

2010 ELECTRICAL

Engine Electrical - Equinox & Terrain

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Application	Specification	
	Metric	English
Battery Hold Down Retainer Bolt (Battery)	10 N.m	89 lb in
Battery Hold Down Retainer Bolt (Radiator Support)	22 N.m	16 lb ft
Battery Negative Cable Clamp Nut (Battery Post)	10 N.m	88 lb in
Battery Negative Cable Engine Block Ground Nut (LAF)	30 N.m	22 lb ft
Battery Negative Cable Engine Block Ground Nut (LF1)	25 N.m	18 lb ft
Battery Negative Cable Frame Ground Nut	25 N.m	18 lb ft
Battery Positive Cable Clamp Nut (Battery Post)	10 N.m	88 lb in
Battery Positive Cable Nut (Battery Fuse Block)	15 N.m	11 lb ft
Battery Positive Cable Nut (at the starter)	13 N.m	115 lb in
Generator BAT + Terminal Nut	20 N.m	15 lb ft
Generator Bolt	22 N.m	16 lb ft
Generator Bracket Bolt (LAF)	22 N.m	16 lb ft
Starter Motor Mounting Bolt	50 N.m	37 lb ft
Starter Shield Bolt	5 N.m	44 lb in
Starter Solenoid Nut	10 N.m	88 lb in

BATTERY USAGE

Application	Specification
LAF	
Cold Cranking Amperage (CCA)	525 A
Amp Hour Rating	60 Ah
LF1 or LFW	
Cold Cranking Amperage (CCA)	615 A
Amp Hour Rating	70 Ah

GENERATOR USAGE

Application	Specification
LAF	
Generator Model	TG13 (Valeo)
Rated Output	125 A

Load Test Output	87 A
LF1 or LFW	
Generator Model	SC2 (Denso)
Rated Output	155 A
Load Test Output	108 A

SCHEMATIC AND ROUTING DIAGRAMS

STARTING AND CHARGING SCHEMATICS

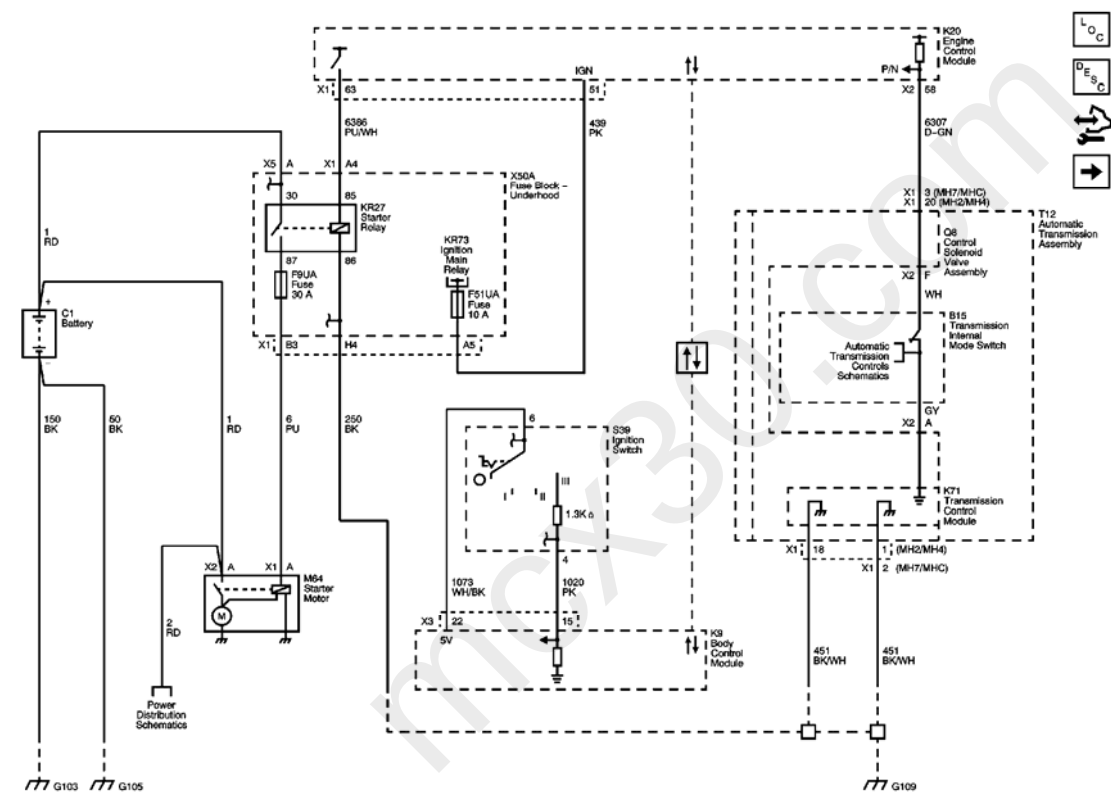


Fig. 1: Starting
Courtesy of GENERAL MOTORS CORP.

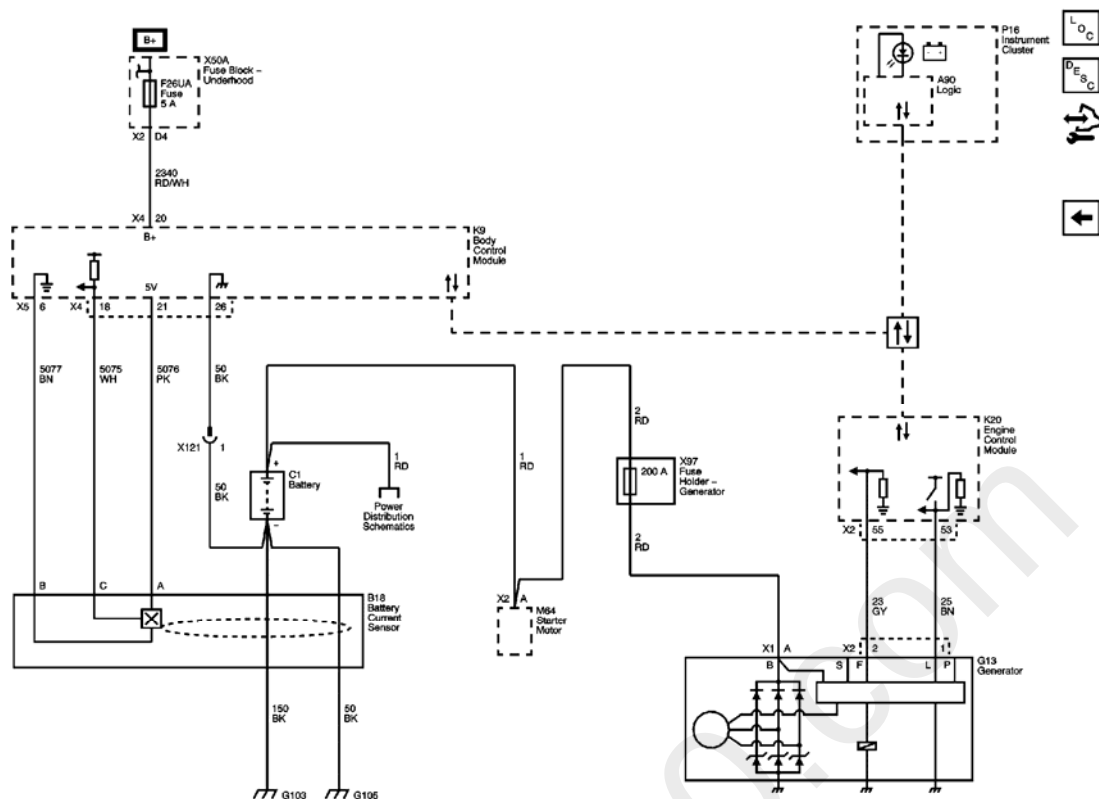


Fig. 2: Charging

Courtesy of GENERAL MOTORS CORP.

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC CODE INDEX

DIAGNOSTIC CODE INDEX

DTC	Description
DTC B1325	B1325 03: Device Power Circuit Voltage Below Threshold B1325 07: Device Power Circuit Voltage Above Threshold
DTC B1516	B1516 08: Battery Current Sensor Signal Invalid B1516 66: Battery Current Sensor Wrong Mounting Position
DTC B1517	B1517 03: Battery Voltage Below Threshold B1517 07: Battery Voltage Above Threshold B1517 5A: Battery Voltage Plausibility Failure
DTC B151A	B151A 58: Low Battery Capacity Detected
DTC B1527	B1527 00: High Parasitic Load Detected
DTC C0800	C0800 03: Device Power 1 Circuit Voltage Below Threshold C0800 07: Device Power 1 Circuit Voltage Above Threshold
DTC P0562	P0562: System Voltage Low

<u>DTC P0563</u>	P0563: System Voltage High
<u>DTC P0615</u>	P0615: Starter Relay Control Circuit
<u>DTC P0621</u>	P0621: Generator L-Terminal Circuit
<u>DTC P0622</u>	P0622: Generator F-Terminal Circuit

DTC B1325

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 03

Device Power Circuit Voltage Below Threshold

DTC B1325 07

Device Power Circuit Voltage Above Threshold

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
B+	B1325 03	B1325 03	-	-
Ground	-	B1325 03	-	-

Circuit/System Description

The following control modules monitor the system voltage through the battery positive (B+) voltage circuits:

- Seat heating control module
- Instrument cluster
- Passenger presence detection module
- Inflatable restraint sensing and diagnostic module
- Seat memory control module
- Multimedia player interface module
- Radio
- Parking assist control module

Conditions for Running the DTC

- The voltages supplied to the control modules are in the range of 7-26 V.
- The ignition is ON.

Conditions for Setting the DTC

B1325 03

The control module detects a system voltage less than 9 V for 5 seconds.

B1325 07

The control module detects a system voltage greater than 18 V for 5 seconds.

Action Taken When the DTC Sets

- The control module immediately disables all outputs when an out of range voltage condition has been detected, with the exception of serial data, which is disabled after a 3 minute delay.
- The setting of other DTCs is inhibited.

Conditions for Clearing the DTC

The DTC passes when the malfunction is no longer present.

Diagnostic Aids

- A high or low voltage value in multiple modules indicates a concern in the charging system.
- Overcharging with a battery charger or jump starting can cause this DTC to set.

Reference Information

Schematic Reference

- **Instrument Cluster Schematics**
- **Driver Seat Schematics**
- **Heated/Cooled Seat Schematics**
- **SIR Schematics**
- **Radio/Navigation System Schematics**
- **Object Detection Schematics**

Control Module References

Connector End View Reference

Component Connector End Views

Description and Operation

Charging 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 Verification

1. Engine running, accessories OFF, measure and record the battery voltage at the C1 battery terminals. The voltage should be between 12.6 and 15.0 V.
 - If the battery voltage is not within the specified range, refer to **Charging System Test**.
2. Observe the appropriate module scan tool Battery Voltage parameter. Verify that the scan tool displays a value that is within 2 V of the C1 battery terminal voltage.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connectors of the appropriate control module.
2. Ignition OFF and scan tool disconnected, open and close the driver door, and wait 1 minute. Test for less than 5 ohms between the ground circuit terminals listed below and ground:
 - Terminal 1 X1, K29 Seat heating control module
 - Terminal 16, P16 Instrument cluster
 - Terminal 19, K36 Inflatable restraint sensing and diagnostic module
 - Terminal 1, K85 Passenger presence detection module
 - Terminal 3 X4, K40 Seat memory control module
 - Terminal 6 X4, K40 Seat memory control module
 - Terminal 11 X1, T11 Multimedia player interface module
 - Terminal 38 X1, A11 Radio
 - Terminal 7, K41 Parking assist control module
 - If greater than the specified range, test the ground circuit for an open/high resistance.
3. Verify that a test lamp illuminates between the B+ circuit terminals listed below and ground:
 - Terminal 2 X1, K29 Seat heating control module
 - Terminal 31, P16 Instrument cluster
 - Terminal 32, P16 Instrument cluster
 - Terminal 2, K36 Inflatable restraint sensing and diagnostic module
 - Terminal A, K85 Passenger presence detection module

- Terminal 1 X4, K40 Seat memory module
 - Terminal 5 X4, K40 Seat memory module
 - Terminal 1 X1, T11 Multimedia player interface module
 - Terminal 44 X1, A11 Radio
 - Terminal 1, K41 Parking assist control module
 - If the test lamp does not illuminate, test the B+ circuit for a short to ground or an open/high resistance.
4. If the circuits test normal, replace the appropriate control module.

Repair Procedures

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

Control Module References for the appropriate control module replacement, setup, and programming

DTC B1516

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 Wrong Mounting Position

Diagnostic Fault Information

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

Circuit/System Description

The battery current sensor is a 3-wire hall effect current sensor. The body control module (BCM) supplies 5 V

and ground to the battery current sensor. the battery current sensor measures the amount of current flowing to or from the battery and supplies a pulse width modulation (PWM) signal to the BCM.

Conditions for Running the DTC

B1516 08

The BCM is awake.

B1516 66

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

Conditions for Setting the DTC

B1516 08

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

B1516 66

The battery current polarity is positive for 2 minutes.

Action Taken When the DTC Sets

The regulated voltage control (RVC) is disabled.

Conditions for Clearing the DTC

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

Reference Information

Schematic Reference

Starting and Charging Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Charging 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

B1516 08

1. Ignition OFF, disconnect the harness connector at the B18 battery current sensor.
2. Ignition OFF and scan tool disconnected, open and close the driver door, and wait 10 minutes. Test for less than 10 ohms between the low reference circuit terminal B and ground.
 - If greater than the specified range, test the low reference circuit for an open/high resistance. If the circuit tests normal, replace the K9 BCM.
3. Ignition ON, test for 4.8-5.2 V between the 5 V reference circuit terminal A and ground.
 - If less than the specified range, test the 5 V reference circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the K9 BCM.
 - If greater than the specified range, test the 5 V reference circuit for a short to voltage. If the circuit tests normal, replace the K9 BCM.
4. Ignition ON, test for 4.8-5.2 V between the signal circuit terminal C and ground.
 - If less than the specified range, test the signal circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the K9 BCM.
 - If greater than the specified range, test the signal circuit for a short to voltage. If the circuit tests normal, replace the K9 BCM.
5. If all circuits test normal, replace the B18 battery current sensor.

B1516 66

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

Repair Procedures

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

- **Battery Negative Cable Replacement (LF1)** or **Battery Negative Cable Replacement (LAF)**
- **Control Module References** for BCM replacement, setup, and programming

DTC B1517

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 B1517 03

Battery Voltage Below Threshold

DTC B1517 07

Battery Voltage Above Threshold

DTC B1517 5A

Battery Voltage Plausibility Failure

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
B+	B1517 03*, B1517 5A*	B1517 03*, B1517 5A*	-	-
Ground	-	B1517 03*, B1517 5A*	-	-
* All B+ and Ground terminals can set these DTCs				

Circuit/System Description

The body control module (BCM) has designated circuits for monitoring vehicle system voltage. The BCM monitors the system voltage to ensure that the voltage stays within the proper range. Damage to components, and incorrect data may occur when the system voltage is out of range. The BCM monitors the system voltage over an extended length of time.

Conditions for Running the DTC

- The BCM has power and ground.
- The ignition is not in the START position.

Conditions for Setting the DTC

B1517 03

- The battery voltage is less than 11 V.
- The engine speed is greater than 1,100 RPM.
- The above conditions are met for 15 seconds.

B1517 07

- The battery voltage is greater than 16 V.
- The engine speed is greater than 1,100 RPM.
- The above conditions are met for 15 seconds.

B1517 5A

The battery voltage differs by 2 V on the BCM battery sense circuits for 10 seconds.

Action Taken When the DTC Sets

- The instrument panel cluster illuminates the charge indicator.
- The driver information center displays the SERVICE BATTERY CHARGING SYSTEM warning message.

Conditions for Clearing the DTC

- The DTC will clear current status when fault is no longer present.
- The history DTC will clear after 50 consecutive ignition cycles have occurred without a malfunction.

Diagnostic Aids

- A high or low voltage DTC set in multiple modules indicates a concern in the charging system. Refer to **Charging System Test**.
- This DTC may be set by overcharging with a battery charger, or by jump starting.
- Inspect the ground connection, and ensure that it is clean and tight.

Reference Information

Schematic Reference

Body Control System Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Charging 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 Verification

1. Engine running, accessories OFF, measure and record the voltage at the battery voltage at the battery terminals. The voltage should be between 12.6 and 15.0 V.
 - If not within the specified range, refer to **Charging System Test**
2. Observe the scan tool BCM Battery Voltage parameter. Verify that the scan tool displays a voltage that is within 2 V of the battery terminal voltage.

Circuit/System Testing

1. Ignition OFF, disconnect all the harness connectors at the K9 BCM.
2. Ignition OFF, test for less than 10.0 ohms between the ground circuit terminals listed below and ground:
 - Terminal 1 X1
 - Terminal 2 X2
 - Terminal 26 X4
 - Terminal 3 X6
 - If not within the specified range, test the ground circuit for an open/high resistance.
3. Ignition ON, verify a test lamp illuminates between the B+ circuit terminals listed below and ground:
 - Terminal 2 X1
 - Terminal 3 X1
 - Terminal 4 X1
 - Terminal 1 X2
 - Terminal 3 X2
 - Terminal 4 X2
 - Terminal 20 X4
 - Terminal 3 X5
 - Terminal 4 X5
 - If the test lamp does not illuminate, test the B+ circuits for a short to ground or an open/high resistance.
4. If all the circuits test normal, test or replace the K9 BCM.

Repair Procedures

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

Control Module References for BCM replacement, setup, and programming

DTC B151A

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

Low Battery Capacity Detected

Circuit/System Description

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

Conditions for Running the DTC

The ignition must be in the crank position for this code to set.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

A driver information center (DIC) message is displayed.

Conditions for Clearing the DTC

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

Reference Information

Schematic Reference

Starting and Charging Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Charging 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 Verification

Before replacing the C1 battery perform the Battery Inspection/Test.

DTC B1527

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

High Parasitic Load Detected

Circuit/System Description

The body control module (BCM) monitors the state of charge of the electrical system. If the BCM senses that the state of charge at ignition On is 30 percent lower than what it was when the engine was running.

Conditions for Running the DTC

The ignition must be in Accessory or Run mode for this code to set.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

There is no battery telltale illuminated or DIC message displayed.

Conditions for Clearing the DTC

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

Reference Information

Schematic Reference

Starting and Charging Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Charging 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 Verification

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

DTC C0800

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 C0800 03

Device Power 1 Circuit Voltage Below Threshold

DTC C0800 07

Device Power 1 Circuit Voltage Above Threshold

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
B+	C0800 03	C0800 03	-	-
IGN	C0800 03	C0800 03	-	-
Ground	-	C0800 03	-	-

Circuit/System Description

The following module/sensors monitor the system voltage circuit to determine if the voltage is within the normal operating range:

- Power steering control module
- Electronic brake control module
- Steering wheel angle sensor
- Rear differential clutch control module
- Multi-axis acceleration sensor

Conditions for Running the DTC

Ignition is ON.

Conditions for Setting the DTC

C0800 03

The module/sensor detects that the system voltage is less than 9.2 V for 7 seconds.

C0800 07

The module/sensor detects that the system voltage is greater than 16 V for 7 seconds.

Action Taken When the DTC Sets

A DIC message and/or a warning indicator may be displayed.

Conditions for Clearing the DTC

The system voltage returns to normal operating range.

Diagnostic Aids

- A high or low voltage DTC set in multiple module/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

- Antilock Brake System Schematics
- Power Steering Schematics
- Rear Axle Schematics

Control Module References

Connector End View Reference

Component Connector End Views

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

1. Engine running, measure and record the voltage at the C1 battery terminals.
2. Verify that the battery voltage is 12.6-15.0 V.
 - If the battery voltage is not within the specified range, refer to Charging System Test.
3. Observe the scan tool of the appropriate module Battery Positive parameter. Verify that the scan tool displays a voltage that is within 2 V of the C1 battery terminal voltage.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connectors at the appropriate module/sensor.
2. Test for less than 3 ohms between the ground circuit terminals listed below and ground:
 - Terminal 1 X2, K43 Power steering control module
 - Terminal 16, K17 Electronic brake control module
 - Terminal F X1, K47 Rear differential clutch control module
 - Terminal 6, B99 Steering wheel angle sensor
 - Terminal 6, B119 Multi-axis acceleration sensor
 - If greater than the specified range, test the ground circuit for an open/high resistance.
3. Ignition ON, verify a test lamp illuminates between the B+/ignition circuits listed below and ground:
 - Terminal 2 X2, K43 Power steering control module
 - Terminal 1, K17 Electronic brake control module
 - Terminal 32, K17 Electronic brake control module
 - Terminal G X1, K47 Rear differential clutch control module
 - Terminal 5, B99 Steering wheel angle sensor
 - Terminal 5, B119 Multi-axis acceleration sensor
 - If the test lamp does not illuminate, test the circuit for an open/high resistance.
4. If all circuits test normal, replace the appropriate module/sensor.

Repair Procedures

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

- **Vehicle Yaw Sensor Replacement**
- **Steering Angle Sensor Replacement**
- **Control Module References** for the appropriate module replacement, setup, and programming

DTC P0562

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 P0562

System Voltage Low

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
B+	P0562	P0562	-	-
Ground	-	P0562	-	-

Circuit/System Description

The following control modules monitor the system voltage to ensure that the voltage stays within the proper range:

- Engine control module
- Fuel pump control module
- Transmission control module

Damage to components, and incorrect data may occur when the voltage is out of range.

Conditions for Running the DTC

Engine Control Module

The system voltage is between 9.5-18 V.

Fuel Pump Control Module

The engine is running.

