

2017 ELECTRICAL**12 V Starting and Charging - Hybrid (HP9) - CT6****SPECIFICATIONS****FASTENER SPECIFICATIONS****Reusable Threaded Fastener Tightening Specifications****NOTE:**

All fasteners listed in this table can be reused after removal.

Application	Specification
	Metric (English)
Auxiliary A/C Evaporator Tube Bracket Fastener	9 N.m (80 lb in)
Battery Distribution Fuse Block Cover Fastener	9 N.m (80 lb in)
Battery Hold Down Bolt	22 N.m (16 lb ft)
Battery Hold Down Strap Fastener	9 N.m (80 lb in)
Battery Negative Cable Ground Bolt	4.0 N.m (35 lb in)
Battery Positive Cable to Battery Distribution Fuse Block Nut	15 N.m (11 lb ft)
Battery Post Negative Cable Clamp Nut	4.5 N.m (40 lb in)
Battery Post Positive Cable Clamp Nut	6 N.m (53 lb in)
Generator Cable to Accessory DC Power Control Module Fastener	12 N.m (106 lb in)
Generator Cable to Battery Distribution Engine Compartment Fuse Block Fastener	12 N.m (106 lb in)

SCHEMATIC WIRING DIAGRAMS**STARTING AND CHARGING WIRING SCHEMATICS****12V Battery Management**

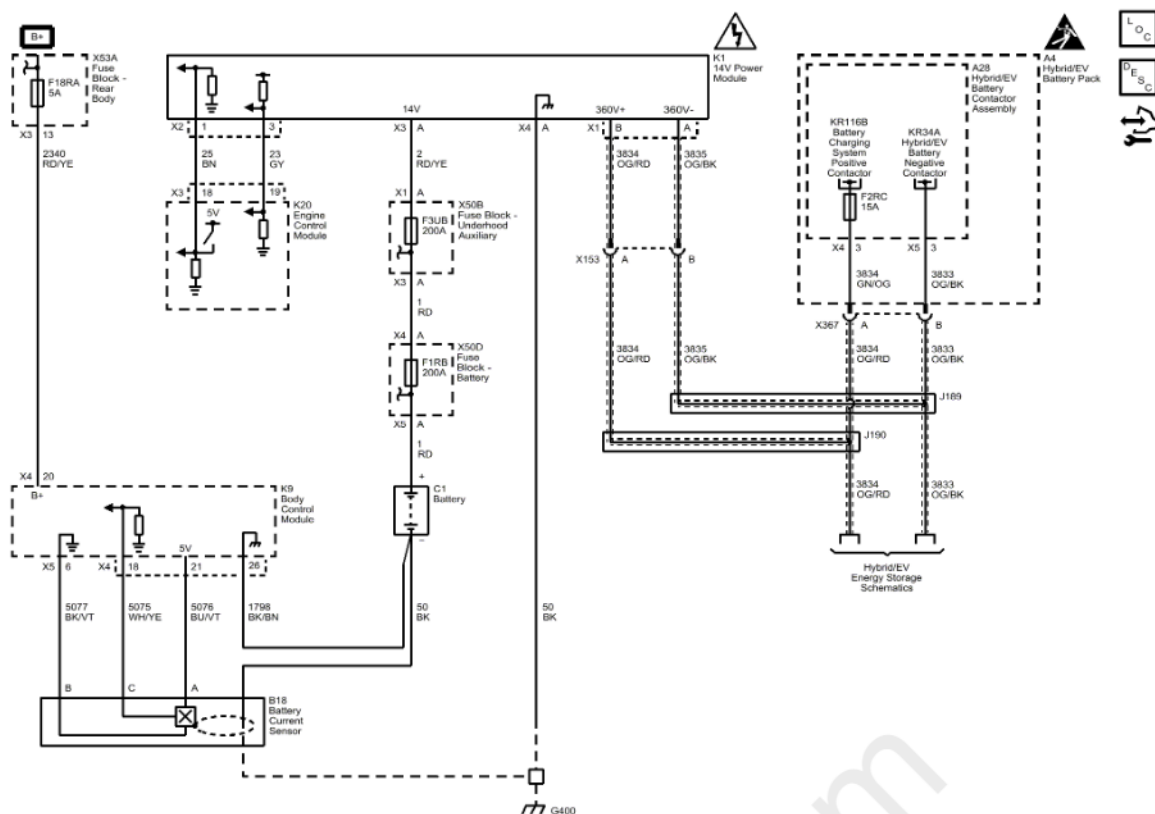


Fig. 1: 12V Battery Management

Courtesy of GENERAL MOTORS COMPANY

DIAGNOSTIC INFORMATION AND PROCEDURES

DTC B1325, B1330, B1517, C0800, C0899, C0900, C12E1, C12E2, P0561-P0563, P1A0C, P1A0D OR P1EFC: DEVICE POWER/BATTERY VOLTAGE/SYSTEM VOLTAGE

Diagnostic Instructions

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

DTC Descriptors

DTC B1325 03

Device Power Circuit Voltage Below Threshold

DTC B1325 07

Device Power Circuit Voltage Above Threshold

DTC B1330 03

Device Power 2 Circuit Voltage Below Threshold

DTC B1330 04

Device Power 2 Circuit Voltage Open Circuit

DTC B1517 03

Battery Voltage Below Threshold

DTC B1517 07

Battery Voltage Above Threshold

DTC B1517 5A

Battery Voltage Plausibility Failure

DTC C0800 03

Device Power 1 Circuit Voltage Below Threshold

DTC C0800 07

Device Power 1 Circuit Voltage Above Threshold

DTC C0800 11

Device Power 1 Circuit High Input

DTC C0800 0D

Device Power 1 Circuit High Resistance

DTC C0899 00

Device Voltage Low

DTC C0899 03

Device Voltage Low

DTC C0900 00

Device Voltage High

DTC C0900 07

Device Voltage Above Threshold

DTC C12E1

Electronic Brake Control Module Supply Circuit Low Voltage

DTC C12E2

Electronic Brake Control Module Supply Circuit High Voltage

DTC P0561

System Voltage Performance

DTC P0562

System Voltage Low Voltage

DTC P0563

System Voltage High Voltage

DTC P1A0C

Battery Energy Control Module System Voltage Low Voltage

DTC P1A0D

Battery Energy Control Module System Voltage High Voltage

DTC P1EFC

Battery Charger Control Module System Voltage Low Voltage

Circuit/System Description

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

Conditions for Running the DTC

The vehicle is ON.

Conditions for Setting the DTC

The control module or sensor detects a system voltage of less than approximately 9 V or greater than 18 V for approximately 5 seconds.

Action Taken When the DTC Sets

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

Conditions for Clearing the DTC

The system voltage returns to normal operating range.

Diagnostic Aids

- A high or low voltage DTC set or voltage value in multiple modules/sensors indicates a concern in the 12 V charging system.
- A possible cause of this DTC could be overcharging with a 12 V battery charger or jump starting.

Reference Information

Schematic Reference

Control Module References

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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. Ignition OFF, disconnect the drive motor battery charger cable from the X98 Hybrid/EV Battery Charger Receptacle. Measure and record the battery voltage at the battery terminals.
2. Verify the battery voltage stabilizes between 12.4 and 12.8 V within a few minutes of turning the ignition OFF.

- **If battery voltage is less than 12.4 V or more than 12.8 V**

Refer to [Battery Inspection/Test](#) .

- **If battery voltage is between 12.4 and 12.8 V**

3. Engine running, headlights ON, measure and record the battery voltage at the battery terminals.
4. Verify the voltage is at least 1 V greater than the voltage measured in step 1, but less than 15 V.

- **If the voltage is not at least 1 V greater than the voltage measured in step 1 or is greater than 15 V.**

Refer to [DC Power Conversion Test](#) .

- **If the voltage is at least 1 V greater than the voltage measured in step 1, but less than 15 V.**

5. Verify the appropriate control module battery voltage and ignition voltage parameters are available in the scan tool.

- **If parameters are not available in the scan tool**

Refer to Circuit/System Testing

- **If parameters are available in the scan tool**

6. Verify the appropriate control module scan tool battery voltage and ignition voltage parameters are within 1 V of the battery voltage.

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

Refer to Circuit/System Testing

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

7. All OK.

Circuit/System Testing

NOTE: Use the schematic to identify the following:

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

NOTE: Some control module ground circuits may require up to 20 min after the ignition is turned off before achieving a resistance reading of less than 10 Ω . In most cases the readings will drop below 20 Ω within 1 min indicating the control module is going to sleep.

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connectors at the appropriate control module. It may take up to 2 min for all vehicle systems to power down.
2. Test for less than 10 Ω between each ground circuit terminal and ground.

- **If 10 Ω or greater**

1. Ignition OFF.

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

- If 2 Ω or greater, repair the open/high resistance in the circuit.
- If less than 2 Ω , repair the open/high resistance in the ground connection.

- **If less than 10 Ω**

3. If equipped, verify a test lamp illuminates between each B+ circuit terminal and ground.

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

1. Ignition OFF.

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

- If 2 Ω or greater, repair the open/high resistance in the circuit.
- If less than 2 Ω , verify the fuse is not open and there is voltage at the fuse.

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

1. Ignition OFF.

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

- If less than infinite resistance, repair the short to ground on the circuit.
- If infinite resistance, replace the appropriate control module.

- **If the test lamp illuminates**

4. Ignition ON.

5. If equipped, verify a test lamp illuminates between each ignition circuit terminal and ground.

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

1. Ignition OFF.

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

- If 2 Ω or greater, repair the open/high resistance in the circuit.
- If less than 2 Ω , verify the fuse is not open and there is voltage at the fuse.

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

1. Ignition OFF.

2. Test for infinite resistance between the ignition circuit and ground.

- If less than infinite resistance, repair the short to ground on the circuit.
- If infinite resistance, replace the appropriate control module.

- **If the test lamp illuminates**

6. Replace the control module.

Repair Instructions

Perform the [Diagnostic Repair Verification](#) after completing the repair.

[Control Module References](#) for control module replacement, programming and setup

DTC B1516: BATTERY CURRENT SENSOR

Diagnostic Instructions

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

DTC Descriptors

DTC B1516 08

Battery Current Sensor Signal Invalid

DTC B1516 66

Battery Current Sensor 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	B1516 08	-
Signal	B1516 08	B1516 08	B1516 08	B1516 08, B1516 66

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

Circuit/System Description

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

Conditions for Running the DTC

B1516 08

The BCM is awake.

B1516 66

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

Conditions for Setting the DTC

B1516 08

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

B1516 66

The battery current polarity is positive for 2 minutes.

Action Taken When the DTC Sets

The regulated voltage control (RVC) is disabled.

Conditions for Clearing the DTC

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

Diagnostic Aids

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

Reference Information

Schematic Reference

Starting and Charging Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Charging System Description and Operation

Electrical Information Reference

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

Control Module References for scan tool information**Circuit/System Testing****B1516 08**

1. Vehicle OFF and all vehicle systems OFF, disconnect the harness connector at the B18 Battery Current Sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 30 Ω between the low reference circuit terminal 2 and ground.
 - **If 30 Ω or greater**
 1. Vehicle OFF, disconnect the X5 harness connector at the K9 Body Control Module.
 2. Test for less than 2 Ω in the low reference circuit end to end.
 - If 2 Ω or greater, repair the open/high resistance in the circuit.
 - If less than 2 Ω , replace the K9 Body Control Module.
 - **If less than 30 Ω**
3. Vehicle in Service Mode.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 1 and ground.
 - **If less than 4.8 V**
 1. Vehicle OFF, disconnect the X4 harness connector at the K9 Body Control Module.
 2. Test for infinite resistance between the 5 V reference circuit and ground.
 - If less than infinite resistance, repair the short to ground on the circuit.
 - If infinite resistance
 3. Test for less than 2 Ω in the 5 V reference circuit end to end.
 - If 2 Ω or greater, repair the open/high resistance in the circuit.
 - If less than 2 Ω , replace the K9 Body Control Module.
 - **If greater than 5.2 V**
 1. Vehicle OFF, disconnect the X4 harness connector at the K9 Body Control Module, Vehicle in Service Mode.
 2. Test for less than 1 V between the 5 V reference circuit and ground.
 - If 1 V or greater, repair the short to voltage on the circuit.
 - If less than 1 V, replace the K9 Body Control Module.
 - **If between 4.8-5.2 V**
5. Test for 4.8-5.2 V between the signal circuit terminal 3 and ground.
 - **If less than 4.8 V**
 1. Vehicle OFF, disconnect the X4 harness connector at the K9 Body Control Module.
 2. Test for infinite resistance between the signal circuit and ground.
 - If less than infinite resistance, repair the short to ground on the circuit.
 - If infinite resistance
 3. Test for less than 2 Ω in the signal circuit end to end.
 - If 2 Ω or greater, repair the open/high resistance in the circuit.
 - If less than 2 Ω , replace the K9 Body Control Module.
 - **If greater than 5.2 V**
 1. Vehicle OFF, disconnect the X4 harness connector at the K9 Body Control Module, Vehicle in Service Mode.
 2. Test for less than 1 V between the signal circuit and ground.
 - If 1 V or greater, repair the short to voltage on the circuit.
 - If less than 1 V, replace the K9 Body Control Module.
 - **If between 4.8-5.2 V**
6. Test or replace the B18 Battery Current Sensor.

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

Repair Instructions

Perform the [Diagnostic Repair Verification](#) after completing the diagnostic procedure.

[Control Module References](#) for BCM replacement, setup and programming

DTC B151A: LOW BATTERY CAPACITY DETECTED

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 vehicle is ON

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

A driver information center message is displayed.

Conditions for Clearing the DTC

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

Reference Information

Schematic Reference

Starting and Charging Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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 the **Battery Inspection/Test** .
- Refer to the **Charging System Test** .

DTC B1527: PARASITIC LOAD

Diagnostic Instructions

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

DTC Descriptor

DTC B1527 00

Parasitic Load

Circuit/System Description

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

Conditions for Running the DTC

The ignition is in Accessory or Run mode.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

There is no battery telltale illuminated or DIC message displayed.

Conditions for Clearing the DTC

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

Reference Information

Schematic Reference

Starting and Charging Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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 P0A8D OR P0A8F: 14V POWER MODULE SYSTEM VOLTAGE

Diagnostic Instructions

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

DTC Descriptors

DTC P0A8D

14V Power Module System Voltage Low Voltage

DTC P0A8F

14V Power Module System Voltage High Voltage

Circuit/System Description

The 14V power module, often referred to as the accessory DC power control module, converts the high voltage (360V) direct current (DC) to low voltage (14V) DC to charge the 12V battery and to operate the power accessories. The ECM controls the 14V power module by supplying a 5V pulse width modulated (PWM) signal through a control circuit. The ECM monitors 12V battery voltage to ensure the 14V power module is maintaining the desired voltage.

Conditions for Running the DTC

14V power module is commanded ON.

Conditions for Setting the DTC

P0A8D

The sensor signal is out of range for greater than 5 seconds.

P0A8F

The sensor signal is out of range for greater than 5 seconds.

or

Accessory wake up serial data 2 signal is not reaching the 14V power module.

Action Taken When the DTC Sets

- The charge indicator is illuminated.
- The 14V power module stops supplying power to the 12V system.
- DTC P0A8D and P0A8F are type C DTCs.

Conditions for Clearing the DTC

DTC P0A8D and P0A8F are Type C DTCs.

Diagnostic Aids

An improperly fastened 200-amp in-line mega-fuse may cause this DTC to set.

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Circuit/System Testing

1. Verify DTC P1F59, P1F5A, P1F5B, P1F5D or P1F5E is not set.

- **If the DTC is set**

Refer to [Diagnostic Trouble Code \(DTC\) List - Vehicle](#) .

- **If the DTC is not set**

2. Perform the [DC Power Conversion Test](#) .

DTC P1F59, P1F5A OR P1F5B: 14 VOLT POWER MODULE STATUS TERMINAL CIRCUIT

Diagnostic Instructions

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

DTC Descriptor

DTC P1F59

14 Volt Power Module Status Terminal Circuit Performance

DTC P1F5A

14 Volt Power Module Status Terminal Circuit Low Voltage

DTC P1F5B

14 Volt Power Module Status Terminal Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Status - F Terminal	P1F59, P1F5A	P1F59, P1F5A	P1F59, P1F5B	P1F59

Circuit/System Description

The ECM uses two circuits to control and monitor the state of the 14V power module, often referred to as the accessory DC power control module.

The status circuit functions much like the F Terminal circuit on a generator equipped vehicle. A high side driver in the 14V power module applies a duty cycled voltage to the ECM. The duty cycle indicates

14V power module internal temperature and operational condition. The ECM will detect faults on the 14V power module status circuit when the vehicle is ON.

Conditions for Running the DTC

The vehicle is ON.

Conditions for Setting the DTC

- P1F5A: The ECM detects a 5% or lower PWM signal on the 14V power module status circuit for 8 seconds out of a 10 second window.
- P1F5B: The ECM detects a 96% or higher PWM signal on the 14V power module status circuit for 8 seconds out of a 10 second window.
- P1F59: The status circuit PWM signal is not in a valid range.

Action Taken When the DTC Sets

DTCs P1F59, P1F5A and P1F5B are type C DTCs.

Conditions for Clearing the DTC

DTCs P1F59, P1F5A and P1F5B are type C DTCs.

Reference Information

Schematic Reference

- [Starting and Charging Schematics](#)
- [Hybrid/EV Controls Schematics](#)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

NOTE: Do not have a 12V battery charger connected during the testing.

2. Verify the DTC does not set.

- **If the DTC sets**

Refer to Circuit/System Testing.

- **If the DTC does not set**

3. All OK.

Circuit/System Testing

1. Vehicle OFF, disconnect the X2 harness connector at the K1 14V Power Module and X3 at the K20 Engine Control Module, Vehicle in Service Mode.
2. Test for less than 1 V between the signal circuit 3 X2 at K1 14V Power Module and ground.
 - If 1 V or greater, repair the short to voltage on the circuit.
 - If less than 1 V
3. Vehicle OFF.
4. Test for infinite resistance between the signal circuit and ground.
 - If less than infinite resistance, repair the short to ground on the circuit.
 - If infinite resistance
5. Test for less than 2 Ω in the circuit end to end.
 - If 2 Ω or greater, repair the open/high resistance in the circuit.
 - If less than 2 Ω , replace the K20 Engine Control Module.
6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
7. Verify the DTC does not set.
 - **If the DTC sets**

Test or Replace K1 14V Power Module.
 - **If the DTC does not set**
8. All OK.

Repair Instructions

Perform the [Diagnostic Repair Verification](#) after completing the repair.

[Control Module References](#) for control module replacement, programming and setup.

DTC P1F5D OR P1F5E: 14 VOLT POWER MODULE L-TERMINAL CIRCUIT

Diagnostic Instructions

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

DTC Descriptor

DTC P1F5D

14 Volt Power Module L-Terminal Circuit Low Voltage

DTC P1F5E

14 Volt Power Module L-Terminal Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control - L Terminal	P1F5D	-	P1F5E	-

Circuit/System Description

The ECM uses two circuits to control and monitor the state of the 14V power module, often referred to as the accessory DC power control module. The control circuit functions much like the L Terminal circuit on a generator equipped vehicle. A high side driver in the ECM applies a duty cycled voltage to the 14V power module. The duty cycle controls the 14V power module output. The ECM monitors the

state of the 14V power module control circuit. The ECM will detect faults on the 14V power module control circuit when the vehicle is ON.

Conditions for Running the DTC

The vehicle is ON.

