starter solenoid cable connector (4).
8. Remove the starter solenoid fastener (1) and remove the starter solenoid cable terminal (2) from the starter.
9. Remove the starter (3) from the vehicle.

Installation Procedure

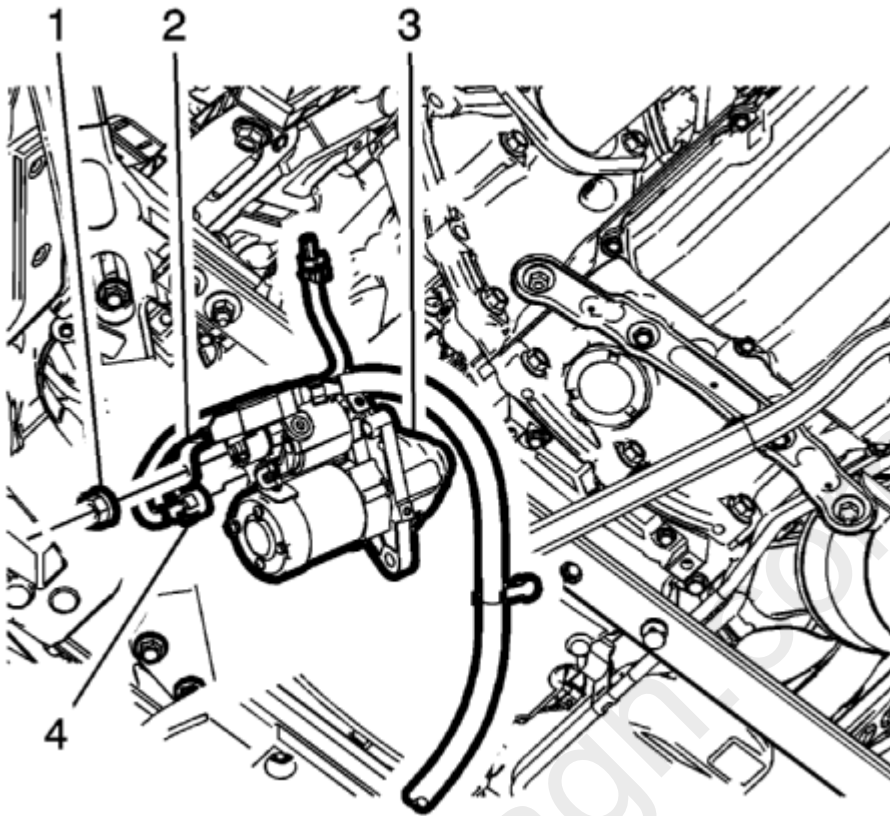


Fig. 89: Starter Solenoid Cable
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

1. Install the solenoid starter cable terminal (2) to the solenoid and tighten the fastener (1) to 12.5 (111 lb in).
2. Connect the starter solenoid cable connector (4) to the starter solenoid.
3. Install the starter (3) into position on the engine block.

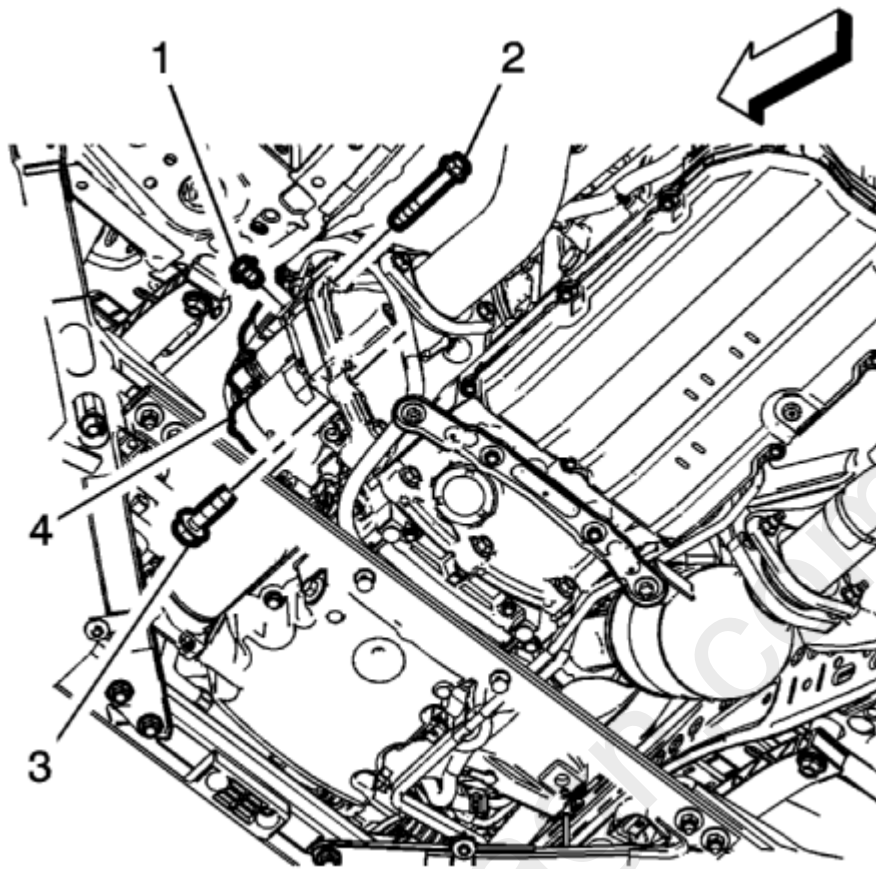


Fig. 90: Starter Mounting Fasteners And Starter
Courtesy of GENERAL MOTORS COMPANY

4. Install the starter mounting fasteners (2, 3) and tighten to 58 (43 lb ft).
5. Install the starter solenoid cable fastener (1) and tighten to 6 (53 lb in).
6. Install the starter heat shield. Refer to **Starter Shield Replacement (LF3)**.
7. Install the left engine mount bracket. Refer to **Engine Mount Bracket Replacement - Left Side (LF3)**.
8. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.

STARTER SHIELD REPLACEMENT (LF3)

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle**.