Transmission Control Module

- Engine speed is 1200 RPM or greater.
- The system voltage is between 8.6-18 V.

Conditions for Setting the DTC

Engine Control Module

The engine control module detects a system voltage below 10 V for 5 seconds.

Fuel Pump Control Module or Transmission Control Module

The module detects a system voltage below 9 V for 4 seconds.

Action Taken When the DTC Sets

DTC P0562 is a C type DTC.

Conditions for Clearing the DTC

DTC P0562 is a C type DTC.

Reference Information

Schematic Reference

- **Engine Controls Schematics** for the LAF engine
- **Engine Controls Schematics** for the LFW engine
- **Automatic Transmission Controls Schematics**

Connector End View Reference

Component Connector End Views

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, accessories OFF, measure and record the battery voltage at the C1 battery terminals. The voltage should be between 12.6 and 15.0 V.
 - If not within the specified range, refer to **Charging System Test**.
2. Observe the scan tool of the appropriate control module Ignition 1 Signal parameter. Verify that the scan tool displays a voltage that is within 2 V of the C1 battery terminal voltage.

Circuit/System Testing

Engine Control Module

1. Ignition OFF, disconnect the harness connectors at the K20 ECM.

2. Ignition OFF, and scan tool disconnected, open and close the driver door, and wait 1 minute. Test for less than 5 ohms between the ground circuit terminals listed below and ground:
 - Terminal 73 X2 (LAF or LFW)
 - Terminal 73 X3 (LAF or LFW)
 - If greater than the specified range, test the ground circuit for an open/high resistance.
3. Connect a 15 A fused jumper wire between B+ and the KR71 engine control module relay switch control terminal 87. Ignition ON, verify that a test lamp illuminates between the IGN/B+ circuit terminals listed below and ground:
 - Terminal 51 X1 (LAF or LFW)
 - Terminal 52 X1 (LAF or LFW)
 - Terminal 73 X1 (LAF or LFW)
 - If the test lamp does not illuminate, test the IGN/B+ circuit for a short to ground or an open/high resistance.
4. If all circuits test normal, replace the K20 ECM.

Fuel Pump Control Module

1. Ignition OFF, disconnect the harness connectors at the K27 fuel pump control module.
2. Ignition OFF and scan tool disconnected, open and close the driver door, and wait 1 minute. Test for less than 5 ohms between the ground circuit terminal 25 and ground.
 - If greater than the specified range, test the ground circuit for an open/high resistance.
3. Verify that a test lamp illuminates between the IGN/B+ circuit terminals listed below and ground:
 - Terminal 1
 - Terminal 21
 - If the test lamp does not illuminate, test the IGN/B+ circuit for a short to ground or an open/high resistance.
4. If all circuits test normal, replace the K27 fuel pump control module.

Transmission Control Module

1. Ignition OFF, disconnect the harness connectors at the T12 transmission.
2. Ignition OFF, and scan tool disconnected, open and close the driver door, and wait 1 minute. Test for less than 5 ohms between the ground circuit terminals listed below and ground:
 - Terminal 1 (MH2/MH4)
 - Terminal 18 (MH2/MH4)
 - Terminal 2 (MH7/MHC)
 - If greater than the specified range, test the ground circuit for an open/high resistance.
3. Ignition ON, verify that a test lamp illuminates between the IGN/B+ circuit terminals listed below and ground:
 - Terminal 10 (MH2/MH4)
 - Terminal 13 (MH2/MH4)

- Terminal 1 (MH7/MHC)
- Terminal 12 (MH7/MHC)
 - If the test lamp does not illuminate, test the IGN/B+ circuit for a short to ground or an open/high resistance.

4. If all circuits test normal, replace the K71 transmission control module.

Repair Procedures

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

Control Module References for the appropriate control module replacement, setup, and programming

DTC P0563

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 P0563

System Voltage High

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
B+	P0562	P0562	-	-
Ground	-	P0562	-	-

Circuit/System Description

The following control modules monitor the system voltage to ensure that the voltage stays within the proper range:

- Engine control module
- Fuel pump control module
- Transmission control module

Damage to components, and incorrect data may occur when the voltage is out of range.

Conditions for Running the DTC

Engine Control Module

- The vehicle speed is above 8 km/h (5 mph).
- The system voltage is between 9.5-18 V.

Fuel Pump Control Module

The ignition is ON.

Transmission Control Module

The system voltage is between 8.6-18.0 V.

Conditions for Setting the DTC

Engine Control Module

The engine control module detects a system voltage above 16 V for less than 1 second.

Fuel Pump Control Module or Transmission Control Module

The module detects the system voltage is greater than 18 V.

Action Taken When the DTC Sets

DTC P0563 is a C type DTC.

Conditions for Clearing the DTC

DTC P0563 is a C type DTC.

Diagnostic Aids

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

Reference Information

Schematic Reference

- **Engine Controls Schematics** for the LAF engine
- **Engine Controls Schematics** for the LFW engine
- **Automatic Transmission Controls Schematics**

Connector End View Reference

Component Connector End Views

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, accessories OFF, measure and record the battery voltage at the battery terminals. The voltage should be between 12.6 and 15.0 V.
 - If not within the specified range, refer to **Charging System Test**.
2. Engine running, observe the scan tool of the appropriate control module Ignition 1 signal parameter. Verify that the scan tool displays a voltage that is within 2 V of the battery terminal voltage.
 - If not within the specified range, replace the appropriate control module.

Repair Procedures

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

Control Module References for the appropriate control module replacement, setup, and programming

DTC P0615

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 P0615

Starter Relay Control Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
B+	1	1	-	-
Signal	2	1	-	-
Control Terminal 85	P0615	P0615, 1	3	-
Control Terminal 87	1	1	3	-
Ground	-	P0615	-	-
1. Starter Solenoid Does Not Click 2. Cranks In Any Gear 3. Cranks All The Time				

Circuit/System Description

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) that crank has been requested. The ECM then verifies that the clutch pedal is depressed or the transmission is in Park/Neutral. If it is, the ECM then supplies 12 V to the control circuit of the starter relay. When this occurs, battery voltage is supplied through the switch of the starter relay to the starter solenoid.

Conditions for Running the DTC

- The Ignition is in the START position.
- The system voltage is between 9.5-18 V.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

DTC P0615 is a C type DTC.

Conditions for Clearing the DTC

DTC P0615 is a C type DTC.

Reference Information

Schematic Reference

Starting and Charging Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Starting 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

Ignition ON, verify that no theft deterrent or automatic transmission DTCs are set that would cause the ECM not to enable engine starting.

Circuit/System Testing

1. Ignition OFF, disconnect the KR27 starter relay.
2. Ignition OFF and scan tool disconnected, open and close the driver door, and wait 1 minute. Test for less than 10 ohms between the relay ground circuit terminal 86 and ground.
 - If greater than the specified range, test the ground circuit for an open/high resistance.
3. Ignition ON, verify a test lamp illuminates between the B+ circuit terminal 30 and ground.
 - If the test lamp does not illuminate, test the B+ circuit for a short to ground or an open/high resistance.
4. Ignition ON, verify that a test lamp does not illuminate between the control circuit terminal 87 and ground.
 - If the test lamp illuminates, test the control circuit for a short to voltage.
5. Parking brake applied, transmission in neutral or park. Momentarily install a 30 A fused jumper wire between the B+ circuit terminal 30 and the control circuit terminal 87. Verify the starter is activated.
 - If the starter does not activate, test the control circuit for a short to ground or an open/high resistance. If the circuit tests normal, test or replace the M64 starter.

6. Ignition OFF, connect a test lamp between the control circuit terminal 85 and the ground circuit terminal 86.
7. With the transmission range selector in park or neutral, cycle the ignition between the OFF and CRANK position. The test lamp should turn ON and OFF when changing between the commanded states.
 - If the test lamp is always ON, test the control circuit for short to voltage. If the circuit tests normal, replace the K20 ECM.
 - If the test lamp is always OFF, test the control circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the K20 ECM.
8. If all circuits tests normal, 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 not within the specified range, replace the relay.
3. Test for infinite resistance between the following terminals:
 - 30 and 86
 - 30 and 87
 - 30 and 85
 - 85 and 87
 - If not the specified value, replace the relay.
4. Install a 5 A fused jumper wire between relay terminal 85 and 12 V. Install a jumper wire between relay terminal 86 and ground. Test for less than 2 ohms between terminals 30 and 87.
 - If greater than specified range, replace the relay.

Repair Procedures

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

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

DTC P0621

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+	P0622	P0622	-	-
Control	P0621	P0621	P0621	-
Signal	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 voltage to the voltage regulator. This controls the voltage regulator to turn the field circuit ON and OFF. The ECM monitors the state of the generator turn ON control circuit. The ECM should detect low voltage on generator turn on control circuit when the ignition is ON and the engine is OFF, or when the charging system malfunctions. With the engine running, the ECM should detect high voltage on the generator turn on control circuit.

Conditions for Running the DTC

- The ignition ON, engine OFF for ignition on test.
- The engine is running for the run test.

Conditions for Setting the DTC

- During the ignition on test, the ECM detects voltage on the generator turn on control circuit for 5 seconds.
- During the run test, the ECM detects low voltage on the generator turn on control circuit for 15 seconds.

Action Taken When the DTC Sets

DTC P0621 is a C type DTC.

Conditions for Clearing the DTC

DTC P0621 is a C type DTC.

Reference Information

Schematic Reference

Starting and Charging Schematics

Connector End View Reference

Component Connector End Views

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 Testing

1. Ignition OFF, verify that a test lamp illuminates between the G13 generator B+ terminal A X1 and ground.
 - If the test lamp does not illuminate, test the B+ circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the M64 starter motor.
2. Disconnect the X2 harness connector at the G13 generator.
3. Ignition ON, test for 4.5-5.5 V between the control circuit terminal 1 and ground.
 - If greater than the specified range, test the control circuit for a short to voltage. If the circuit tests normal, replace the K20 ECM.
 - If less than the specified range, test the control circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the K20 ECM.
4. If all circuits test normal, replace the G13 generator.

Repair Procedures

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Generator Replacement (LAF) or Generator Replacement (LF1)
- Control Module References for ECM replacement, setup, and programming

DTC P0622

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+	P0622	P0622	-	-
Control	P0621	P0621	P0621	-
Signal	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 percent. When the engine is running, the duty cycle should be between 5-99 percent.

Conditions for Running the DTC

- Ignition ON engine OFF, for the Ignition ON test.
- Engine running, engine speed less than 3,000 RPM for the RUN test.

Conditions for Setting the DTC

- DTC P0621 is not set.
- Ignition ON engine OFF, the ECM detects a PWM signal that is greater than 65 percent for 5 seconds.
- Engine running, the ECM detects a PWM signal that is less than 5 percent for 15 seconds.

Action Taken When the DTC Sets

DTC P0622 is a C type DTC.

Conditions for Clearing the DTC

DTC P0622 is a C type DTC.

Reference Information

Schematic Reference

Starting and Charging Schematics

Connector End View Reference

Component Connector End Views

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

Engine running, observe the scan tool GEN-F Terminal Signal Circuit parameter. The GEN-F Terminal Signal Circuit parameter should display between 5-99 percent.

Circuit/System Testing

1. Verify that a test lamp illuminates between the G13 generator B+ output circuit terminal A X1 and ground.
 - If the test lamp does not illuminate, test the B+ circuit for a short to ground or an open/high resistance.
2. Ignition OFF, disconnect the X2 harness connector at the G13 generator.
3. Ignition ON, verify the scan tool ECM GEN-F Terminal Signal parameter displays less than 5 percent.

- If greater than the specified range, test the signal circuit terminal 2 for a short to voltage. If the circuit tests normal, replace the K20 ECM.
- 4. Install a 3 A fused jumper wire between B+ and the signal circuit terminal 2.
- 5. Verify the scan tool ECM GEN-F Terminal Signal parameter displays greater than 95 percent.
 - If less than the specified range, test the signal circuit terminal 2 for a short to ground or an open/high resistance. If the circuit tests normal, replace the K20 ECM.
- 6. If the circuit tests normal replace the G13 generator.

Repair Procedures

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

- **Generator Replacement (LAF)** or **Generator Replacement (LF1)**
- **Control Module References** for ECM replacement, setup, and programming

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**
 - **Load Shed 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

Special Tools

EL 42000: Battery Tester

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

Diagnostic Aids

WARNING: Refer to **Battery Disconnect Warning** .

NOTE:

- The battery test using the EL 42000 Battery Tester requires correct connections to the battery terminals. A 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 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 EL 42000 clips on the terminal bolt. This may cut through any coating or through any oxidation that may be present on the bolt.

Even new bolts contain a protective coating that may insulate or cause a resistance in the test circuit.

- If correct connections to the battery terminal bolts in the vehicle are in doubt, perform the following steps:
 1. Disconnect the negative battery cable.
 2. Disconnect the positive battery cable.
 3. Install the test adapters on the terminals.
 4. 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.
 3. Install the tester adapters.

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.

4. Follow the instructions for testing a removed battery.
5. 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.

- Use the correct terminal adapters.

Do not use any common bolts or a combination of bolts, of nuts, and of washers as adapters when testing the battery.

Use the test adapters that are provided with the EL 42000 or GM P/N 12303040 terminal adapters. If the adapters that are provided with the EL 42000 require replacement, use GM P/N 12303040. Any other adapter may not contact the correct areas of the battery terminal, causing a resistance that may result in an invalid battery test result.

Circuit/System Testing

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

For Vehicles equipped with OnStar® (UE1) with Back Up Battery: The Back Up Battery is a redundant power supply to allow limited OnStar® functionality in the event of a main vehicle battery power disruption to the VCIM (OnStar® module). Do not disconnect the main vehicle battery or remove the OnStar® fuse with the ignition key in any position other than OFF. Retained accessory power (RAP) should be allowed to time out or be disabled (simply opening the driver door should disable RAP) before disconnecting power. Disconnecting power to the

OnStar® module in any way while the ignition is On or with RAP activated may cause activation of the OnStar® Back-Up Battery (BUB) system and will discharge and permanently damage the back-up battery. Once the Back-Up Battery is activated it will stay on until it has completely discharged. The BUB is not rechargeable and once activated the BUB must be replaced.

1. Inspect the C1 battery for a cracked, broken, or damaged case, which may be indicated by battery acid leakage.
 - If there is any apparent damage, replace the C1 battery.
2. Verify the cold cranking amperage and amp hour rating of the battery to the original battery or original equipment (OE) specification. Refer to **Battery Usage**.
 - If the C1 battery does not meet or exceed specifications, replace the C1 battery.
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, clean as required and tighten as specified.
 - If the battery cables are damaged, replace then tighten as specified.
4. Install the EL 42000 and follow directions supplied by the tester.
 - If the tester calls for charging the battery, refer to **Battery Charging**.

Repair Procedures

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

- **Battery Negative Cable Replacement (LF1)** or **Battery Negative Cable Replacement (LAF)**
- **Battery Positive Cable Replacement (LF1)** or **Battery Positive Cable Replacement (LAF)**
- **Battery Replacement**

BATTERY CHARGING

Special Tools

EL 42000: Battery Tester

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

Diagnostic Aids

- For best results, use an automatic taper-rate battery charger with a voltage capability of 16 V.
- The charging area should be well ventilated.
- Do not charge a battery that appears to be frozen. Allow the battery to warm to room temperature and test it using the EL 42000 before charging.

Battery State of Charge

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

The maintenance-free batteries state of charge is estimated by reading the voltage of the battery across the battery terminals. Because the voltage is affected by current flow into or out of the battery, the engine must be stopped and all electrical loads turned OFF, including parasitic loads, when checking the voltage. The voltage can also be affected if the battery has just been charged or discharged, so it is important to consider what has happened to the battery in the time just before testing. Use the following procedure to determine the batteries 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: Tighten the battery side terminal adapters to 15 N.m (11 lb ft).

Use the following procedure to charge the battery:

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

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

4. Connect the negative charger lead to a solid engine ground or to a ground stud in the engine compartment that is connected directly to the battery negative terminal, but away from the battery. If the negative battery cable is disconnected and a terminal adapter is being used, connect directly to the adapter.

5. Turn ON the charger and set to the highest setting for normal charging.
6. Inspect the battery every half hour after starting the battery charger.
 - Charge the battery until the taper-rate charger indicates that the battery is fully charged.
 - Estimate the battery temperature by feeling the side of the battery. If it feels hot to the touch or its temperature is over 45°C (125°F), discontinue charging and allow the battery to cool before resuming charging.
7. After charging, test the battery. Refer to **Battery Inspection/Test**.

BATTERY ELECTRICAL DRAIN/PARASITIC LOAD TEST

12 V Battery

The following procedure is for the 12 V battery only.

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** 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.

Circuit/System Description

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

Diagnostic Aids

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

the vent solenoid will stay energized for as long as 45 minutes. The typical current draw for this is about 1 A.

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

NOTE: **The battery specification listed below is a generic specification. Refer to Battery Usage when testing the battery.**

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

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

Reference Information

Schematic Reference

Control Module References

Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL 38758: Parasitic Draw Test Switch

For equivalent regional tools, refer to Special Tools.

Circuit/System Verification

NOTE:

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

- Any delay lighting OFF
- If equipped with an under hood lamp disable it
- HVAC after blow OFF
- Any accessory that can work with ignition OFF inactive or OFF
- Wait up to 2 minutes or longer, after all other listed conditions are met

Using an Inductive Pickup Probe

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

Using the EL 38758 Parasitic Draw Test Switch

WARNING: Refer to Battery Disconnect Warning .

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

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

1. Ignition OFF, disconnect the battery negative cable from the battery. Refer to Battery Negative Cable Disconnection and Connection.
2. Turn the **EL 38758:** switch knob to the OFF position.
3. Install the male end of the **EL 38758:** switch to the battery ground terminal.
4. Install the battery negative cable to the female end of the **EL 38758:** switch.
5. Turn the **EL 38758:** switch knob to the ON position.
6. Road test the vehicle and activate all of the accessories such as the radio and air conditioning.
7. Ignition OFF, connect a 10 A fused jumper wire to the test switch tool terminals.
8. Turn the **EL 38758:** switch knob to the OFF position. The current now flows through the jumper wire.
9. Check the fuse in the jumper wire. The fuse should be OK.
 - Failed: If the jumper wire fuse is blown, refer to Circuit/System Testing.

- Passed

10. Turn the **EL 38758**: switch knob to the ON position. Remove the fused jumper wire.
11. Connect a DMM set to the 10 A DC scale between the test switch tool terminals.
12. Turn the **EL 38758**: switch knob to the OFF position. The current now flows through the DMM.
13. As the vehicle systems shut down test for less than 30 mA of parasitic current drain.
 - If greater than the specified range, refer to Circuit/System Testing.

Circuit/System Testing

NOTE:

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

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

- Stuck switch
- Stuck relay
- Control module

Repair Procedures

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

Control Module References for control module replacement, programming and setup

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.

Reference Information

Schematic Reference

Starting and Charging Schematics

Connector End View Reference

Component Connector End Views

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

Engine running, observe the charge indicator on the instrument cluster or message in the driver information center display. The charge indicator on the instrument cluster should be turned OFF and the driver information center display should not display any charging system message.

Circuit/System Testing

1. Ignition ON, 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.
2. Ignition OFF, measure the voltage across the battery terminals. The voltage should read 12.0 V or greater at room temperature.
 - If not within the specified value, refer to Battery Inspection/Test.

NOTE: **Ensure vehicle accessories are OFF for the next step.**

3. Engine ON, increase engine speed to 2,500 RPM. Verify the battery voltage is between 12.6-15.0 V.
 - If not within specified range, replace the G13 generator.
4. Engine ON, increase engine speed to 2,500 RPM. Turn ON all vehicle accessories. Verify the battery voltage is between 12.6-15.0 V.
 - If not within specified range, replace the G13 generator.

Repair Procedures

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

Generator Replacement (LAF) or Generator Replacement (LF1)

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 misrouted or be the cause of noise being transmitted into the passenger compartment.
4. Ignition OFF, remove the engine drive belt. Verify the generator, A/C compressor, water pump pulley, power steering pump, idler pulley, and tensioner pulley spin freely.
 - If any of the pulleys do not spin freely, replace the affected component.
5. Start the engine, with the drive belt removed. Verify that the noise goes away. Operate the engine for no longer than 30-40 seconds.
 - If the noise is still present, the generator is not the cause of the noise.
6. Loosen all generator mounting bolts and ensure the generator is properly aligned. Tighten the mounting bolts to specification, refer to **Generator Replacement (LAF)** or **Generator Replacement (LF1)**.

Repair Procedures

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

- **Drive Belt Replacement** for the 2.2L or 2.4L engines
- **Drive Belt Tensioner Replacement** for the 2.2L or 2.4L engines
- **Drive Belt Replacement** for the 2.8L, 3.0L, 3.2L and 3.6L engines
- **Drive Belt Tensioner Replacement** for the 2.8L, 3.0L, 3.2L and 3.6L engines
- **Drive Belt Idler Pulley Replacement** for the 2.8L, 3.0L, 3.2L and 3.6L engines

- **Generator Replacement (LAF)** or **Generator Replacement (LF1)**

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	-	-
Control Terminal 85	P0615	P0615, 1	3	-
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 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 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 solenoid.