Conditions for Setting the DTC

- P1F5D: The ECM detects a low voltage on the 14V power module control circuit for 8 seconds out of a 10 second window.
- P1F5E: The ECM detects a high voltage on the 14V power module control circuit for 8 seconds out of a 10 second window.

Action Taken When the DTC Sets

DTCs P1F5D and P1F5E are type C DTCs.

Conditions for Clearing the DTC

DTCs P1F5D and P1F5E are type C DTCs.

Reference Information

Schematic Reference

- [Starting and Charging Schematics](#)
- [Hybrid/EV Controls Schematics](#)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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](#) for Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

[Control Module References](#) for scan tool information

Circuit/System Verification

1. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

NOTE: Do not have a 12V battery charger connected during the testing.

2. Verify the DTC does not set.

- **If the DTC sets**

Refer to Circuit/System Testing.

- **If the DTC does not set**

3. All OK.

Circuit/System Testing

1. Vehicle OFF, disconnect the X1 harness connector at the K1 14V Power Module, Vehicle On
2. Test for 3.0 - 5.5 V between the signal circuit terminal 1 X2 and ground.
 - **If less than 3.0 V**
 1. Vehicle OFF, disconnect the harness connector at the K20 Engine Control Module.
 2. Test for infinite resistance between the signal circuit and ground.
 - If less than infinite resistance, repair the short to ground on the circuit.
 - If infinite resistance
 3. Test for less than 2 Ω in the signal circuit end to end.
 - If greater the 2 Ω , repair the open/high resistance in the circuit.
 - If less than 2 Ω , replace the K20 Engine Control Module.
 - **If greater than 5.5 V**
 1. Vehicle OFF, disconnect the harness connector at the K20 Engine Control Module, Vehicle in Service Mode.
 2. Test for less than 1 V between the signal circuit 1 X2 and ground.
 - If greater than 1 V, repair the short to voltage on the circuit.
 - If less than 1 V, replace the K20 Engine Control Module.
 - **If between 3.0 - 5.5 V**
3. Test or replace the K1 14V Power Module.

Repair Instructions

Perform the [Diagnostic Repair Verification](#) after completing the repair.

[Control Module References](#) for control module replacement, programming and setup.

SYMPTOMS - ENGINE ELECTRICAL

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:
 - The power modes are correct.
 - The control modules can communicate via the serial data link.
 - There are no DTCs set.
- 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](#)
 - [Starting System Description and Operation](#)

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the 12 V charging system. 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 Charging](#)
- [Battery Electrical Drain/Parasitic Load Test](#)
- [Charging System Test](#)

BATTERY INSPECTION/TEST

Diagnostic Instructions

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

Diagnostic Aids

NOTE: For Warranty repairs -

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

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

Reference Information

Schematic Reference

[Starting and Charging Schematics](#)

Connector End View Reference

[COMPONENT CONNECTOR END VIEWS - INDEX](#)

Description and Operation

[Starting System Description and Operation](#)

Electrical Information Reference

- [Circuit Testing](#)
- [Connector Repairs](#)
- [Testing for Intermittent Conditions and Poor Connections](#)
- [Wiring Repairs](#)

Scan Tool Reference

[Control Module References](#) for scan tool information

Special Tools

EL 50313 Battery Tester For equivalent regional tools, refer to [Special Tools](#)

[Circuit/System Testing](#)

WARNING:

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

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

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

1. Verify the C1 Battery or C1B Battery - Auxiliary (if equipped) case is not cracked, broken or damaged, which may be indicated by battery acid leakage.
 - **If there is any apparent damage**

Replace the C1 Battery or C1B Battery - Auxiliary.
 - **If there is no damage**
2. Verify that the battery cables are clean and tight. The battery terminal bolts should be torqued as specified in [Fastener Specifications](#).
 - **If the battery cables need to be cleaned or tightened**

Clean as required and tighten as specified.
 - **If the battery cables are clean and tight**
3. Disconnect battery from the vehicle. There is no need to remove the battery from the vehicle.
4. Connect the **EL-50313** directly to the battery terminal posts.
5. Select "Charging," "Diagnostic" and "Out of Vehicle" when setting up the test.
6. Select the proper battery type, Flooded, AGM or Stop/Start AGM.
7. Enter the CCA as shown on the battery label.
8. Verify the test result is not REPLACE BATTERY or BAD CELL-REPLACE

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 Out of Vehicle test.

- **If the test result is REPLACE BATTERY or BAD CELL-REPLACE**

Replace the C1 Battery or C1B Battery - Auxiliary.

- **If the test result is not REPLACE BATTERY or BAD CELL-REPLACE**

9. All OK.

Perform the [Diagnostic Repair Verification](#) after completing the repair.

Battery Replacement

BATTERY CHARGING

12 V Battery

The following procedure is for the 12 V battery only.

Special Tools

EL 50313 Midtronics GR8 Battery Tester Charger

For equivalent regional tools, refer to [Special Tools](#).

Diagnostic Aids

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

- The charging area should be well ventilated.
- Do not charge a battery that appears to be frozen. Allow the battery to warm to room temperature and test it using the **EL 50313** before charging.
- An AGM battery may be damaged if charged to more than 14.5 V.
- A Flooded Cell battery may be damaged if charged to more than 16.5 V.
- Vehicles with dual batteries must be charged individually which will result in two printouts.

Battery State of Charge

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

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

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

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

Battery Voltage	% Charge at 0Å,Å°C (32Å,Å°F)	% Charge at 25Å,Å°C (75Å,Å°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.

Use the following procedure to charge the battery:

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

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. Select "Charging," "PDI" and "In Vehicle" when setting up the charger.
5. Select the proper battery type, Flooded, AGM, Spiral AGM or Stop/Start AGM.
6. Enter the CCA as shown on the battery label.

BATTERY ELECTRICAL DRAIN/PARASITIC LOAD TEST

300 V Battery

For information about the 355 V hybrid drive motor battery, refer to [Drive Motor Battery System Description](#).

Absorbent Glass Mat Battery

This vehicle is equipped with an absorbent glass mat battery. This is similar to current vehicle lead acid flood batteries, except they use glass mats that absorb electrolytes that are pressed between the plates instead of immersing the plates in electrolytes. This allows a smaller, lighter battery with the same amount of power and is less susceptible to heat.

The maximum permissible voltage allowed for the absorbent glass mat battery is 14.8 V (at room temperature).

12 V Battery

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.

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.

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 the battery specification label on the original battery for the cold cranking amperage rating for this vehicle.

CHARGING SYSTEM TEST

The accessory power module (APM) supplies the energy that flows between the high voltage (300 volt) direct current (DC) and low voltage (14 volt) DC to charge the 12 volt battery and power accessories. To test the charging system, refer to [DC Power Conversion Test](#).

REPAIR INSTRUCTIONS

BATTERY NEGATIVE CABLE DISCONNECTION AND CONNECTION

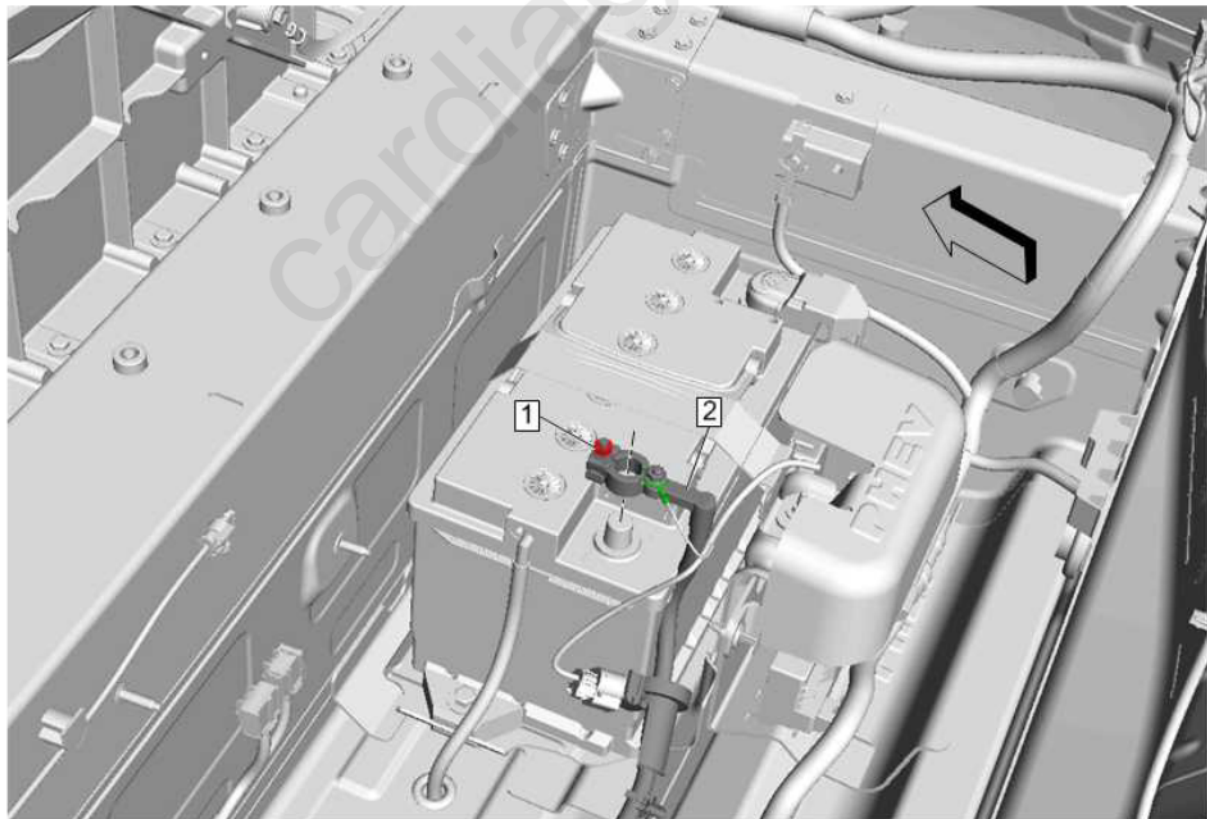


Fig. 2: Battery Negative Post Clamp Nut

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure	
<u>Rear Compartment Floor Stowage Compartment Tray Replacement (With HP9)</u>	

Callout	Component Name
1	Battery Negative Post Clamp Nut WARNING: Refer to Battery Disconnect Warning . CAUTION: Refer to Fastener Caution . Tighten 4 N.m (35 lb in)
2	Battery Negative Cable

BATTERY NEGATIVE CABLE REPLACEMENT

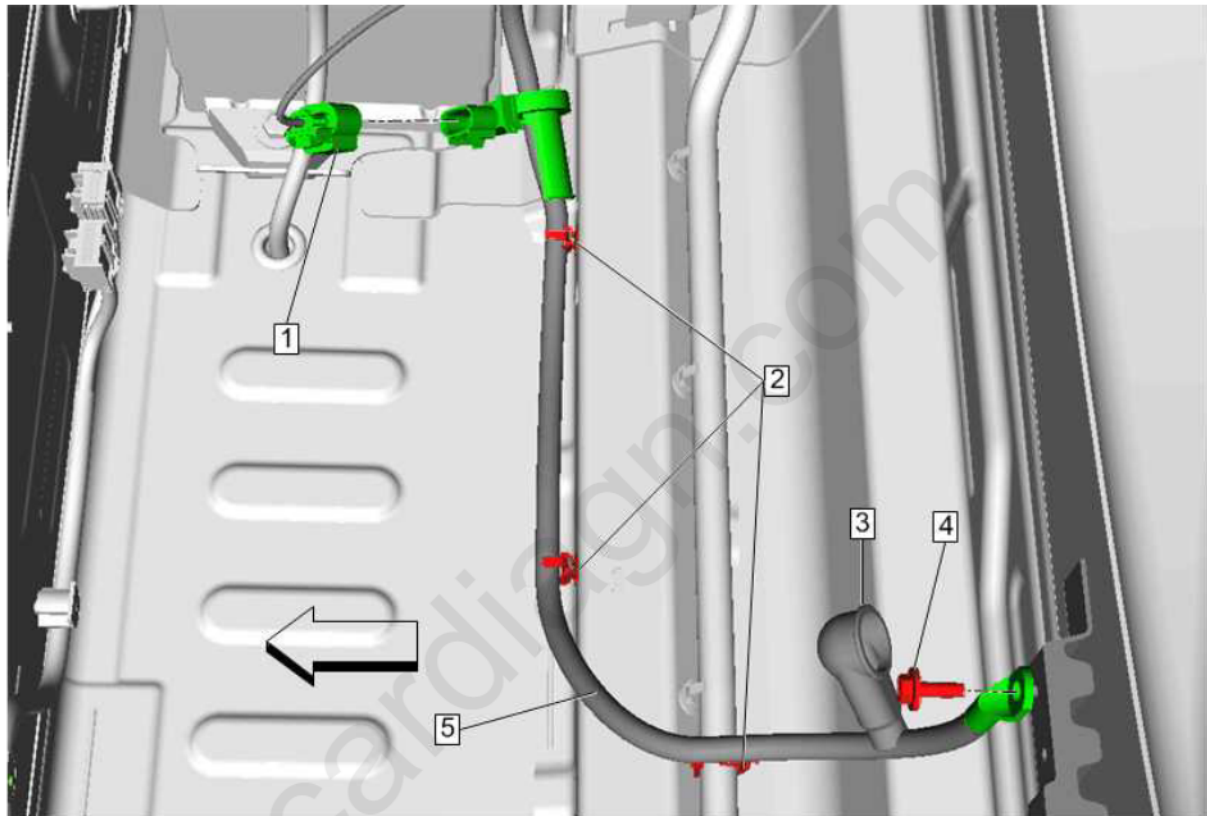


Fig. 3: Battery Negative Cable Retainers
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure <u>Battery Negative Cable Disconnection and Connection</u>	
1	Battery Current Sensor Connector
2	Retainer [3x]
3	Protective Boot
4	Battery Negative Cable Ground Fastener CAUTION: Refer to Fastener Caution . Tighten 22 N.m (16 lb ft)
5	Battery Negative Cable

BATTERY POSITIVE CABLE REPLACEMENT

1. Rear Compartment Floor Stowage Compartment Tray (2)» Remove - [Rear Compartment Floor Stowage Compartment Tray Replacement \(With HP9\)](#)

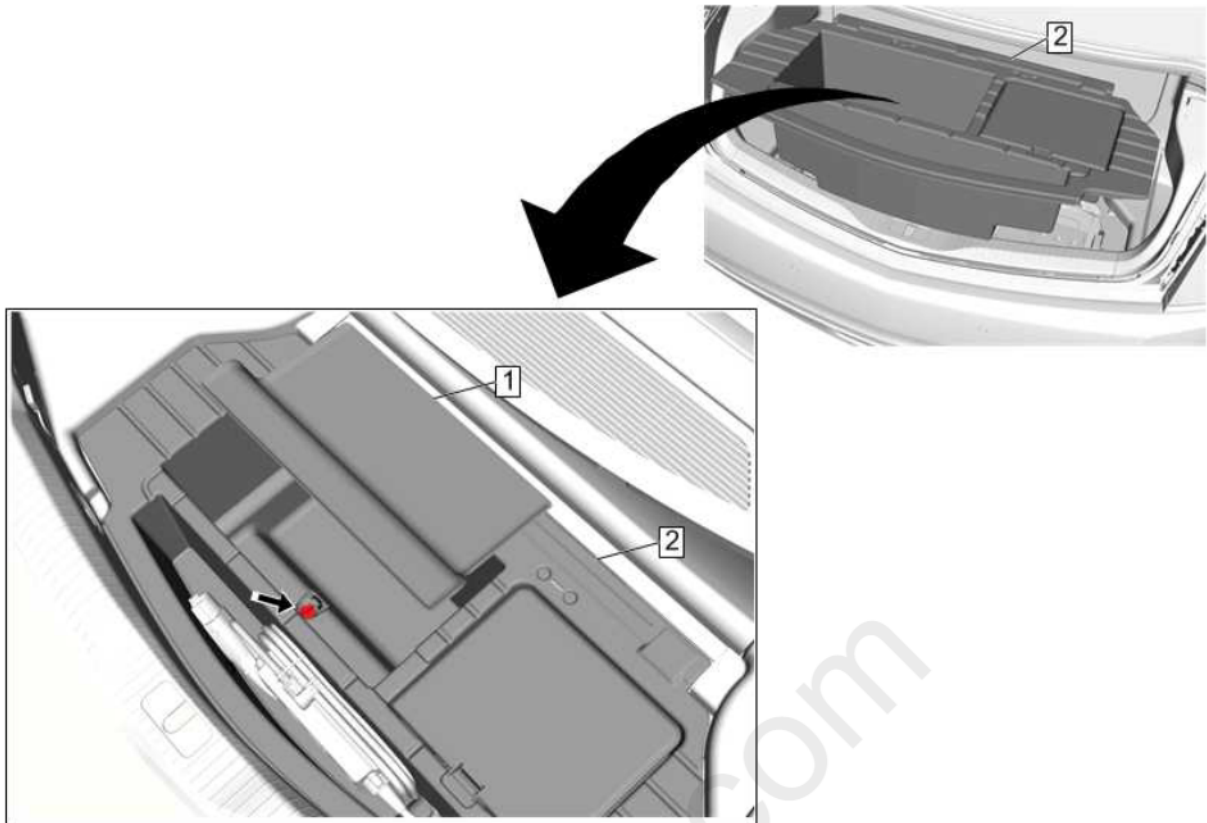


Fig. 4: Rear Compartment Floor Stowage Compartment Tray_(With HP9)
Courtesy of GENERAL MOTORS COMPANY

2. Disconnect the negative battery cable. Refer to [Battery Negative Cable Disconnection and Connection](#)
3. Battery Distribution Fuse Block Cover Fastener (2)» Remove

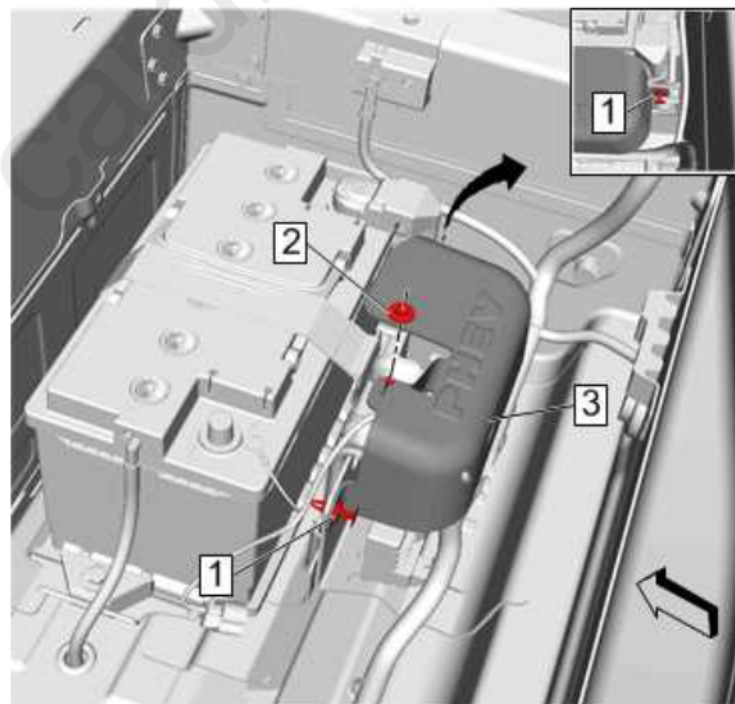


Fig. 5: Battery Distribution Fuse Block Cover
Courtesy of GENERAL MOTORS COMPANY

4. Battery Distribution Fuse Block Cover Retainer (1)» Disengage [2x]
5. Battery Distribution Fuse Block Cover (3)» Remove
6. Battery Positive Cable Nut (1)» Remove