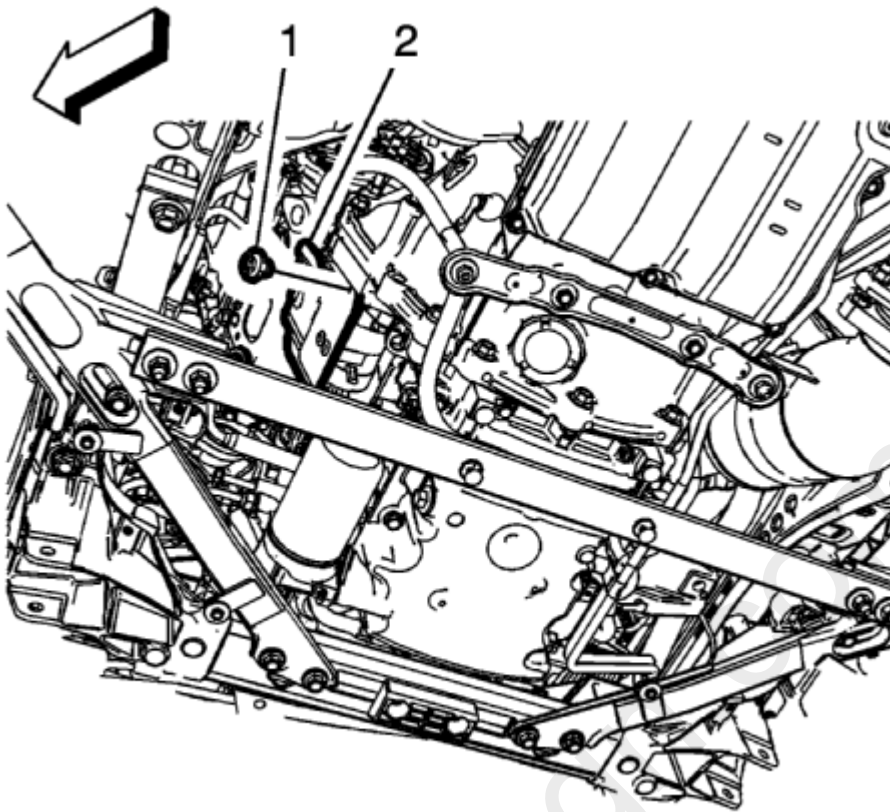


Fig. 91: Starter Shield Fastener
Courtesy of GENERAL MOTORS COMPANY

2. Remove the starter shield fastener (1).

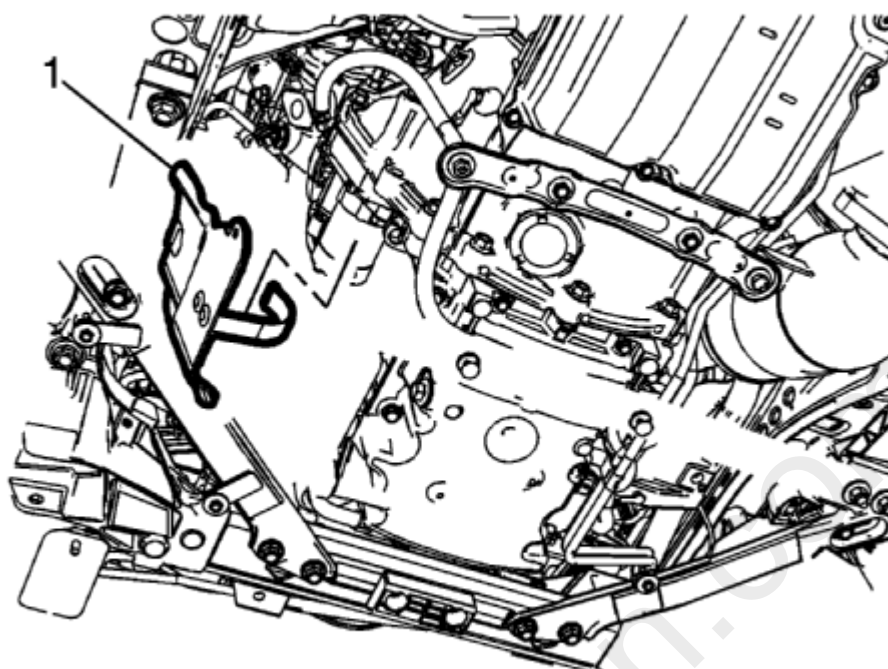


Fig. 92: Starter Heat Shield

Courtesy of GENERAL MOTORS COMPANY

3. Disconnect the starter shield holding clip and remove the starter heat shield (1) from the starter.

Installation Procedure

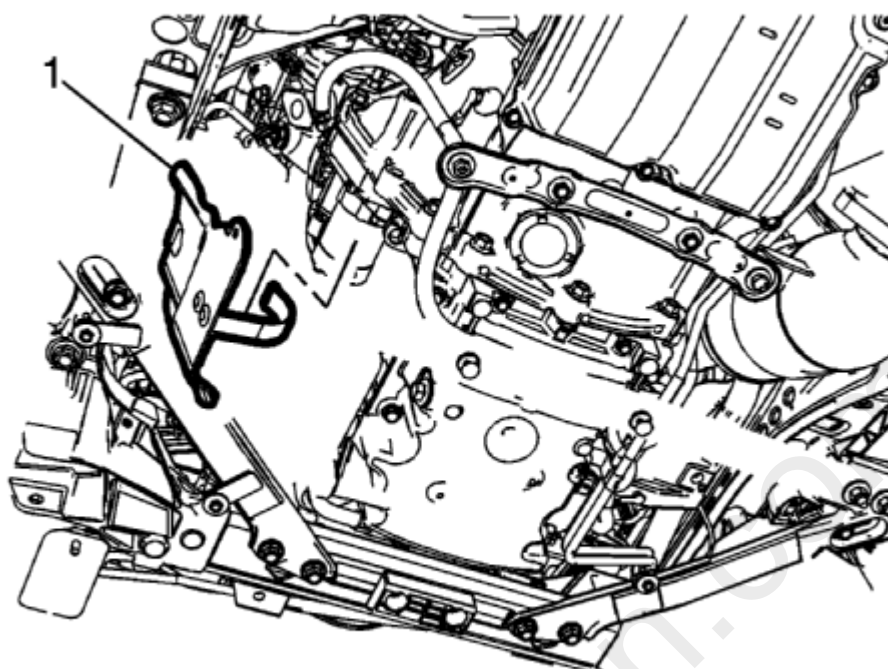


Fig. 93: Starter Heat Shield

Courtesy of GENERAL MOTORS COMPANY

1. Position the starter shield (1), to the starter, with the retaining clip.

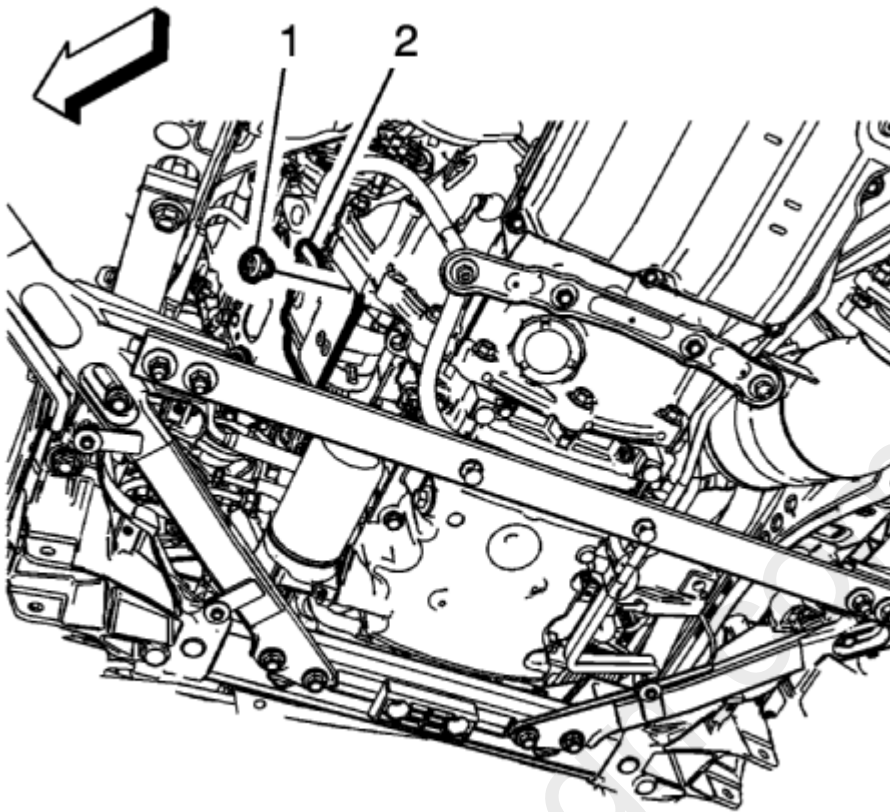


Fig. 94: Starter Shield Fastener
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Install the starter shield fastener (1) and tighten to 4.7 (42 lb in).
3. Lower the vehicle.

GENERATOR REPLACEMENT (LFX)

Removal Procedure

1. Disconnect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection.
2. Remove the drive belt. Refer to Drive Belt Replacement .
3. Remove the power brake booster pump. Refer to Power Brake Booster Pump Replacement (LFX, LF3) .