Reference Information

Schematic Reference

- **Starting and Charging Schematics**
- **Automatic Transmission Controls Schematics** for the MH2 and MH4 transmission
- **Automatic Transmission Controls Schematics** for the MH7 transmission

Connector End View Reference

Component Connector End Views

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 Verification

1. Ignition ON, verify that no ignition, starter relay, brake pedal position sensor, theft deterrent, or automatic 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** .
2. Ignition ON, transmission in park, observe the scan tool BCM 5 V Ignition Switch parameter. Place the ignition switch in the crank position, the parameter should display Crank Request.
 - If not the specified value, refer to **Symptoms - Wiring Systems** .
3. Transmission in park, verify the scan tool Transmission Control Module (TCM) Internal Mode Switch parameter displays Park.
 - If the TCM Internal Mode Switch parameter does not indicate Park. Refer to **Transmission Internal Mode Switch Logic** for the MH2 or MH4 transmission or **Transmission Internal Mode Switch Logic** for the MH7 transmission.
4. Transmission in park or neutral attempt to start the vehicle. The crank relay should click and the engine should begin cranking.
 - If the starter relay does not click or the engine does not crank, refer to Circuit/System Testing.

Circuit/System Testing

1. Ignition ON and transmission in Park, with a scan tool verify the ECM Park/Neutral Position Switch parameter displays Active.
 - If the parameter does not display Active, test the ECM Park/Neutral signal circuit terminal 58 X2 for a short to ground or an open/high resistance.
2. Ignition ON, verify the scan tool ECM Ignition 1 Signal parameter is greater than 10 V.
 - If less than the specified range, test the ECM ignition circuit terminal 51 X1 for a short to ground or an open/high resistance. If the circuit tests normal, replace the K20 ECM.
3. Ignition OFF, disconnect the KR27 starter relay.
4. Ignition OFF and scan tool disconnected, open and close the driver door and wait 1 minute. Test for less than 10 ohms between the relay ground circuit terminal 86 and ground
 - If greater than the specified range, test the ground circuit for an open/high resistance.

5. Verify that a test lamp illuminates between the B+ circuit terminal 30 and ground.
 - If the test lamp does not illuminate, test the B+ circuit for a short to ground or an open/high resistance.
6. Ignition ON, verify that a test lamp does not illuminate between the control circuit terminal 87 and ground.
 - If the test lamp illuminates, test the control circuit for a short to voltage.
7. Connect a 30 A fused jumper wire between the B+ circuit terminal 30 and the control circuit terminal 87. Verify the M64 starter motor is activated.
 - If the M64 starter motor does not activate, test the control circuit for a short to ground and an open/high resistance. If the circuit tests normal, test or replace the M64 starter motor.
8. Connect a test lamp between the control circuit terminal 85 and the ground circuit terminal 86.
9. Command the starter relay ON and OFF with a scan tool. The test lamp should turn ON and OFF when changing between the commanded states.
 - If the test lamp is always ON, test the control circuit for a short to voltage. If the circuit tests normal, replace the K20 ECM.
 - If the test lamp is always OFF, test the control circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the K20 ECM.
10. If all circuits test normal, 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 not within the specified range, replace the relay.
3. Test for infinite resistance between the following terminals:
 - 30 and 86
 - 30 and 87
 - 30 and 85
 - 85 and 87
 - If not the specified value, replace the relay.
4. Install a 5 A fused jumper wire between relay terminal 86 and 12 V. Install a jumper wire between relay terminal 85 and ground. Test for less than 2 ohms between terminals 30 and 87.
 - If greater than specified range, replace the relay.

Repair Procedures

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

- **Manual Shift Detent Lever with Shaft Position Switch Assembly Replacement** for the MH2/MH4 transmission

- **Manual Shift Detent Lever with Shaft Position Switch Assembly Replacement** for the MH7 transmission
- **Relay Replacement (Attached to Wire Harness)** or **Relay Replacement (Within an Electrical Center)**
- **Control Module References** for ECM replacement, setup, and programming

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

Component Connector End Views

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 Verification

1. Ignition OFF, measure and record the battery voltage at the C1 battery terminals. The voltage should be between 12.0-15.0 V.
 - If not within the specified range, refer to **Battery Charging**.
2. Remove the drive belts. Refer to **Drive Belt Tensioner Replacement** , **Drive Belt Replacement** for the

LAF engine, **Drive Belt Tensioner Replacement** , or **Drive Belt Replacement** for the LFW engine.

3. Using the appropriate tools, rotate the crankshaft by hand and verify the crankshaft rotates.
 - If the crankshaft does not rotate, refer to **Engine Will Not Crank - Crankshaft Will Not Rotate** for the LAF engine or **Engine Will Not Crank - Crankshaft Will Not Rotate** for the LFW engine.
4. Place the ignition to the CRANK position.
 - If the engine cranks, inspect the engine and belt drive system for mechanical binding, power steering pump, or seized generator, etc.
5. Verify that a test lamp illuminates between the M64 starter motor B+ terminal A X2 and ground.
 - If the test lamp does not illuminate, test the B+ circuit for a short to ground or an open/high resistance.
6. Test for less than 0.5 V between the positive battery cable and terminal A X2 at the M64 starter motor as the S39 ignition switch is placed to the START position.
 - If greater than the specified value, replace the positive battery cable.
7. Test for less than 0.5 V between the negative battery cable and the M64 starter motor case as the S39 ignition switch is placed to the START position.
 - If greater than the specified value, replace the negative battery cable.
8. If all circuits test normal, replace the M64 starter motor.

Repair Procedures

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

- **Battery Positive Cable Replacement (LF1)** or **Battery Positive Cable Replacement (LAF)**
- **Battery Negative Cable Replacement (LF1)** or **Battery Negative Cable Replacement (LAF)**
- **Starter Replacement (LAF)** or **Starter Replacement (LF1)**

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

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 Verification

1. Ignition OFF, measure and record the battery voltage at the C1 battery terminals. The voltage should be between 12.0-15.0 V.
 - If not within the specified range, refer to Battery Charging.
2. Remove the drive belts. Refer to Drive Belt Tensioner Replacement, Drive Belt Replacement for the LAF engine, Drive Belt Tensioner Replacement, or Drive Belt Replacement for the LFW engine.
3. Place the ignition to the CRANK position. verify the engine does not crank normal.
 - If the engine cranks normal, inspect the engine and belt drive system for mechanical binding, seized engine, or seized generator, etc.
4. Test for less than 0.5 V between the positive battery cable and terminal A X2 at the M64 starter motor as the ignition is placed to the CRANK position.
 - If greater than the specified value, replace the positive battery cable.
5. Test for less than 0.5 V between the negative battery cable and the M64 starter motor case as the ignition switch is placed to the CRANK position.
 - If greater than the specified value, replace the negative battery cable.
6. If all circuits test normal, replace the M64 starter motor.

Repair Procedures

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Battery Positive Cable Replacement (LF1) or Battery Positive Cable Replacement (LAF)
- Battery Negative Cable Replacement (LF1) or Battery Negative Cable Replacement (LAF)
- Starter Replacement (LAF) or Starter Replacement (LF1)

STARTER 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.

Circuit/System Description

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

Reference Information

Description and Operation

Charging System Description and Operation

Circuit/System Verification

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

Circuit/System Testing

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

Repair Procedures

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

- **Engine Flywheel Removal**
- **Engine Flywheel Removal**
- **Starter Replacement (LAF)** or **Starter Replacement (LF1)**

REPAIR INSTRUCTIONS

BATTERY NEGATIVE CABLE DISCONNECTION AND CONNECTION

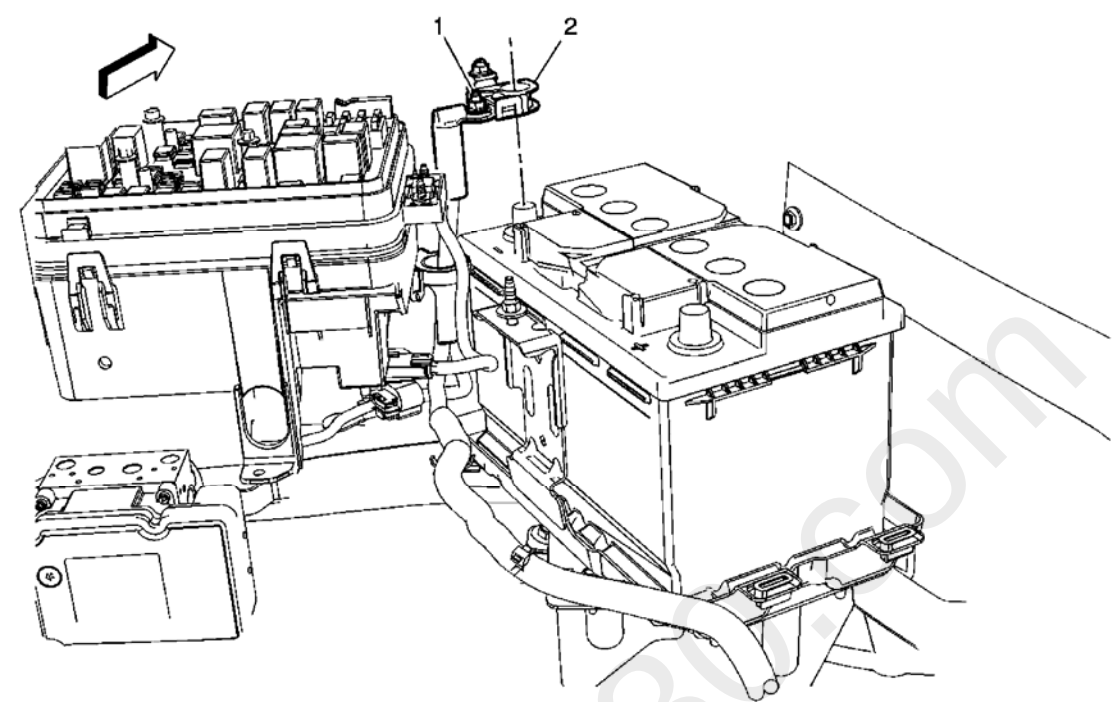


Fig. 3: Battery Negative Cable
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
Preliminary Procedures	
1. Turn on the radio and record all of the radio station presets. 2. Ensure all lamps and accessories are turned off. 3. Ensure the ignition switch is in the OFF position, and remove the ignition key.	
1	Negative Battery Cable Terminal Nut CAUTION: Refer to <u>Fastener Caution</u> . Tighten: 10 N.m (80 lb in)
2	Negative Battery Cable Clamp

BATTERY NEGATIVE CABLE REPLACEMENT (LF1)

Removal Procedure

1. Record all of the radio station presets.
2. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection**.

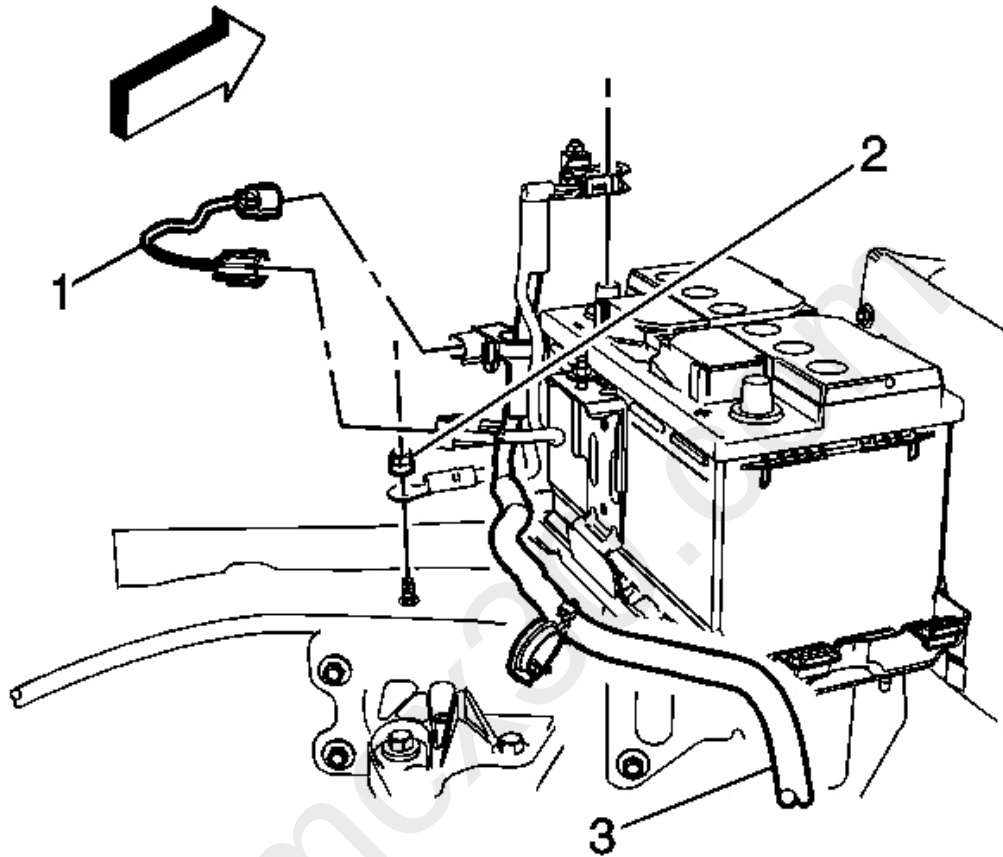


Fig. 4: Battery Negative Cable Ground Nut & Body Harness
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the battery current sensor from the body harness (1)
4. Remove the battery negative cable ground nut (2) from the frame rail.

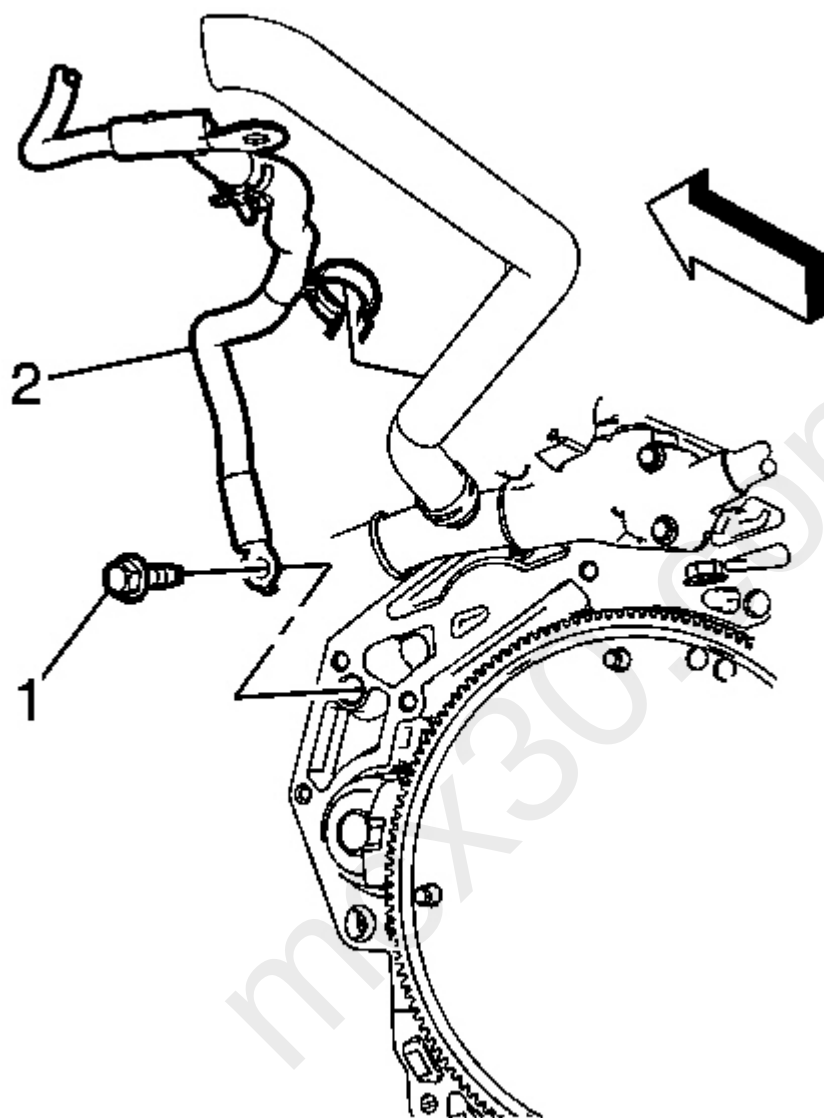


Fig. 5: Battery Negative Cable & Engine Ground Bolt
Courtesy of GENERAL MOTORS CORP.

5. Remove the battery negative cable engine ground bolt (1) from the engine block..
6. Remove the battery negative cable (2).

NOTE: **Observe how the battery negative cable was routed within the engine compartment.**

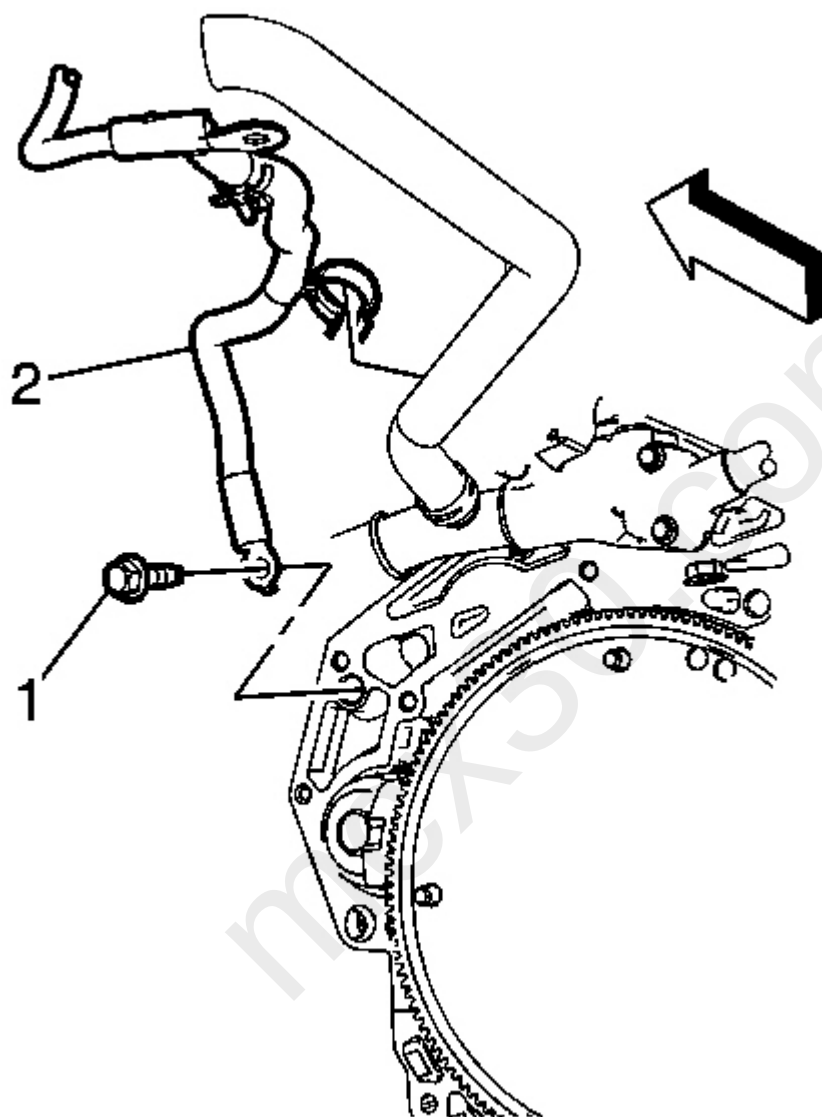


Fig. 6: Battery Negative Cable & Engine Ground Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the battery negative cable engine ground nut (1) to the engine and tighten to 25 N.m (18 lb ft).

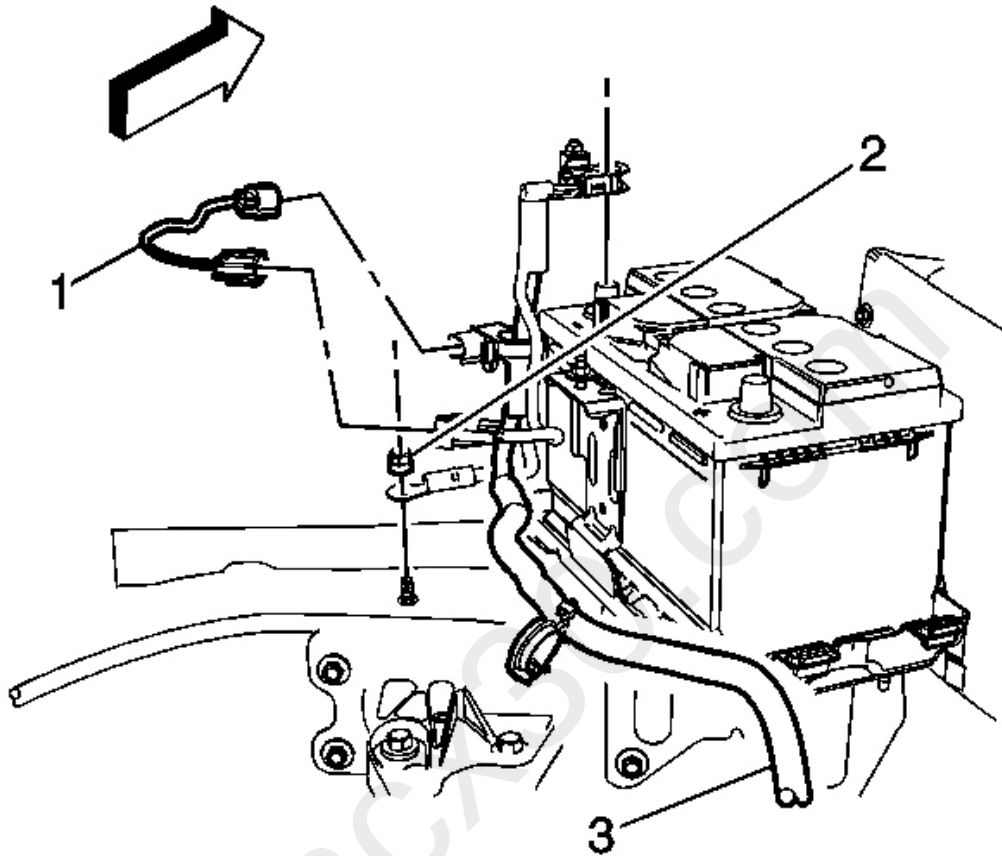


Fig. 7: Battery Negative Cable Ground Nut & Body Harness
Courtesy of GENERAL MOTORS CORP.