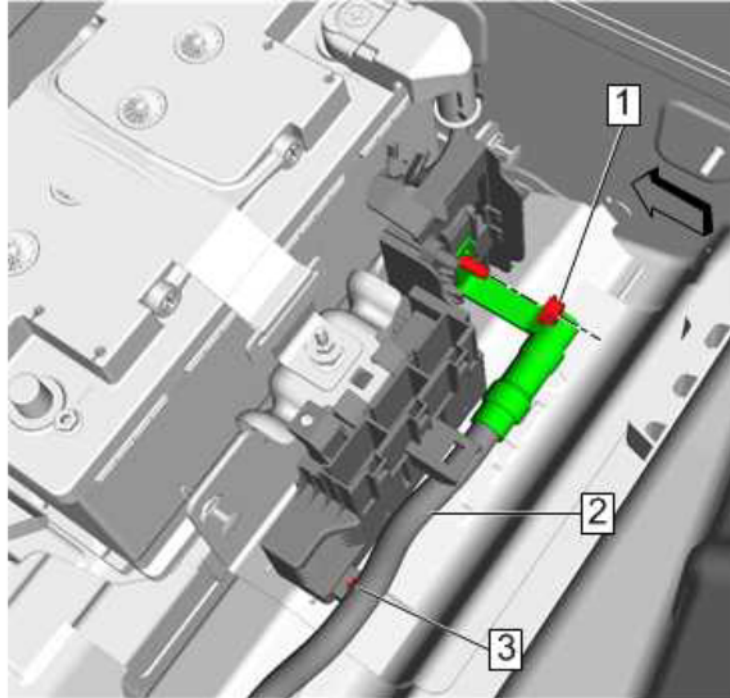


Fig. 6: Battery Positive Cable Nut

Courtesy of GENERAL MOTORS COMPANY

- 7. Retainer (3) » Disengage
- 8. Battery Positive Cable (2) » Remove
- 9. Retainer (1) » Disengage [4x]

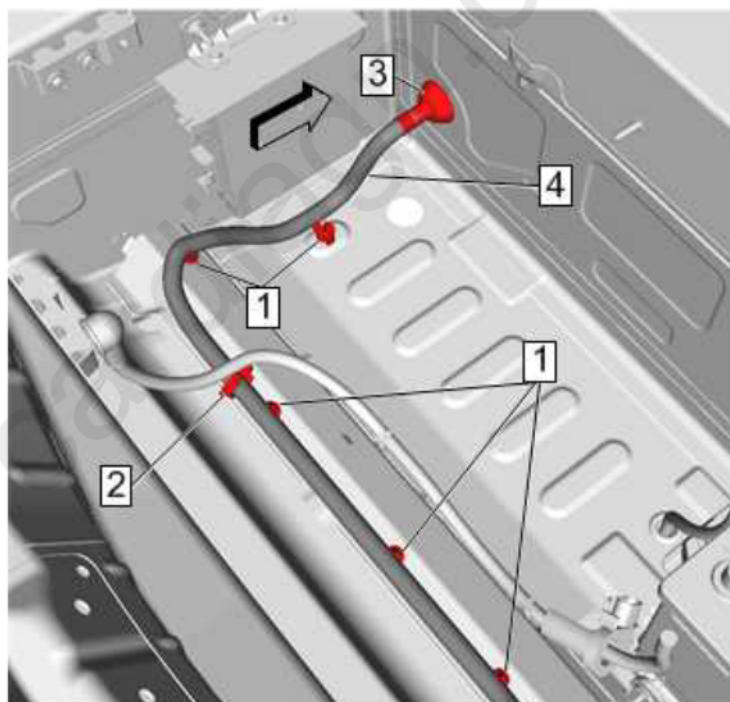


Fig. 7: Retainers, Rubber Grommet And Retainer Clip

Courtesy of GENERAL MOTORS COMPANY

- 10. Rubber Grommet (3) » Disengage
- 11. Retainer Clip (2) » Disengage
- 12. Feed the battery positive cable (4) through rear compartment opening.
- 13. Raise and support the vehicle. Refer to [Lifting and Jacking the Vehicle](#)
- 14. Fuel Tank (1) » Remove - [Fuel Tank Replacement](#)

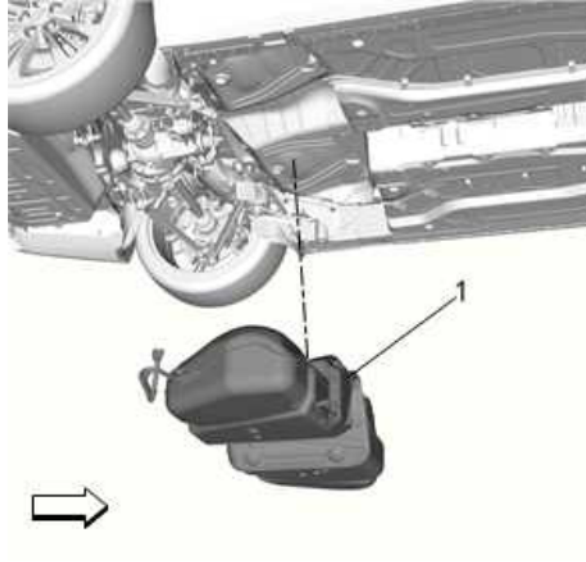


Fig. 8: Fuel Tank

Courtesy of GENERAL MOTORS COMPANY

15. Front Body Exhaust Heat Shield - Left (3) » Remove - **Front Body Exhaust Heat Shield Replacement (Right Side, LTG)** **Front Body Exhaust Heat Shield Replacement (Left Side, LTG)** **Front Body Exhaust Heat Shield Replacement (Right Side, LGW, LGX)** **Front Body Exhaust Heat Shield Replacement (Left Side, LGW, LGX)**

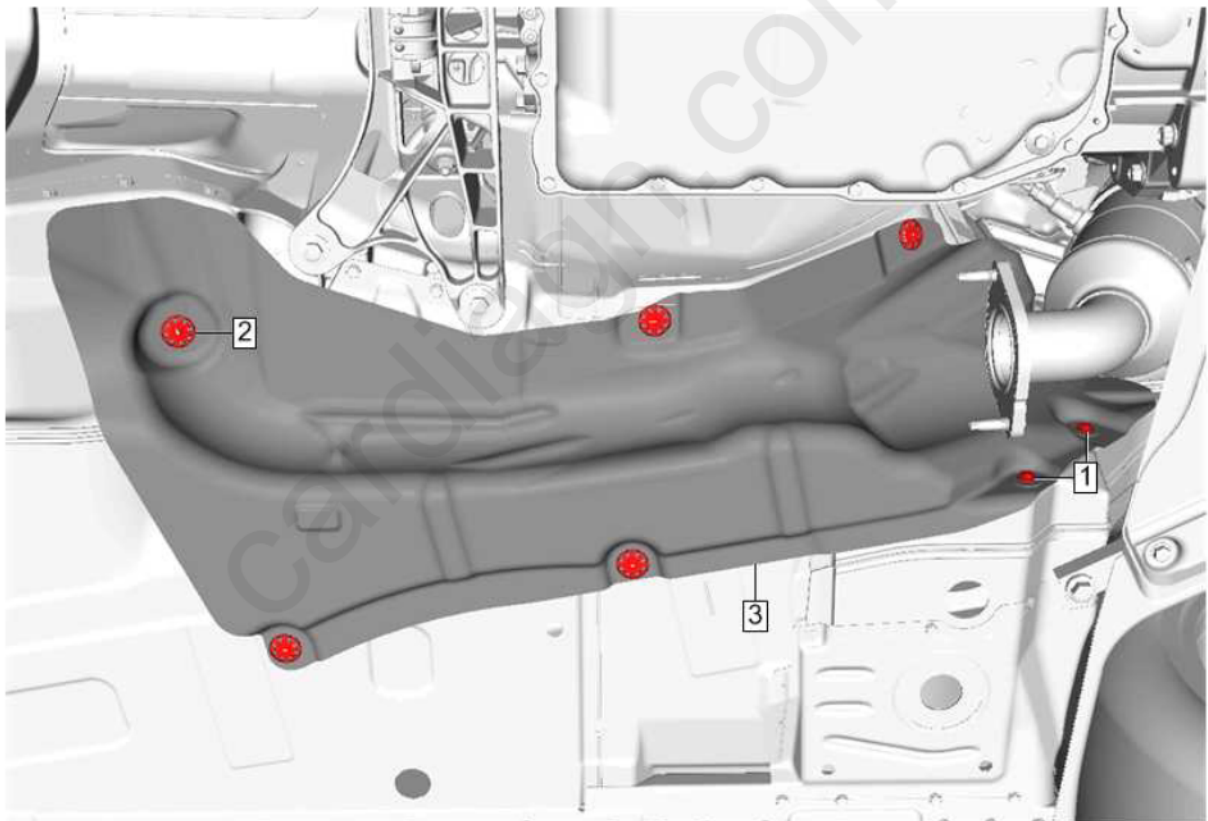


Fig. 9: Front Body Exhaust Heat Shield

Courtesy of GENERAL MOTORS COMPANY

16. Retainer (1) » Disengage [6x]

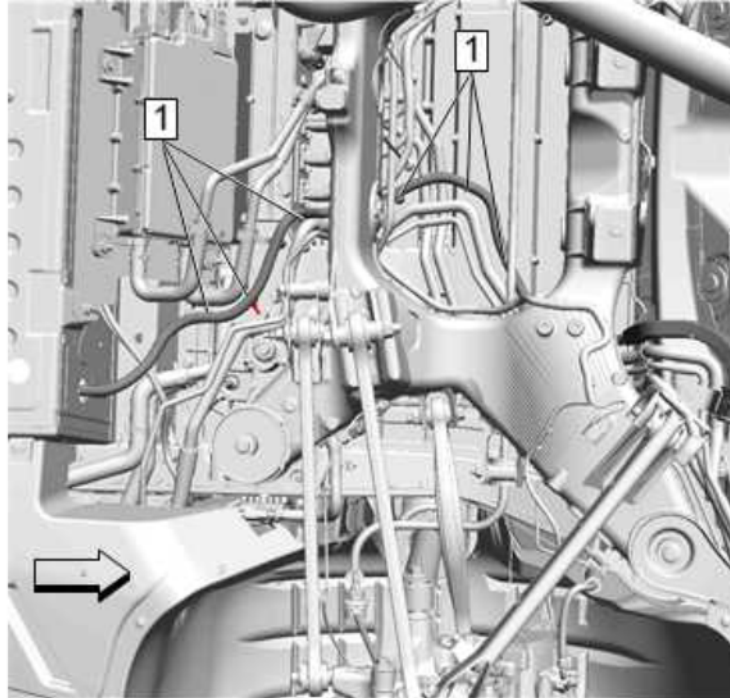


Fig. 10: Retainers

Courtesy of GENERAL MOTORS COMPANY

17. Release the clips with a suitable tool. (1) [4x]

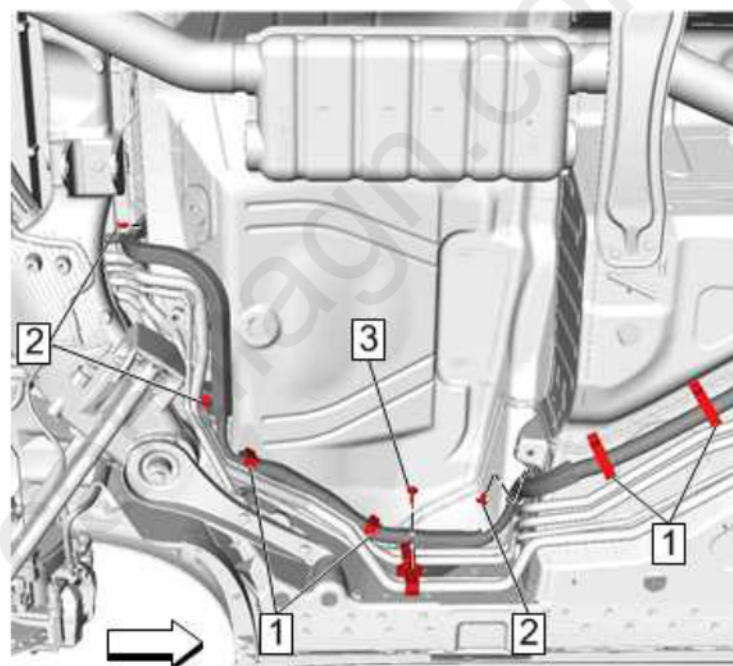


Fig. 11: Auxiliary A/C Evaporator Tube Bracket Fastener, Clips And Retainers

Courtesy of GENERAL MOTORS COMPANY

18. Remove the auxiliary A/C evaporator tube bracket fastener. (3)
19. Retainer (2)» Disengage [3x]
20. Release the clips with a suitable tool. (1) [3x]

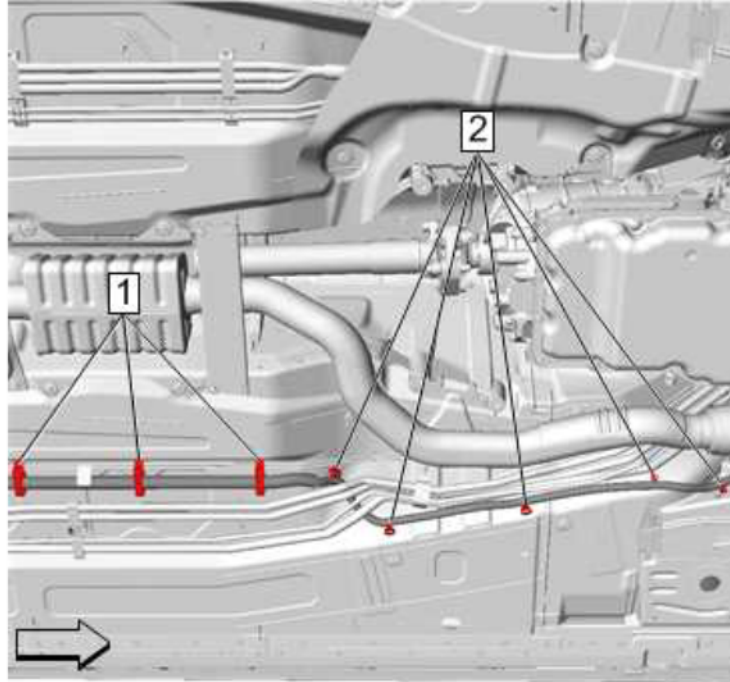


Fig. 12: Clips And Retainers

Courtesy of GENERAL MOTORS COMPANY

- 21. Retainer (2) » Disengage [5x]
- 22. Lower the vehicle.
- 23. Retainer (1) » Disengage [9x]