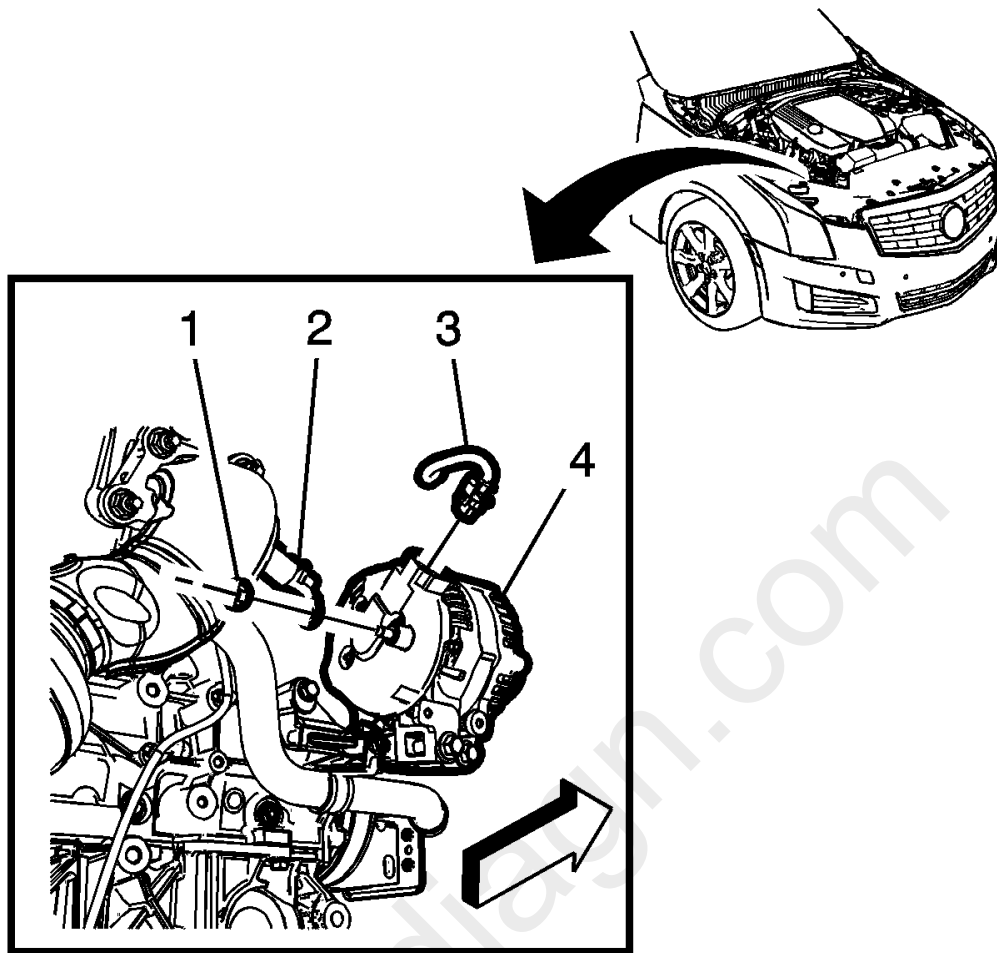


Fig. 95: Generator Engine Harness Connector
Courtesy of GENERAL MOTORS COMPANY

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

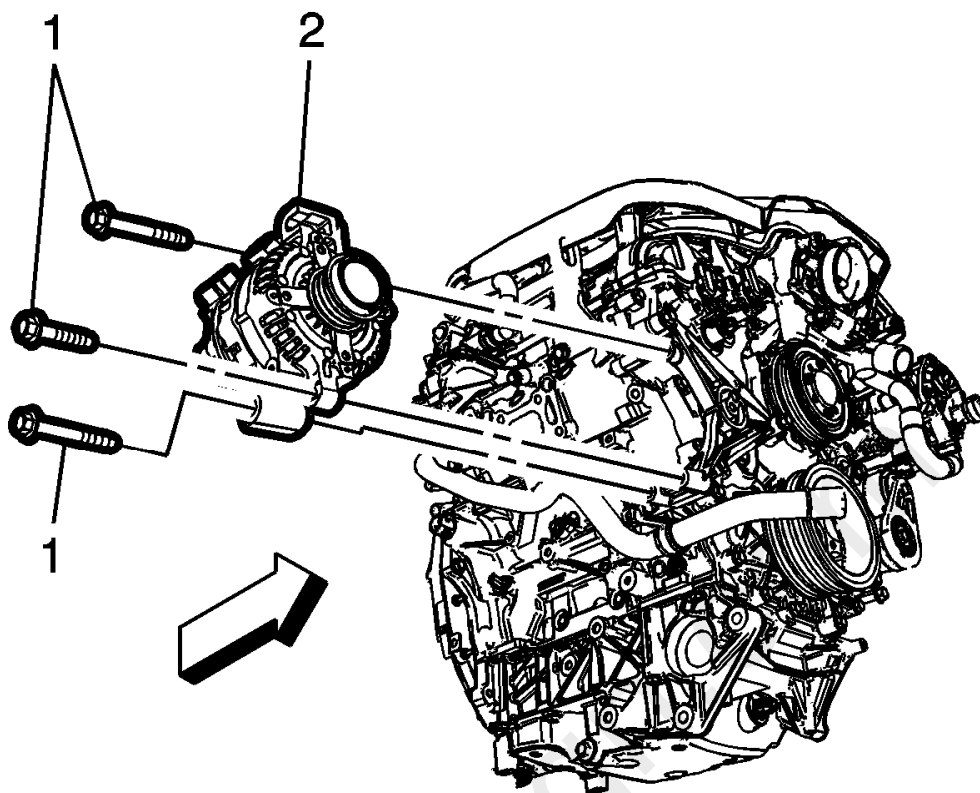


Fig. 96: Generator Mounting Fasteners
Courtesy of GENERAL MOTORS COMPANY

6. Remove the generator mounting fasteners (1).

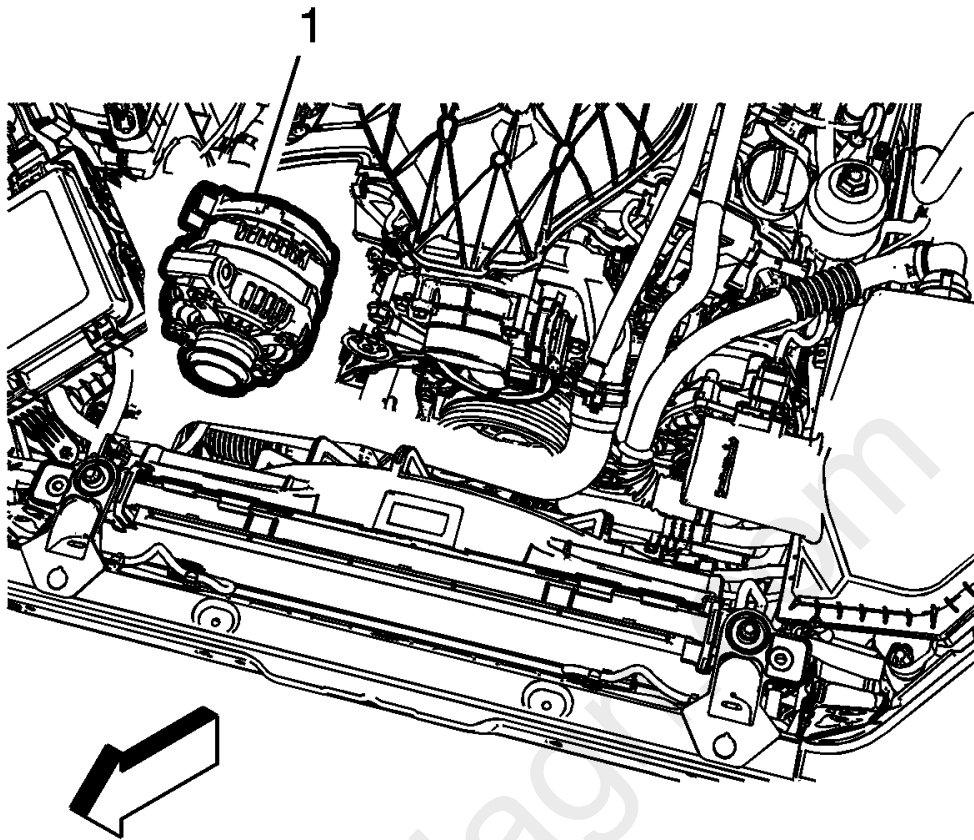


Fig. 97: Generator

Courtesy of GENERAL MOTORS COMPANY

7. Remove the generator (1) from the front of the engine compartment.

Installation Procedure

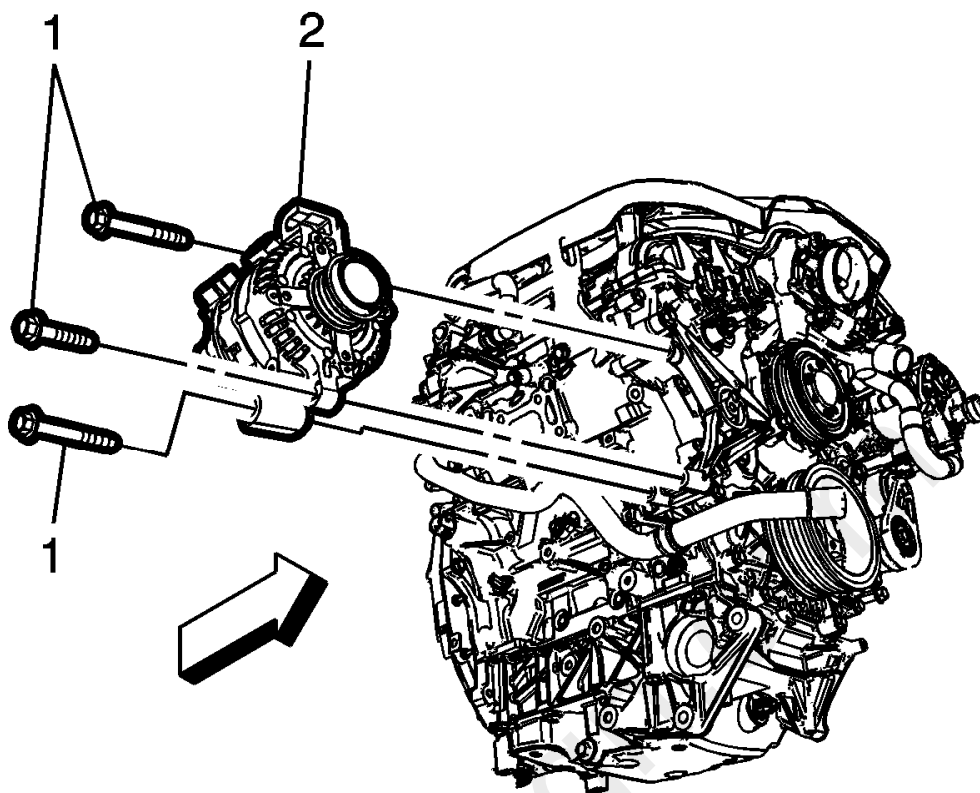


Fig. 98: Generator Mounting Fasteners
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