2. Install the battery negative cable frame ground nut (1) to the frame rail and tighten to 25 N.m (18 lb ft).
3. Install battery negative cable clamp to the battery post. Refer to **Battery Negative Cable Disconnection and Connection**
4. Reset the radio channel presets.

BATTERY NEGATIVE CABLE REPLACEMENT (LAF)

Removal Procedure

1. Record all of the radio station presets.
2. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection**.

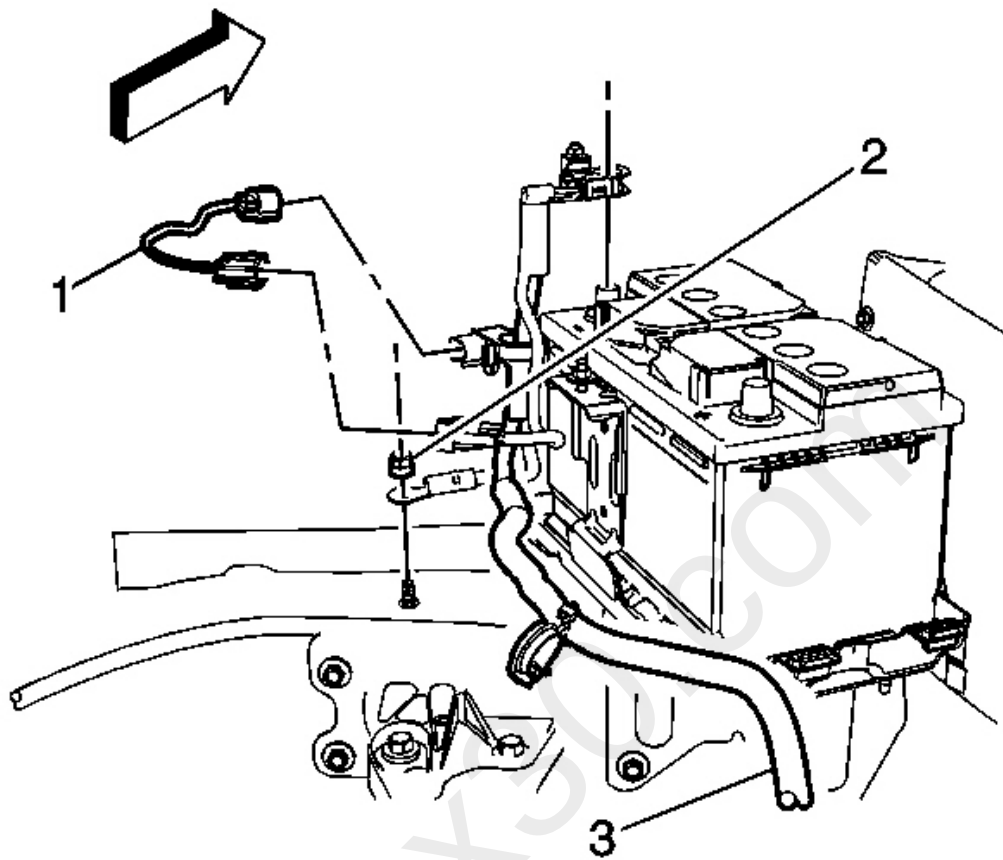


Fig. 8: Battery Negative Cable Ground Nut & Body Harness
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the battery current sensor from the body harness (1)
4. Remove the battery negative cable ground nut (2) from the frame rail.

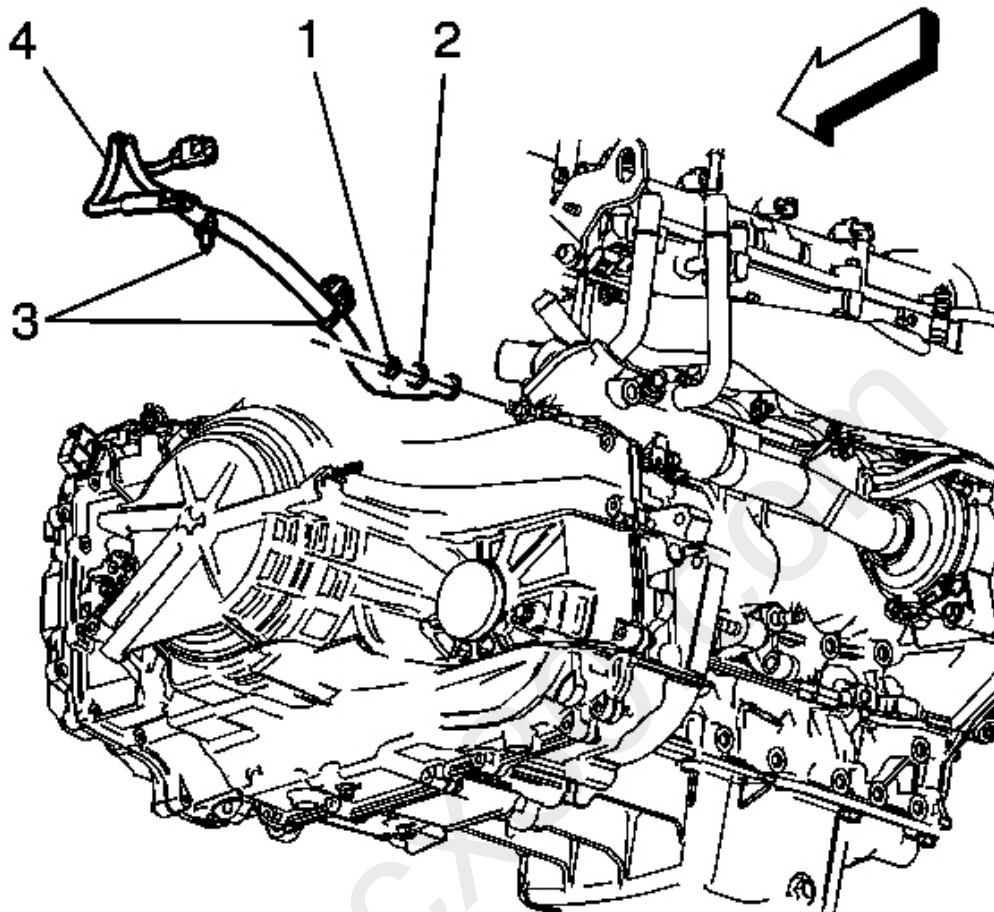


Fig. 9: Battery Negative Cable, Engine Ground Nut & Washer
Courtesy of GENERAL MOTORS CORP.

5. Remove the battery negative cable engine ground nut (1) and washer (2) from the engine block stud.
6. Remove the retainers (3).

NOTE: **Observe how the battery negative cable was routed within the engine compartment.**

7. Remove the battery negative cable (4).

Installation Procedure

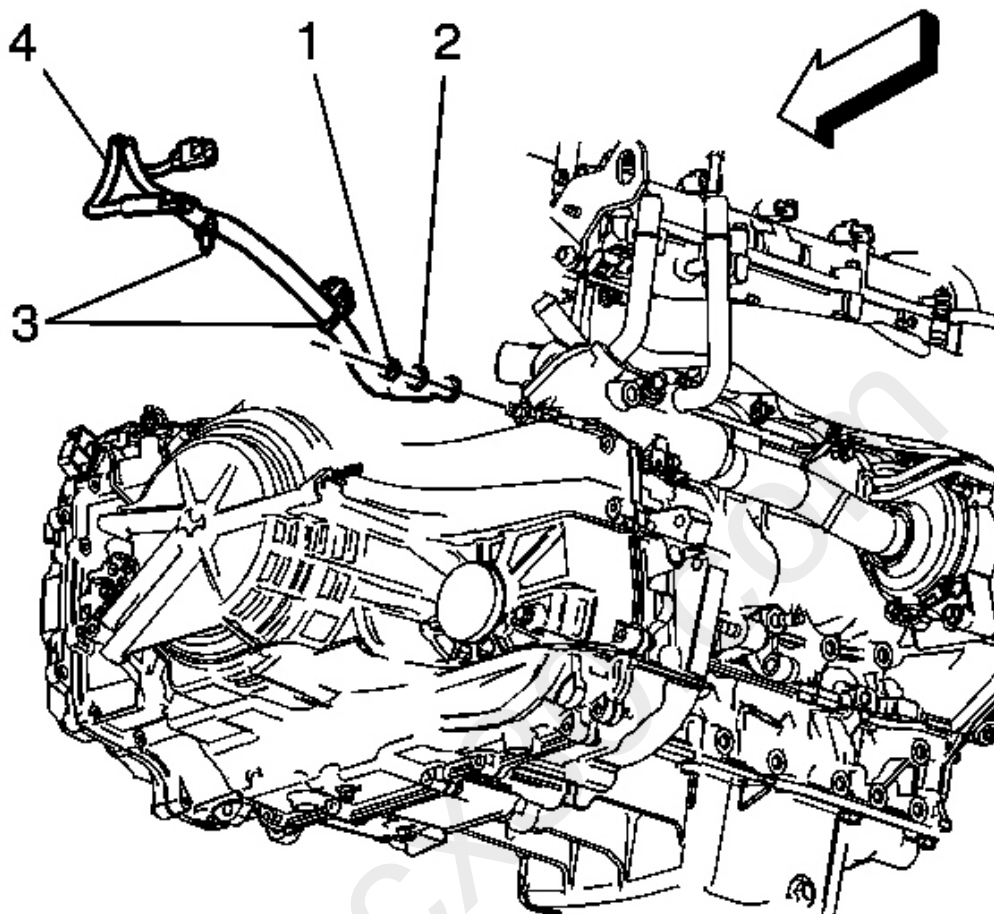


Fig. 10: Battery Negative Cable, Engine Ground Nut & Washer
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the battery negative cable engine ground nut (1) and washer (2) to the engine block stud and tighten to 30 N.m (22 lb ft).

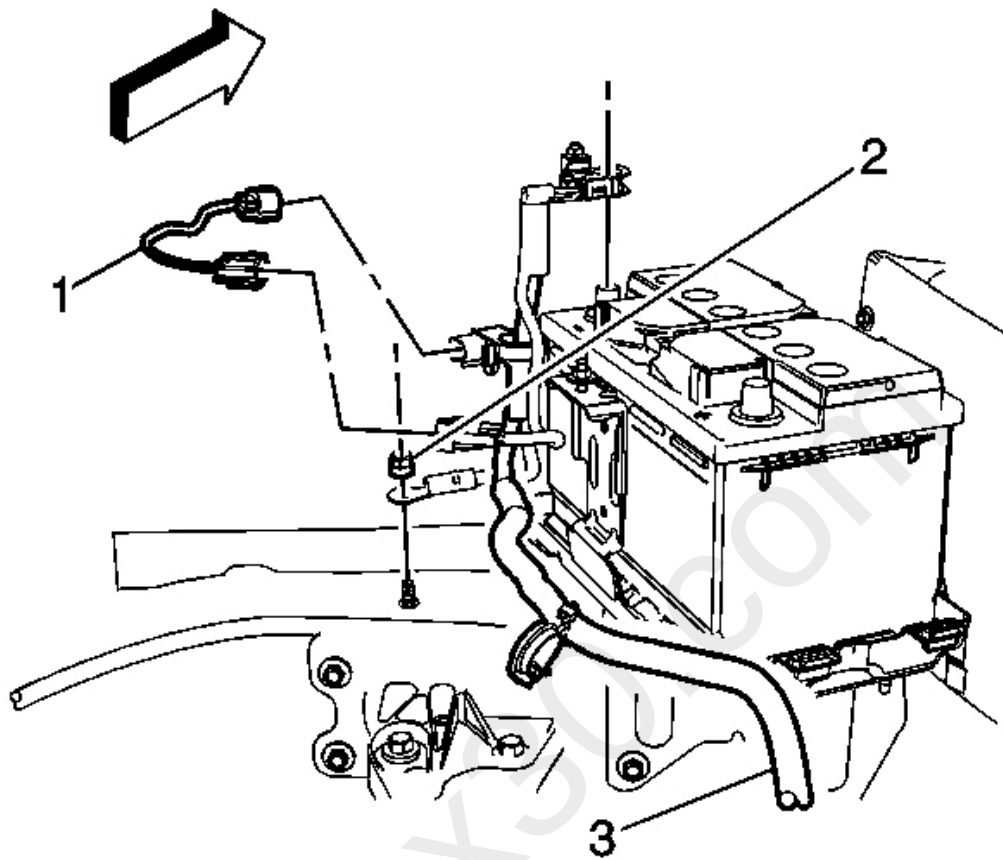


Fig. 11: Battery Negative Cable Ground Nut & Body Harness
Courtesy of GENERAL MOTORS CORP.

2. Install the battery negative cable frame ground nut (2) to the frame rail and tighten to 25 N.m (18 lb ft).
3. Connect the body harness connector (1) to the battery current sensor.
4. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection**.
5. Reset the radio channel presets.

BATTERY POSITIVE CABLE REPLACEMENT (LF1)

Removal Procedure

1. Record all of the radio station presets.
2. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection**.
3. Remove the ECM mounting bracket.

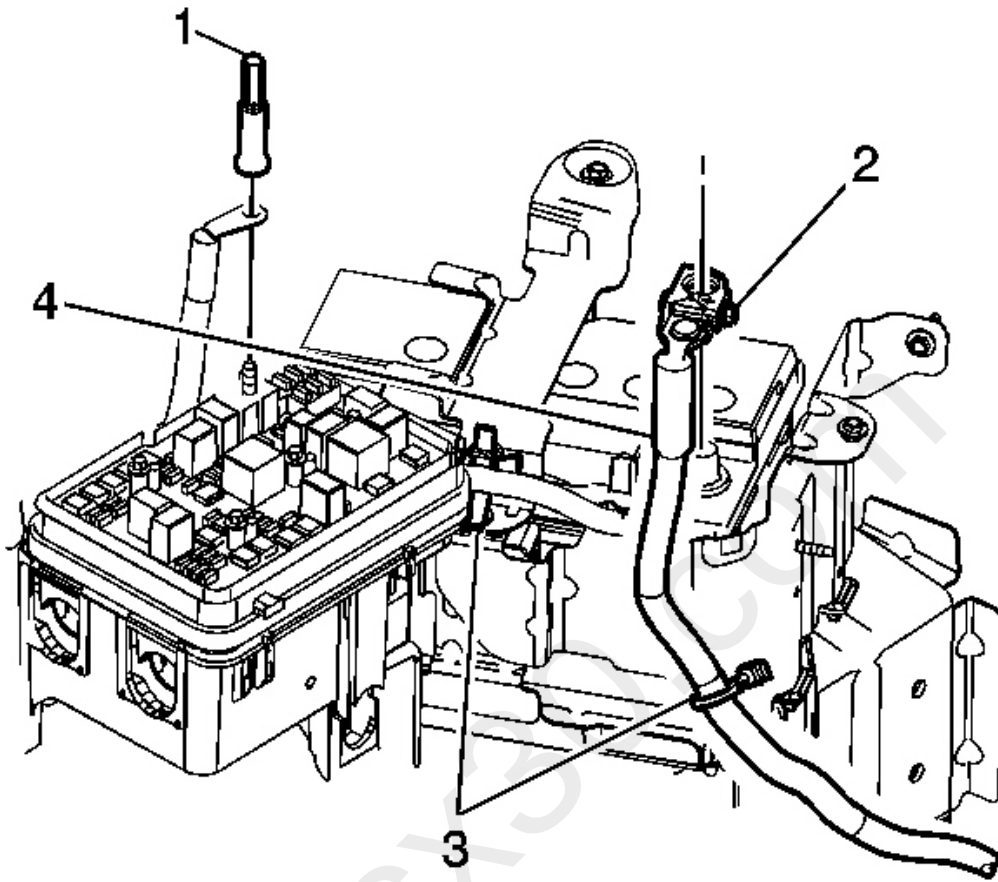


Fig. 12: Identifying Battery Positive Terminal Components
Courtesy of GENERAL MOTORS CORP.

4. Remove the battery positive post clamp nut (2).
5. Remove the battery retainer bracket and the battery. Refer to **Battery Replacement**.
6. Remove battery positive terminal (1) at the fuse block.
7. Disconnect retainers (3) holding battery positive cable (4).

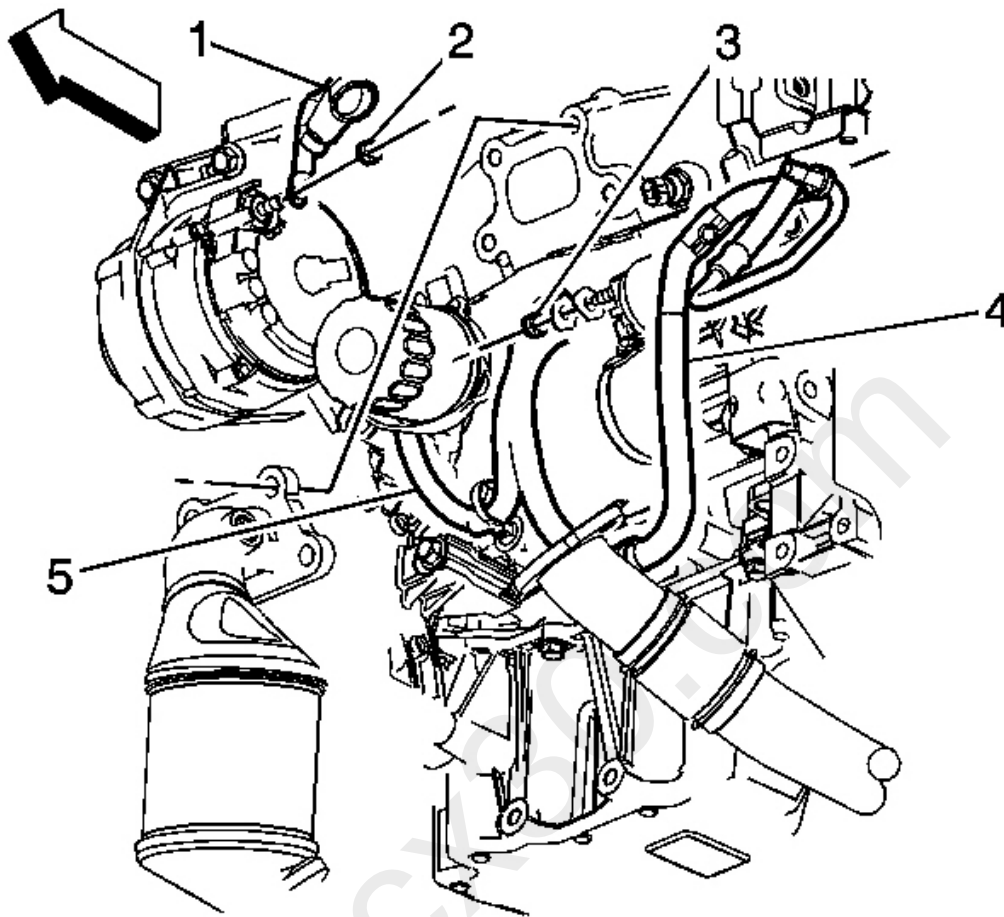


Fig. 13: Identifying Battery Positive Cable Components (LF1)
Courtesy of GENERAL MOTORS CORP.

8. Remove generator boot (1) and nut (2) from the generator B+ stud.
9. Remove the starter solenoid nut (3).
10. Remove the battery positive (Starter) cable (4) and the battery positive (Generator) cable (5) from the vehicle.