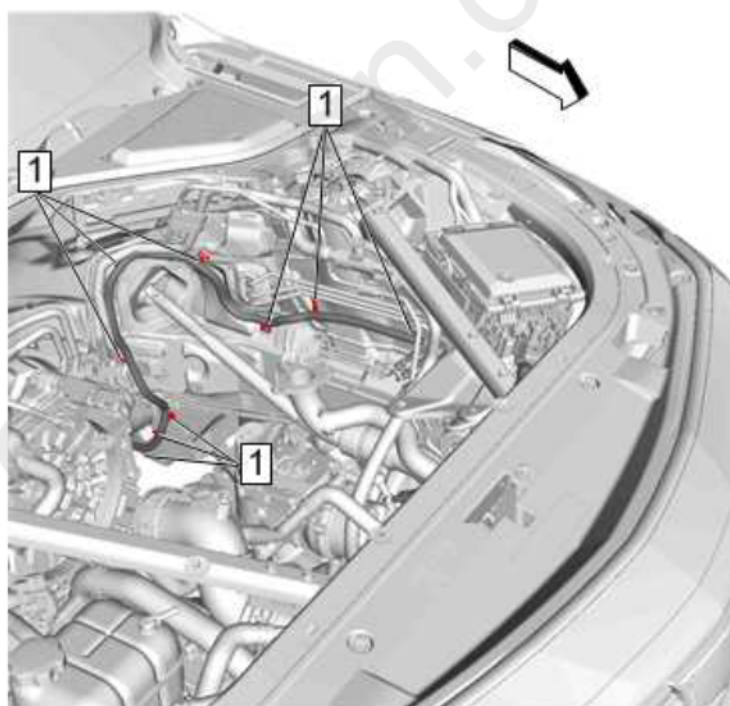


Fig. 13: Retainers

Courtesy of GENERAL MOTORS COMPANY

- 24. Power Distributor Fuse Block Cover (1) » Remove

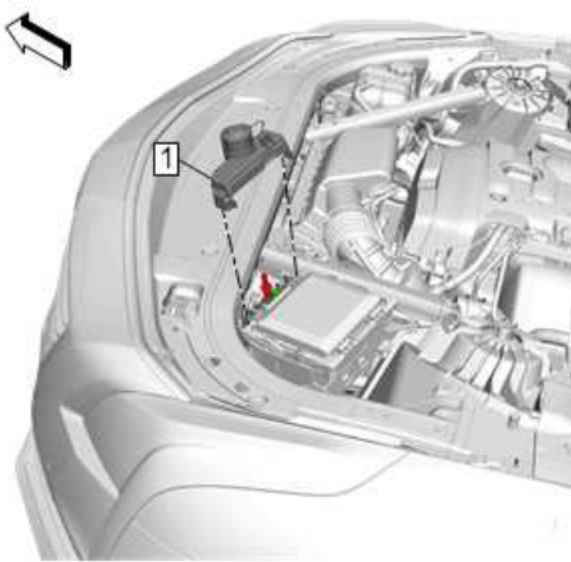


Fig. 14: Power Distributor Fuse Block Cover
 Courtesy of GENERAL MOTORS COMPANY

25. Battery Positive Cable Nut (1)» Remove

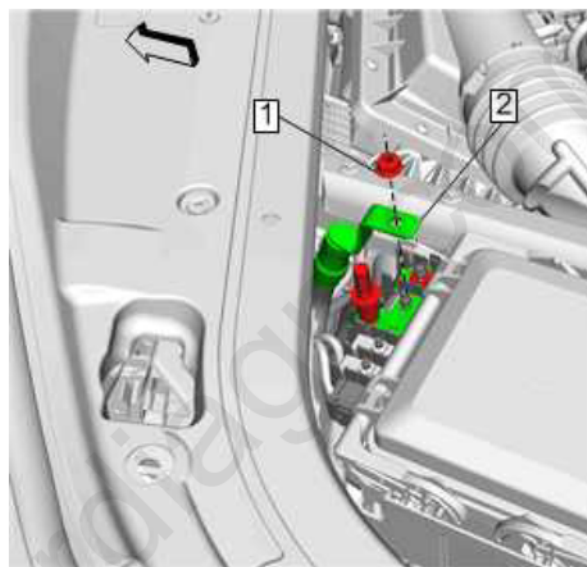


Fig. 15: Battery Positive Cable Nut
 Courtesy of GENERAL MOTORS COMPANY

26. Battery Positive Cable (2)» Remove

Installation Procedure

1. Battery Positive Cable (2)» Install

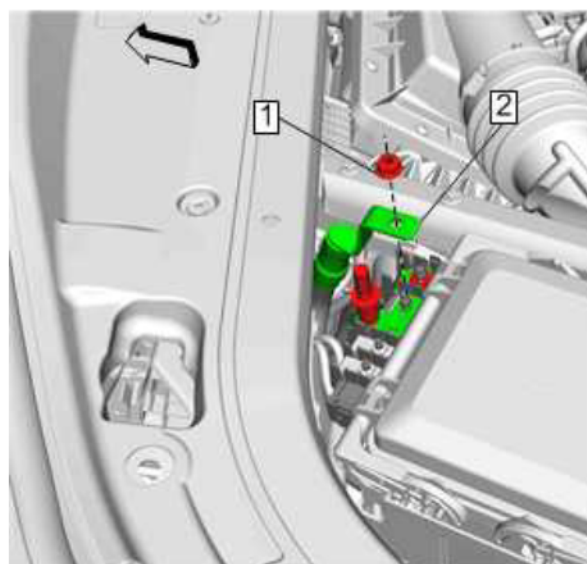


Fig. 16: Battery Positive Cable Nut
Courtesy of GENERAL MOTORS COMPANY

2. Battery Positive Cable Nut (1)» Install and tighten 22 N.m (16 lb ft)

CAUTION: Refer to **Fastener Caution**

3. Power Distributor Fuse Block Cover (1)» Install

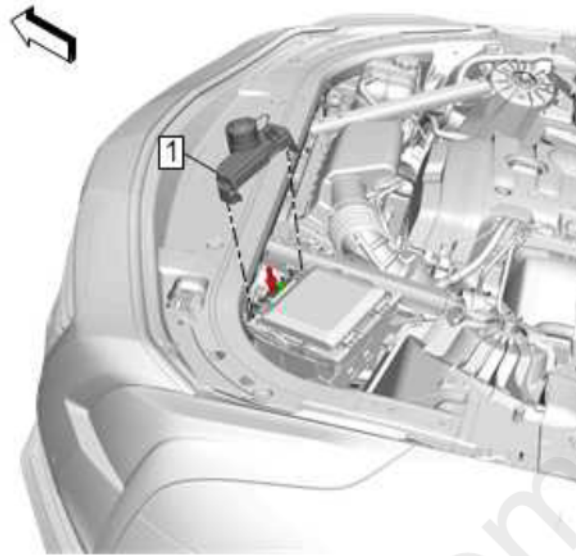


Fig. 17: Power Distributor Fuse Block Cover
Courtesy of GENERAL MOTORS COMPANY

4. Retainer (1)» Engage [9x]

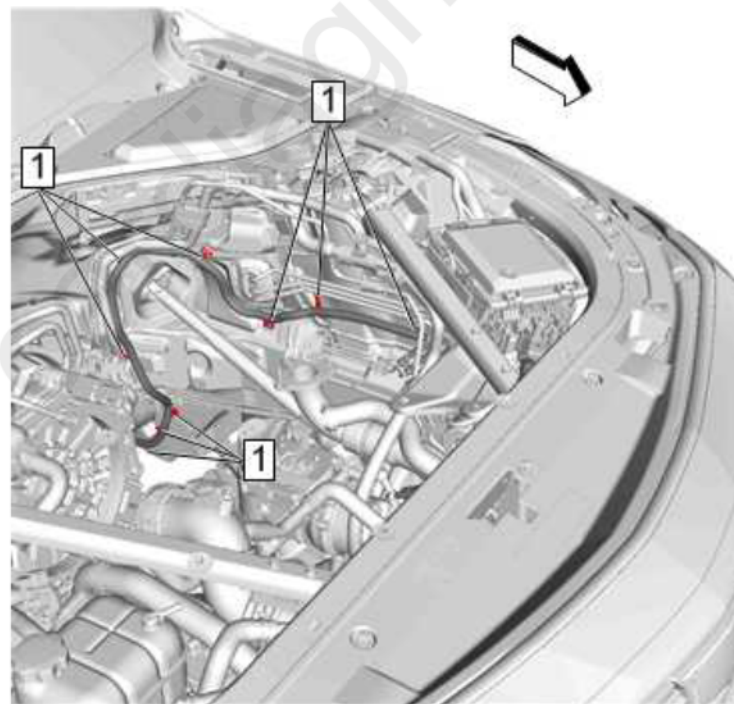


Fig. 18: Retainers
Courtesy of GENERAL MOTORS COMPANY

5. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle**
6. Retainer (2)» Engage [5x]

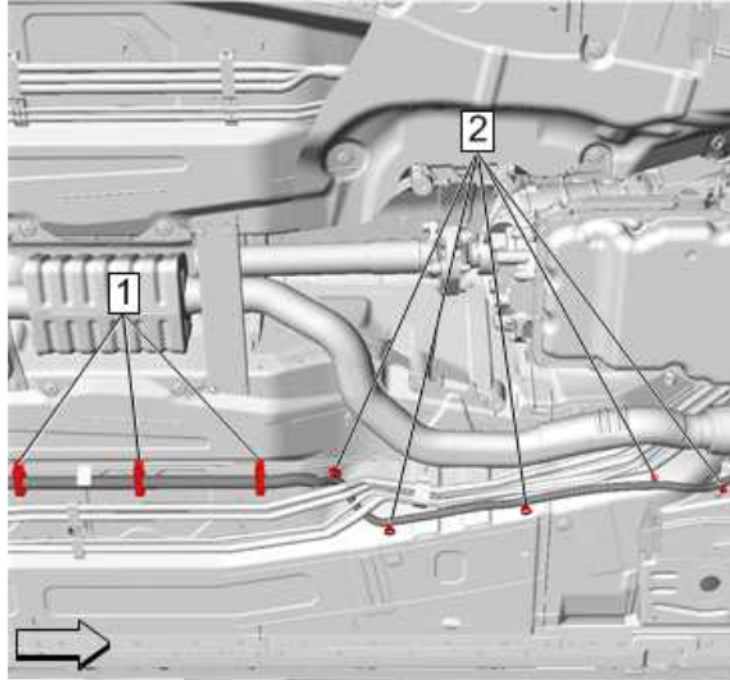


Fig. 19: Clips And Retainers

Courtesy of GENERAL MOTORS COMPANY

7. Secure the clips. (2) [3x]
8. Secure the clips. (1) [4x]

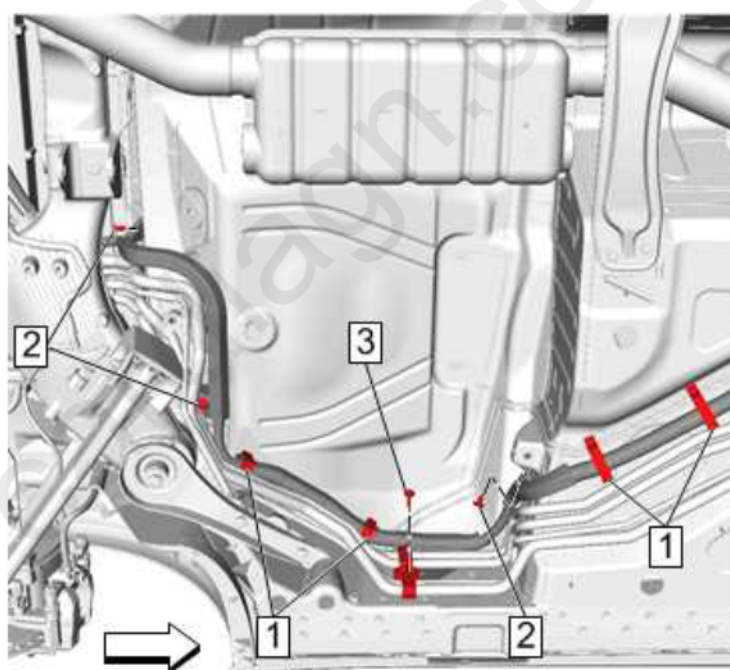


Fig. 20: Auxiliary A/C Evaporator Tube Bracket Fastener, Clips And Retainers

Courtesy of GENERAL MOTORS COMPANY

9. Install the auxiliary A/C evaporator tube bracket fastener. (3) Tighten 9 N.m (80 lb in)
10. Retainer (2) Engage [3x]
11. Retainer (1) Engage [6x]

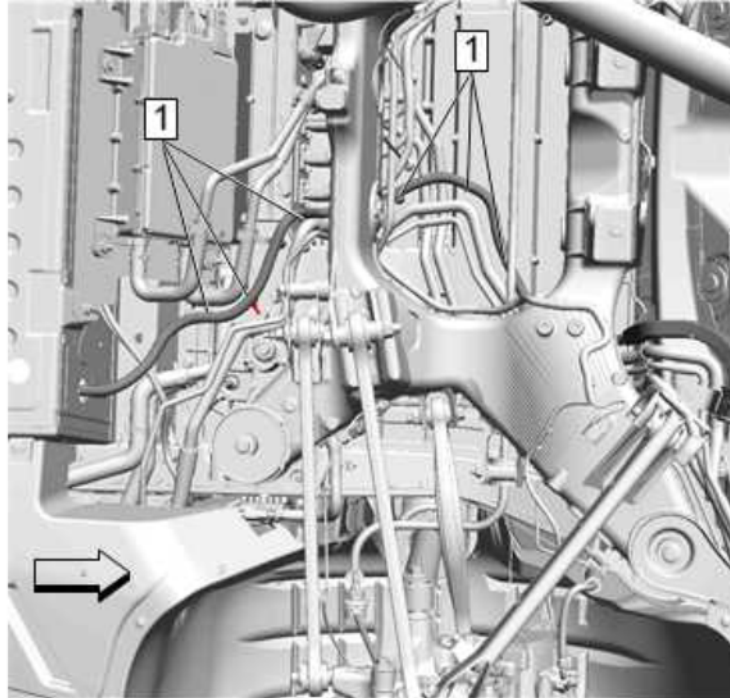


Fig. 21: Retainers

Courtesy of GENERAL MOTORS COMPANY

12. Feed the battery positive cable through rear compartment opening.
13. Fuel Tank (1)» Install - **Fuel Tank Replacement**

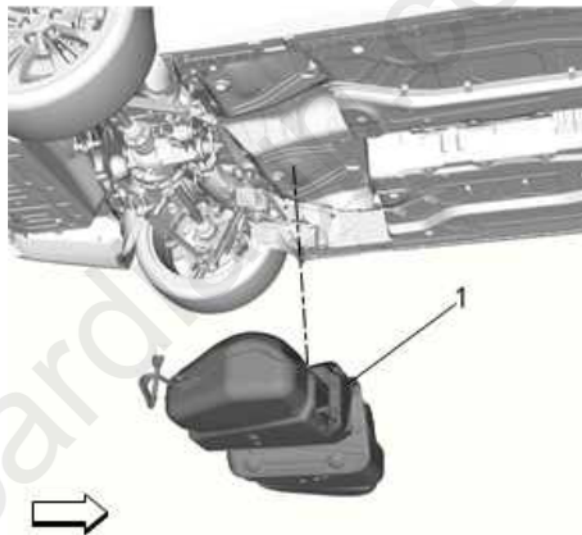


Fig. 22: Fuel Tank

Courtesy of GENERAL MOTORS COMPANY

14. Front Body Exhaust Heat Shield - Left (3)» Install - **Front Body Exhaust Heat Shield Replacement (Right Side, LTG) Front Body Exhaust Heat Shield Replacement (Left Side, LTG) Front Body Exhaust Heat Shield Replacement (Right Side, LGW, LGX) Front Body Exhaust Heat Shield Replacement (Left Side, LGW, LGX)**

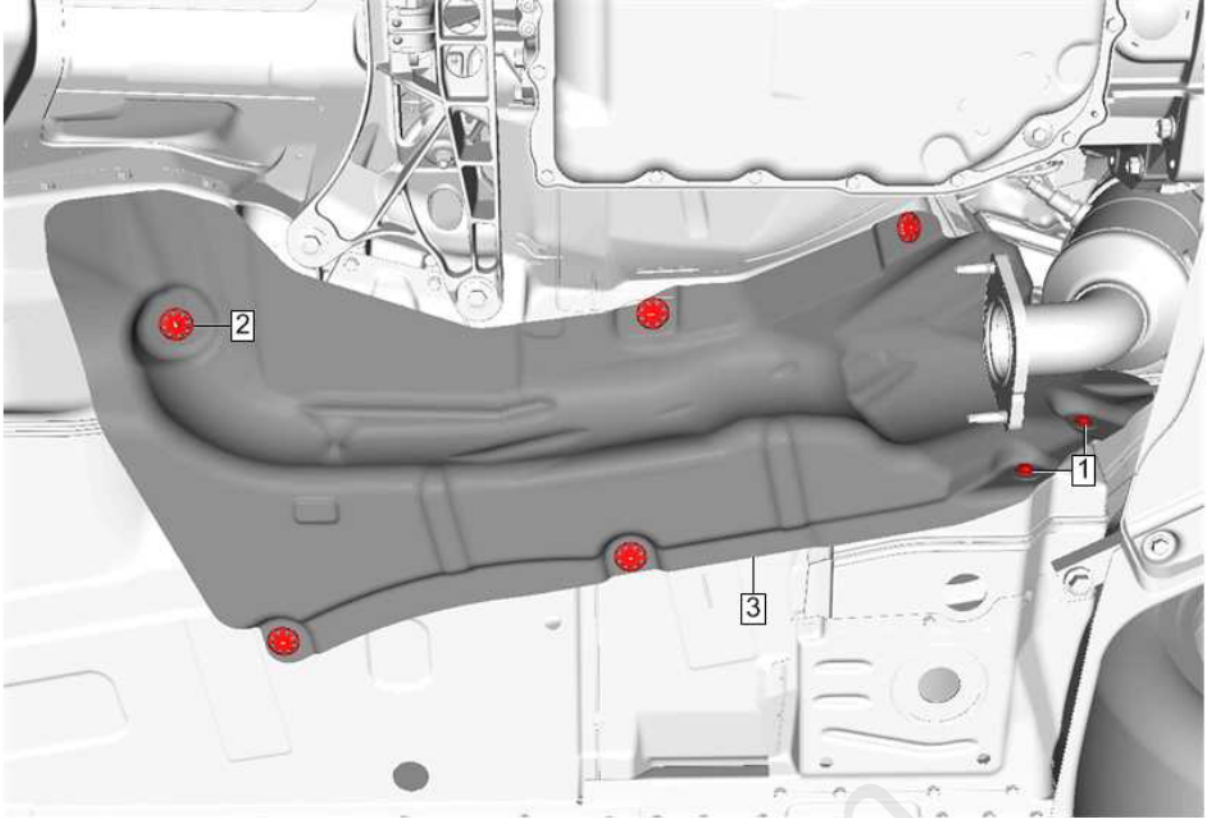


Fig. 23: Front Body Exhaust Heat Shield
 Courtesy of GENERAL MOTORS COMPANY

- 15. Lower the vehicle.
- 16. Rubber Grommet (3)» Install

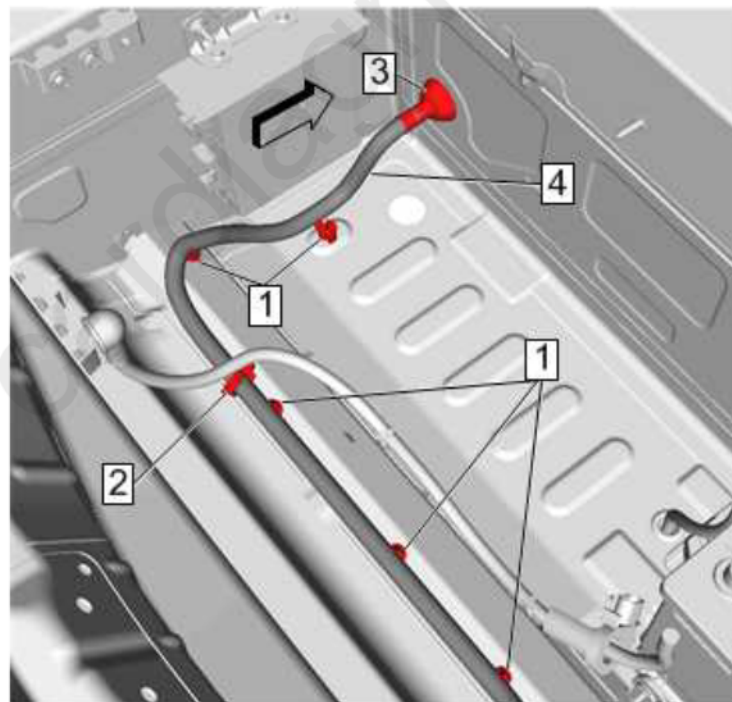


Fig. 24: Retainers, Rubber Grommet And Retainer Clip
 Courtesy of GENERAL MOTORS COMPANY

- 17. Retainer (1)» Engage [4x]
- 18. Retainer Clip (2)» Engage
- 19. Battery Positive Cable (2)» Install

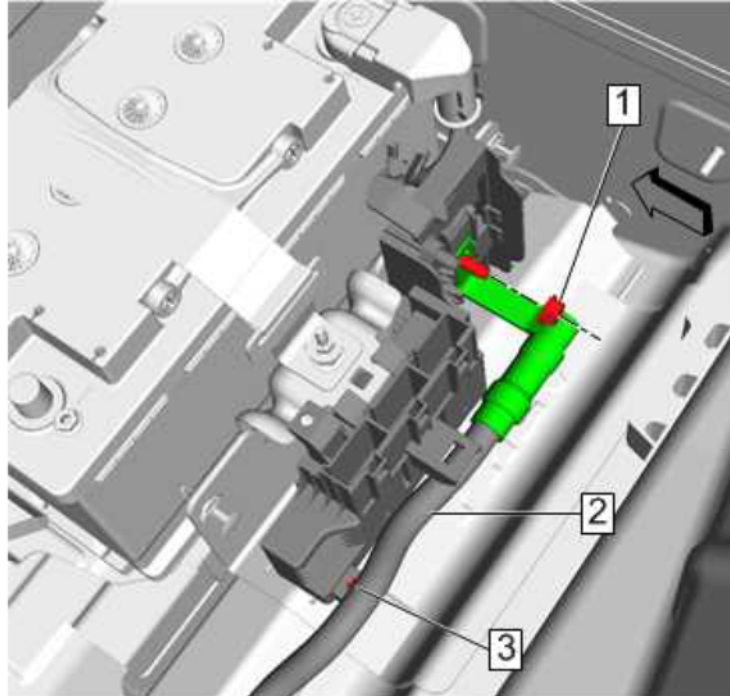


Fig. 25: Battery Positive Cable Nut

Courtesy of GENERAL MOTORS COMPANY

- 20. Battery Positive Cable Nut (1)» Install and tighten 15 N.m (11 lb ft)
- 21. Retainer (2)» Engage
- 22. Battery Distribution Fuse Block Cover (3)» Install