1. Install the generator (2) into position and tighten the mounting fasteners (1) to 58 (43 lb ft).

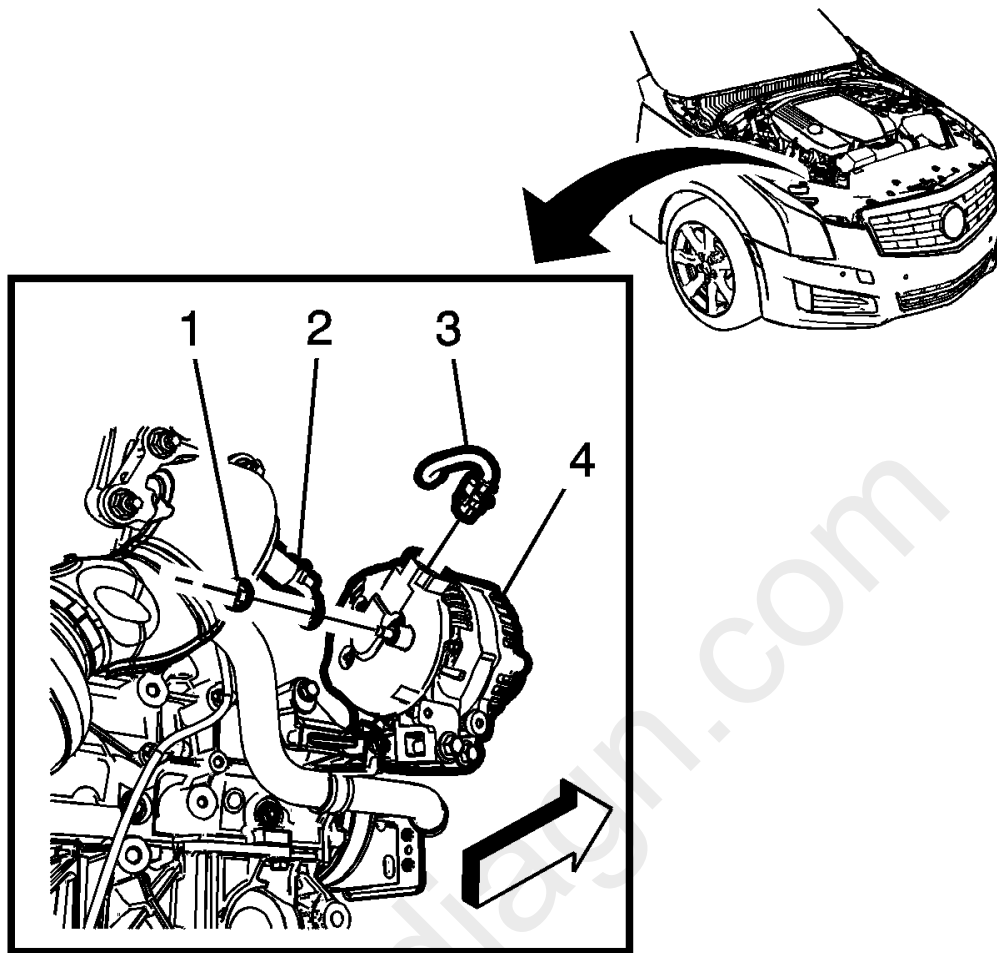


Fig. 99: Generator Engine Harness Connector
Courtesy of GENERAL MOTORS COMPANY

2. Connect the engine harness connector (3) and the engine harness battery positive terminal (2) to the generator. Tighten the fastener (1) to 22 (16 lb ft).
3. Install the drive belt. Refer to **Drive Belt Replacement** .
4. Install the power brake booster pump. Refer to **Power Brake Booster Pump Replacement (LTG)** , **Power Brake Booster Pump Replacement (LFX, LF3)** .
5. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.

GENERATOR REPLACEMENT (LTG)

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.
2. Remove the drive belt. Refer to **Drive Belt Replacement** .
3. Remove the radiator surge tank with the hoses and set aside. Refer to **Radiator Surge Tank Replacement (LTG)** .

4. Remove the charge air cooler outlet air tube. Refer to **Charge Air Cooler Outlet Air Tube Replacement** .

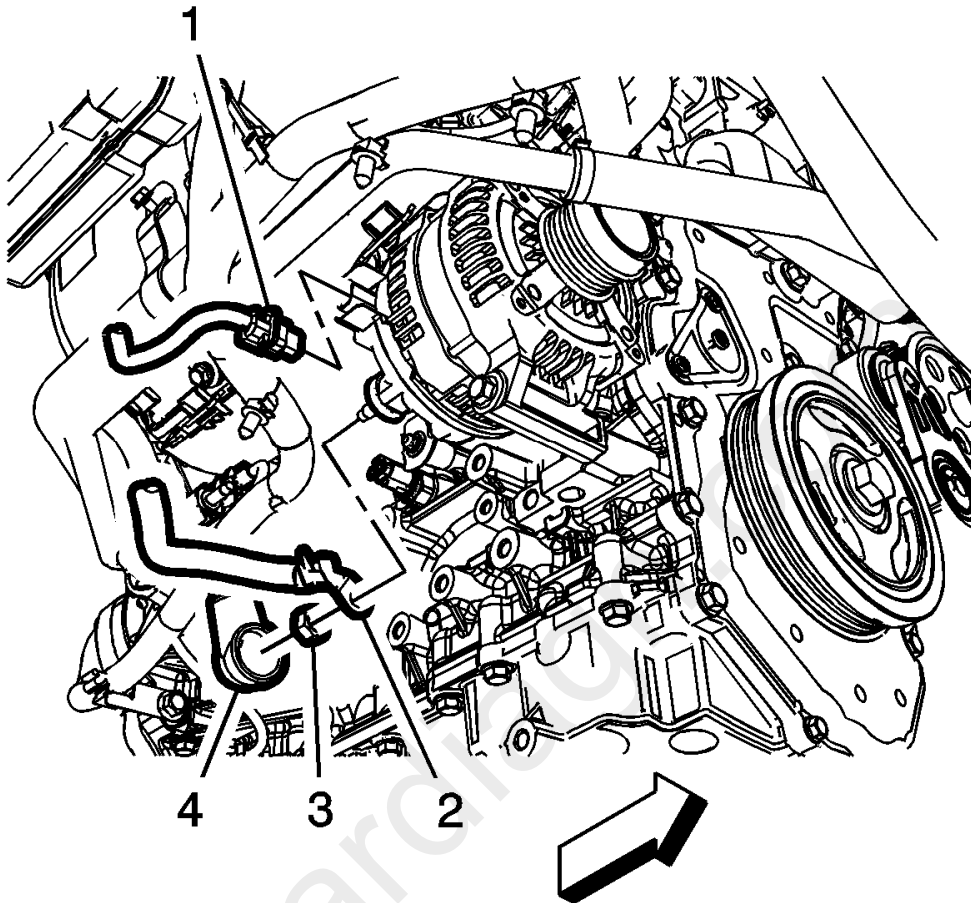


Fig. 100: Engine Harness Connector
Courtesy of GENERAL MOTORS COMPANY

5. Disconnect the engine harness connector (1) and remove the B + generator protective boot (4).
6. Remove the fastener (3) and the engine harness battery positive terminal (2), from the back of the generator.

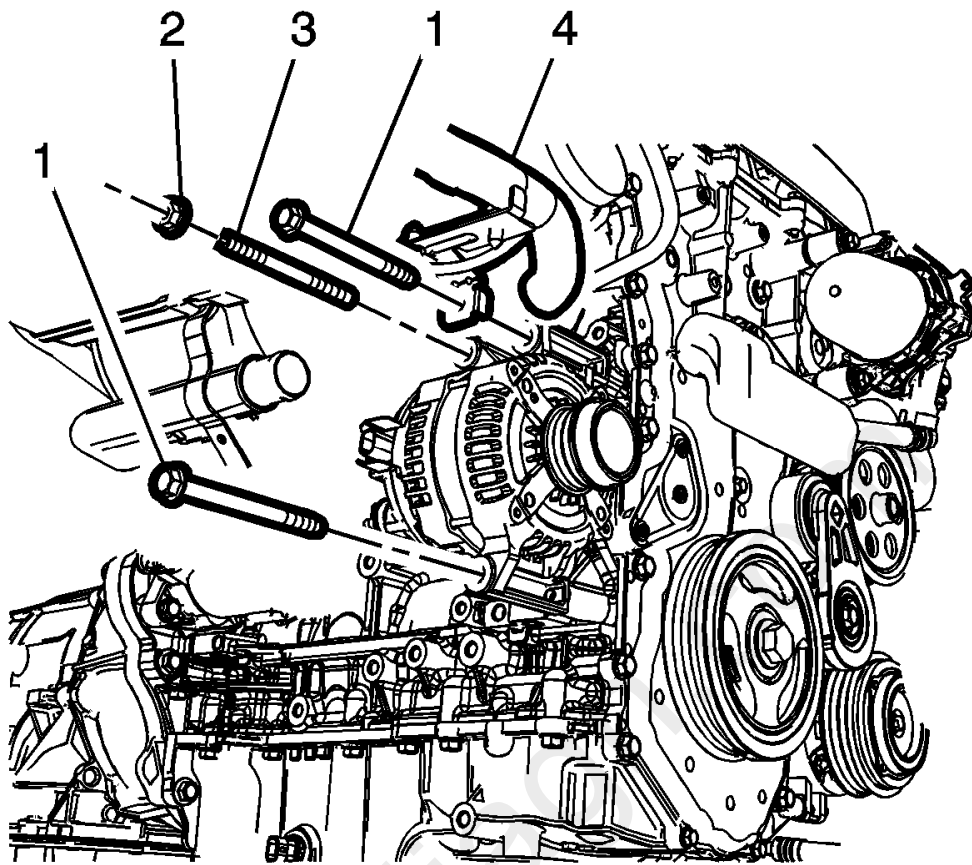


Fig. 101: Generator Mounting Fasteners
Courtesy of GENERAL MOTORS COMPANY

7. Remove the generator mounting fasteners (1) and the engine harness bracket retainer (4).
8. Remove the generator mounting fastener (2) and the generator mounting stud (3).