NOTE: **Observe how the battery positive cable was routed within the engine compartment.**

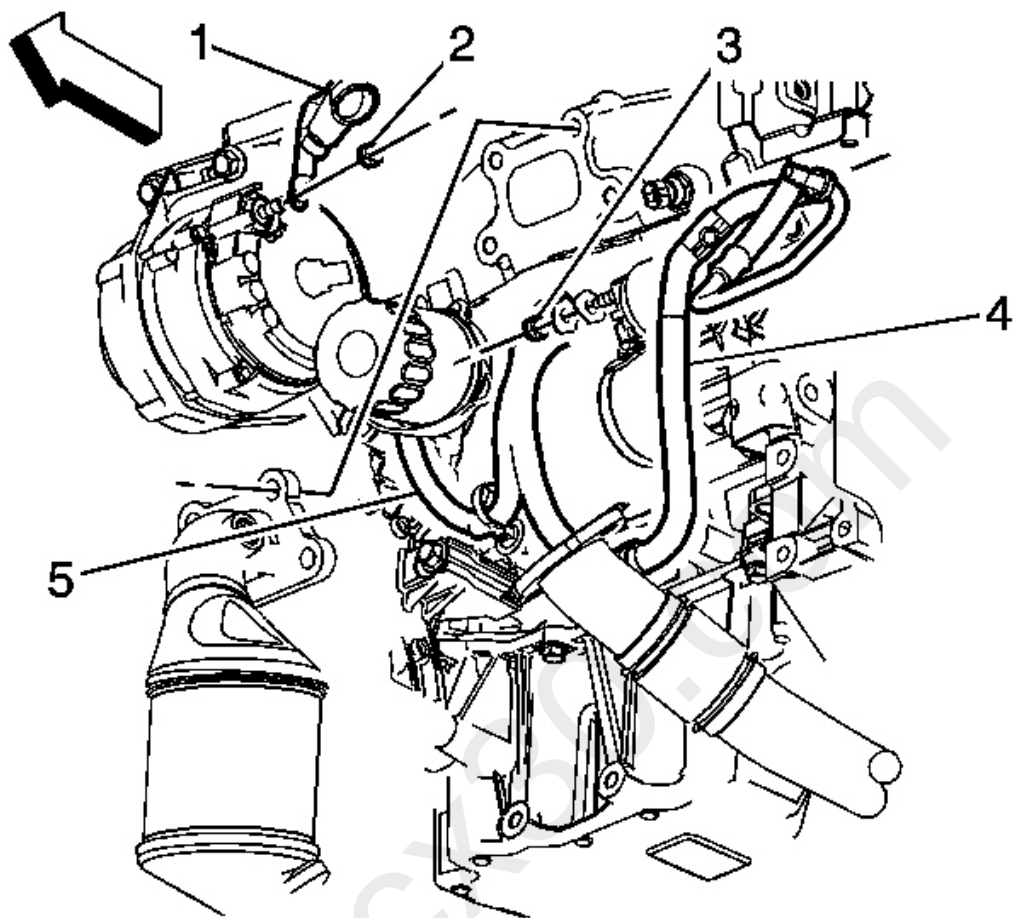


Fig. 14: Identifying Battery Positive Cable Components
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the battery positive cable nut (2) to the B+ generator stud and tighten to 20 N.m (15 lb ft).
2. Install battery positive cable nut (3) and terminals (Starter/Generator), to the starter solenoid. Tighten to 10 N.m (88 lb in)

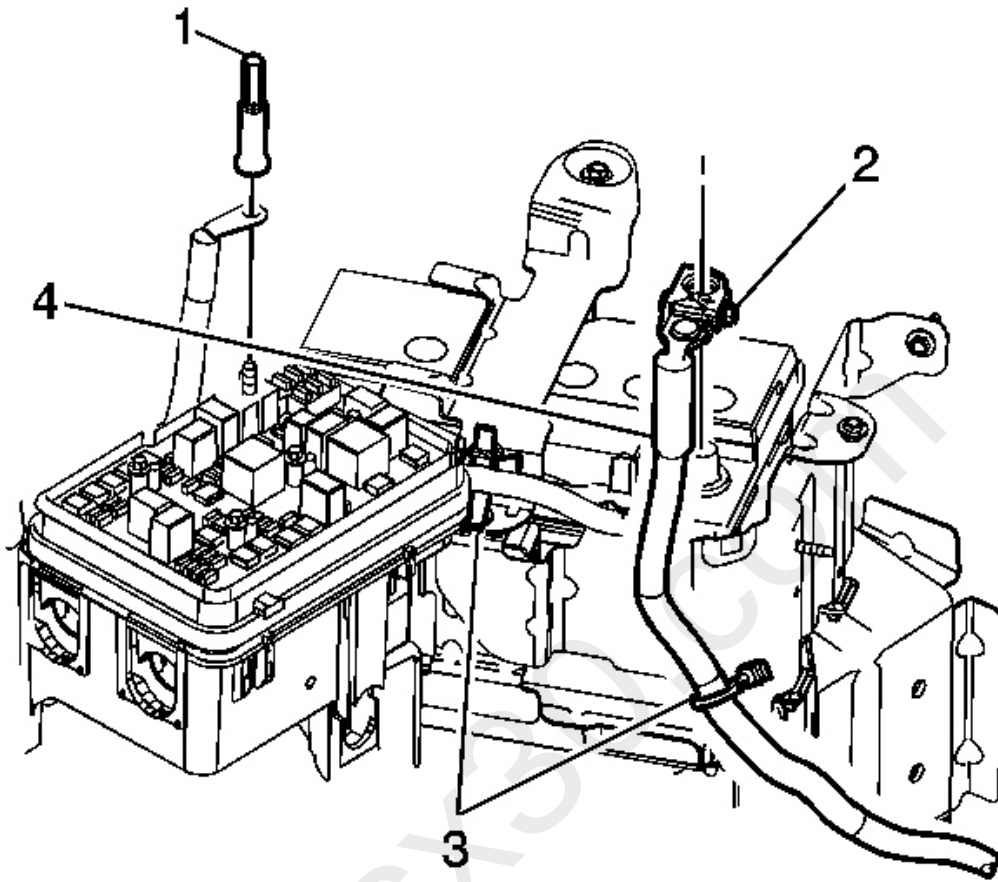


Fig. 15: Identifying Battery Positive Terminal Components (LF1)
Courtesy of GENERAL MOTORS CORP.

3. Install the battery positive cable terminal nut (1) to the fuse block and tighten to 16 N.m (12 lb ft).
4. Install battery positive cable clamp nut (2) to the battery post and tighten to 10 N.m (88 lb in)
5. Install engine control module (ECM) and battery cover.
6. Reset the radio channel presets.

BATTERY POSITIVE CABLE REPLACEMENT (LAF)

Removal Procedure

1. Record all of the radio station presets.
2. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection.**

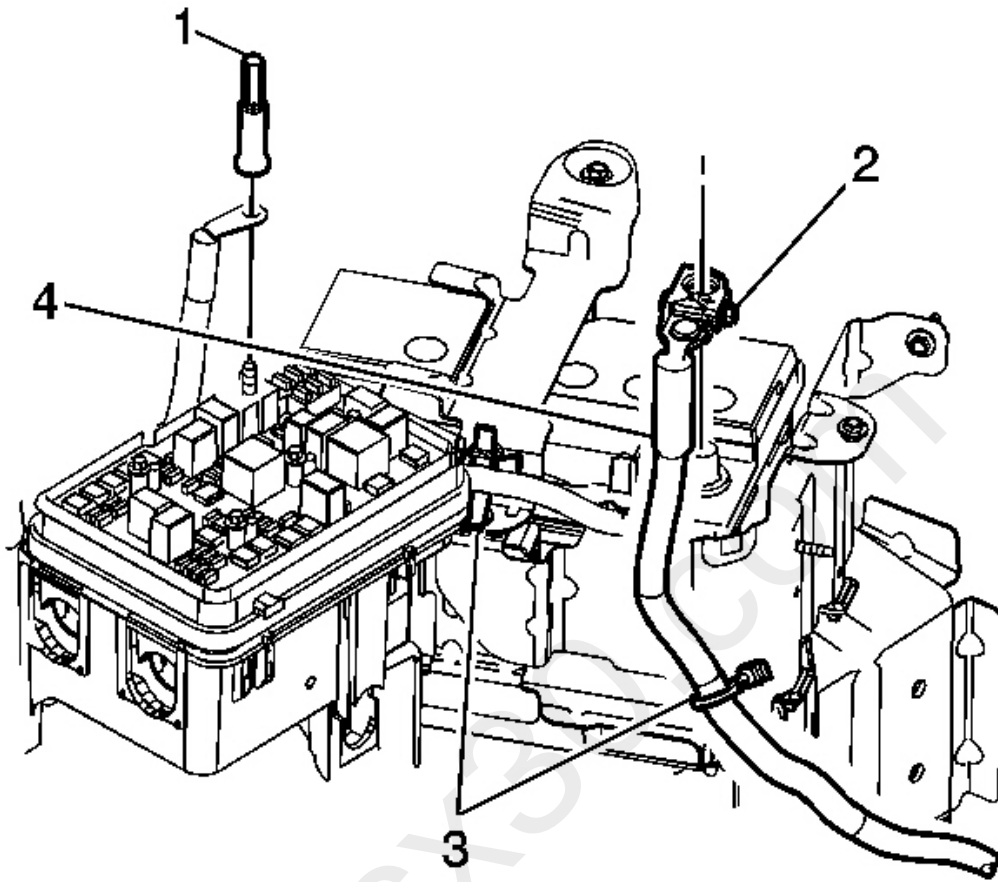


Fig. 16: Identifying Battery Positive Terminal Components
Courtesy of GENERAL MOTORS CORP.

3. Remove the battery positive post clamp nut (2).
4. Remove battery positive terminal (1) at the fuse block.
5. Disconnect retainers (3) holding battery positive cable (4).

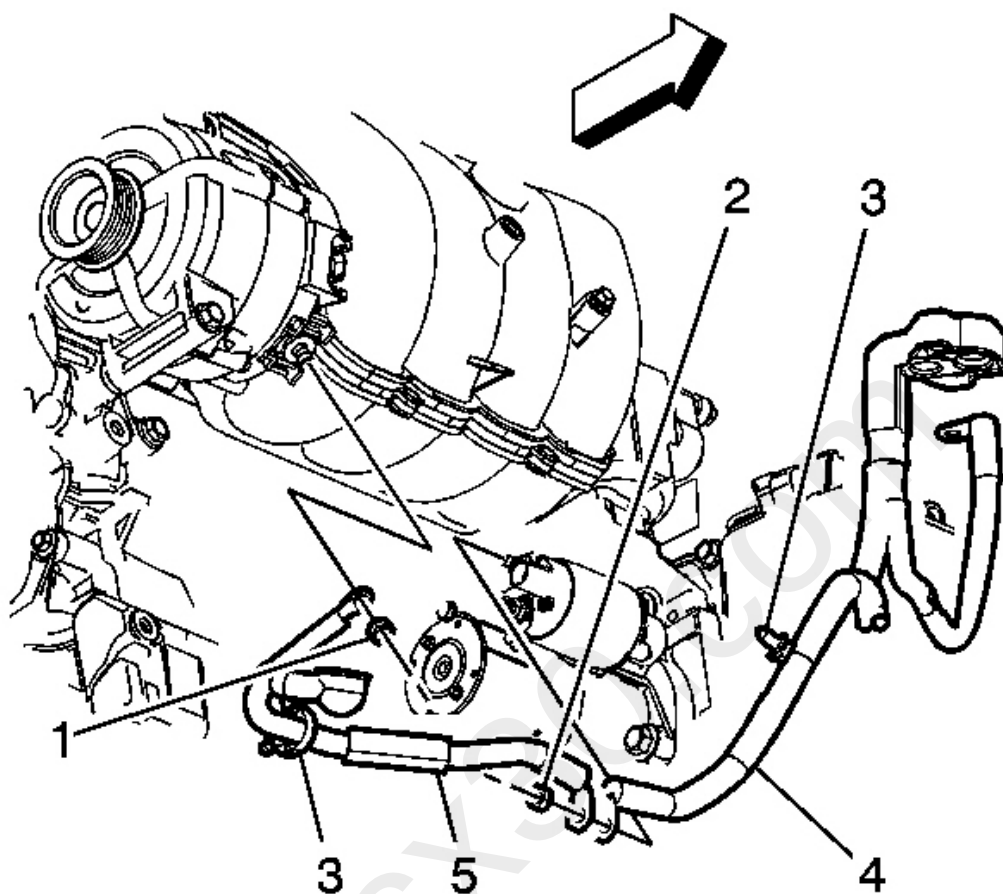


Fig. 17: Identifying Battery Positive Cable Components (LAF)

Courtesy of GENERAL MOTORS CORP.

6. Remove generator nut (1) from the generator B+ stud.
7. Remove the starter solenoid nut (2).
8. Remove the battery positive (Starter) cable (4) and the battery positive (Generator) cable (5) from the vehicle.
9. Remove the retainers (3) holding the battery positive cables to the engine.

NOTE: **Observe how the battery positive cable was routed within the engine compartment.**

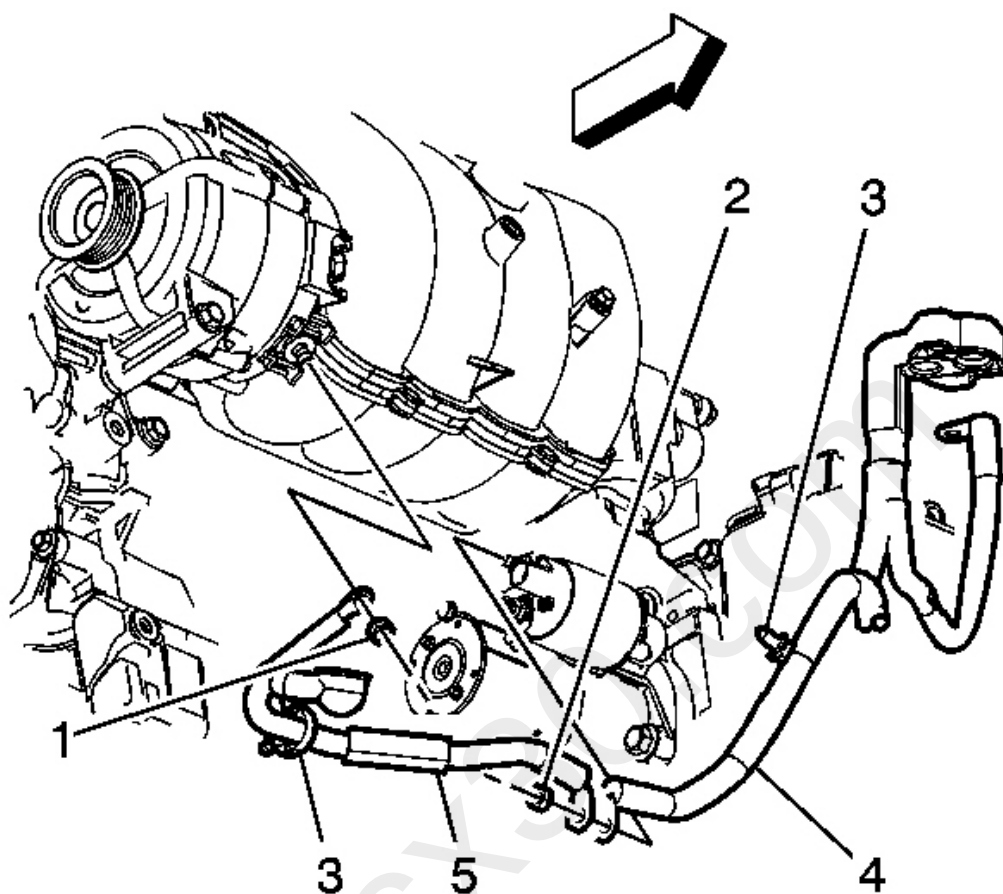


Fig. 18: Identifying Battery Positive Cable Components (LAF)
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the battery positive cable nut (2) to the B+ generator stud and tighten to 20 N.m (15 lb ft).
2. Install battery positive cable nut (2) and terminals (Starter/Generator), to the starter solenoid. Tighten to 10 N.m (88 lb in)
3. Install retainers (3) to the engine.

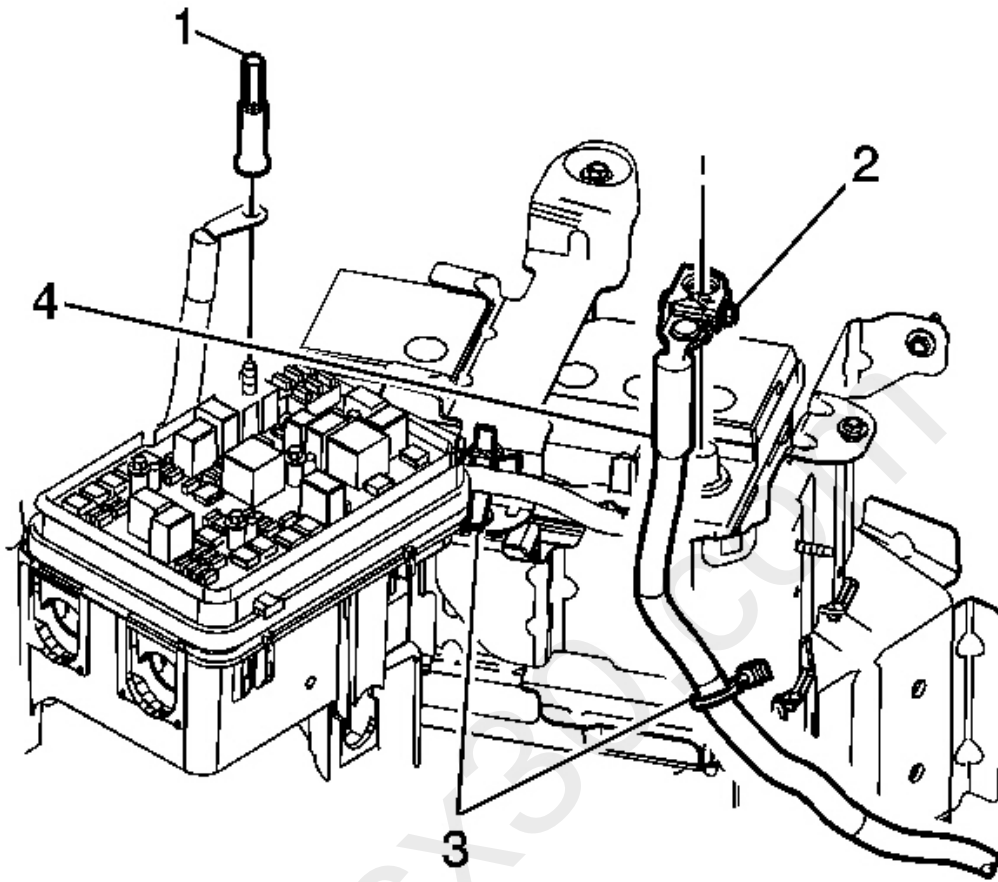


Fig. 19: Identifying Battery Positive Terminal Components
Courtesy of GENERAL MOTORS CORP.

4. Install the battery positive cable terminal nut (1) to the fuse block and tighten to 16 N.m (12 lb ft).
5. Install battery positive cable clamp nut (2) to the battery post and tighten to 10 N.m (88 lb in)
6. Install engine control module (ECM) and battery cover.
7. Reset the radio channel presets.

BATTERY REPLACEMENT

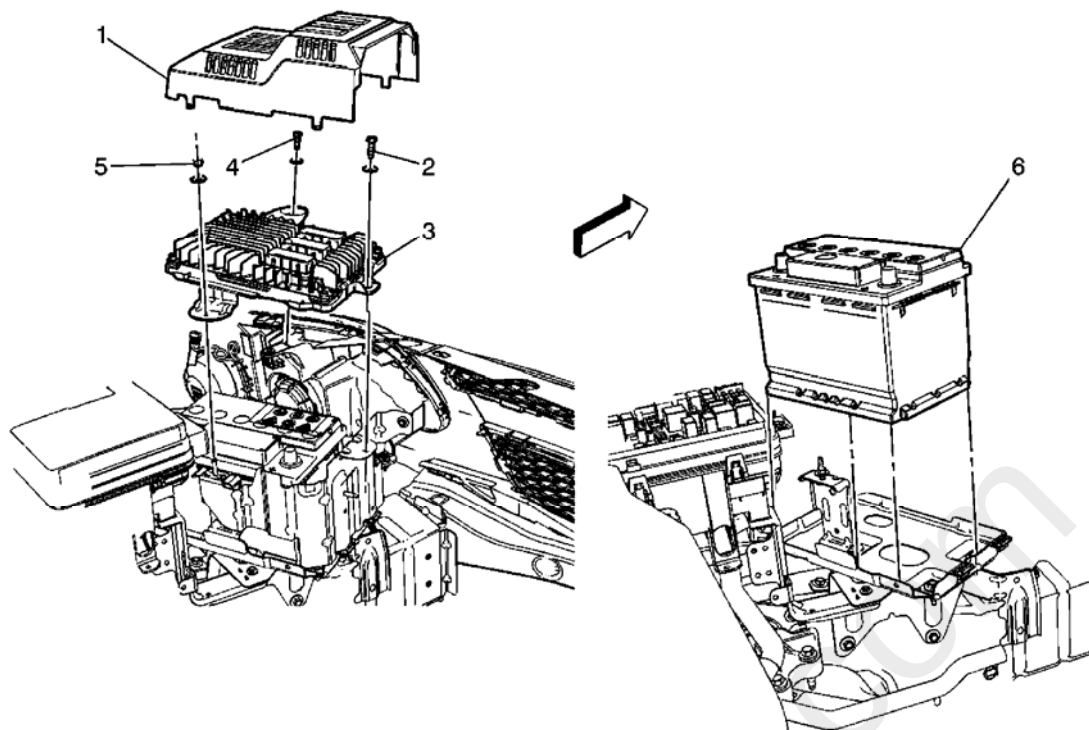


Fig. 20: Battery

Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
Preliminary Procedure	
1.	Disconnect the negative battery cable. Refer to <u>Battery Negative Cable Disconnection and Connection</u> .
2.	Remove the front bumper fascia opening cover. Refer to <u>Front Bumper Fascia Opening Cover Replacement (Equinox)</u> or <u>Front Bumper Fascia Opening Cover Replacement (Terrain)</u>
3.	Reposition the engine control module bracket/battery hold-down retainer. Refer to <u>Engine Control Module Replacement</u> .
4.	Remove the positive battery cable from the battery post. Refer to <u>Battery Positive Cable Replacement (LF1)</u> or <u>Battery Positive Cable Replacement (LAF)</u>
1	Battery Cover
2	Engine Control Module Bracket Bolt CAUTION: Refer to <u>Fastener Caution</u> . Tighten: 22 N.m (16 lb ft)
3	Engine Control Module
	Battery Retainer Bracket Bolt

4	Tighten: 22 N.m (16 lb ft)
5	Battery Retainer Bracket Nut Tighten: 9 N.m (80 lb in)
6	Battery

BATTERY TRAY REPLACEMENT

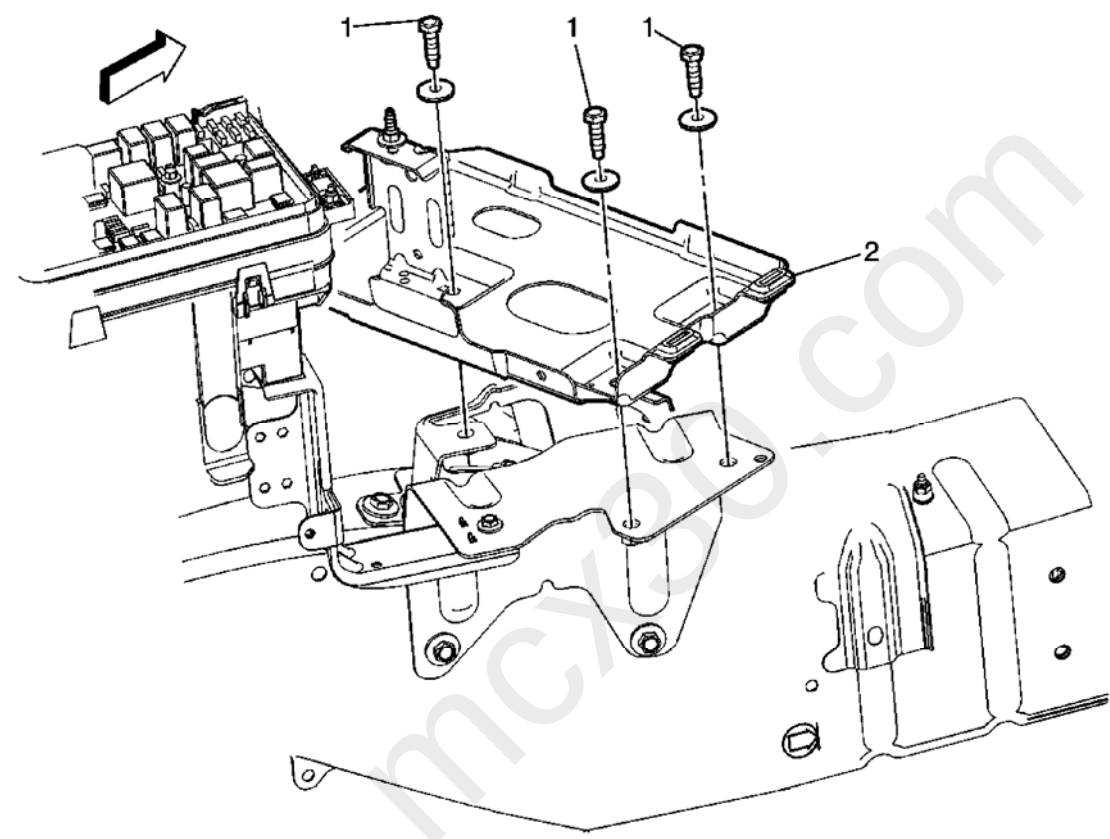


Fig. 21: Battery Tray
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
Preliminary Procedure: Remove the battery.Refer to <u>Battery Replacement</u>	
1	Bolt (Qty: 3) CAUTION: Refer to <u>Fastener Caution</u> . Tighten: 22 N.m (16 lb ft).