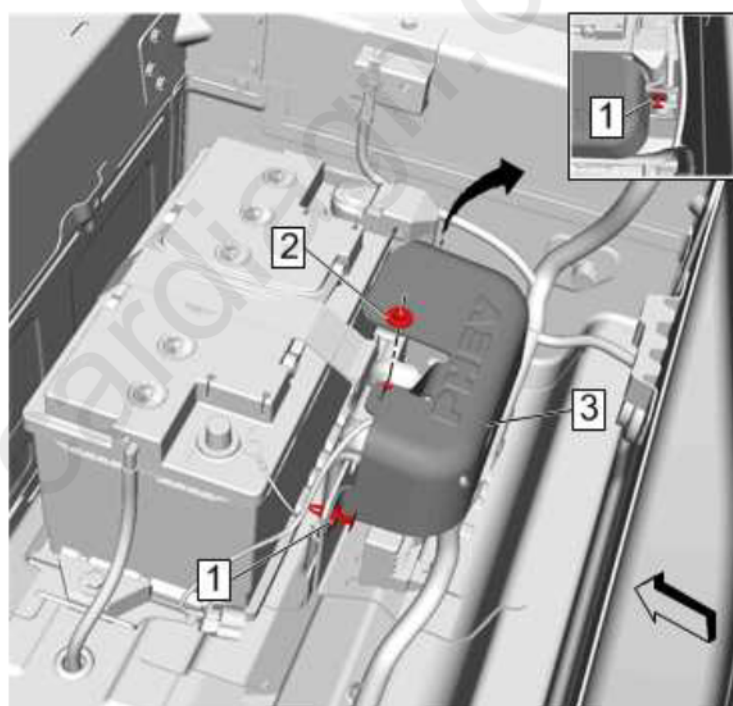


Fig. 26: Battery Distribution Fuse Block Cover

Courtesy of GENERAL MOTORS COMPANY

- 23. Battery Distribution Fuse Block Cover Retainer (1)» Engage [2x]
- 24. Battery Distribution Fuse Block Cover Fastener (2)» Install and tighten 9 N.m (80 lb in)
- 25. Connect the negative battery cable. Refer to [Battery Negative Cable Disconnection and Connection](#)
- 26. Rear Compartment Floor Stowage Compartment Tray (2)» Remove - [Rear Compartment Floor Stowage Compartment Tray Replacement \(With HP9\)](#)

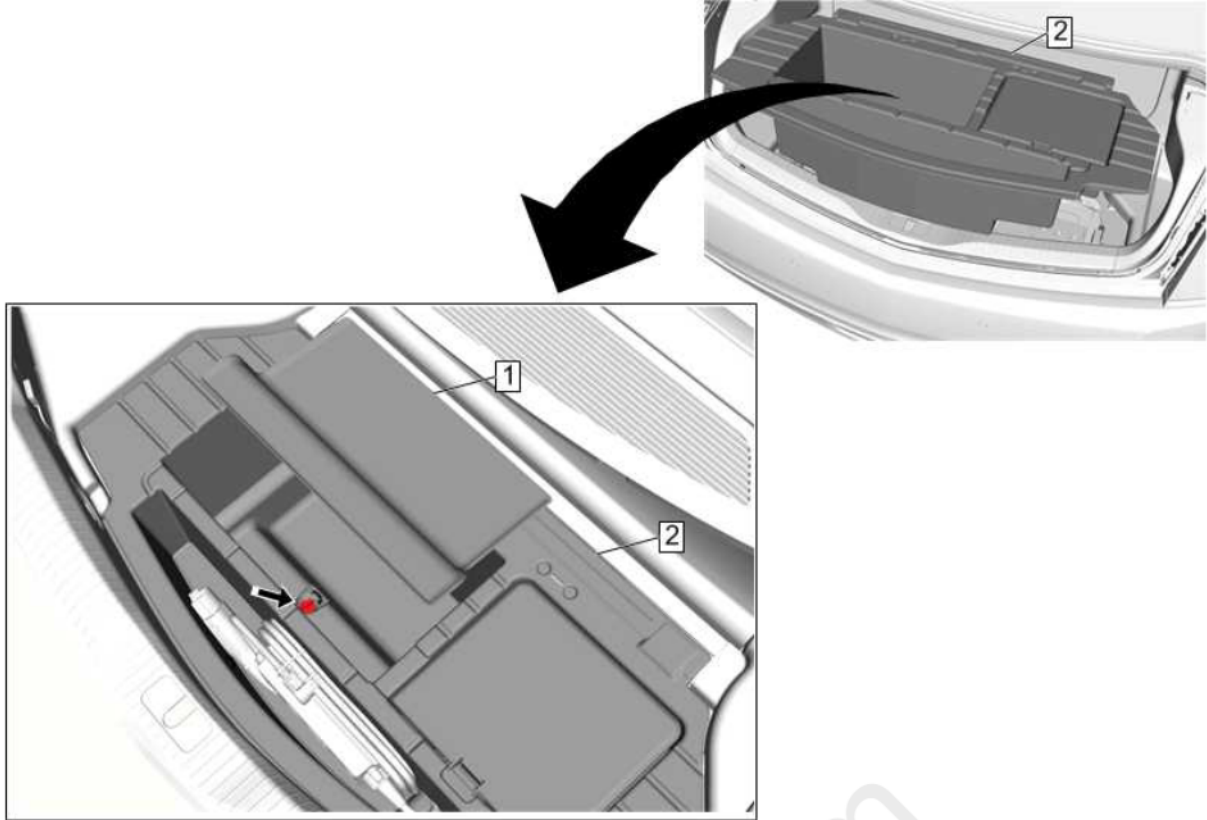


Fig. 27: Rear Compartment Floor Stowage Compartment Tray (With HP9)
 Courtesy of GENERAL MOTORS COMPANY

BATTERY REPLACEMENT

Removal Procedure

1. Disconnect the negative battery cable. Refer to [Battery Negative Cable Disconnection and Connection](#)
2. Battery Distribution Fuse Block Cover Fastener (2) » Remove

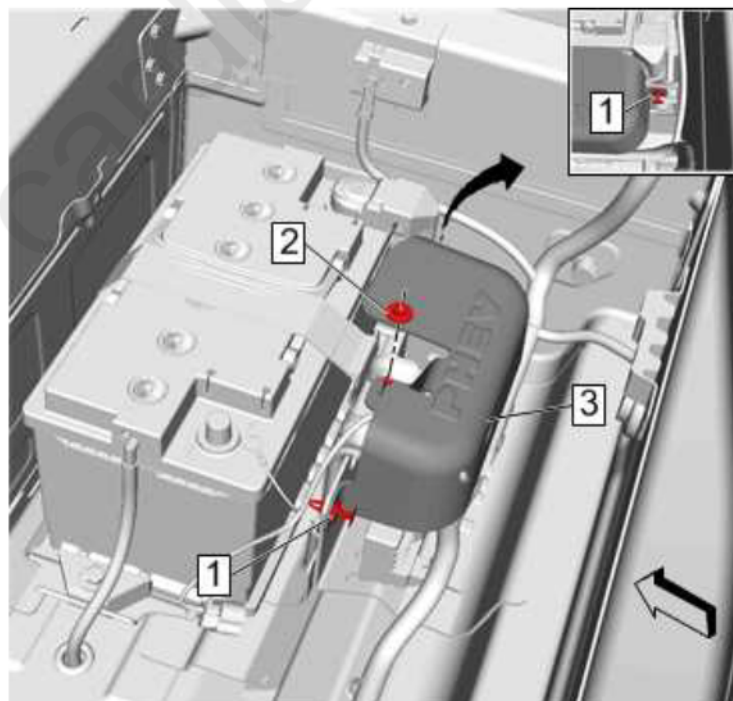


Fig. 28: Battery Distribution Fuse Block Cover
 Courtesy of GENERAL MOTORS COMPANY

3. Battery Distribution Fuse Block Cover Retainer (1) » Disengage [2x]
4. Battery Distribution Fuse Block Cover (3) » Remove
5. Battery Positive Post Cover (2) » Remove

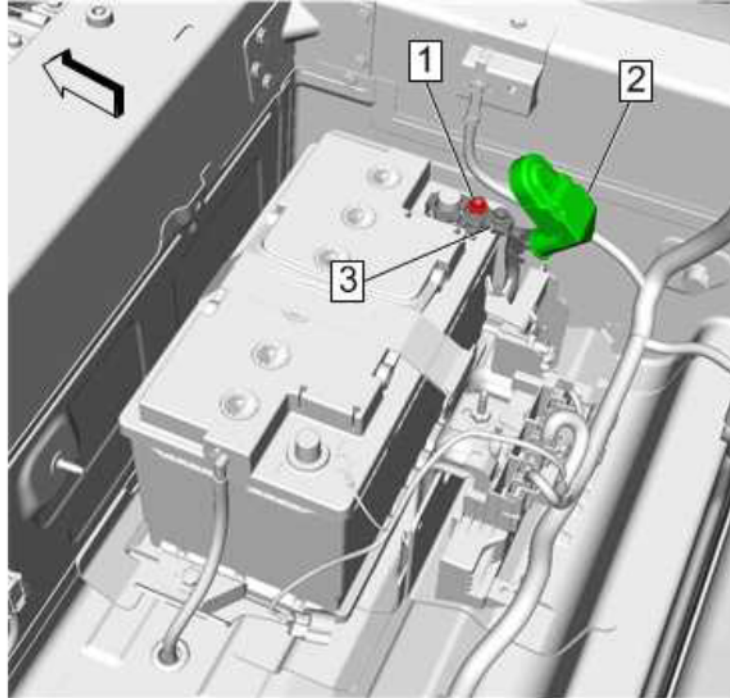


Fig. 29: Battery Positive Post Cover And Clamp Nut
Courtesy of GENERAL MOTORS COMPANY

- 6. Battery Positive Post Clamp Nut (1)» Loosen
- 7. Battery Positive Cable (3)» Reposition away
- 8. Battery Hold Down Strap Fastener (1)» Remove

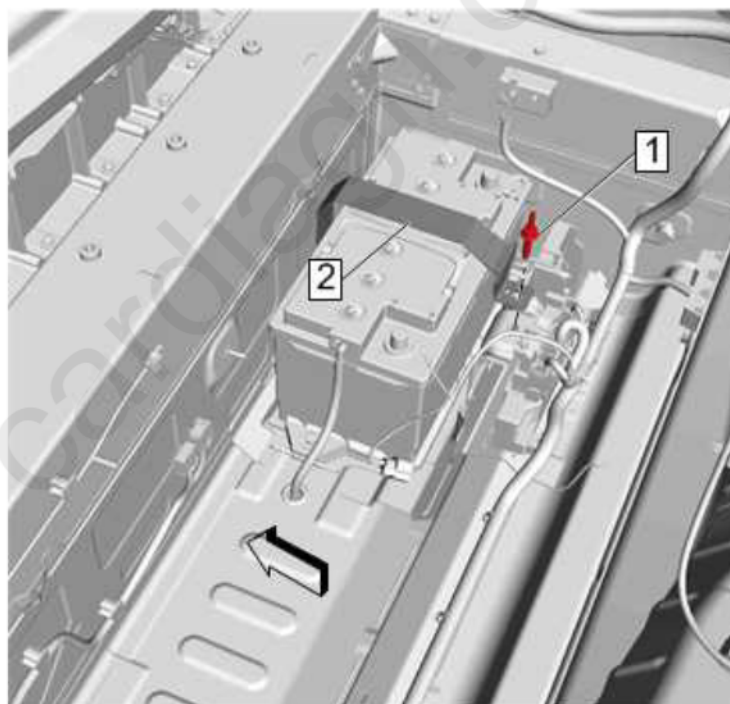


Fig. 30: Battery Hold Down Strap Fastener
Courtesy of GENERAL MOTORS COMPANY

- 9. Battery Hold Down Strap (2)» Reposition away
- 10. Battery Vent Tube (2)» Disengage

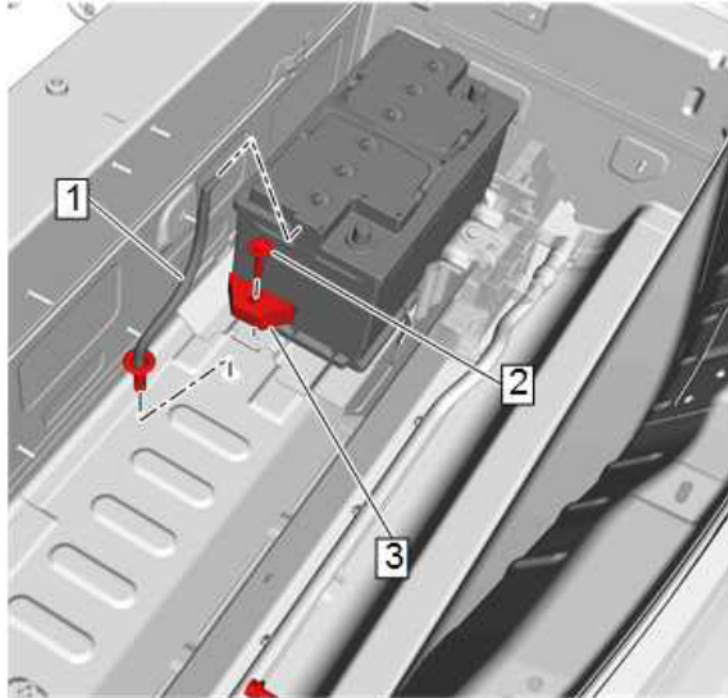


Fig. 31: Battery Vent Tube And Battery Hold Down Bolt
Courtesy of GENERAL MOTORS COMPANY

11. Battery Hold Down Bolt (1) » Remove
12. Battery Hold Down Retainer (3) » Remove
13. Battery (1) » Remove

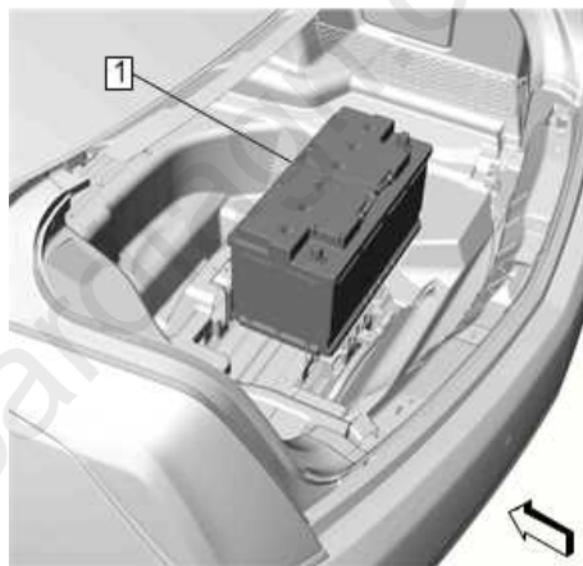


Fig. 32: Battery
Courtesy of GENERAL MOTORS COMPANY

Installation Procedure

1. Battery (1) » Install

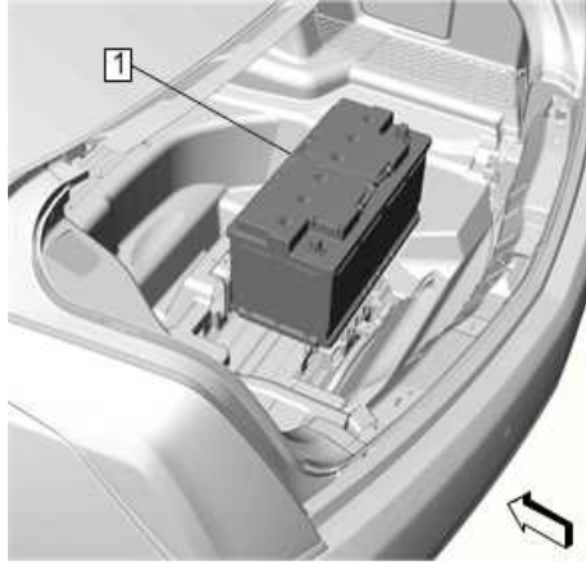


Fig. 33: Battery

Courtesy of GENERAL MOTORS COMPANY

2. Battery Vent Tube (2) » Engage

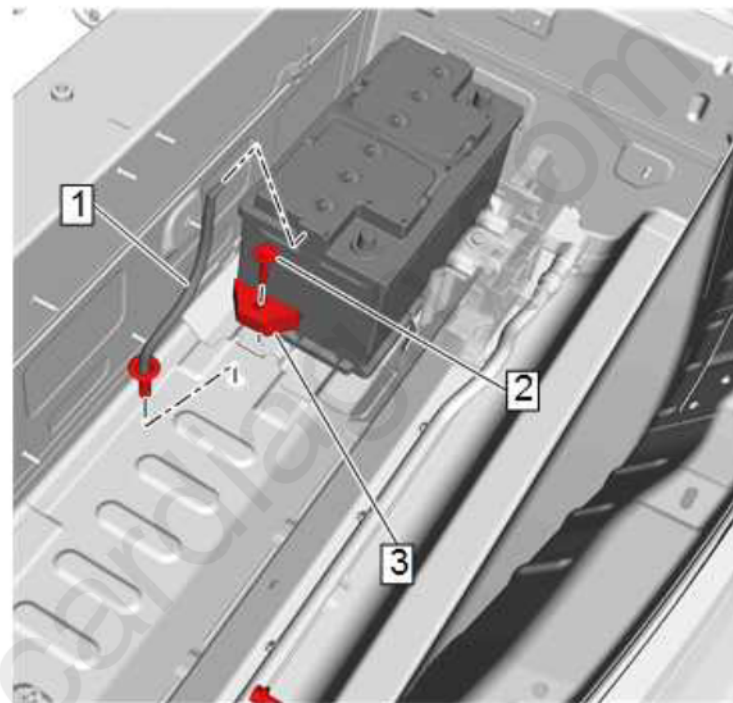


Fig. 34: Battery Vent Tube And Battery Hold Down Bolt

Courtesy of GENERAL MOTORS COMPANY

3. Battery Hold Down Retainer (3) » Install
4. Battery Hold Down Bolt (1) » Install and tighten 22 N.m (16 lb ft)

CAUTION: Refer to **Fastener Caution**

5. Battery Hold Down Strap (2) » Install

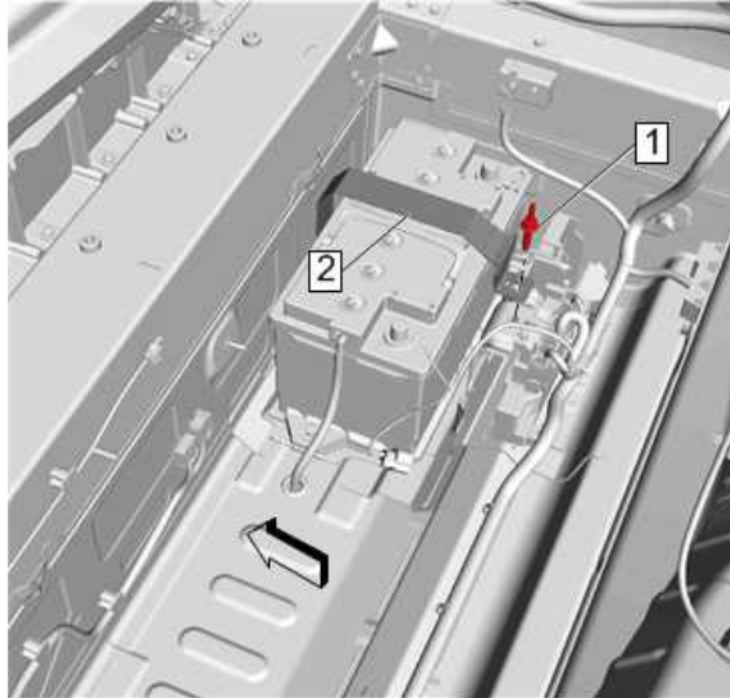


Fig. 35: Battery Hold Down Strap Fastener

Courtesy of GENERAL MOTORS COMPANY

- 6. Battery Hold Down Strap Fastener (1)» Install and tighten 9 N.m (80 lb in)
- 7. Battery Positive Cable (3)» Install