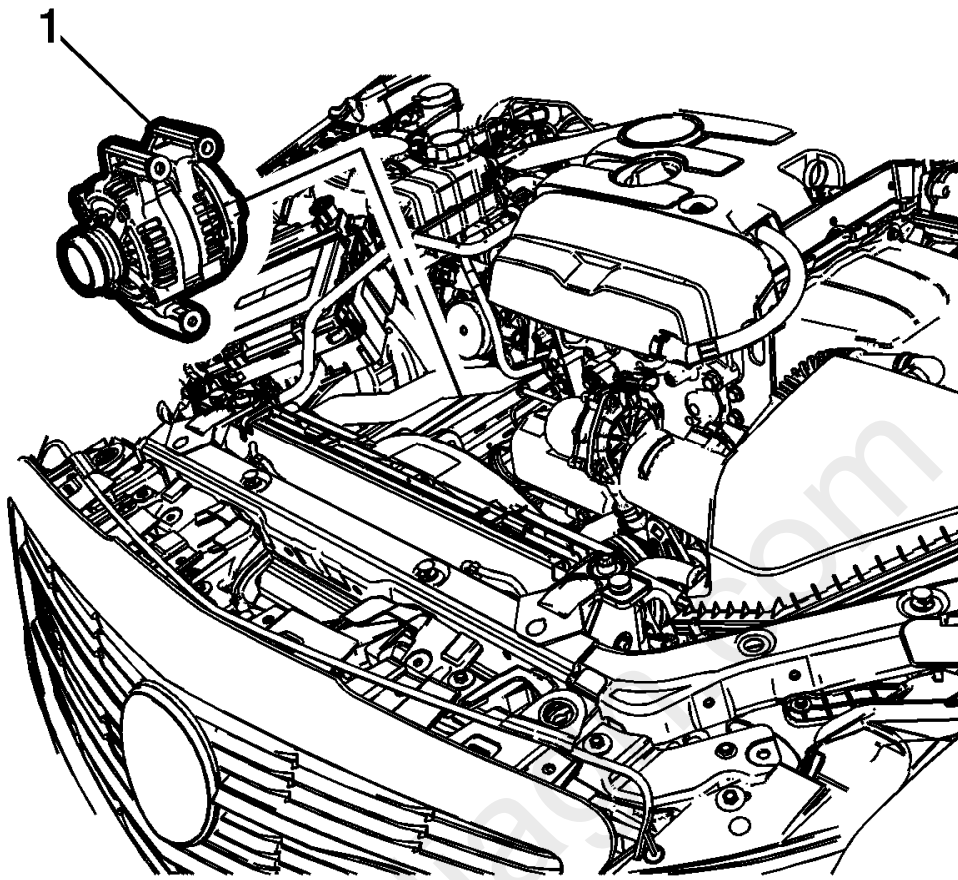


Fig. 102: Generator
Courtesy of GENERAL MOTORS COMPANY

9. Remove the generator (1) from the engine compartment.

Installation Procedure

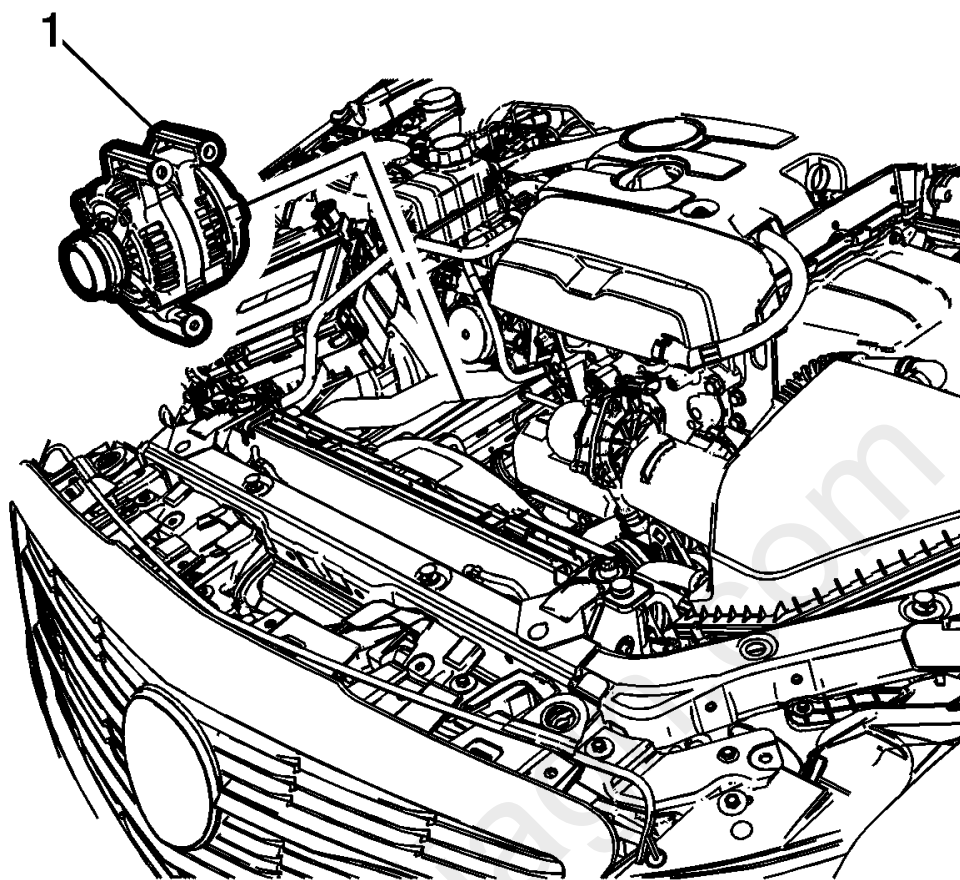


Fig. 103: Generator

Courtesy of GENERAL MOTORS COMPANY

1. Install the generator (1) into position on the engine.

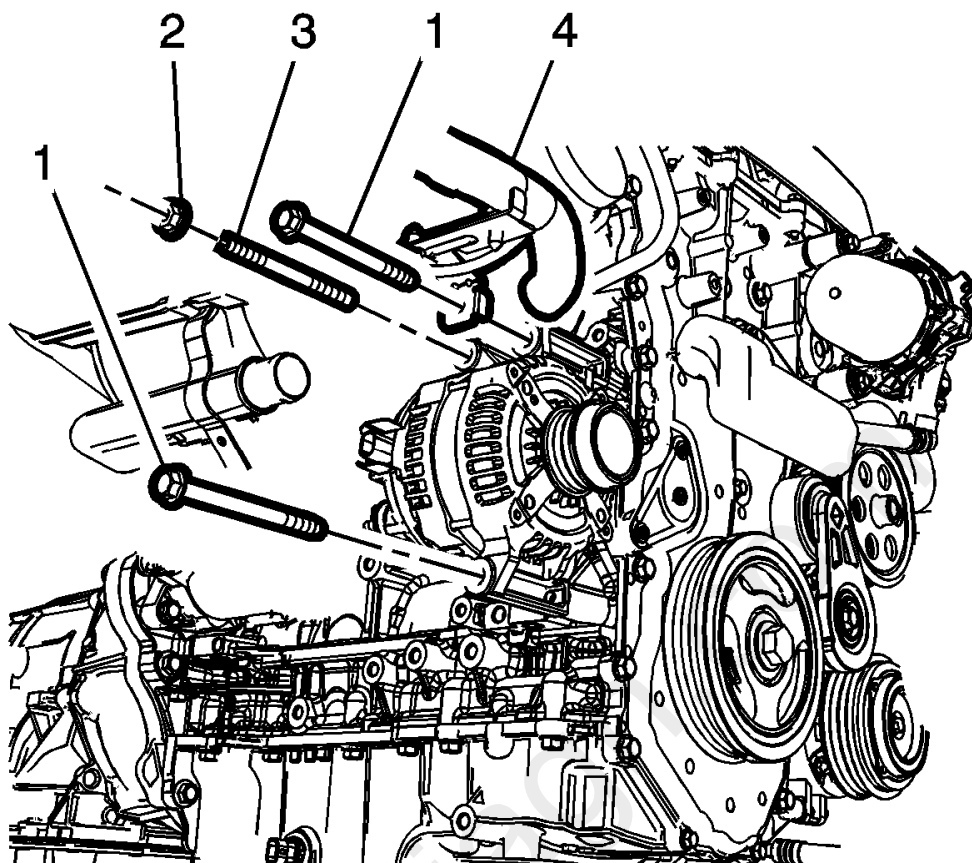


Fig. 104: Generator Mounting Fasteners
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Install the generator mounting stud (3) and tighten to 9 (80 lb in).
3. Install the engine harness bracket (4) and the generator mounting fasteners (1). Tighten to 22 (16 lb ft).
4. Tighten the generator mounting fastener (2) to 22 (16 lb ft).