Tip: Unclip the harness retainers from the battery tray.

BATTERY TRAY SUPPORT REPLACEMENT

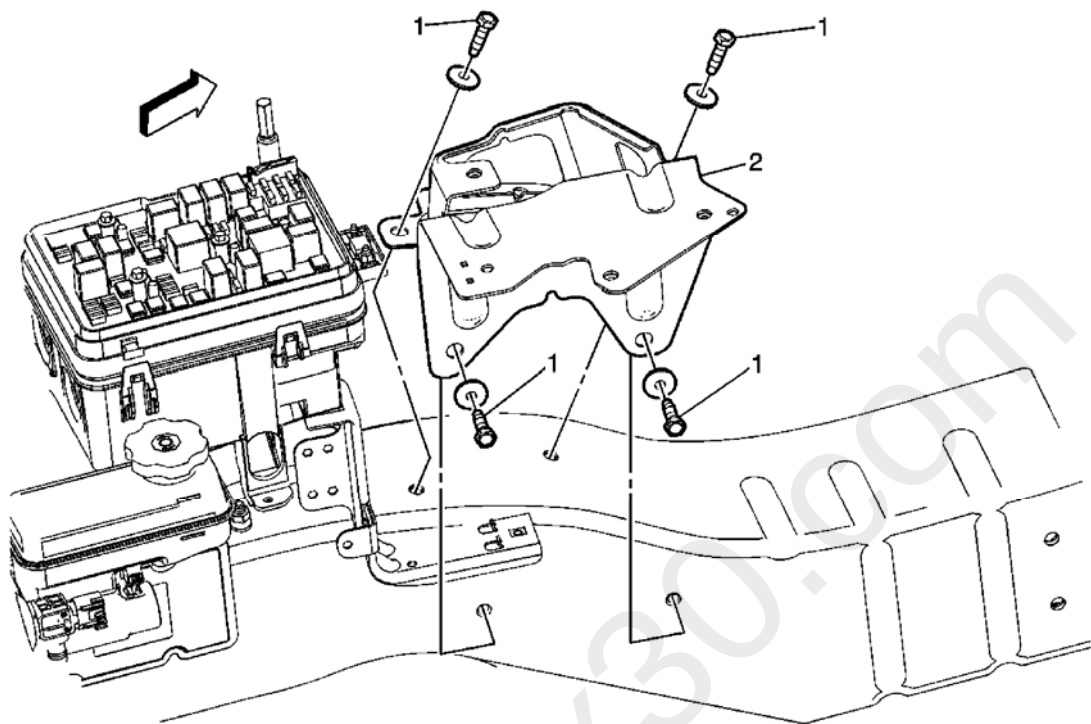


Fig. 22: Battery Tray Support

Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
Preliminary Procedure 1. Disconnect the negative battery cable. Refer to <u>Battery Negative Cable Disconnection and Connection</u>. 2. Remove the positive battery cable. Refer to <u>Battery Positive Cable Replacement (LF1)</u> or <u>Battery Positive Cable Replacement (LAF)</u> 3. Remove the battery. Refer to <u>Battery Replacement</u> 4. Remove the battery tray. Refer to <u>Battery Tray Replacement</u>	
1	Bolt (Qty: 4) CAUTION: Refer to <u>Fastener Caution</u> . Tighten: 22 N.m (16 lb ft).

BATTERY HEAT SHIELD REPLACEMENT

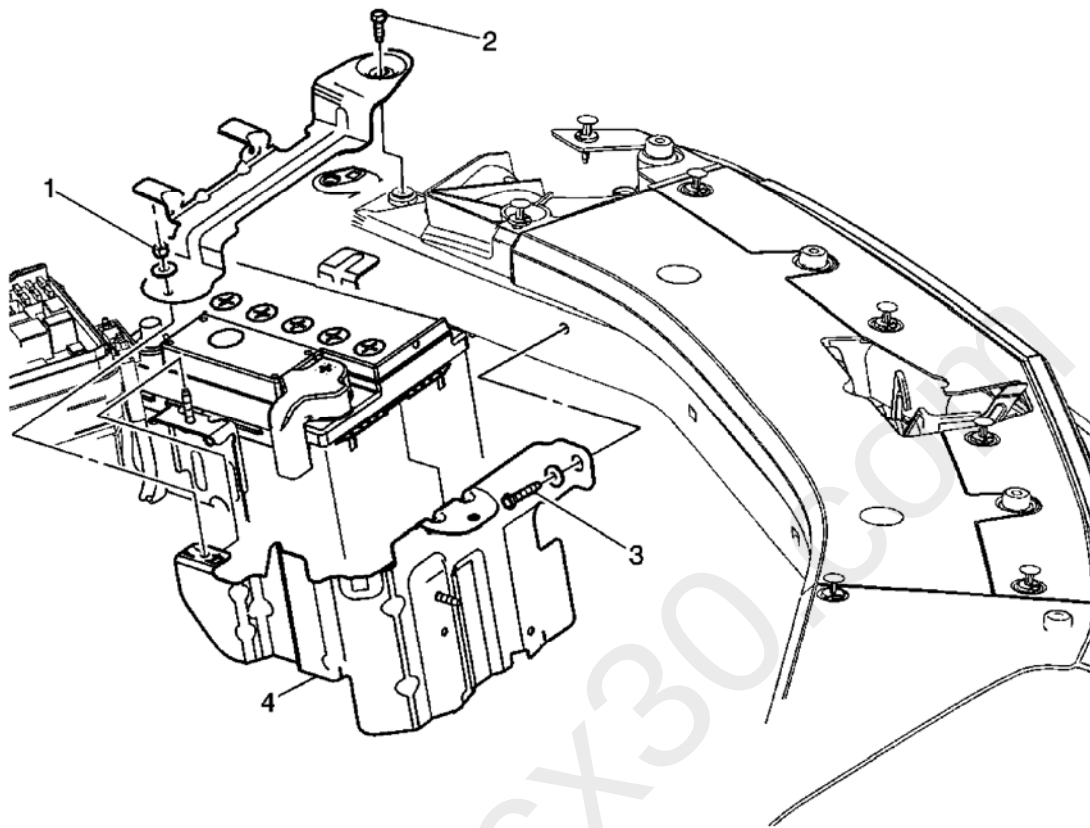


Fig. 23: Battery Heat Shield

Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
Preliminary Procedure	
1. Remove the front bumper fascia opening cover. Refer to <u>Front Bumper Fascia Opening Cover Replacement (Equinox)</u> or <u>Front Bumper Fascia Opening Cover Replacement (Terrain)</u> 2. Disconnect the negative battery cable. Refer to <u>Battery Negative Cable Disconnection and Connection</u>. 3. Remove the engine control module (ECM). Refer to <u>Engine Control Module Replacement</u>.	
1	Nut CAUTION: Refer to <u>Exhaust Service Warning</u> .

	CAUTION: Refer to <u>Fastener Caution</u> . Tighten: 9 N.m (80 lb in).
2	Bolt Tighten: 22 N.m (16 lb ft).
3	Bolt Tighten: 22 N.m (16 lb ft).
4	Battery Heat Shield

STARTER REPLACEMENT (LAF)

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.
2. Remove the power vacuum brake booster pump. Refer to **Power Brake Booster Pump Replacement (2.4L)** or **Power Brake Booster Pump Replacement (3.0L)**
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

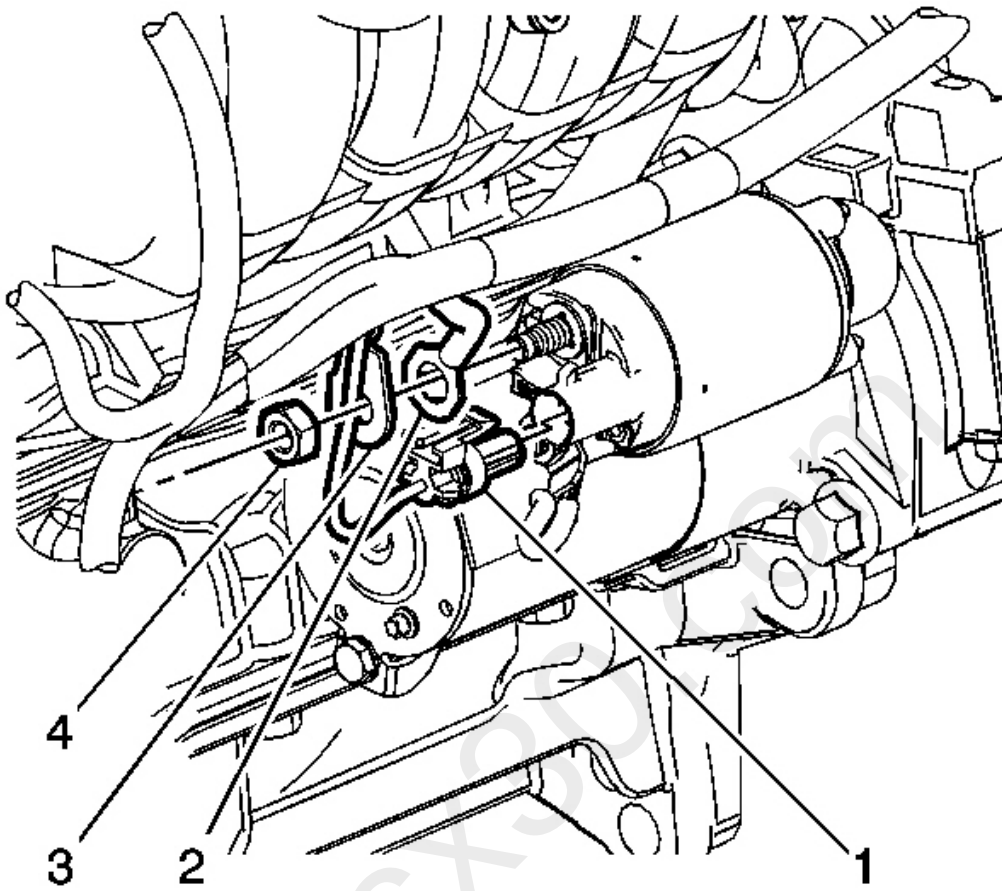


Fig. 24: Starter Connectors (LAF)
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the engine harness connector (1) from the starter.
5. Remove the starter solenoid terminal nut (4).
6. Remove the positive battery cable terminal (3) from the starter.
7. Remove the starter solenoid wire terminal (2) from the starter.

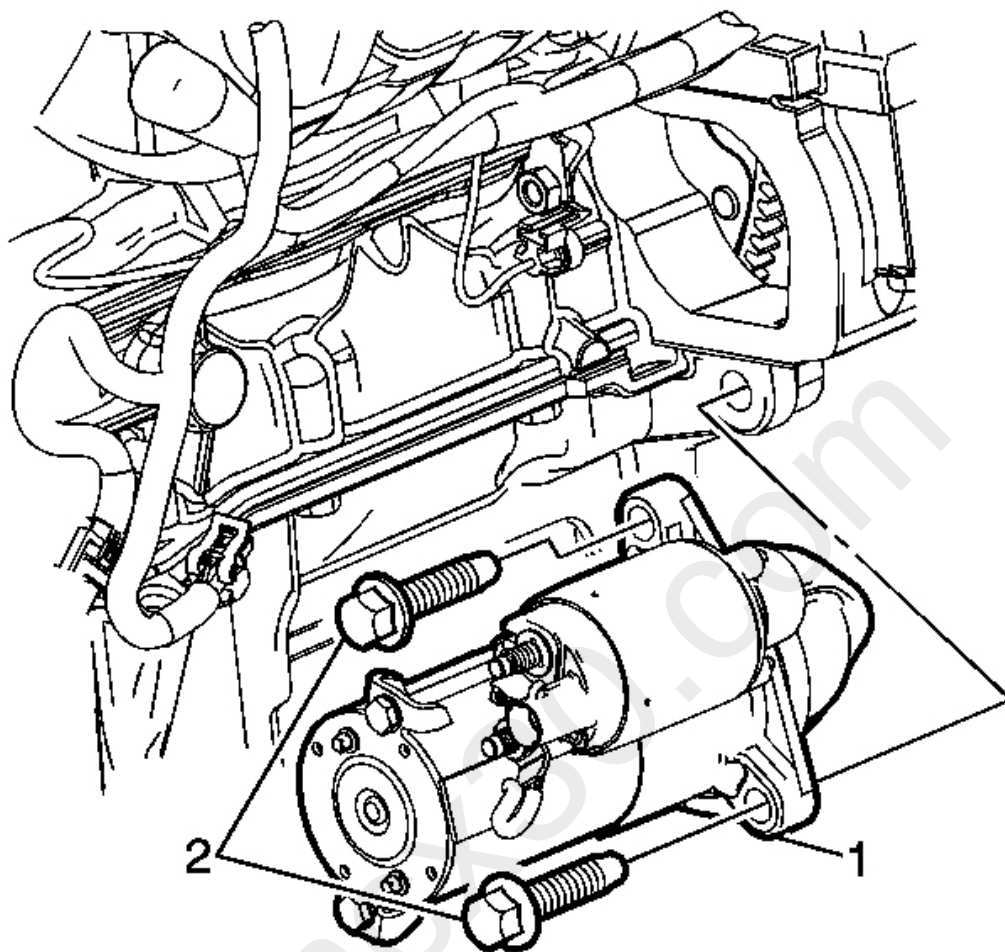


Fig. 25: Starter (LAF)
Courtesy of GENERAL MOTORS CORP.

8. Remove the starter bolts (2).
9. Remove the starter (1).

Installation Procedure

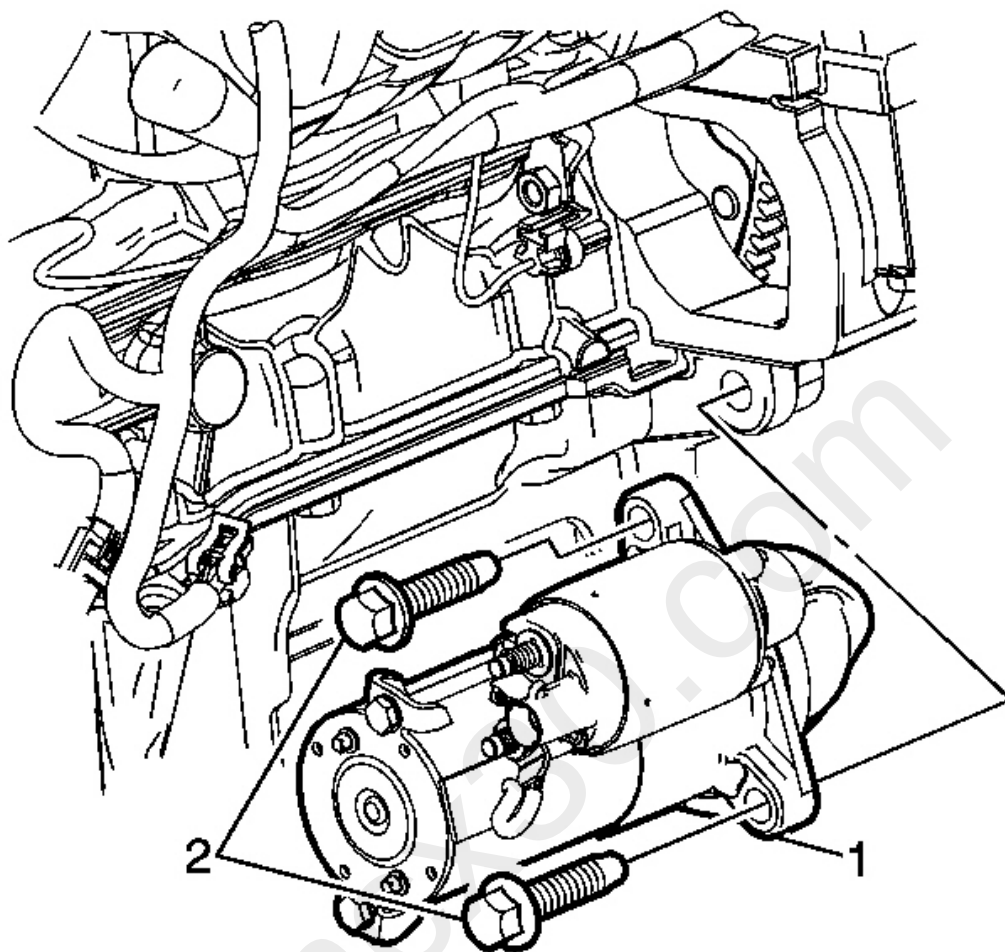


Fig. 26: Starter (LAF)
Courtesy of GENERAL MOTORS CORP.

1. Position the starter (1) to the engine.

CAUTION: Refer to Fastener Caution .

2. Install the starter bolts (2) and tighten to 40 N.m (30 lb ft).

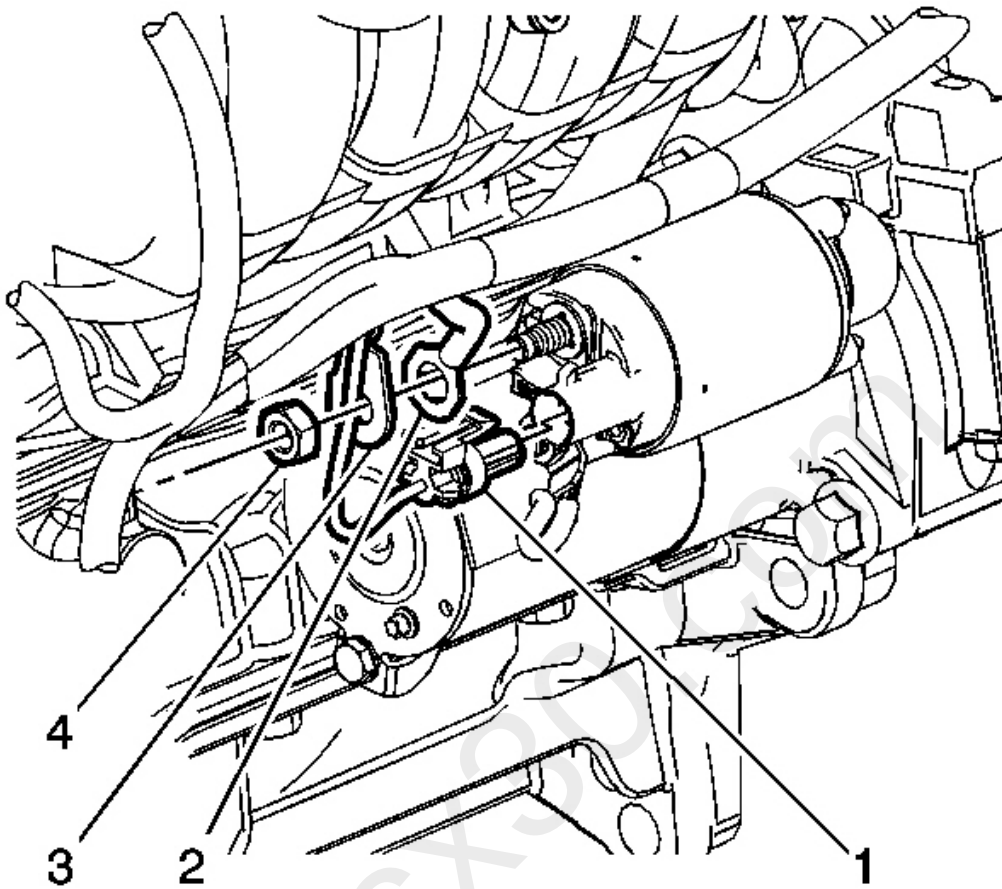


Fig. 27: Starter Connectors (LAF)
Courtesy of GENERAL MOTORS CORP.