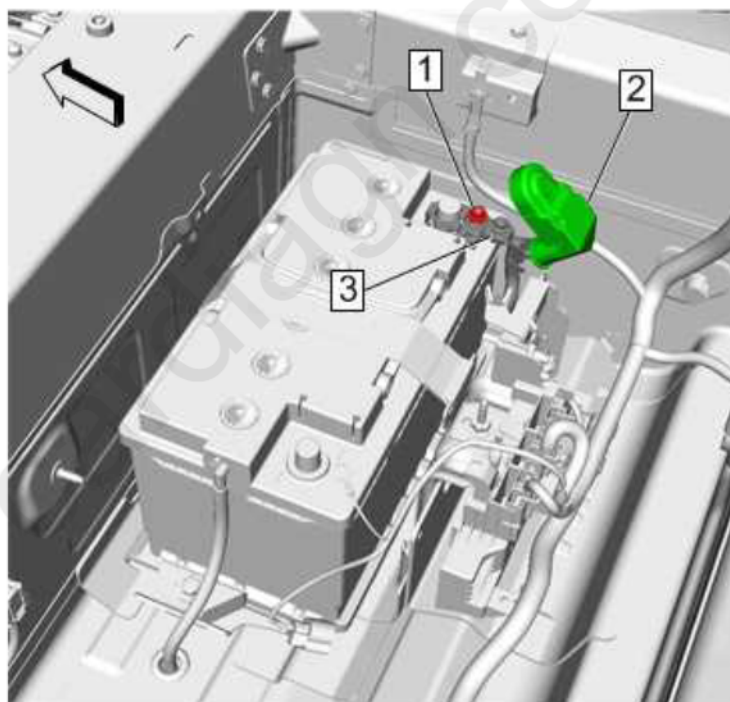


Fig. 36: Battery Positive Post Cover And Clamp Nut

Courtesy of GENERAL MOTORS COMPANY

- 8. Battery Positive Post Clamp Nut (1)» Tighten 6 N.m (53 lb in)
- 9. Battery Positive Post Cover (2)» Install
- 10. Battery Distribution Fuse Block Cover (3)» Install

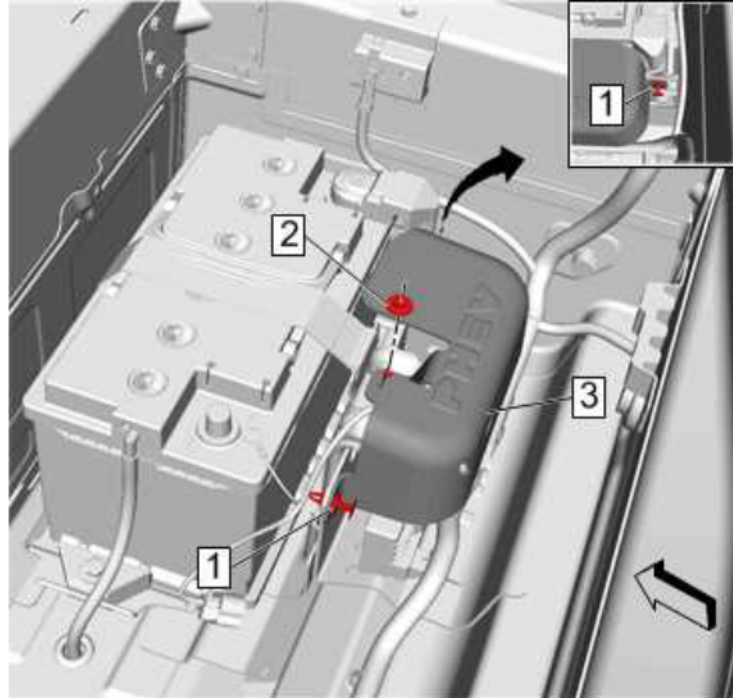


Fig. 37: Battery Distribution Fuse Block Cover
 Courtesy of GENERAL MOTORS COMPANY

11. Battery Distribution Fuse Block Cover Retainer (1) » Engage [2x]
12. Battery Distribution Fuse Block Cover Fastener (2) » Install and tighten 9 N.m (80 lb in)
13. Connect the negative battery cable. Refer to [Battery Negative Cable Disconnection and Connection](#)

GENERATOR CABLE REPLACEMENT

WARNING: Always perform the High Voltage Disabling procedure prior to servicing any High Voltage component or connection. Personal Protection Equipment (PPE) and proper procedures must be followed.

The High Voltage Disabling procedure includes the following steps:

- Identify how to disable high voltage.
- Identify how to test for the presence of high voltage.
- Identify condition under which high voltage is always present and personal protection equipment (PPE) and proper procedures must be followed.

Before working on any high voltage system, be sure to wear the following Personal Protection Equipment:

- Safety glasses with appropriate side shields when within 15 N.m (50 feet) of the vehicle, either indoors or outdoors.
- Certified and up-to-date Class "0" Insulation gloves rated at 1000V with leather protectors.
 - Visually and functionally inspect the gloves before use.
 - Wear the Insulation gloves with leather protectors at all times when working with the high voltage battery assembly, whether the system is energized or not.

Failure to follow the procedures may result in serious injury or death.

Removal Procedure

1. Disable the high voltage system. Refer to [High Voltage Disabling](#)
2. Air Cleaner Assembly (1) » Remove - [Air Cleaner Assembly Replacement](#)

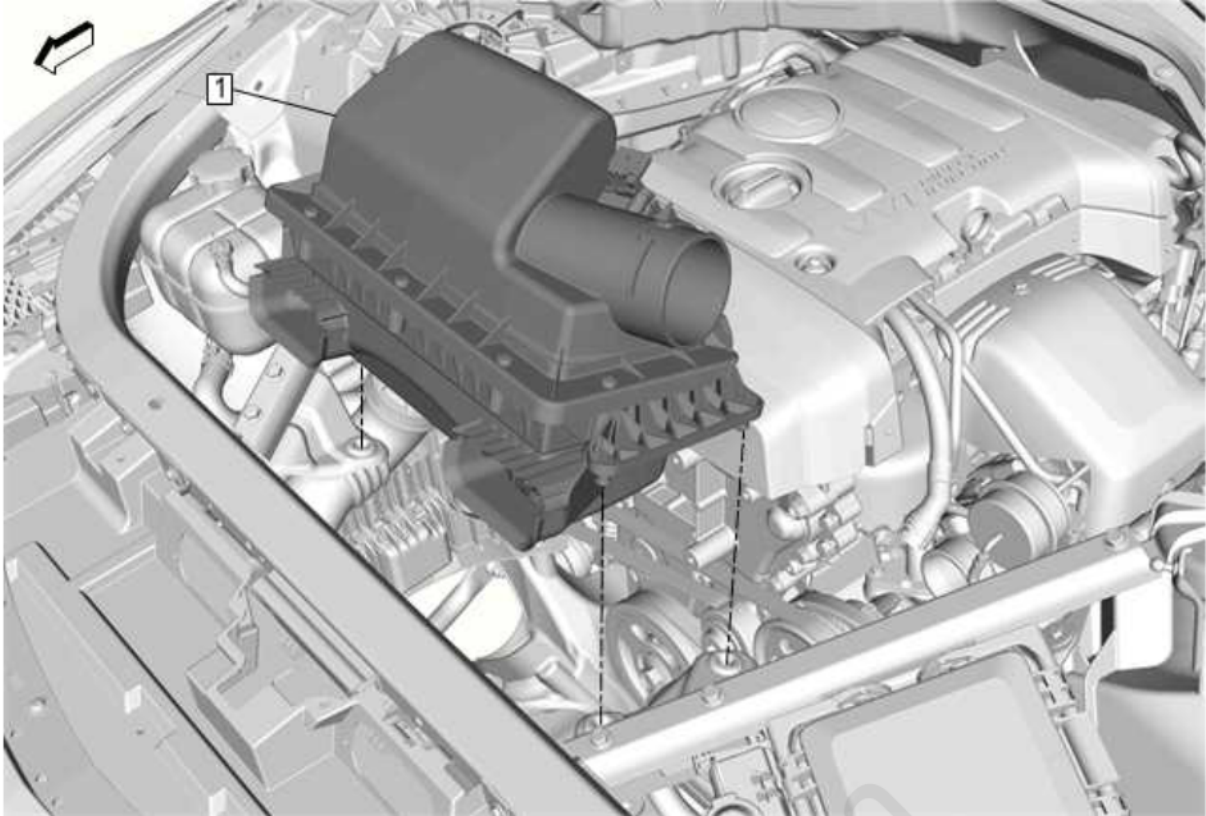


Fig. 38: Air Cleaner Assembly

Courtesy of GENERAL MOTORS COMPANY

3. Power Distributor Fuse Block Cover (1)» Remove

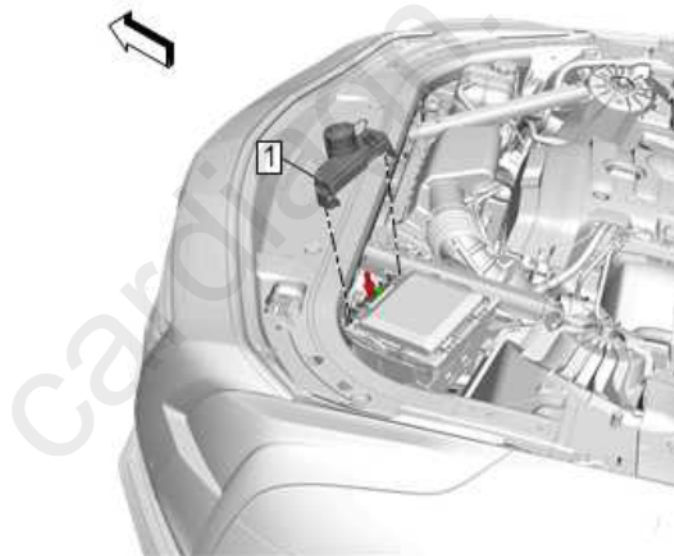


Fig. 39: Power Distributor Fuse Block Cover

Courtesy of GENERAL MOTORS COMPANY

4. Generator Cable Fastener (2)» Remove

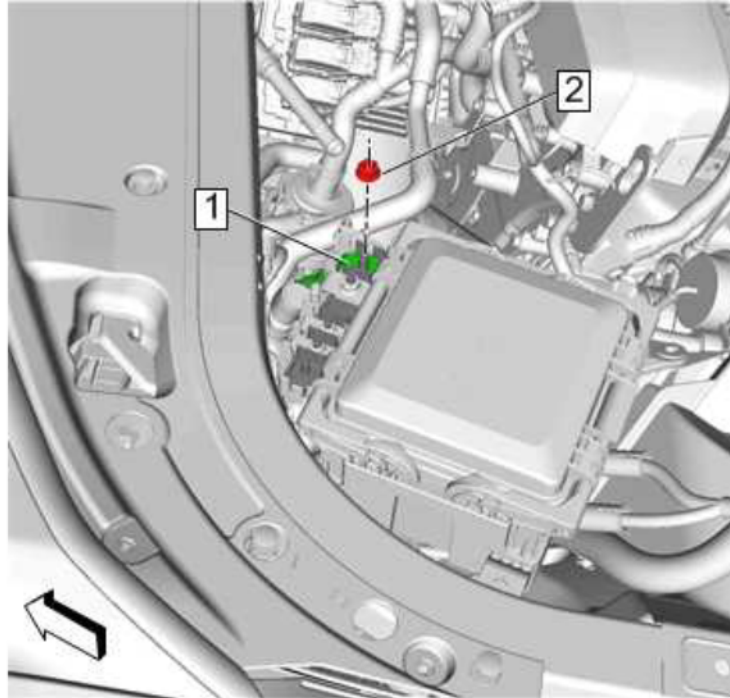


Fig. 40: Generator Cable And Fastener

Courtesy of GENERAL MOTORS COMPANY

5. Generator Cable (1) » Remove
6. Retainer (1) » Disengage [2x]

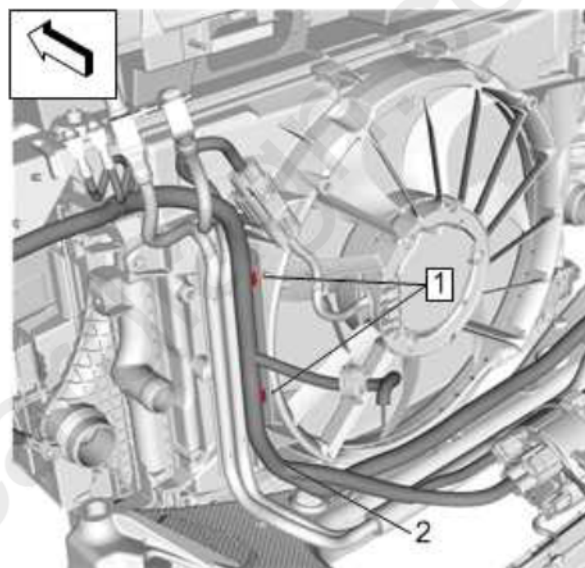


Fig. 41: Wiring Harness Retainer

Courtesy of GENERAL MOTORS COMPANY

7. Engine Wiring Harness (2) » Reposition away
8. Retainer (1) » Disengage [2x]

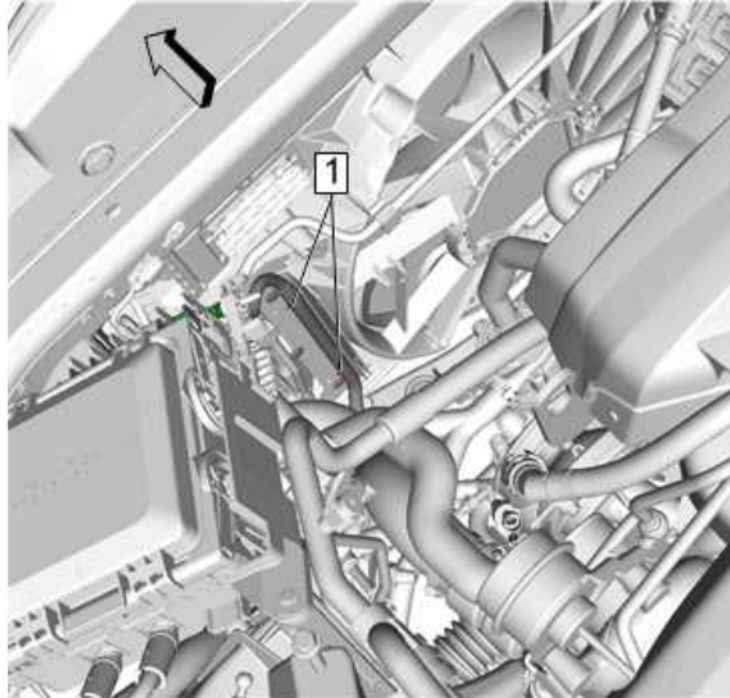


Fig. 42: Retainers

Courtesy of GENERAL MOTORS COMPANY

9. Underbody Front Air Deflector (4) » Remove - **Underbody Front Air Deflector Replacement**

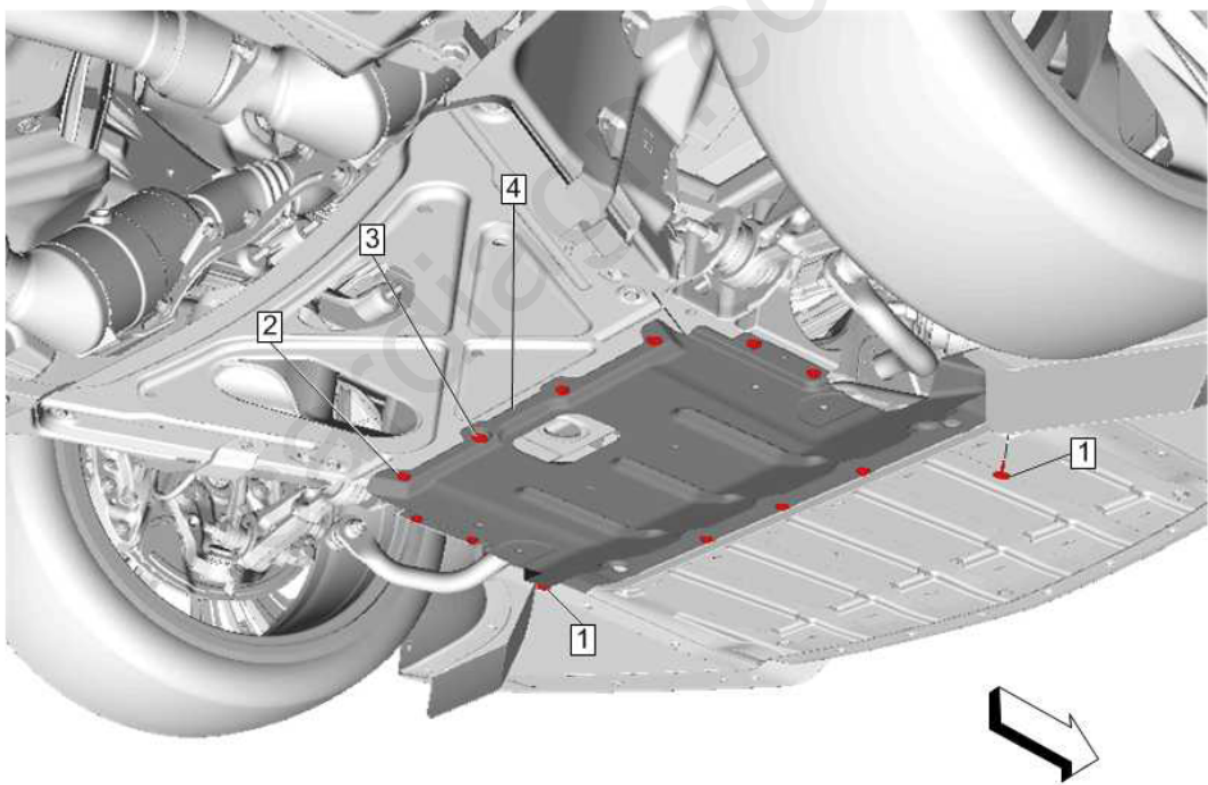


Fig. 43: Underbody Front Air Deflector

Courtesy of GENERAL MOTORS COMPANY

10. Retainer (1) » Disengage

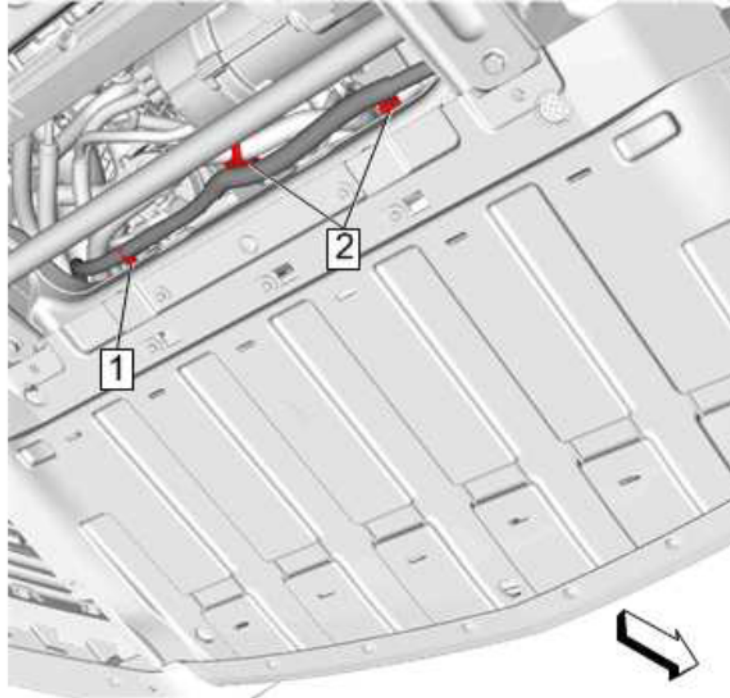


Fig. 44: Retainer And Clips

Courtesy of GENERAL MOTORS COMPANY

- 11. Retainer Clip (2)» Disengage [2x]
- 12. Retainer (1)» Disengage [2x]