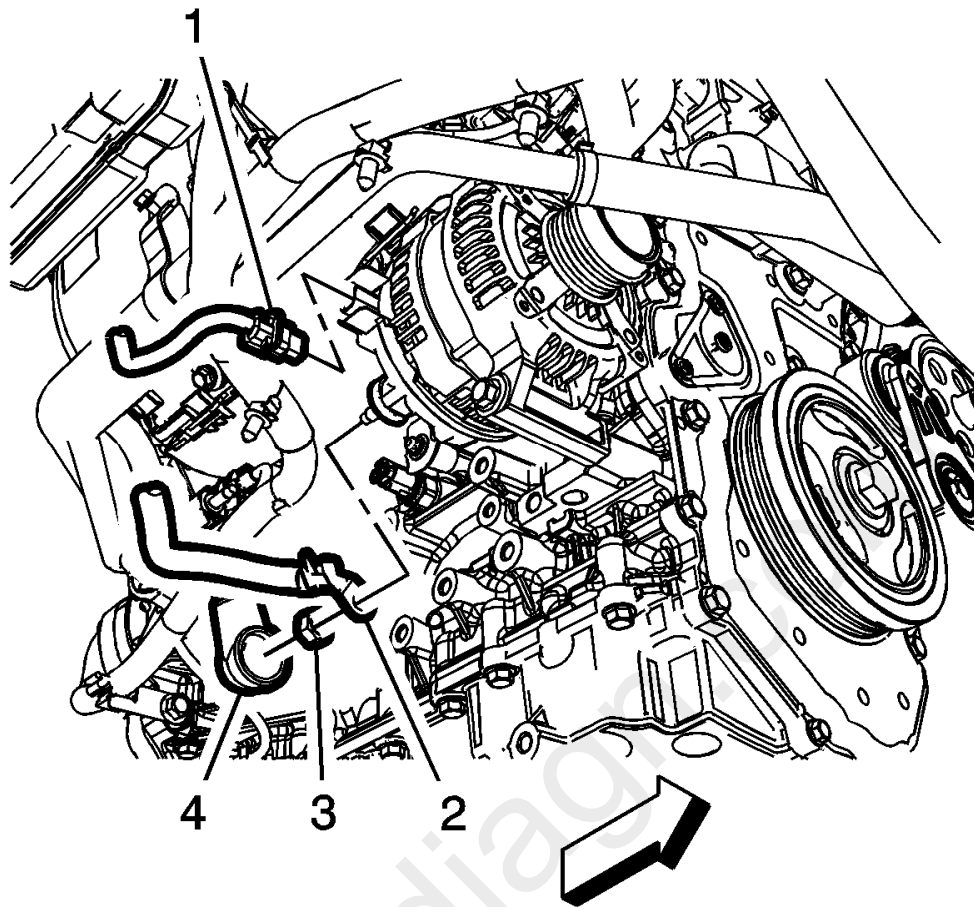


Fig. 105: Engine Harness Connector
Courtesy of GENERAL MOTORS COMPANY

5. Connect the engine harness connector (1) and the engine harness battery positive terminal (2) to the generator. Tighten the fastener (3) to 22 (16 lb ft).
6. Install the generator B + protective boot (4).
7. Install the charge air cooler outlet air tube. Refer to **Charge Air Cooler Outlet Air Tube Replacement** .
8. Install the radiator surge tank. Refer to **Radiator Surge Tank Replacement (LTG)** .
9. Install the drive belt. Refer to **Drive Belt Replacement** .
10. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection.**

GENERATOR REPLACEMENT (LF3)

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection.**
2. Remove the drive belt. Refer to **Drive Belt Replacement** .

3. Remove the radiator surge tank with the hoses and set aside. Refer to **Radiator Surge Tank Replacement (LFX, LF3)** .
4. Remove the air cleaner rear outlet duct. Refer to **Air Cleaner Outlet Rear Duct Replacement (LF3)** .
5. Remove the turbocharger coolant return pipe - bank 1. Refer to **Turbocharger Coolant Return Pipe Replacement (LF3 - Bank 2)** , **Turbocharger Coolant Return Pipe Replacement (LF3 - Bank 1)** .

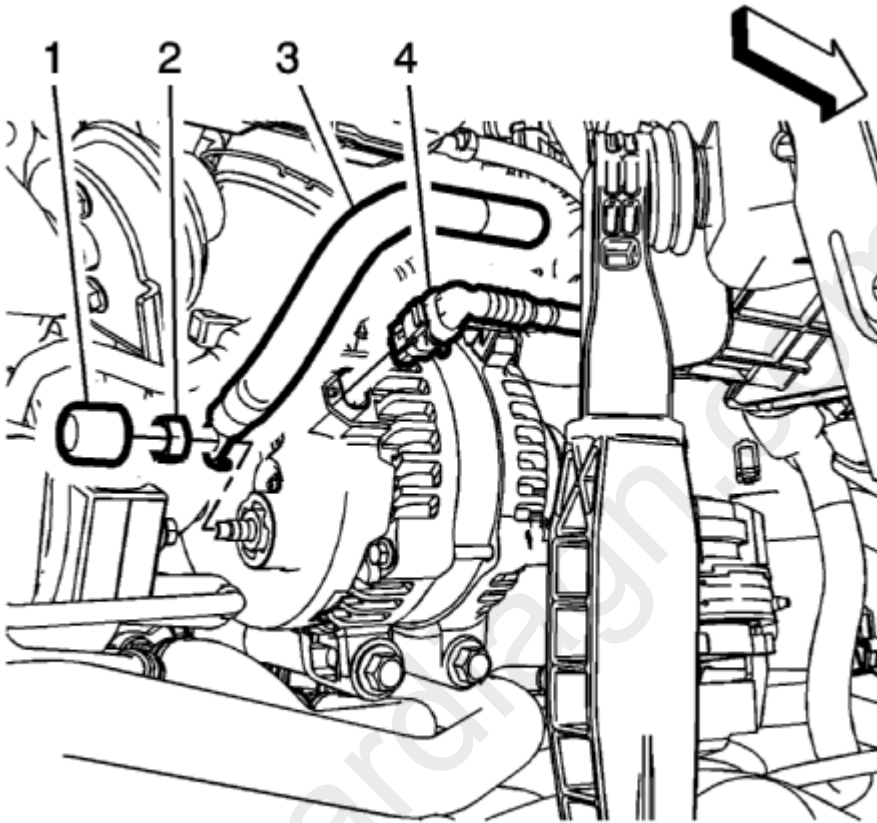


Fig. 106: Generator Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Disconnect the engine harness connector (4) and remove the B + generator protective cap (1).
7. Remove the fastener (2) and the engine harness battery positive terminal (3), from the back of the generator.