3. Install the starter solenoid wire terminal (2) to the starter.
4. Install the positive battery cable terminal (3) to the starter. Ensure that the anti-rotational tab is correctly located into the indexing slot.
5. Install the starter solenoid terminal nut (4) and tighten to 17 N.m (13 lb ft).
6. Connect the engine harness connector (1) to the starter.
7. Install the power vacuum brake booster pump. Refer to **Power Brake Booster Pump Replacement (2.4L)** or **Power Brake Booster Pump Replacement (3.0L)**
8. Lower the vehicle.
9. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection.**

STARTER REPLACEMENT (LF1)

Removal Procedure

1. Turn OFF the ignition.
2. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection**.

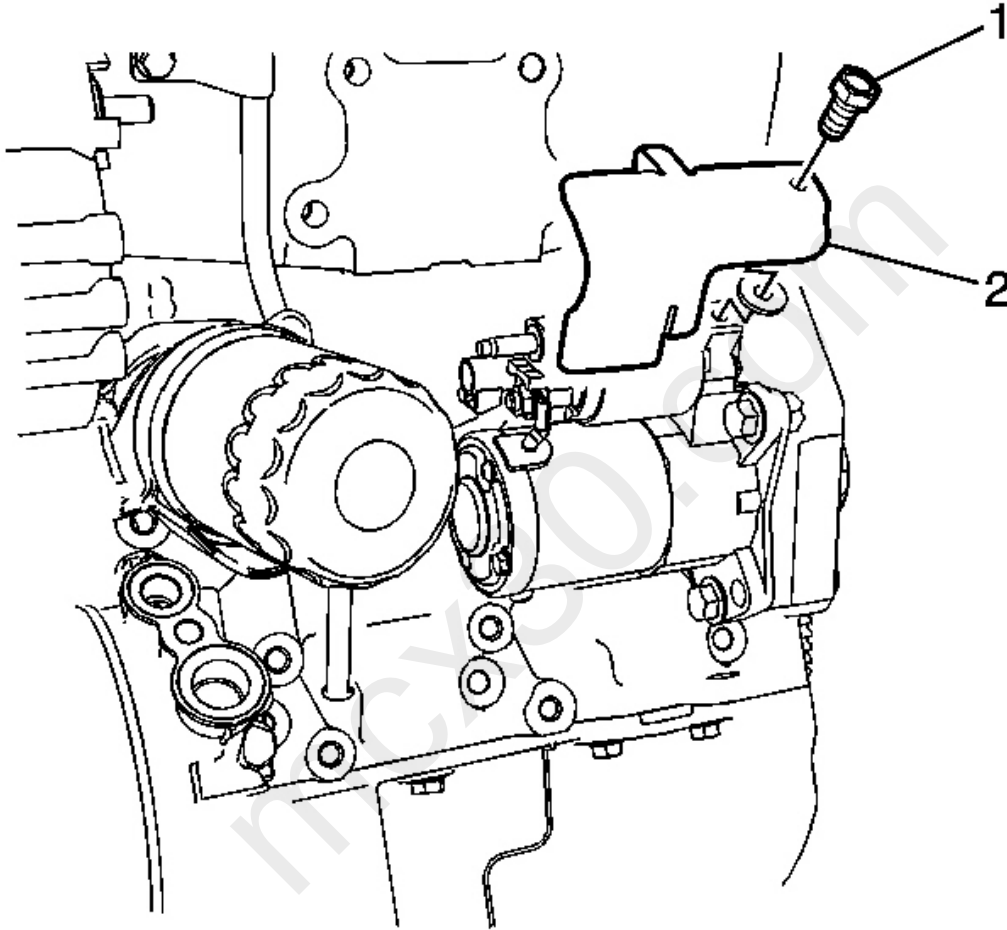


Fig. 28: Starter Heat Shield

Courtesy of GENERAL MOTORS CORP.

3. Remove the heat shield (2) from the starter.
4. Disconnect the knock sensor connector.
5. Disconnect and remove the bank 1 sensor 2 oxygen sensor after the left catalytic converter. Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2 (LF1)**

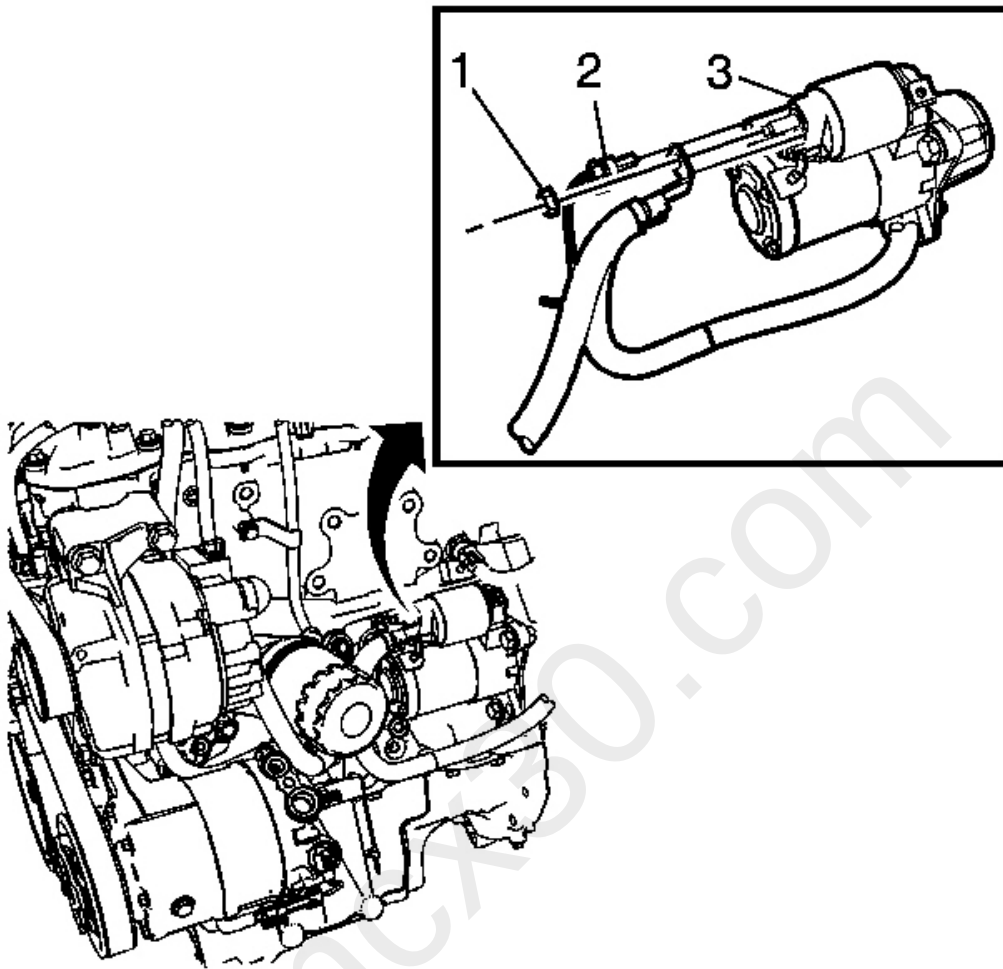


Fig. 29: Starter Connections (LF1)
Courtesy of GENERAL MOTORS CORP.

6. Remove the battery positive nut (1) and the engine harness connector (2), from the starter solenoid (3).

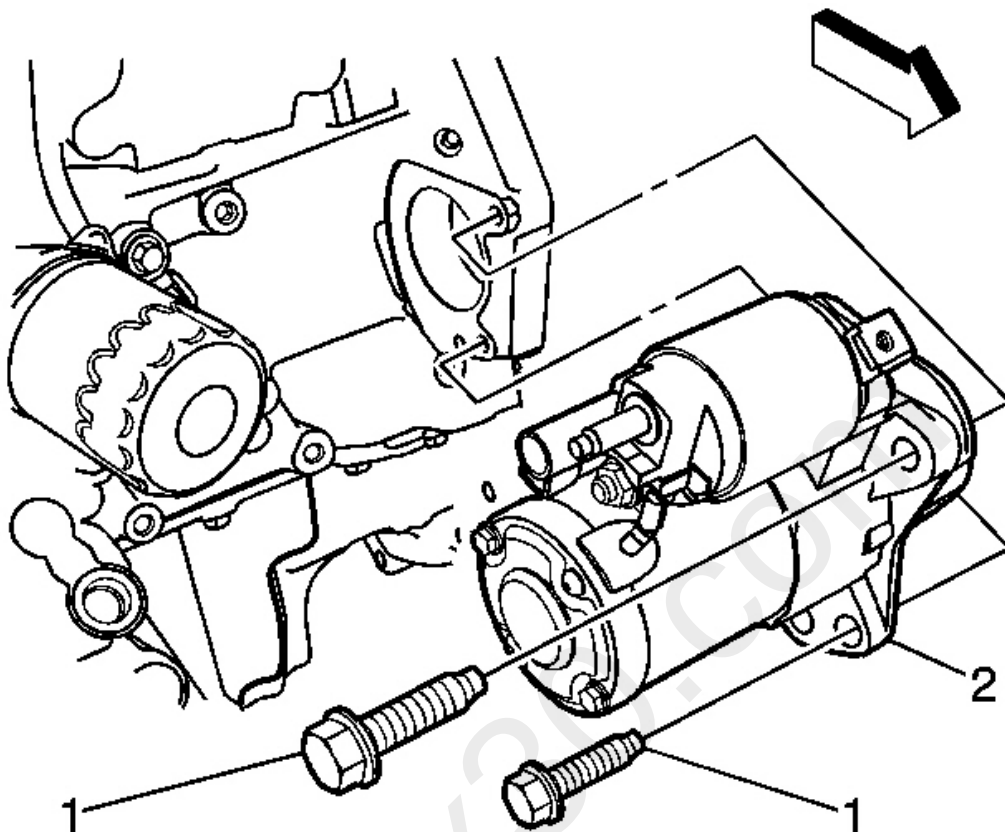


Fig. 30: Starter (LF1)
Courtesy of GENERAL MOTORS CORP.

7. Remove the starter motor bolts (1).
8. Remove the starter motor (2).

Installation Procedure

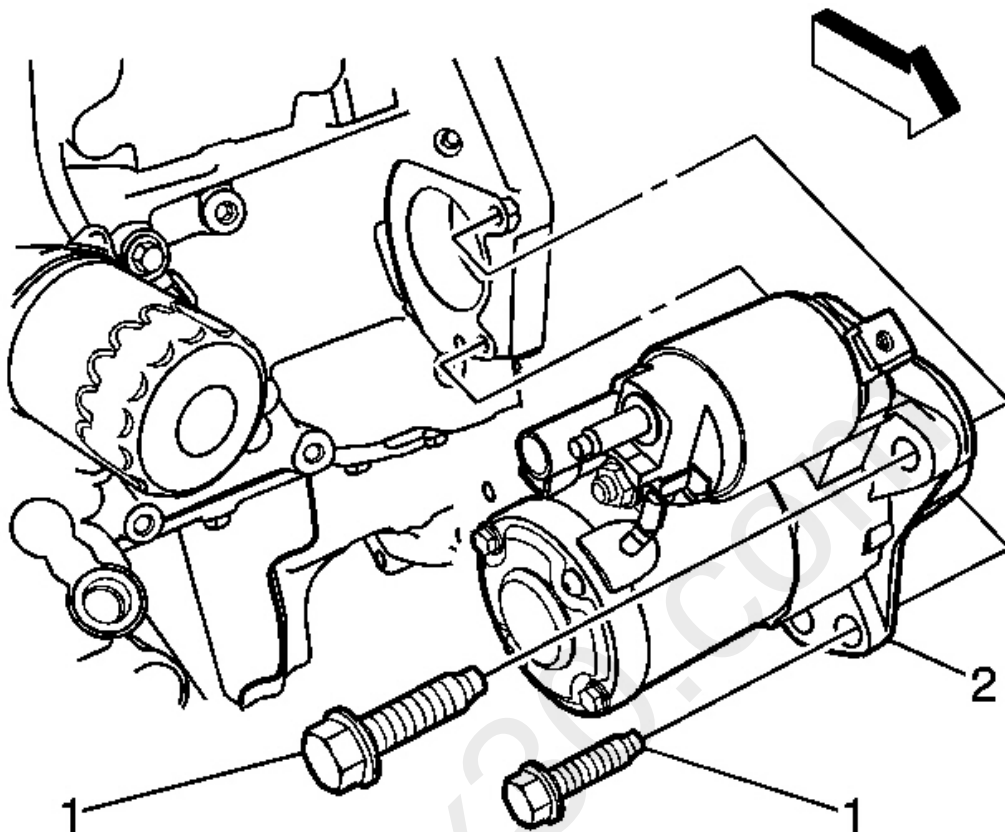


Fig. 31: Starter (LF1)
Courtesy of GENERAL MOTORS CORP.

1. Install the starter motor (2).

CAUTION: Refer to Fastener Caution .

2. Install the starter motor mounting bolts. Tighten to 58 N.m (43 lb ft).

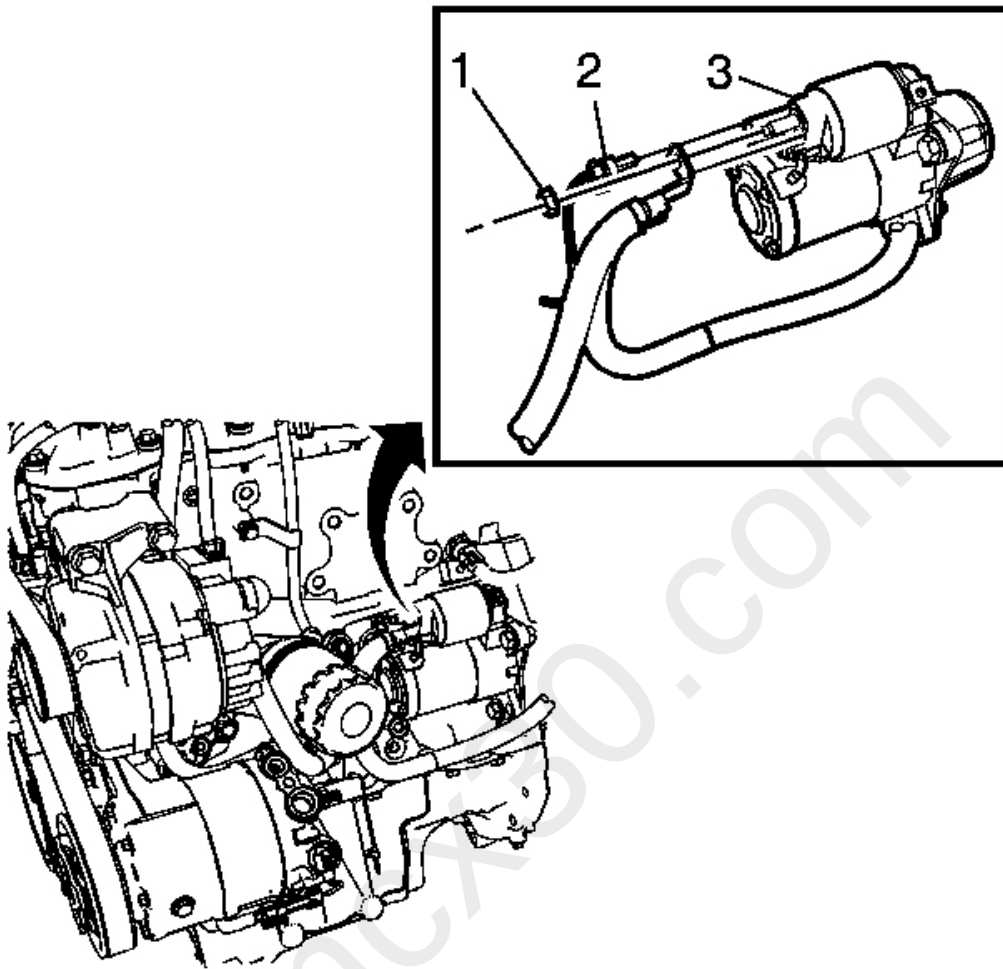


Fig. 32: Starter Connections (LF1)

Courtesy of GENERAL MOTORS CORP.

3. Install the battery positive cable and engine harness connector to the starter. Tighten the battery positive cable nut (1) to 25 N.m (18 lb ft).
4. Install the engine harness connector to the starter solenoid.

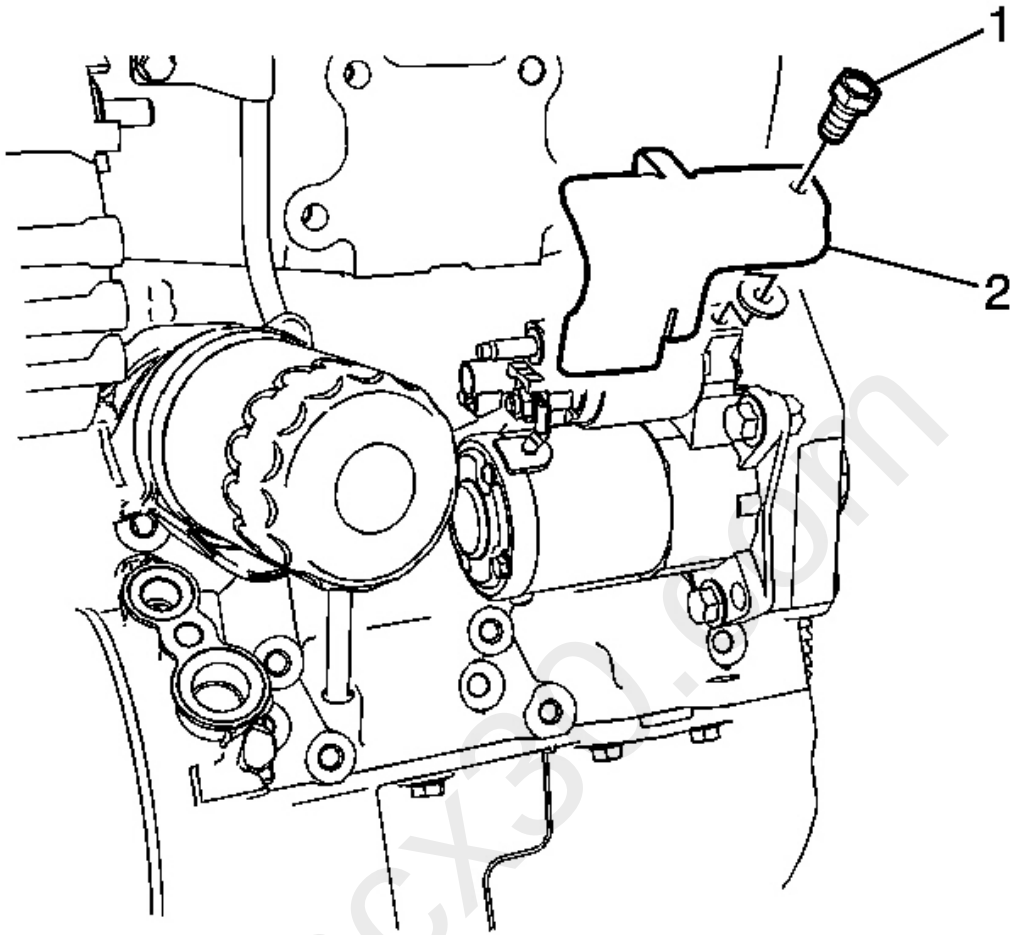


Fig. 33: Starter Heat Shield

Courtesy of GENERAL MOTORS CORP.

5. Install the starter heat shield (2) and tighten the bolt (1) to 7 N.m (62 lb in).
6. Connect the knock sensor connector.
7. Install and connect the bank 1 sensor 2 oxygen sensor.