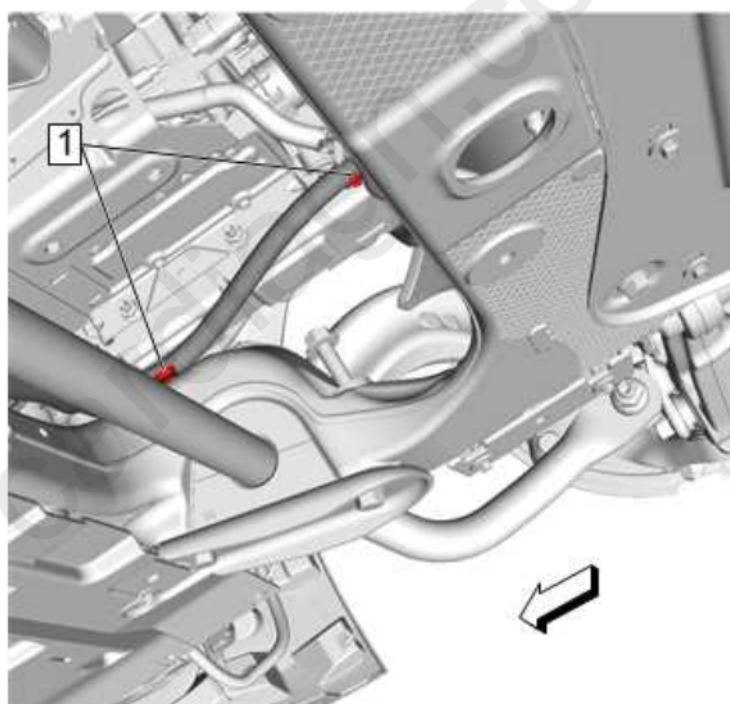


Fig. 45: Retainers

Courtesy of GENERAL MOTORS COMPANY

- 13. Radiator Inlet Hose (2)» Remove - **Radiator Inlet Hose Replacement (LTG without HP9)** , **Radiator Inlet Hose Replacement (LGW)** , **Radiator Inlet Hose Replacement (LGX)** and/or **Radiator Inlet Hose Replacement (LTG with HP9)**

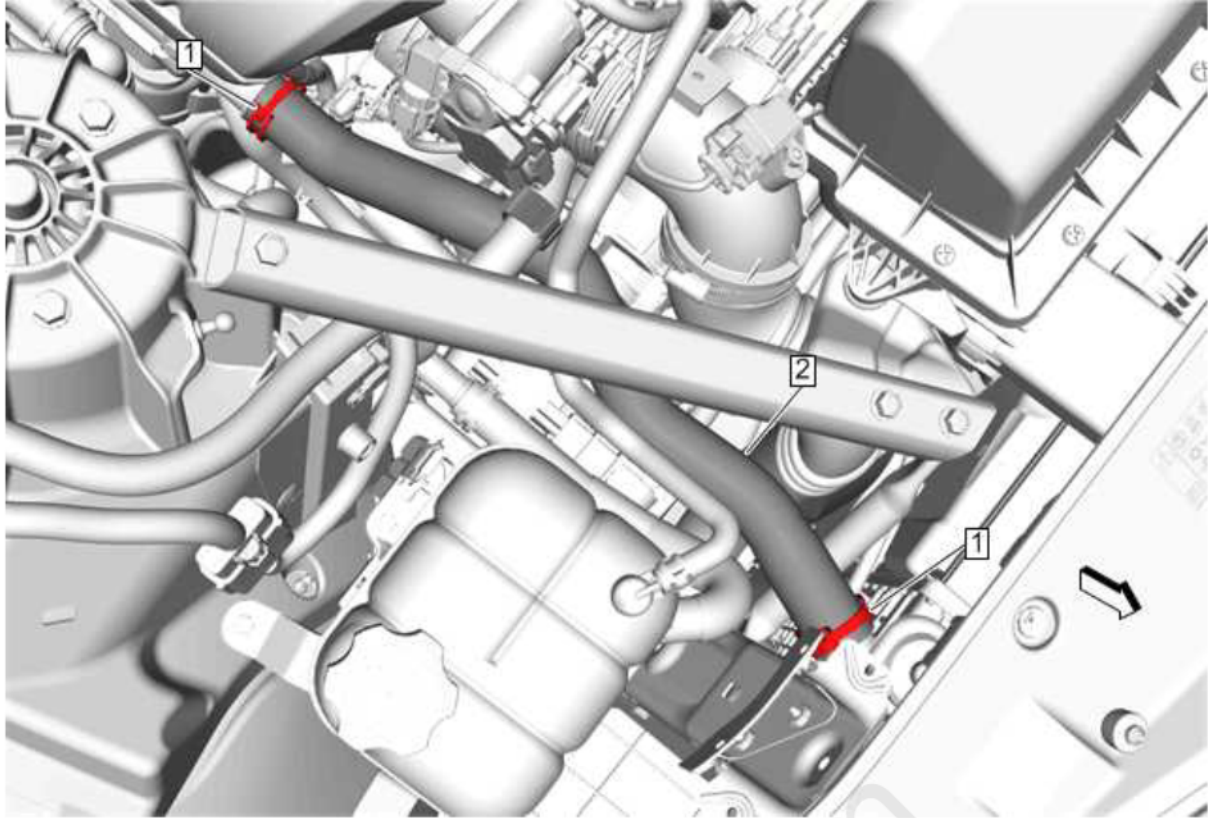


Fig. 46: Radiator Inlet Hose

Courtesy of GENERAL MOTORS COMPANY

14. Retainer (1) » Disengage

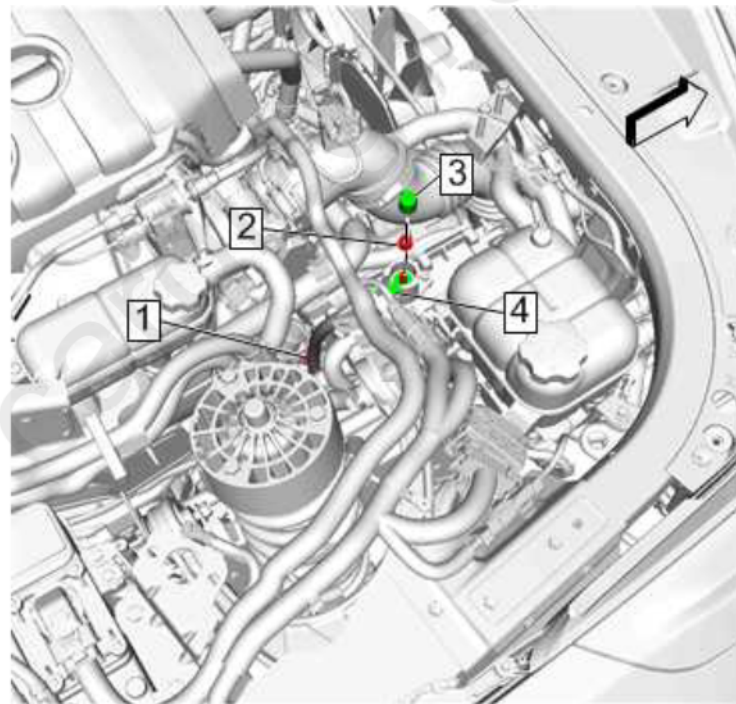


Fig. 47: Retainer, Protective Cap, Generator Cable And Fastener

Courtesy of GENERAL MOTORS COMPANY

- 15. Protective Cap (3) » Remove
- 16. Generator Cable Fastener (2) » Remove
- 17. Generator Cable (4) » Remove

Installation Procedure

- 1. Generator Cable (4) » Install

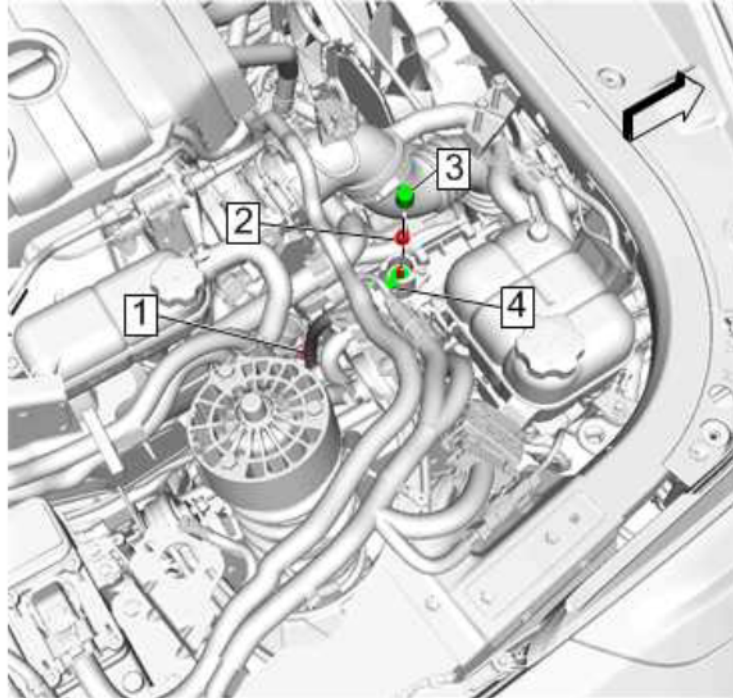


Fig. 48: Retainer, Protective Cap, Generator Cable And Fastener
 Courtesy of GENERAL MOTORS COMPANY

2. Generator Cable Fastener (2) » Install and tighten 12 N.m (106 lb in)

CAUTION: Refer to [Fastener Caution](#)

3. Protective Cap (3) » Install
4. Retainer (1) » Engage
5. Radiator Inlet Hose (2) » Install - [Radiator Inlet Hose Replacement \(LTG without HP9\)](#) , [Radiator Inlet Hose Replacement \(LGW\)](#) , [Radiator Inlet Hose Replacement \(LGX\)](#) and/or [Radiator Inlet Hose Replacement \(LTG with HP9\)](#)

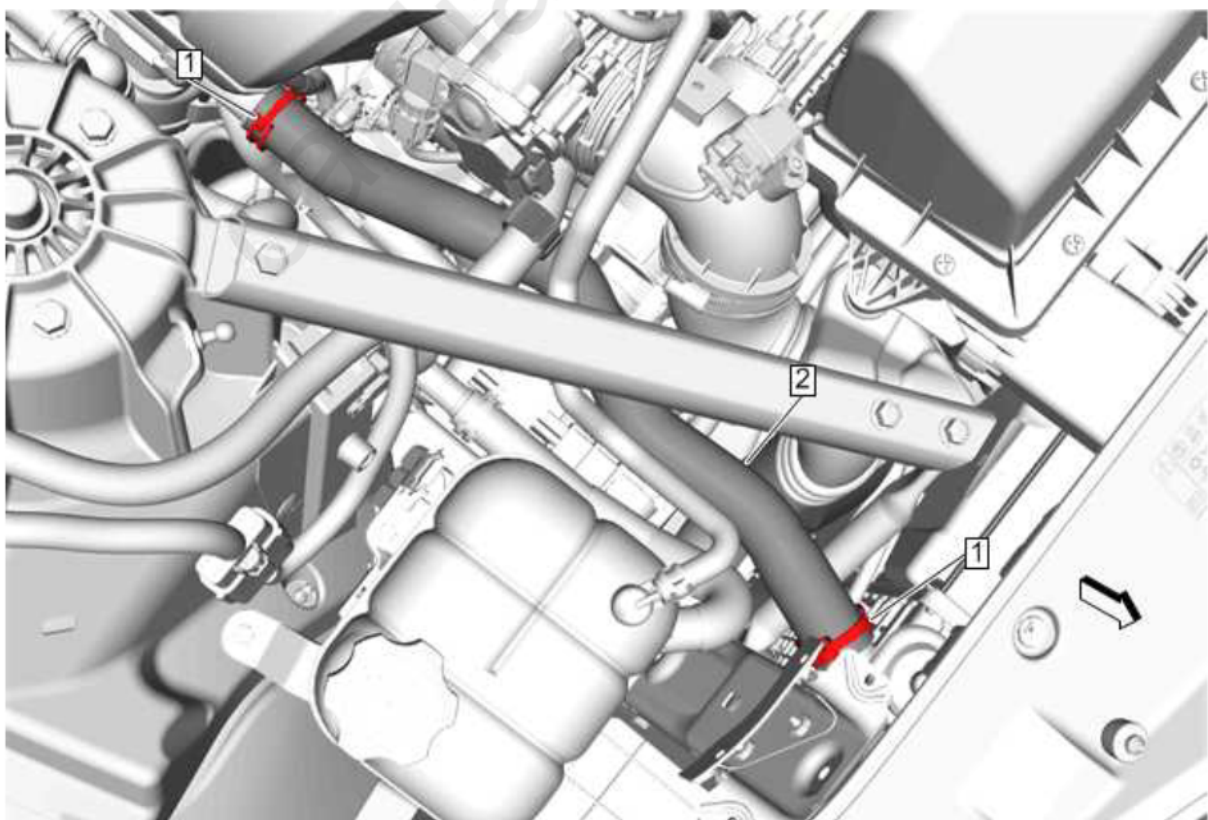


Fig. 49: Radiator Inlet Hose
 Courtesy of GENERAL MOTORS COMPANY

6. Retainer (1) » Engage [2x]

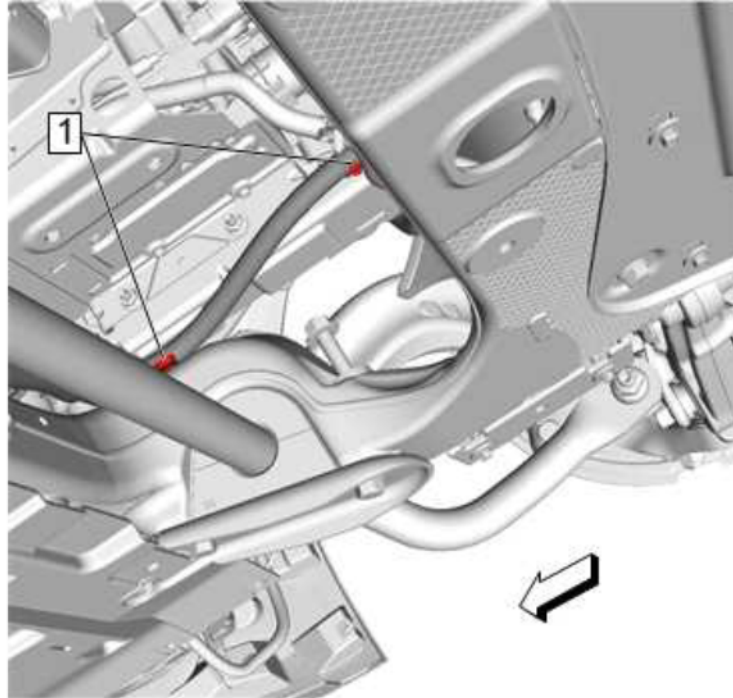


Fig. 50: Retainers

Courtesy of GENERAL MOTORS COMPANY

7. Retainer (1) » Engage

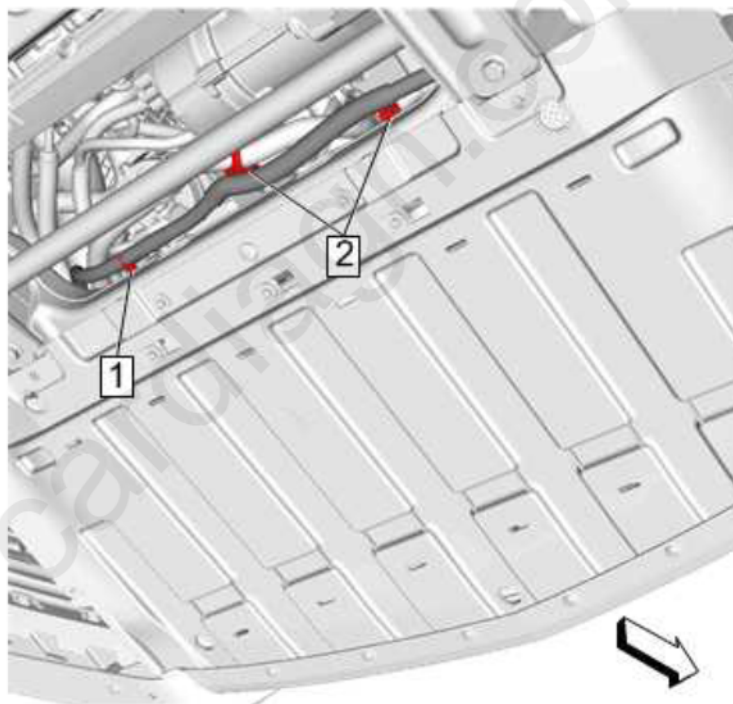


Fig. 51: Retainer And Clips

Courtesy of GENERAL MOTORS COMPANY

8. Retainer Clip (2) » Engage [2x]
 9. Underbody Front Air Deflector (4) » Install - [Underbody Front Air Deflector Replacement](#)