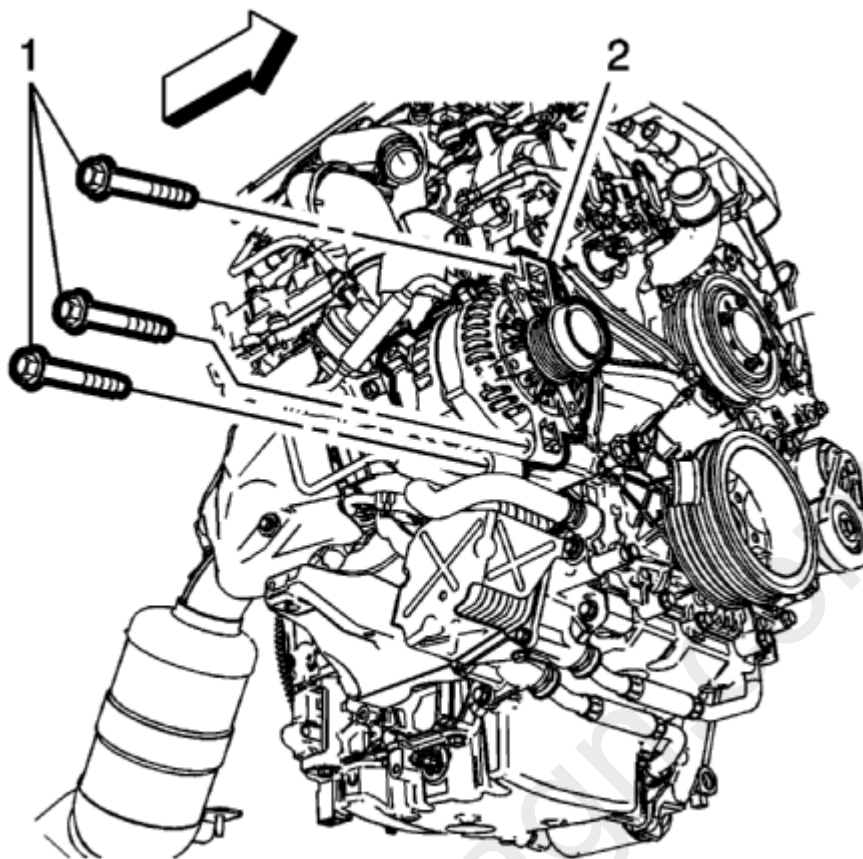


Fig. 107: Generator Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

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

Installation Procedure

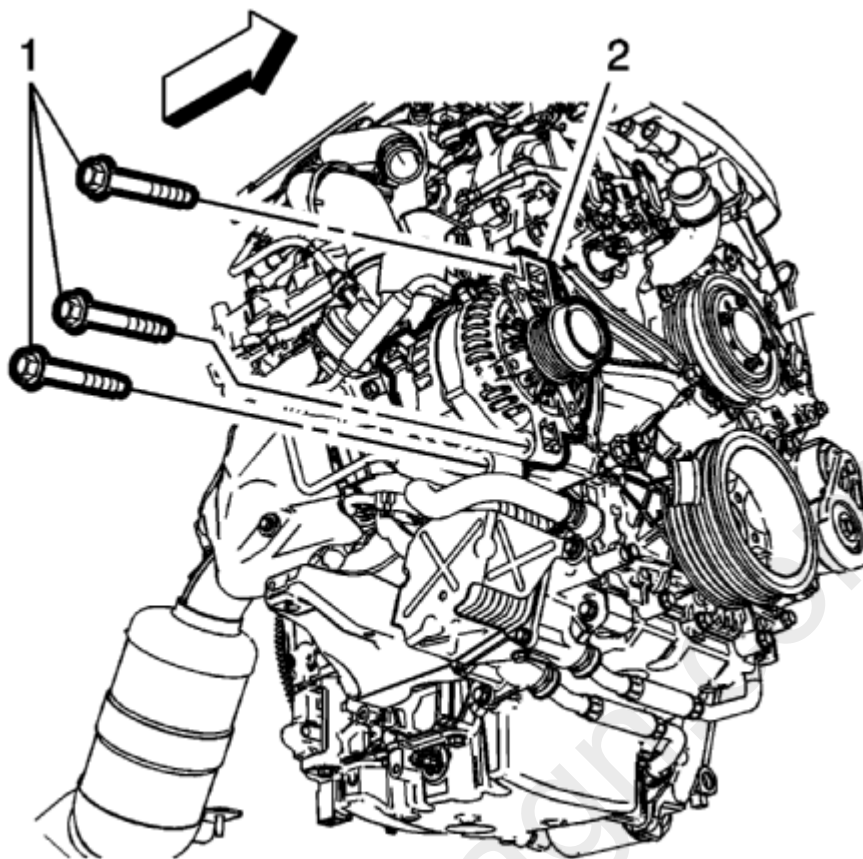


Fig. 108: Generator Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

1. Install the generator (2) into position and tighten the fasteners (1) to 58 (43 lb ft).

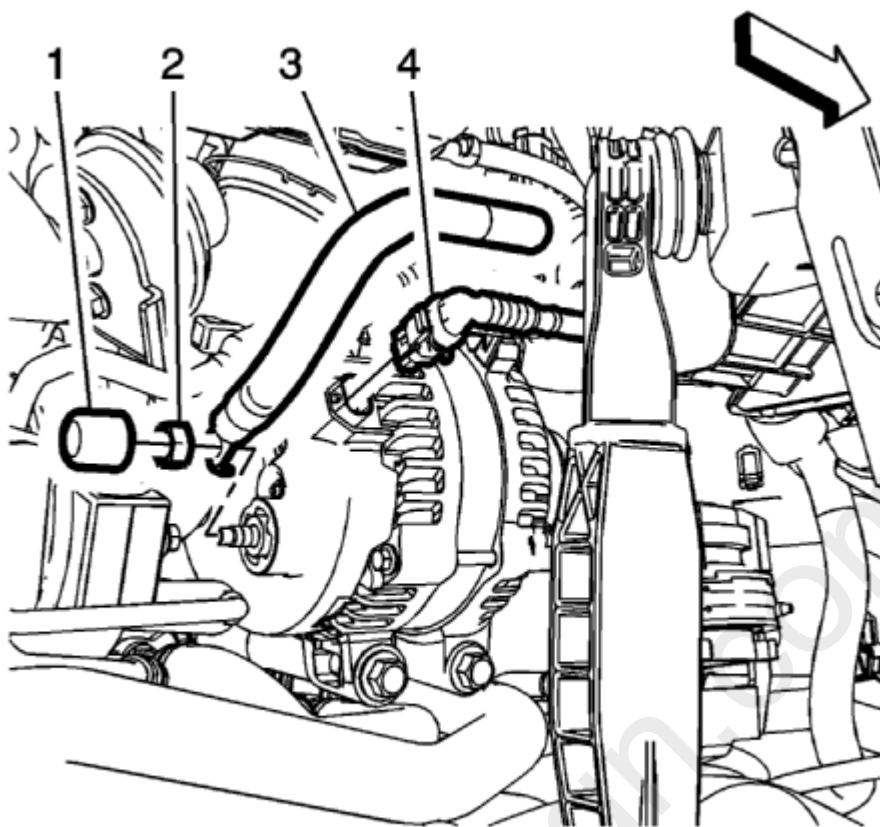


Fig. 109: Generator Mounting Bolts
 Courtesy of GENERAL MOTORS COMPANY

2. Connect the engine harness connector (4) and the engine harness battery positive terminal (3) to the generator. Tighten the fastener (2) to 15 (11 lb ft).
3. Install the generator B + protective cap (1).
4. Install the turbocharger coolant return pipe - bank 1. Refer to **Turbocharger Coolant Return Pipe Replacement (LF3 - Bank 2)** , **Turbocharger Coolant Return Pipe Replacement (LF3 - Bank 1)** .
5. Install the radiator surge tank. Refer to **Radiator Surge Tank Replacement (LFX, LF3)** .
6. Install the drive belt. Refer to **Drive Belt Replacement** .
7. Install the air cleaner rear outlet duct. Refer to **Air Cleaner Outlet Rear Duct Replacement (LF3)** .
8. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.

BATTERY SENSOR MODULE CALIBRATION

Calibration Criteria

NOTE: This procedure is only for vehicles equipped with a Battery Sensor Module. Attempting to run this procedure without a Battery Sensor Module may cause unwanted results. If this occurs, the BCM will need to be reset with an ignition

cycle.

The battery sensor module is attached directly to the negative battery terminal and is used to determine the battery condition by calculating the battery state of charge, state of function, and state of health. The battery condition is used to help determine if the 12 volt stop/start system will allow a stop/start event to occur when the vehicle has come to a stop.

To determine the battery condition, the battery sensor module must be calibrated. In normal operation, all current entering or exiting the battery flows through the battery sensor module and is monitored. Any action which charges or discharges the battery that is not monitored by the battery sensor module will require the calibration procedure be performed. Such instances are:

- The battery was replaced by a battery with the same part number
- The battery was replaced by a battery with a different part number or different specifications
- The battery was recharged while outside the vehicle
- The battery was discharged while outside the vehicle
- The battery was improperly charged:

To properly charge the battery, the negative lead of the charger must be connected to chassis ground, NOT directly to the negative battery post. Connecting to chassis ground allows current to flow through the battery sensor module during charging and be measured. Connecting directly to the negative battery post charges the battery, but the current is not measured by the battery sensor module.

If any of these conditions have occurred, the battery sensor module must be calibrated to maintain proper 12 volt start/stop operation.

Battery Sensor Module Calibration

NOTE: To complete the battery sensor module calibration, there must be no parasitic electrical drains on the battery. A parasitic electrical drain greater than 100 mA will result in an inability to complete the calibration. All parasitic electrical drains must be corrected before the battery sensor module calibration can be completed. Refer to Battery Electrical Drain/Parasitic Load Test.

1. Apply the parking brake.
2. Ignition ON, engine OFF.
3. Install a scan tool.
4. Clear all DTCs before proceeding.
5. Navigate to the Configuration/Reset Functions menu of the BCM.
6. Select the Battery Sensor Module procedure and follow the directions displayed on the screen.

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.

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 Block Diagram

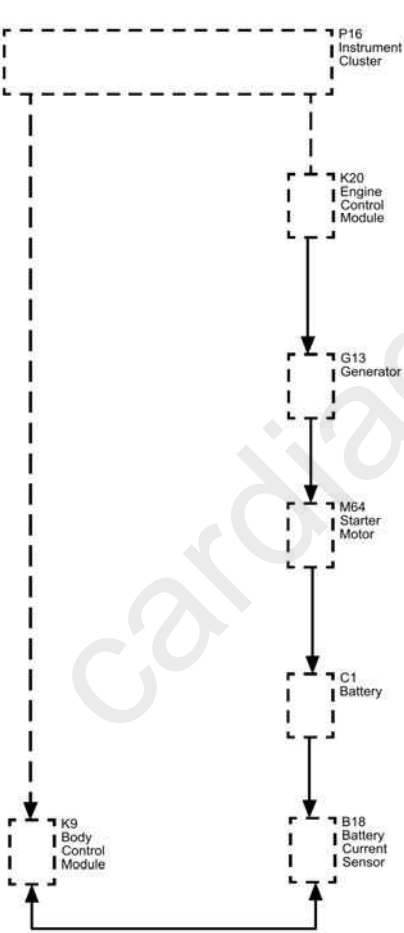


Fig. 110: Charging System Block Diagram
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
DB	Serial Data - GMLAN Low Speed
DB	Serial Data - GMLAN Low Speed

HW	Hard-Wired
HW	Hard-Wired
HW	Hard-Wired
HW	Hard-Wired
HW	Hard-Wired
P16	P16 Instrument Cluster
K20	K20 Engine Control Module
G13	G13 Generator
M64	M64 Starter Motor
C1	C1 Battery
B18	B18 Battery Current Sensor
K9	K9 Body Control Module

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
- Head lamp 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 through 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.