GENERATOR REPLACEMENT (LAF)

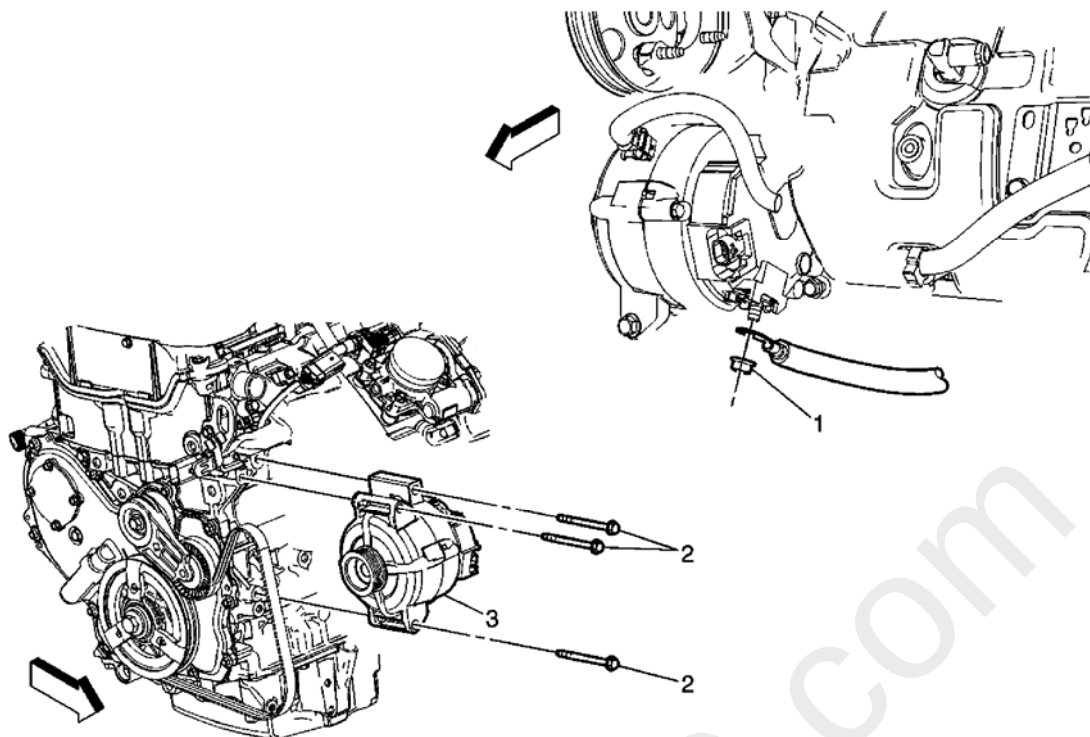


Fig. 34: Generator (LAF)

Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
Preliminary Procedures	
1. Disconnect the negative battery cable. Refer to <u>Battery Negative Cable Disconnection and Connection</u>. 2. Remove the drive belt. Refer to <u>Drive Belt Replacement</u>. 3. Disconnect the engine harness generator connector.	
1	Generator Battery Positive Nut CAUTION: Refer to <u>Fastener Caution</u> Tighten: 20 N.m (15 lb ft)
2	Generator Bolt (QTY: 3) Tighten: 22 N.m (16 lb ft)
3	Generator

GENERATOR REPLACEMENT (LF1)

Removal Procedure

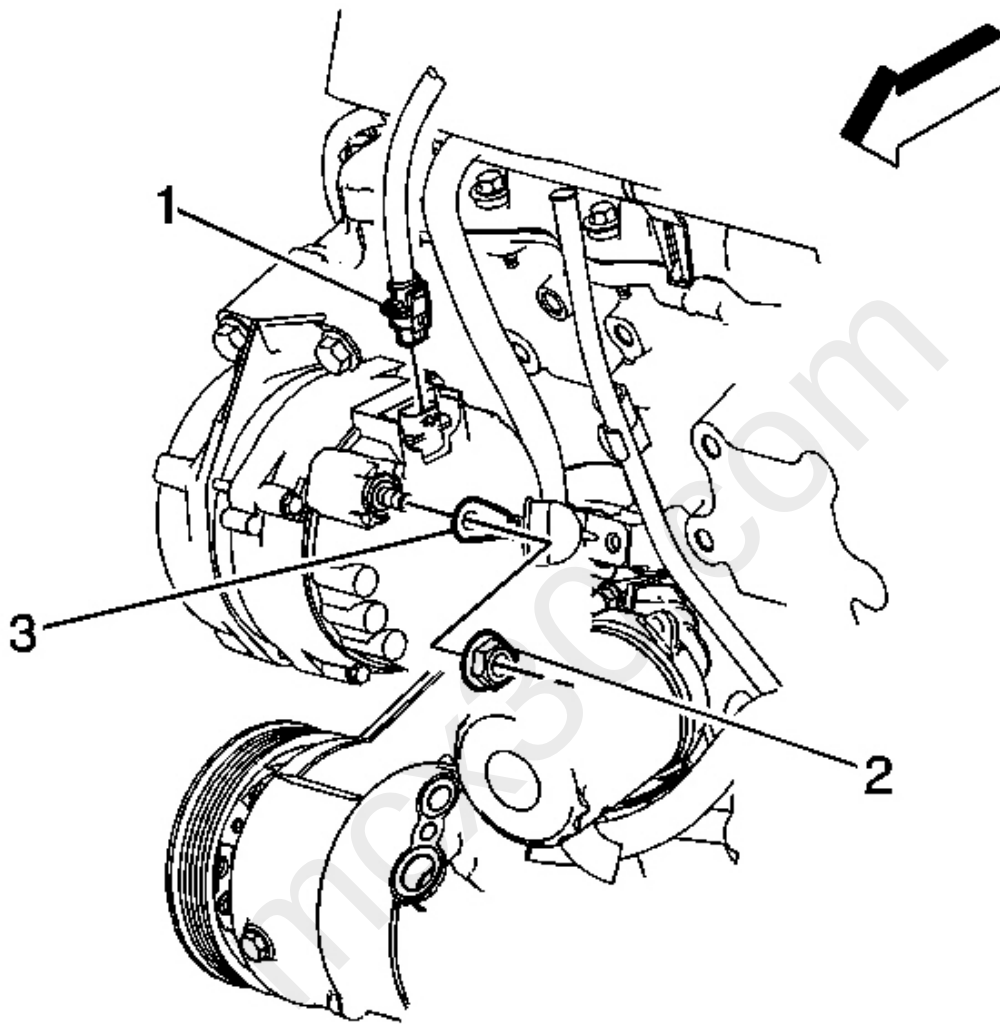


Fig. 35: Generator Components (LF1)
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.
2. Reposition the positive battery cable boot at the generator terminal.
3. Disconnect the engine harness electrical connector (1) from the generator.
4. Remove the positive battery cable nut (2) at the generator.
5. Remove the positive battery cable terminal (3) from the generator.

6. Remove the drive belt. Refer to Drive Belt Replacement .

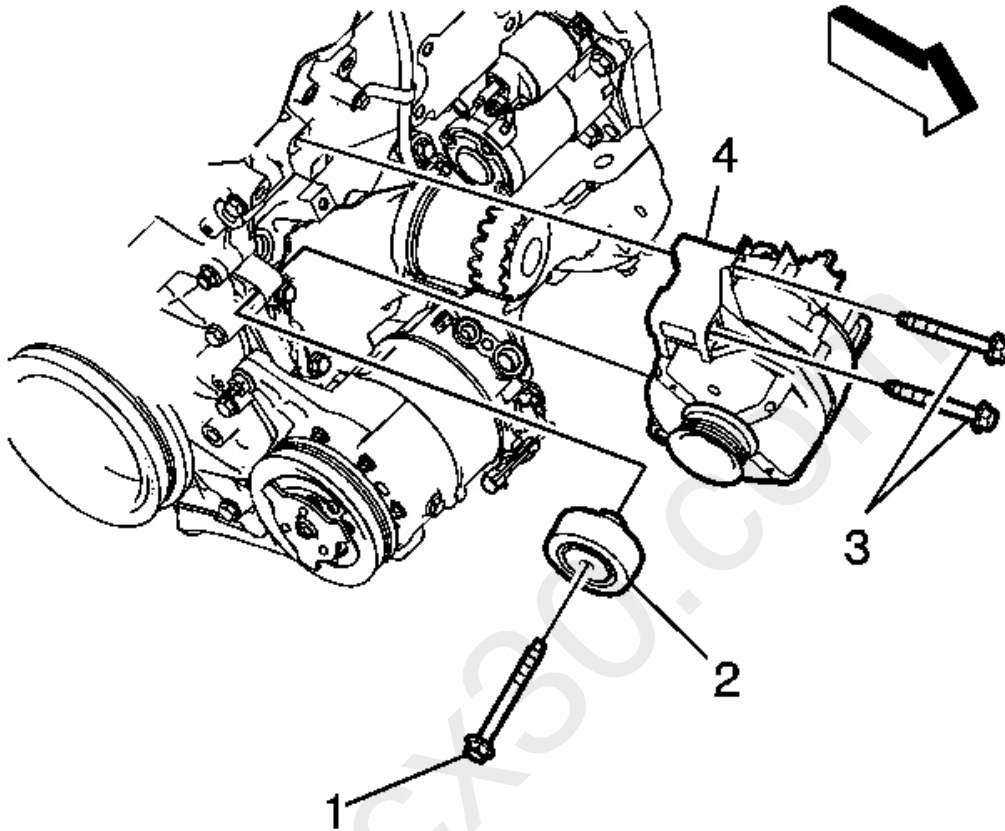


Fig. 36: Generator (LF1)
Courtesy of GENERAL MOTORS CORP.

7. Remove the idler pulley bolt (1) and idler pulley (2). Refer to Drive Belt Idler Pulley Replacement .
8. Remove the generator bolts (3).

NOTE: When removing the generator from the vehicle, it may be necessary to maneuver the generator to remove it from the vehicle.

9. Remove the generator(4).

Installation Procedure

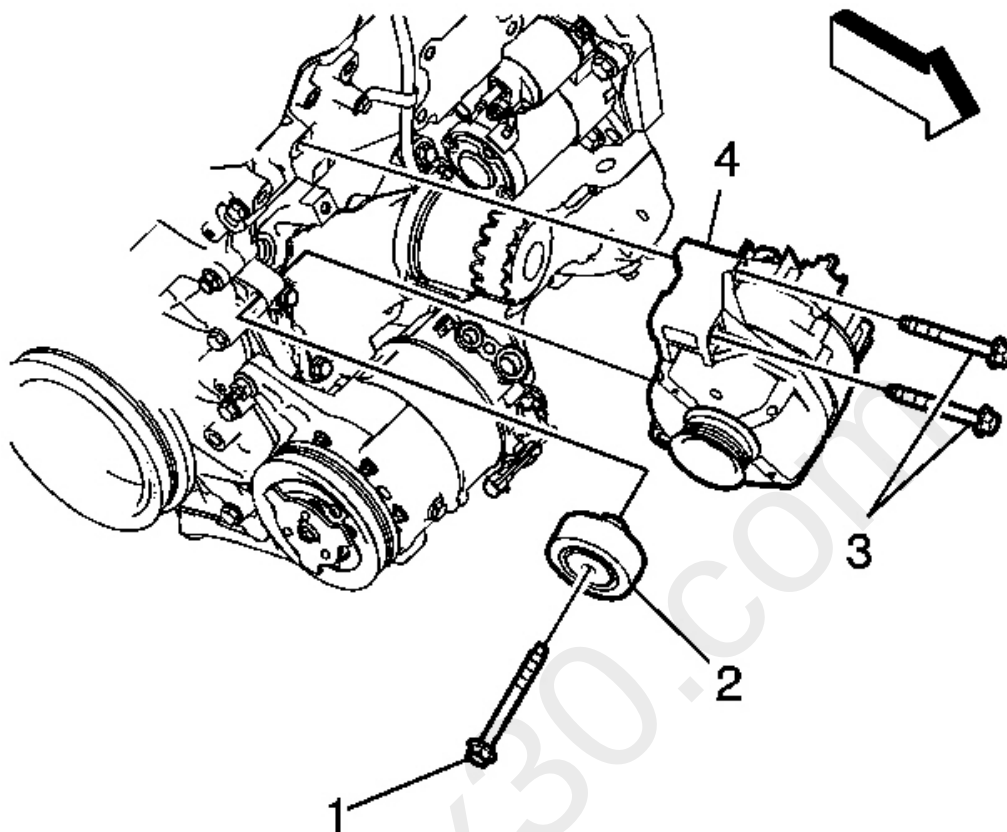


Fig. 37: Generator (LF1)

Courtesy of GENERAL MOTORS CORP.

1. Position the generator (4) to the engine.
2. Loosely install the generator bolts (3).
3. Install the idler pulley. Refer to **Drive Belt Idler Pulley Replacement** .

CAUTION: Refer to Fastener Caution .

4. Tighten the generator bolts to 50 N.m (37 lb ft).

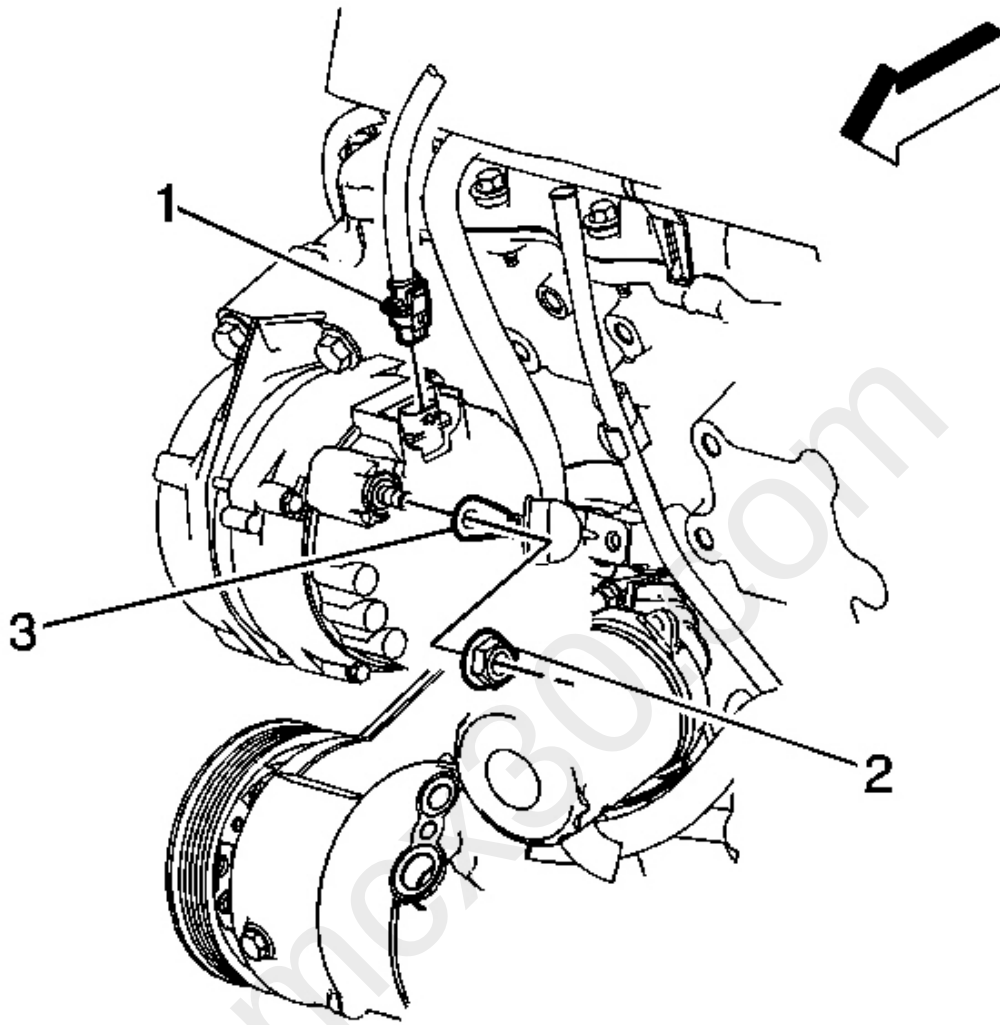


Fig. 38: Generator Components (LF1)
Courtesy of GENERAL MOTORS CORP.

5. Install the drive belt. Refer to **Drive Belt Replacement** .
6. Connect the engine harness electrical connector (1) to the generator.
7. Install the positive battery cable terminal (3) to the generator.
8. Install the positive battery cable nut (2) at the generator and tighten to 20 N.m (15 lb ft).
9. Position the positive battery cable boot at the generator terminal.
10. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.

DESCRIPTION AND OPERATION

BATTERY DESCRIPTION AND OPERATION

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

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

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

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

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

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

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

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

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

Battery Low Start Vehicle Message

When the vehicle's battery is severely discharged, 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
- Amp hours

When a battery is replaced use a battery with similar ratings. Refer to the battery specification label on the original battery or refer to **Battery Usage**.

Amp Hours

The amp hour rating tells you how much amperage is available when discharged evenly over a 20 hour period. The amp hour rating is cumulative, so in order to know how many constant amps the battery will output for 20 hours, you have to divide the amp hour rating by 20. Example: If a battery has an amp 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 amp 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. Refer to **Battery Usage** for the cold cranking amperage rating for this vehicle.

CHARGING SYSTEM DESCRIPTION AND OPERATION

Electrical Power Management Overview

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

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

The battery condition is estimated during ignition-off and during ignition-on. During ignition-off the state-of-charge of the battery is determined by measuring the open-circuit voltage. The state-of-charge is a function of

the acid concentration and the internal resistance of the battery, and is estimated by reading the battery open circuit voltage when the battery has been at rest for several hours.

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

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

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

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

Charging System Components

Generator

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

Body Control Module (BCM)

The body control module (BCM) is a GMLAN device. It communicates with the engine control module (ECM) and the instrument panel cluster for electrical power management (electrical power management) operation. The BCM determines the output of the generator and sends the information to the ECM for control of the generator turn on signal circuit. It monitors the generator field duty cycle signal circuit information sent from the ECM for control of the generator. It monitors a battery current sensor, the battery positive voltage circuit, and estimated battery temperature to determine battery state of charge. The BCM performs idle boost.

Battery Current Sensor

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

Engine Control Module (ECM)

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

Instrument Panel Cluster

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

Charging System Operation

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

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

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

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

80%	14.94 V
90%	15.5 V

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

Battery Sulfation Mode

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

Charge Mode

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

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

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

Fuel Economy Mode

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

Headlamp Mode

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

Start Up Mode

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

Voltage Reduction Mode

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

Instrument Panel Cluster Operation

Charge Indicator Operation

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

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

BATTERY NOT CHARGING SERVICE CHARGING SYSTEM

The BCM and the ECM will send a GMLAN message to the driver information center for the BATTERY NOT CHARGING SERVICE 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.

SERVICE BATTERY CHARGING SYSTEM

The BCM and the ECM will send a GMLAN message to the driver information center for the 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.

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

Idle boost is activated in incremental steps, idle boost 1 must be active before idle boost 2 can be active. The criteria used by the body control module (BCM) to regulate electrical power management are outlined below:

Function	Battery Temperature Calculation	Battery Voltage Calculation	Amp-hour Calculation	Action Taken
Idle Boost 1 Start	Less Than -15°C (5°F)	Less Than 13 V	-	First level Idle boost requested
Idle Boost 1 Start	-	-	Battery has a net loss greater than 0.6 AH	First level Idle boost requested
Idle Boost 1 Start	-	Less Than 11 V	-	First level Idle boost requested
Idle Boost 1 End	Greater Than -15°C (5°F)	Greater Than 12 V	Battery has a net loss less than 0.2 AH	First level Idle boost request cancelled
Idle Boost 2 Start	-	Less Than 11 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 11 V	-	Third level Idle boost requested
Idle Boost 3 End	-	Greater Than 12 V	Battery has a net loss of less than 6 AH	Third level Idle boost request cancelled

LOAD SHED SYSTEM DESCRIPTION AND OPERATION

Electrical Power Management

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

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

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

Each electrical power management function, either idle boost or load shed, is discrete. No two functions are active at the same time. Idle boost is activated in incremental steps, idle boost 1 must be active before idle boost

2 can be active. The criteria used by the body control module (BCM) to regulate electrical power management are outlined below:

Function	Battery Temperature Calculation	Battery Voltage Calculation	Amp-Hour Calculation	Action Taken
Idle Boost 1 Start	Less Than -15°C (5°F)	Less Than 13 V	-	First level Idle boost requested
Idle Boost 1 Start	-	-	Battery has a net loss greater than 0.6 AH	First level Idle boost requested
Idle Boost 1 Start	-	Less Than 10.9 V	-	First level Idle boost requested
Idle Boost 1 End	Greater Than -15°C (5°F)	Greater Than -12 V	Battery has a net loss less than 0.2 AH	First level Idle boost request cancelled
Load Shed 1 Start	-	-	Battery has a net loss of 4 AH	Rear Defrost, Heated Mirrors, Heated Seats cycled OFF for 20% of their cycle
Load Shed 1 Start	-	Less Than 10.9 V	-	Rear Defrost, Heated Mirrors, Heated Seats cycled OFF for 20% of their cycle
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 10.0 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
				Rear Defrost, Heated Mirrors,

Load Shed 2 Start	-	Less Than 10.9 V	Battery has a net loss greater than 12 AH	Heated Seats cycled OFF for 50% of their cycle. The BATTERY SAVER ACTIVE message will be displayed on the DIC
Load Shed 2 Start	-	Less Than 10.9 V	-	Rear Defrost, Heated Mirrors, Heated Seats cycled OFF for 50% of their cycle. The BATTERY SAVER ACTIVE message will be displayed on the DIC
Load Shed 2 End	-	Greater Than 12.6 V	Battery has a net loss of less than 10.5 AH	Clear Load Shed 2
Load Shed 3 Start	-	Less Than 11.9 V	Battery has a net loss greater than 20 AH	Rear Defrost, Heated Mirrors, Heated Seats cycled OFF for 100% of their cycle. The BATTERY SAVER ACTIVE message will be displayed on the DIC
Load Shed 3 End	-	Greater Than 12.6 V	Battery has a net loss of less than 15 AH	Clear Load Shed 3

STARTING SYSTEM DESCRIPTION AND OPERATION

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

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

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

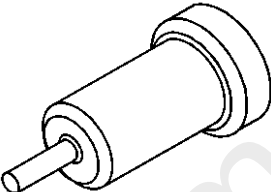
The magnetic fields of the pull-in and hold-in windings now oppose one another. This action of the windings, along with the help of the return spring, causes the starter drive assembly to disengage and the solenoid switch contacts to open simultaneously. As soon as the contacts open, the starter circuit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

Circuit Description (Key Start)

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

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Illustration	Tool Number/Description
	EL 38758 EL 50074 J 38758 Parasitic Draw Test Switch
	EL 42000 EL 50076 J 42000 Battery Tester