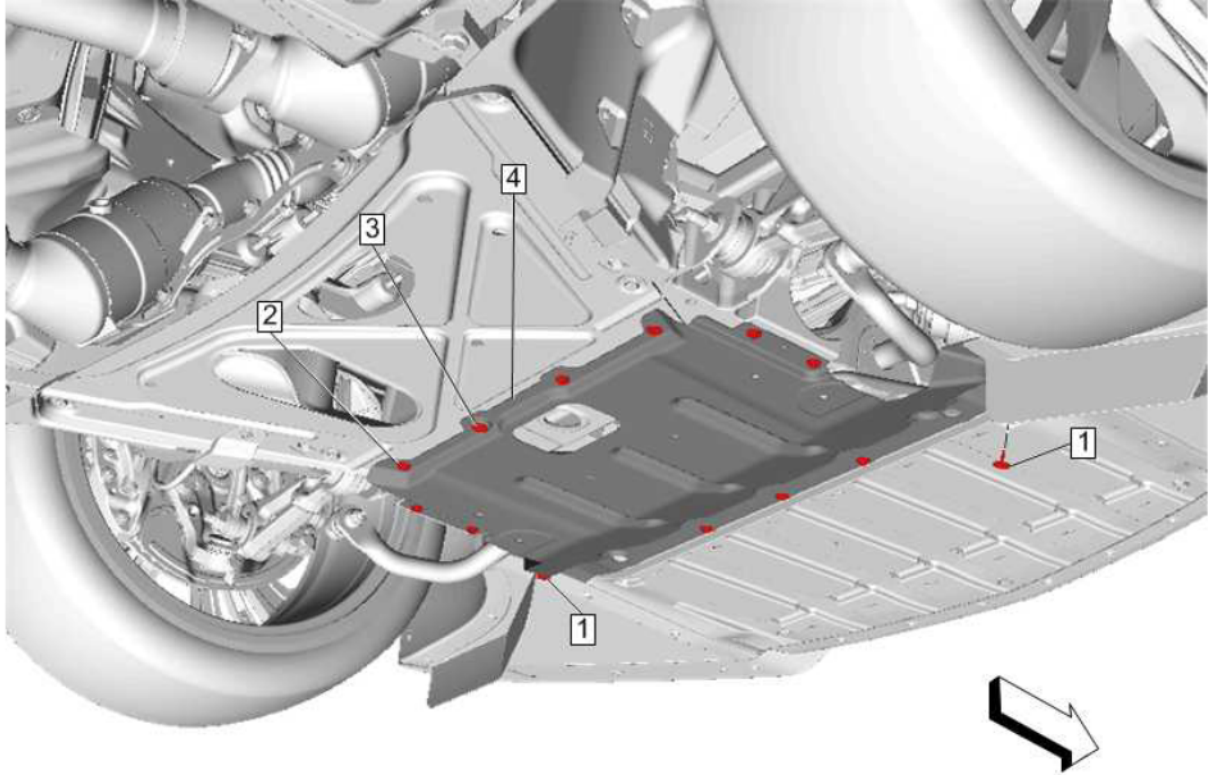


Fig. 52: Underbody Front Air Deflector
 Courtesy of GENERAL MOTORS COMPANY

10. Retainer (1) Engage [2x]

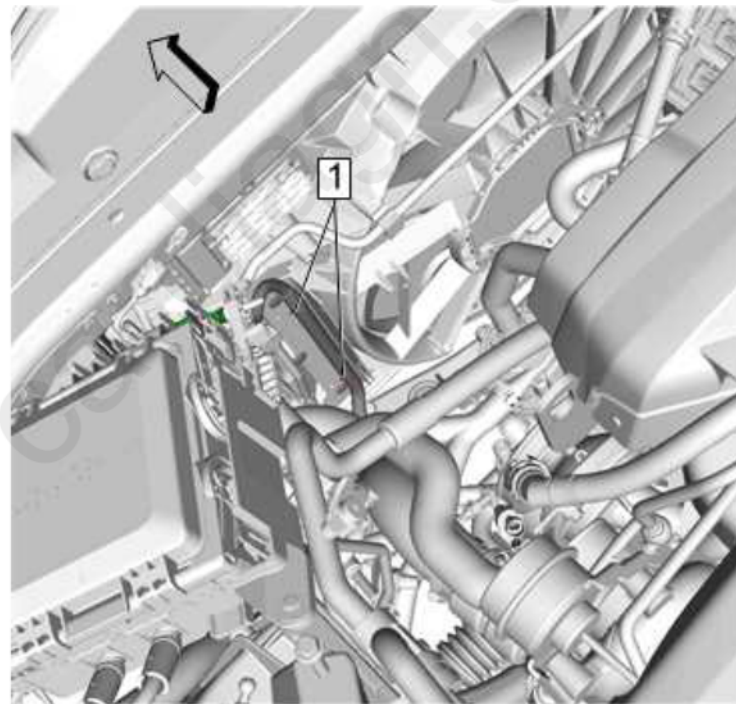


Fig. 53: Retainers
 Courtesy of GENERAL MOTORS COMPANY

11. Wiring Harness Retainer (1) Engage [2x]

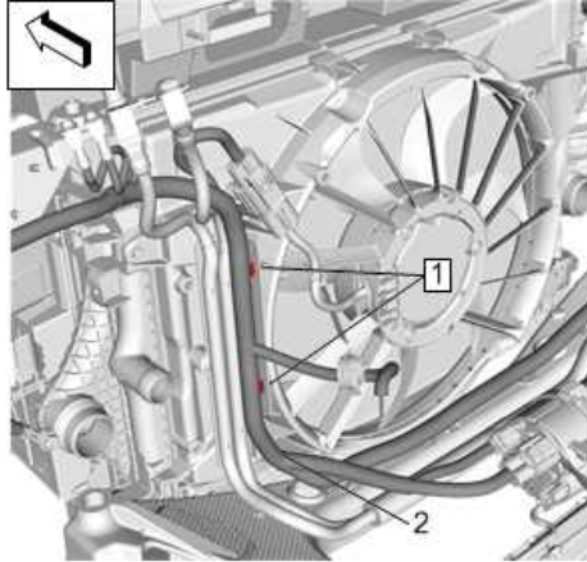


Fig. 54: Wiring Harness Retainer

Courtesy of GENERAL MOTORS COMPANY

12. Generator Cable (1)» Install

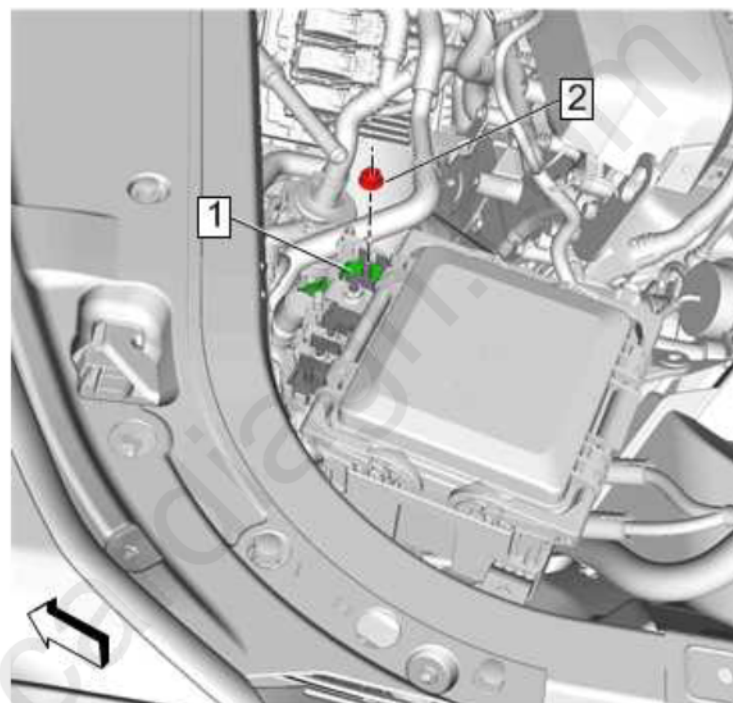


Fig. 55: Generator Cable And Fastener

Courtesy of GENERAL MOTORS COMPANY

13. Generator Cable Fastener (2)» Install and tighten 12 N.m (106 lb in)

14. Power Distributor Fuse Block Cover (1)» Install

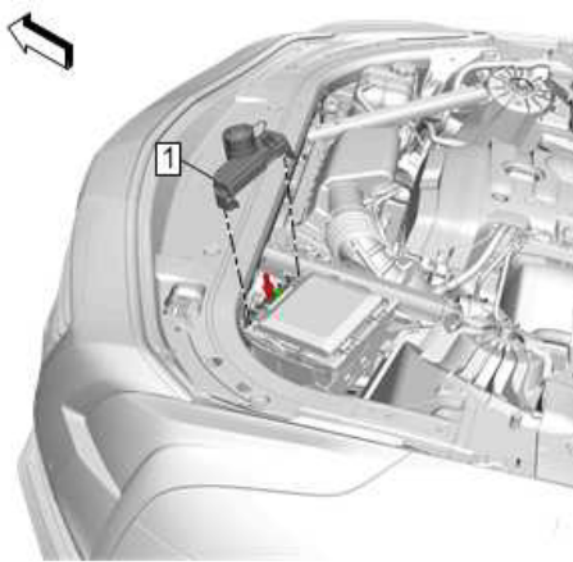


Fig. 56: Power Distributor Fuse Block Cover
 Courtesy of GENERAL MOTORS COMPANY

15. Air Cleaner Assembly (1)» Install - [Air Cleaner Assembly Replacement](#)

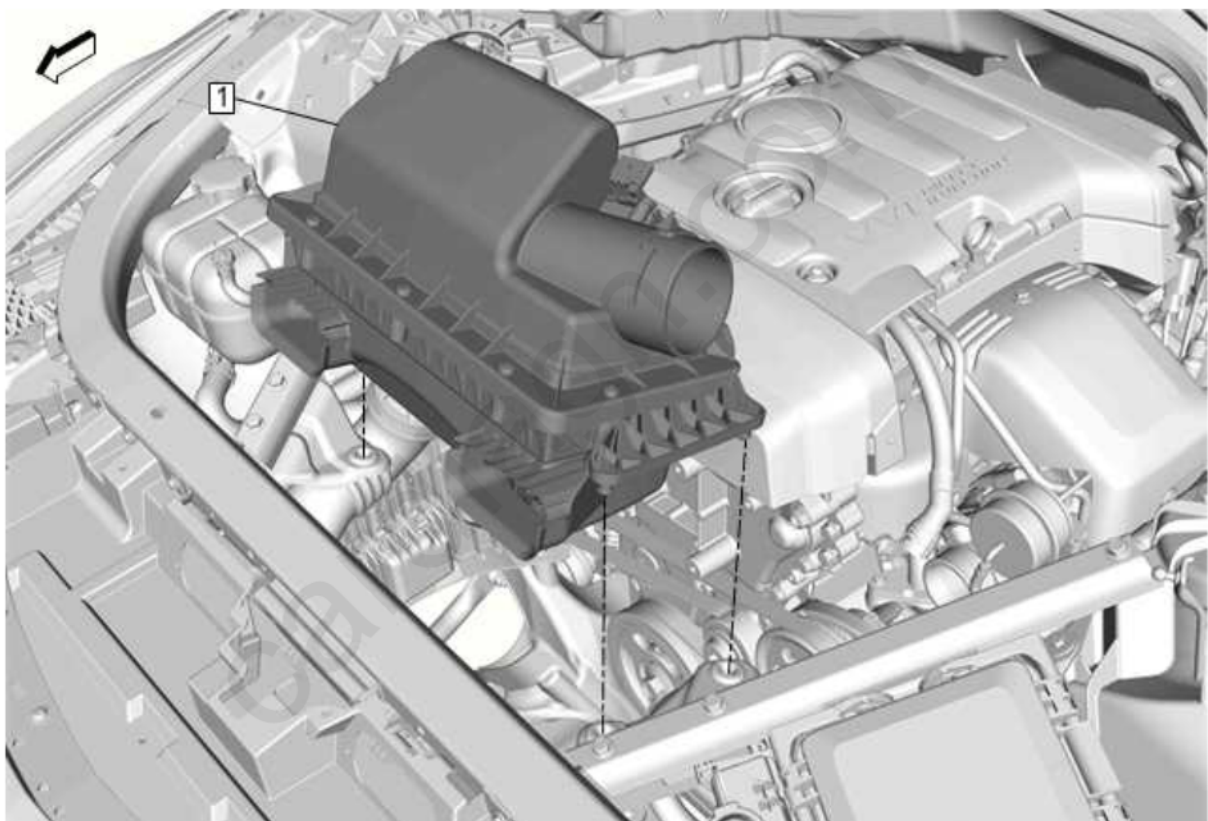


Fig. 57: Air Cleaner Assembly
 Courtesy of GENERAL MOTORS COMPANY

16. Enable the high voltage system. Refer to [High Voltage Enabling](#)

DESCRIPTION AND OPERATION

BATTERY DESCRIPTION AND OPERATION

300 V Battery

For information about the 355 V hybrid drive motor battery, refer to [Drive Motor Battery System Description](#) .

Absorbent Glass Mat Battery

This vehicle is equipped with an absorbent glass mat battery. This is similar to current vehicle lead acid flood batteries, except they use glass mats that absorb electrolytes that are pressed between the plates

instead of immersing the plates in electrolytes. This allows a smaller, lighter battery with the same amount of power and is less susceptible to heat.

The maximum permissible voltage allowed for the absorbent glass mat battery is 14.8 V (at room temperature).

12 V Battery

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.

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.

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 the battery specification label on the original battery for the cold cranking amperage rating for this vehicle.

CHARGING SYSTEM DESCRIPTION AND OPERATION

12 V Battery

The following information is for the 12 V battery only.

For information about charging the high voltage drive motor batteries, refer to [**Drive Motor Battery System Description**](#).

Charging System Operation

The purpose of the charging system is to maintain the battery charge and vehicle loads. The main difference between a conventional generator charging system and this system is that the generator has been replaced by the 14V Power Module. The 14V Power Module provides the power to charge the battery from the high voltage system. There are 7 modes of operation and they include:

- Battery Sulfation Mode
- Normal Mode
- Fuel Economy Mode
- Headlamp Mode
- Voltage Reduction Mode
- Battery Maintenance Mode
- Plant Assembly Mode

Charging Block Diagram

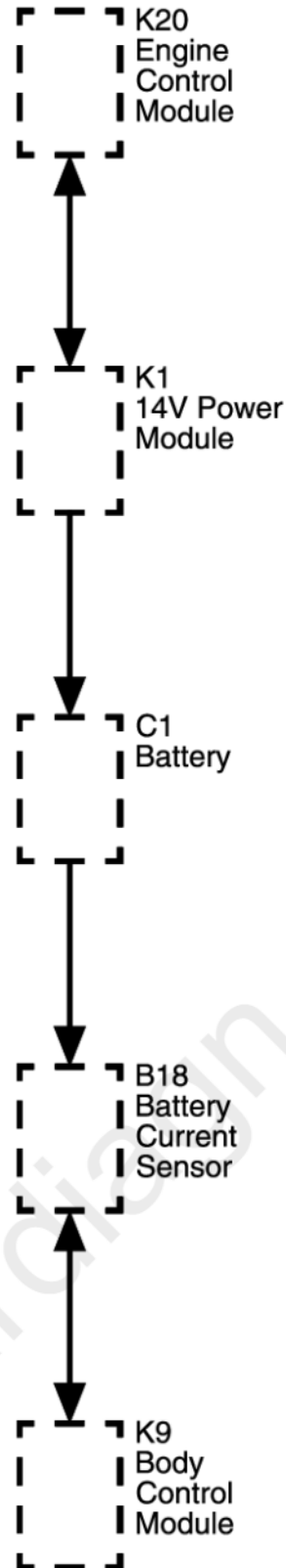


Fig. 58: Charging Block Diagram

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
K1	K1 14V Power Module
C1	C1 Battery
B18	B18 Battery Current Sensor
K20	K20 Engine Control Module
K9	K9 Body Control Module

Charging System Components

14 V Power Module

The 14V Power Module provides the power to charge the battery from the high voltage system. The ECM provides a pulse width charge request signal (L Terminal) to the 14V Power Module. The 14V

Power Module returns a PWM feedback signal (F Terminal) to the ECM. The 14V Power Module reports status and fault modes as a function of duty cycle. The 14V Power Module charges the battery based on the ECM signal.

Drive Motor/Generators

The drive motor/generators are serviceable components located within the transmission housing. When the rotors are spun, an alternating current (AC) is induced into the stator windings. This AC voltage is then sent to the drive motor generator power inverter module (PIM) where it is converted to high voltage direct current (DC) power. The output of the PIM is converted into low voltage electrical power by the accessory DC power converter module 14V Power Module for use by the vehicle's electrical system to maintain electrical loads and battery charge.

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 operation. The BCM determines the desired voltage set point and sends the information to the engine control module (ECM) which sends this information to the 14V Power Module. The BCM monitors a battery current sensor, the battery positive voltage circuit and estimated battery temperature to determine battery state of charge.

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 V 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)

The ECM receives control decisions based on messages from the BCM as well as the HPCM2

Instrument Panel Cluster

The instrument panel cluster provides a means of customer notification in case of a failure and a voltmeter. There are 2 means of notification, a charge indicator and a driver information center message of SERVICE BATTERY CHARGING SYSTEM.

Hybrid/EV Powertrain Control Module 2 (HPCM2)

The Hybrid/EV Powertrain control module (HPCM2) is a GMLAN device. It communicates with the engine control module (ECM) to control the voltage set point sent to the 14V Power Module during the battery maintenance mode.

Battery Sulfation Mode

Battery sulfation mode is used to help maintain the battery life. The charging system will enter a battery sulfation mode which tries to increase the vehicle charging when the charging system voltage is less than 13.2 V for about 30 minutes. Once in this mode, the BCM will set a targeted output voltage between 13.9 - 15.5 V for about 5 minutes. Following this 5 minutes, the BCM will then determine which mode to enter depending on the system voltage requirements.

Normal Mode

The BCM will enter Normal Mode whenever one of the following conditions are met.

- The wipers are ON for more than 3 seconds.
- GMLAN Climate Control Voltage Boost Mode Request is true, as sensed by the HVAC control head. High speed cooling fan, rear defogger and HVAC high speed blower operation can cause the BCM to enter the Charge Mode.
- The estimated battery temperature is less than 0°C (32°F).
- Vehicle Speed is greater than 145 km/h (90 mph)

- Current Sensor Fault Exists
- System Voltage was determined to be below 12.56 V
- Tow/Haul Mode is enabled

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 ambient air temperature is at least 0°C (32°F) but less than or equal to 80°C (176°F), the calculated battery current is greater than -8 A but less than 5 A and the battery state of charge is greater than or equal to 85 percent. Its targeted 14 V Power Module set-point voltage is the open circuit voltage of the battery and can be between 12.6 - 13.2 V. The BCM will exit this mode and enter Normal Mode when any of the conditions described above are present.

Headlamp Mode

The BCM will enter Headlamp Mode whenever the high or low beam headlamps are ON. Voltage will be regulated between 13.9 - 14.5 V.

Voltage Reduction Mode

The BCM will enter Voltage Reduction Mode when the calculated battery temperature is above 0°C (32°F) and the calculated battery current is greater than -7 A but less than 1 A. Its targeted 14V Power Module set-point voltage is 12.9-13.2 V. The BCM will exit this mode once the criteria are met for Normal Mode.

Battery Maintenance Mode

That battery maintenance mode is designed to ensure the 12V battery has a good state of charge. It accomplishes this by checking the voltage of the 12V battery and providing a charge if needed.

When the vehicle cord is plugged in

- The Hybrid/EV Powertrain control module (HPCM2) will check the 12V battery every 6 hours if the ignition is off. If the voltage is below a temperature dependent threshold ranging from 12.1 (cold) to 12.4 (warm) V, the Hybrid/EV Powertrain control module (HPCM2) will send the voltage set point to the engine control module (ECM). The engine control module (ECM) will send this to the 14V Power Module. Battery maintenance mode will charge the battery for 2-3 hours. If the Ignition is ON, the APM will cycle on as needed to maintain the 12V SOC.

When the vehicle cord is not plugged in

- The Hybrid/EV Powertrain control module (HPCM2) will check the 12V battery every 4 days (2.5 to 3 days) and if the voltage is below a threshold of 12.0 may activate battery maintenance. If the high voltage battery state of charge is greater than 40% and the propulsion system is not active, Hybrid/EV Powertrain control module (HPCM2) will send the voltage set point to the engine control module (ECM). The engine control module (ECM) will send this to the 14V Power Module. Battery maintenance mode will charge the battery for 45-90 minutes.

Plant Assembly Mode

The BCM will increase charging voltage for the first 500 miles of operation in an effort to ensure that the 12 V battery is fully charged when the vehicle is delivered to the customer.

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. This electrical power management system primarily utilizes existing on-board computer capability to maximize the effectiveness of the charging system, 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 adjusting the regulated voltage.
- It performs diagnostics and driver notification.

The battery condition is estimated during Vehicle OFF and during Vehicle in Service Mode. During Vehicle 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. During Vehicle ON mode, 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.

Instrument Panel Cluster Operation

Charge Indicator Operation

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

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

Battery Voltage Gauge Operation

The instrument panel cluster displays the system voltage as received from the BCM over the GMLAN serial data circuit. If there is no communication with the BCM then the gauge will indicate minimum.

This vehicle is equipped with a regulated voltage control system. This will cause the voltmeter to fluctuate between 12-14 V, as opposed to non-regulated systems which usually maintain a more consistent reading of 14 V. This fluctuation with the regulated voltage control system is normal system operation and NO repairs should be attempted.

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 displayed whenever the charge indicator is commanded ON due to a failure.

STARTING SYSTEM DESCRIPTION AND OPERATION

The HQ1 hybrid system does not use a conventional starter. Refer to [**Hybrid Modes of Operation Description**](#) for information about the starting system.