Head lamp Mode

The BCM will enter Head lamp Mode when ever the head lamps 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:

Electrical Power Management Block Diagram

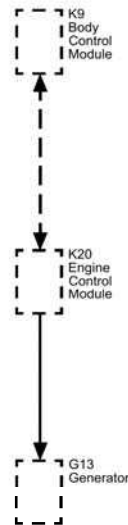


Fig. 111: Electrical Power Management Block Diagram
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
DD	Serial Data - GMLAN High Speed
HW	Hard-Wired
K9	K9 Body Control Module
K20	K20 Engine Control Module
G13	G13 Generator

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	Greater Than -12 V	Battery has a net	First level Idle boost request

	(5°F)		loss less than 0.2 Ah	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
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.

Starting System Block Diagram

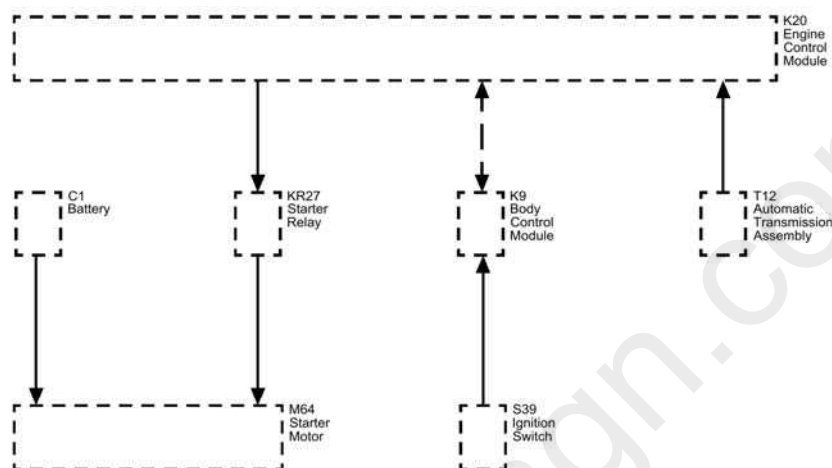
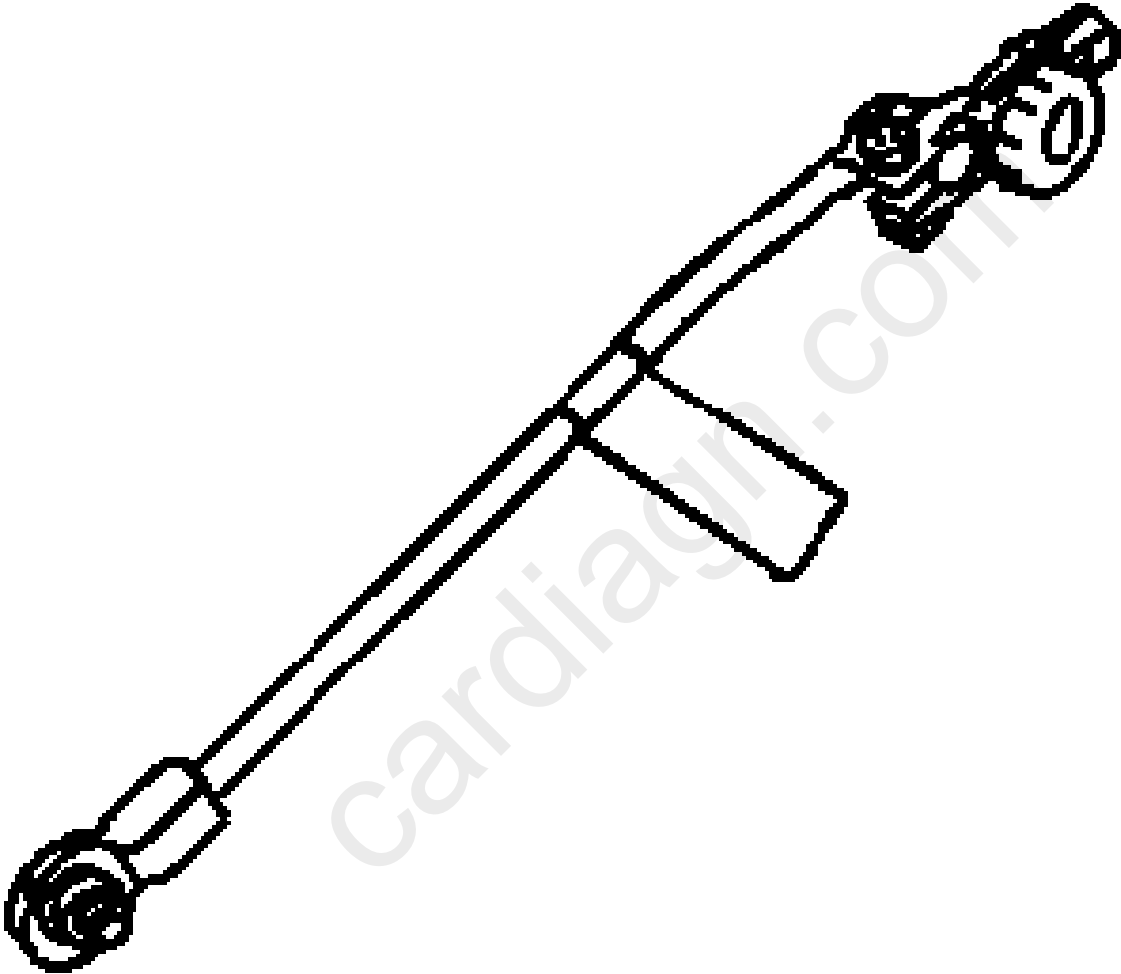


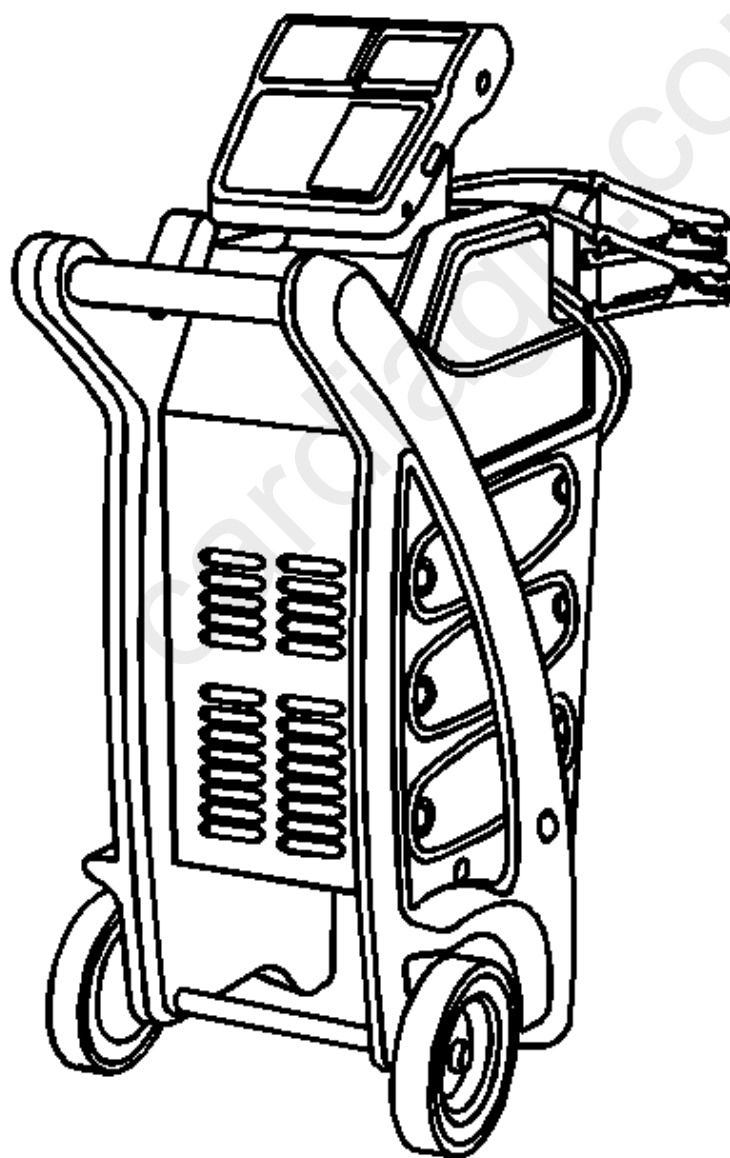
Fig. 112: Starting System Block Diagram
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
HW	Hard-Wired
HW	Hard-Wired
HW	Hard-Wired
HW	Hard-Wired
DD	Serial Data - GMLAN High Speed
HW	Hard-Wired
K20	K20 Engine Control Module
C1	C1 Battery
KR27	KR27 Starter Relay
K9	K9 Body Control Module
T12	T12 Automatic Transmission Assembly
M64	M64 Starter Motor
S39	S39 Ignition Switch

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Illustration	Tool Number/Descrip
	EL 38758 EL 50074 J 38758 Parasitic Draw T Switch



EL 50313
EL 42000
EL 50076
J 42000
Battery Tester

